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Social and personal skills related to physical education and physical activity

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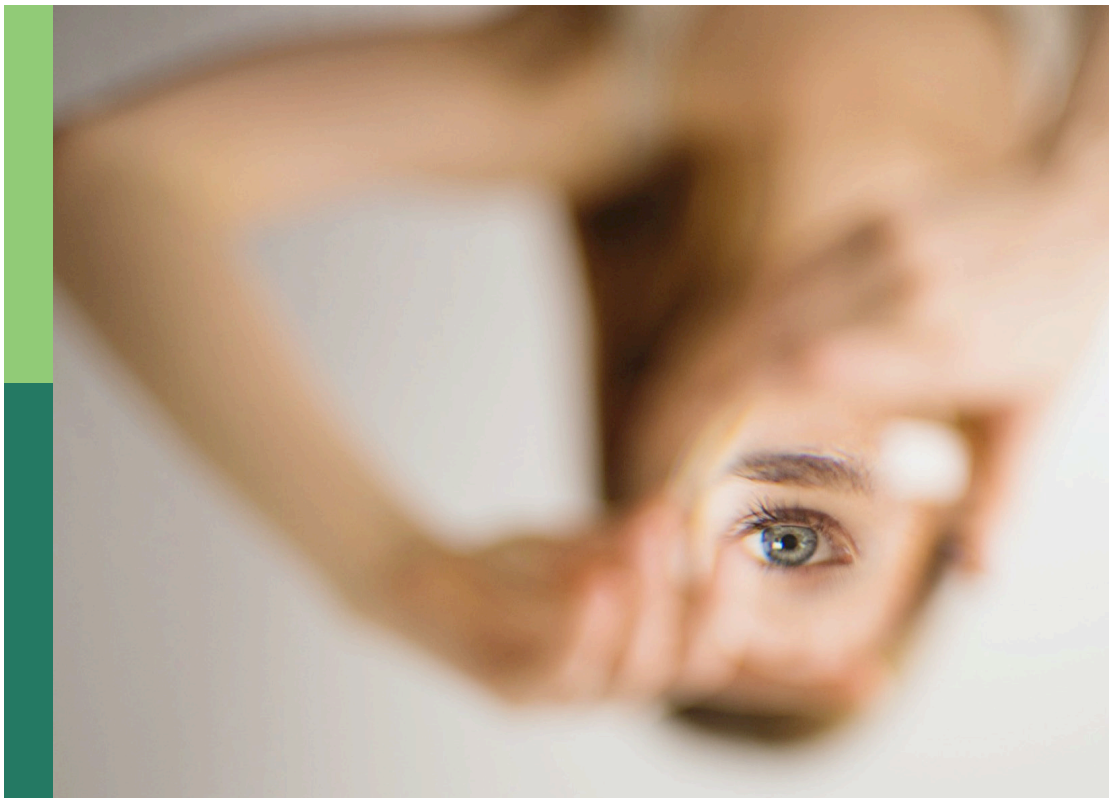

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Social and personal skills related to physical education and physical activity

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Editorial: Social and personal skills related to physical education and physical activity

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Editorial on the Research Topic
Social and personal skills related to physical education and physical activity

Maintaining an active lifestyle is an effective approach to promoting and supporting physical and psychological health throughout the lifespan. Participation in physical education, sport, exercise and leisure-time physical activity may play an important role in the development of an individual's competence, skills, and social and personal abilities. However, nowadays children and adolescents are immersed in a sedentary society, where healthy lifestyle choices can be influenced by different issues leading to a decrease in the practice of these activities linked to active and healthy lifestyles. As an example, industrialization and increasing technological development have led children and adolescents to acquire increasingly sedentary lifestyles, as well as being exposed to a series of other psychological problems and risks. In this case, a good example could be those related to personality alteration, which enhance certain symptoms such as increased irritability, depression and/or nervousness, among others. Each and every one of these symptoms is harmful to the mental health of this population group. Actually, they are also exposed to other types of situations or alterations such as those related to eating disorders or the acquisition of inappropriate eating habits, as well as altered sleep patterns (Klavina et al.).

This special issue was intended to increase the knowledge of the benefits of engaging in an active lifestyle habit and the practice of well-planned physical education for the improvement of physical and psychological health. Likewise, it also aims to increase the positive evidence of planned interventions, particularly those having a more effective impact on the achievement of some of these physical, educational or psychosocial aspects, through physical education or physical-sporting activity (Figure 1).

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Physical education (PE) subject, it may provide benefits in four related areas: cognitive, affective, psychomotor and social. Interventions in the PE field provide scientific evidence of improvements in these four areas, highlighting the potential of PE not only as a mere instrument for improving the teaching-learning process in the classroom, but also as a tool with great potential for the development of healthier lifestyles in students. This is accomplished by raising awareness of appropriate or unhealthy habits, allowing the practice of physical activity to be contextualized in an appropriate way, generating active patterns in this population group (Dudley et al.). Being more specific, for example, in the cognitive area, the development of collaborative problem solving through specific approaches and styles within PE contributes to improving this competence when problems of the same type are posed, but from the perspective of mathematics. Therefore, this allows us to draw a conclusion such as the apparent existence of transversality, cognitive improvement and transfer of learning in collaborative problem solving from PE (Kano et al.).

It is also possible to propose intervention programmes for improving socio-emotional skills. A good example is the study developed by Malinauskas et al. In this study, 15-min interventions were carried out during 48 sessions. All sessions focused on enhancing the social-emotional skills of: empathy, cooperation, assertiveness, self-control, optimism, ability to understand and analyse emotions, appraisal and use of emotions. For this purpose, training methods were used including impulse control (autogenic training), post-activity discussion of shared experiences, group learning (cooperative learning), role-play scenarios, video viewing and written student worksheets (Malinauskas et al.). Similarly, with the application of other educational interventions, as in the study by Muñoz-Llerena et al., factors also related to socio-emotional skills such as personal and social responsibility were improved through the design of an adapted educational methodology (Positive Youth Development PYD) in an out-of-school context. These types of studies indicate that not only in formal education, but also in areas related to extracurricular sports activities and organized physical activity, it is more than advisable to propose innovative and hybrid proposals such as PYD, in order to obtain the greatest possible benefits in practice.

On the basis of all the above-mentioned evidence, active teachers and university students of physical education should be trained in these methodologies and interventions promoting the training of learners in social and personal aspects. Along these lines, we could also include and introduce methodologies that are currently being used in a multitude of educational and social projects, such as the service learning (SL) methodology, which fosters the personal and civic values of participants

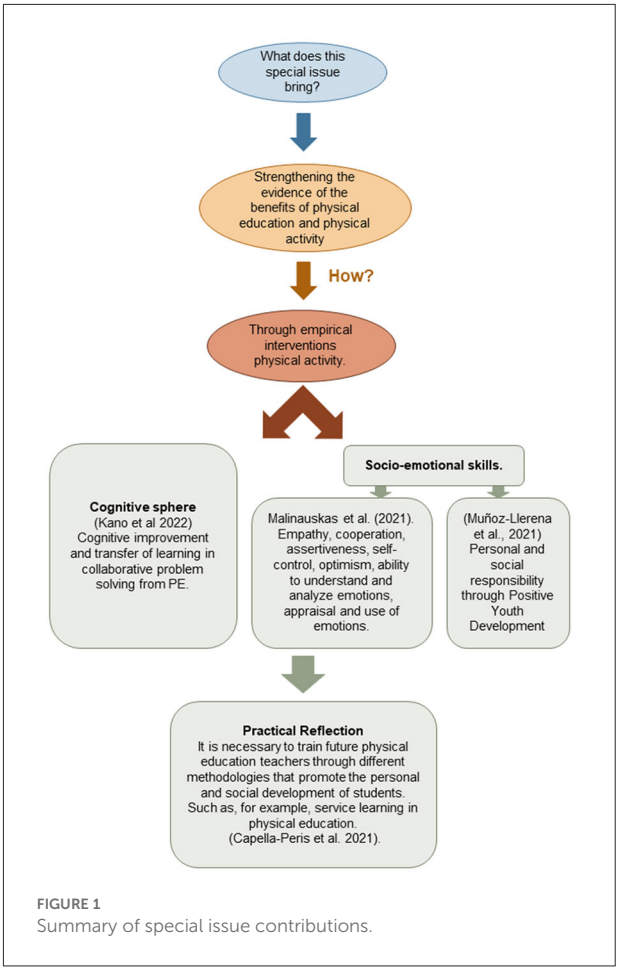

FIGURE 1
Summary of special issue contributions.

(Capella-Peris et al.). This can be considered a good strategy and tool in the pedagogical, human and social training of future PE teachers.

Summarizing the contributions of this special issue, recommendations for coaches when intervening in competitive sport are suggested, as follows: (a) setting two different types of goals, sporting goals and life skills goals; (b) integrating PYD strategies into coaching tasks; (c) using the methodological strategies offered to facilitate the promotion of PYD and life skills learning; (d) involving all players in all roles throughout the season and letting them make their own decisions; and (e) maintaining a balance between sporting outcomes and PYD intervention (Muñoz-Llerena et al.).

Therefore, in this special issue some contributions on the benefits of the practice of physical activity and physical education have been carried out with a formative intention, based on the evidence provided by interventions developed with scientific thoroughness. This should help teachers in their approach to objectives and the design of teaching practices.

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Author's note

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Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The Associations Between Problematic Internet Use, Healthy Lifestyle Behaviors and Health Complaints in Adolescents

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This study aimed to explore relationship between problematic internet use (PIU), healthy lifestyle behaviors and subjective health complaints.

Methods: Participants (396 adolescents, aged 11–18 years) from 34 general education schools across Latvia completed online survey. The PIU was assessed by the Problematic and Risky Internet Use Screening Scale (PRIUSS) collecting data on social impairment, emotional impairment, and risky/impulsive internet use. The subjective health complaints assessed were somatic and psychological symptoms. Healthy lifestyle behaviors assessed were daily physical activities, time spent in using information technologies (IT), eating habits, and duration of sleep.

Results: This study found that 31.00% (n = 124) of the participants scored at risk for PIU. Correlates associated with PIU were subjective health complaints, low physical activity, lack of meals together with family and disturbed sleeping regimes on weekends (P < 0.001). Stepwise multiple regression analyses showed that 34% of the variance in the PRIUSS scores was explained by psychological health complaints (irritability, depression, and nervousness), screen time use on weekends, physical activity, drinking sweetened soft drinks and unhealthy eating habits.

Conclusion: PIU behaviors among adolescents in Latvia are associated with psychological symptoms and unhealthy lifestyle. Further effective measures and interventions are needed to prevent development of psychosomatic health problems.

Keywords: health, adolescents, problematic internet use, physical activity, education

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INTRODUCTION

Adolescence is a period when independent lifestyle behaviours are developed which can significantly impact current and long-term health and education aspects (e.g., body composition, fitness level, academic performance, sleep quality, and psychosocial behaviors) (Biddle et al., 2004; Costigan et al., 2013).

Numerous previous studies involving adolescents have demonstrated associations between lower levels of daily physical activity and greater time engaged in sedentary behaviors such as screen time

(Hashem et al., 2018; Marques et al., 2019). Several authors have indicated that excessive screen time is associated with adverse effects on irritability, mood disturbances and psychosocial impairments, leading to poor educational performance (Rayner et al., 2017; Bianco et al., 2019). Recently published European statistics demonstrated that in some countries (e.g., Ireland, Portugal, Germany, and Finland) there is greater than 10% prevalence rates for chronic depression for adolescents aged 15 years and over (Eurostat Statistics Explained, 2018). While it is recommended that children and adolescents should spend each day at least 60 min in moderate-to- vigorous activity (World Health Organization, 2020), European national studies reported that majority of adolescent population are not meeting current recommendations of the World Health Organization related to healthy lifestyle (e.g., daily physical activity, nutrition, screen time) (Lowry et al., 2015). Moreover, almost one-third of responders reported multiple health complaints (Marques et al., 2019).

Also, the evidence increases that compulsive and/or problematic internet use behavior can have negative effects on physical and psychological health in adolescents (Lam and Peng, 2010; Derbyshire et al., 2013; Fineberg et al., 2018). The term "Problematic Internet Use" (PIU) was introduced by Beard and Wolf to identify excessive Internet use causing psychological, social, educational, and work problems in people's lives (Beard and Wolf, 2001). Furthermore, several studies suggests that PIU are associated with and influencing each other instead of existing independently. This raises interest for the probable associations of PIU in relation to their possible associations with other unhealthy behaviors and health outcomes, which has relevance for future health promotion intervention (Eaton et al., 2012; Cliff et al., 2016).

To date, few prospective studies have investigated risk factors for PIU. Cross-sectional adjusted studies have demonstrated different factors associated with PIU, for example, gender and age (Vigna-Taglianti et al., 2017), type of school, academic performance, urban context, socio-economic status (Durkee et al., 2012), family context (e.g., single parent, relationship with parents (Chang et al., 2015), parental communication about the Internet, psychosocial risk factors (Kormas et al., 2011), coping skills, self-esteem, depression (Korczak et al., 2017), amount of hours spent on the internet (Anderson et al., 2016), and screen time media use (Ngantcha et al., 2018).

However, the association between PIU and healthy lifestyle behaviors and subjective health complaints have not been explored so far. Because of the increase Internet use among adolescents, and related multiple adverse health consequences, PIU could become a public health problem in the next years. While subjective health complaints might include symptoms persons experiencing without a medical diagnosis, these complaints represent overall situation of the public health because subjective health feelings are linked to health outcomes (Bombak, 2013). Furthermore, subjective health complaints in adolescents are related to lower level of academic performance leading to dropping out of school (De Ridder et al., 2013), and may become chronic mental or physical health issue in adulthood (Bianco et al., 2019).

The existing evidence from the national surveys of the Health Behaviour in School-aged Children (HBSC) in Latvia obtained in 2018 (n = 4,396, age 11–15 years old) have revealed that 55.9% of girls and 35.5% of boys have spent by screens more than 3 h during working days. During weekends the screen time increases 42.1% and 61.2%, accordingly (Pudule et al., 2020). In order to better understand associations between unhealthy lifestyle behaviors (e.g., excessive screen time, problematic internet use, limited daily physical activities etc.) and subjective health complaints national studies are required.

Research hypotheses in this study suggested that problematic internet use may be a contributing factor to multiple health complaints because it may replace daily physical activity, increase unhealthy eating habits and sleep problems. This study aimed to explore relationship between problematic internet, healthy lifestyle behaviors and subjective health complaints.

METHODS

Sample Selection

A cross-sectional study design formed the basis of this survey conducted among adolescents representing general education schools from the four cultural regions and the capital of Latvia, Riga. Data for this study were drawn from the national longitudinal research project. The target population was made up of Latvian adolescents from 11 to 18 years of age. Sampling methods included proportional random sampling to select schools from the four cultural regions of Latvia and Riga. The local education departments in each region were contacted for random school selection from their area and Riga. When schools agreed to participate, then class groups of grades from 5th to 11th were randomly selected for participation in the survey. The research team obtained written consent from the school administration priori to ask consent from adolescents' parents. In total 34 randomly selected schools were involved in this study. The link to a self-completed on-line survey was provided by the researchers to the school administration or directly to adolescents after receiving signed consents. Participants completed 15–10 min online survey by using their smartphones or computers. Of the total 615 participants involved in the project baseline phase, a total of 396 adolescents (64%) completed all survey questions online. Age ranged from 11 to 18 years of age (mean age 14.01 years SD = 2.23). Of all participants 230 (58.08%) were girls (mean age 14.14, SD = 2.21) and 166 (41.91%) were boys (mean age 13.81, SD = 2.26). Participants were recruited from 34 state schools representing rural, town and urban districts of Latvia. According to Cohen (1988) and sample size calculation formula presented in Krejcie and Morgan (1970) this study had adequate sample size (n = 396) for data analyses.

The study was approved by the Health Care Ethics Review Committee at the Latvian Academy of Sport Education (Latvia) and has been developed in line with the Declaration of Helsinki (World Medical Association). Data were collected between May–October 2020.

During this time all education settings were open, however, some schools or classes had remote teaching for some weeks because of quarantine condition during COVID 19 pandemic.

VARIABLES AND MEASURES

Problematic Internet Use

Adolescents' problematic internet use (PIU) was assessed by the Problematic and Risky Internet Use Screening Scale (PRIUSS), a validated adolescent screening instrument (Jelenchick et al., 2014). The PRIUSS is an 18-item risk-based screening scale for problematic internet use with questions organized into the three subscales: 1) social impairment (six items), 2) emotional impairment (five items), and 3) risky/impulsive internet use (seven items). The PRIUSS response selections use a Likert scale with scores of 0 through 4 (from "never" = 0 to "very often" = 4). A PRIUSS score ≥26 indicates that the adolescent is at high risk for PIU, and score from 15–25 indicates intermediate risk for PIU (Moreno et al., 2011).

For healthy behaviour and subjective health complaints data collection questions derived from the Health Behavior in School-aged Children (HBSC) (Ravens-Sieberer et al., 2008). Since 1990, Latvia has been a member of the Health Behavior in School-Aged Children–HBSC research project.

Subjective Health Complaints

The subjective health complaints were assessed using the HBSC symptom checklist.The HBSC symptom checklist has shown good reliability and validity (Haugland and Wold, 2001). Subjective health complaints questions were related to four somatic and four psychological complaints (headache, stomach-ache, backache, dizziness, feeling depressed, irritability, feeling nervous and difficulties getting to sleep). Participants responded on a 5-point scale ranging from 1 - *"rarely or never"* to 5 - "*about every day"*. A multiple health complaints variables was identified if the participant reported two or more health complaints observed four or more complaints weekly.

Healthy Lifestyle Behaviors

Healthy lifestyle behaviors were related to: 1) free time physical activity (four items); 2) time spent using information technologies (two item), and 3) eating habits (five items). To assess free-time daily physical activity, adolescents were asked to indicate the number of days and hours over the past week during which they were doing moderate-vigorous physical activities out of school. Responses were dichotomized into seven times/hours per week and daily, according to the physical activity guidelines (World Health Organization, 2020). Furthermore, responders were asked to report how many hours per day they spent using information technologies (IT) (e.g., watching TV, playing games, chatting, emailing, messaging on Internet etc.) during the weekday and weekend, according to the guidelines of the scoring system used in the Health Behaviour in School-aged Children (HBSC) (Ravens-Sieberer et al., 2008). A cut off of 3 h per day was used to allow for time spent reporting various ITs, and to keep the results comparable to a recent international comparison study (Hoare et al., 2016).

Finally, adolescents were asked to respond on five questions related to their eating habits. The frequency of the eating habits was assessed by questions:" How often do you usually have breakfast (in school, or at home)? ", "How many times a week do you consume fruit/vegetables/sweetened soft drinks/sweets?", "How often do you eat with your family?", "How often do you eat while being at the screen?", and "How often do you drink sweetened soft drinks such as Coca-Cola, Fanta etc.?" Sleep duration was assessed by asking questions about the time when adolescents went to sleep and woke up on weekdays and weekends.

Statistical Analyses

Data analyses included descriptive statistics calculating means and standard deviations for all study outcomes. Differences between boys and girls were analyzed using ANOVA. Spearman correlation between variables was calculated. Stepwise multiple linear regression analyses to determine the variables to predict variance in PRIUSS total scores. A statistical significance level of at least $p < 0.05$ was used for all analyses. Statistical analyses were performed using IBM SPSS 22.

RESULTS

The characteristics of the obtained results are presented in **Table 1**. The mean PRIUSS score was 21.13 (SD = 10.44), however, for 124 (31.00%) responders' results were >26 points indicating high psychosocial health risks related to PIU. In this study adolescents presented very low daily physical activity time per week (2.33 h/week, SD = 2.12).

Although boys reported average participation in physical activities in significantly more days per week than girls (4.19 days/w and 3.87 days/w, respectively, $p < 0.05$), they did not present daily participation as recommended by the World Health Organization (WHO). The mean of screen time use on weekends was higher than during weekdays (4.30, SD = 1.94 and 3.92, SD = 2.03 respectively), The prevalence of psychological health complaints was significantly higher than somatic health complaints ($p < 0.05$). Moreover, a significantly higher proportion of girls reported experiencing all health complaints than boys in both categories, somatic and psychological domain ($p < 0.05$).

The analyses of relationship between PRIUSS total scores and subjective health complaints and healthy lifestyle behaviors are summarized in **Table 2**.

There was significant negative correlation between PRIUSS total scores and physical activity, having meals together with family and sleeping regimes on weekends ($p < 0.05$). Furthermore, significant positive association was between PRIUSS total score and each of somatic and psychological health complaints, unhealthy eating habits and screen time use ($p < 0.05$). However, no clear correlations

TABLE 1 | Descriptive data of the study participants, by gender.

Variables	Overall, mean ± SD, *n* = 396	Girls, mean ± SD, *n* = 230	Boys, mean ± SD, *n* = 166	*p*-values
PRIUSS total	21.13 ± 10.44	21.76 ± 11.61	20.27 ± 8.57	0.361
Healthy lifestyle behaviors				
Physical activities (days/per week)	4.00 ± 1.40	3.87 ± 1.38	4.19 ± 1.42	0.011
Physical activities (hours per week)	2.33 ± 2.12	2.12 ± 1.97	2.66 ± 2.3	0.051
Screen time use on weekdays	3.92 ± 2.03	4.12 ± 2.06	3.66 ± 1.98	0.027
Screen time use on weekends	4.30 ± 1.94	4.43 ± 2.02	4.14 ± 1.85	0.097
Sleep duration on weekdays	8.21 ± 1.19	8.22 ± 1.17	8.21 ± 1.24	0.994
Sleep duration on weekends	9.56 ± 1.50	9.63 ± 1.44	9.49 ± 1.6	0.590
Eat breakfast	2.10 ± 0.98	2.00 ± 1.07	2.26 ± 0.84	0.034
Eat with family members	1.81 ± 0.89	1.76 ± 0.92	1.9 ± 0.87	0.130
Eat at the screen	1.58 ± 0.92	1.65 ± 0.94	1.49 ± 0.92	0.078
Eat fruits and vegetables	1.97 ± 0.72	2.00 ± 0.73	1.96 ± 0.73	0.546
Drink carbonated or sweetened drinks	1.17 ± 0.78	1.12 ± 0.77	1.25 ± 0.82	0.122
Eat ready-to-use packaging	0.77 ± 0.75	0.74 ± 0.74	0.83 ± 0.78	0.110
Subjective health complaints				
Somatic health complaints				
Headache	0.92 ± 1.20	1.16 ± 1.31	0.62 ± 0.97	0.000
Abdominal pain	0.71 ± 0.93	0.82 ± 1.01	0.57 ± 0.88	0.006
Back pain	0.99 ± 1.33	1.26 ± 1.44	0.64 ± 1.11	0.000
Dizziness	0.64 ± 1.05	0.79 ± 1.17	0.46 ± 0.85	0.004
Psychological health complaints				
Depression	1.17 ± 1.27	1.29 ± 1.41	1.02 ± 1.31	0.043
Irritability or bad mood	1.92 ± 1.35	2.07 ± 1.35	1.73 ± 1.35	0.015
Nervousness	1.71 ± 1.45	1.91 ± 1.46	1.44 ± 1.42	0.001
Difficulty falling asleep	1.38 ± 1.46	1.51 ± 1.51	1.22 ± 1.41	0.046

p values are based on analysis of variance of gender differences.

between the PRIUSS scores and other study parameters were noted.

Results of stepwise multiple regression analyses with PRIUSS scores as dependent variable are presented in **Table 3**.

These outcomes revealed that 34% of the variance in the PRIUSS scores was explained by the three out of the four psychological health complaints (irritability, depression, and nervousness), hours of screen time use on weekend, physical activity days during week, drinking sweetened soft drinks and eating habits such as fast-food meals and frequently having snacks while being at the screen.

DISCUSSION

This study examined the association between problematic internet use (PIU) related psychosocial behaviors, subjective health complaints (somatic and psychological) and healthy lifestyle habits in adolescents (11–18 years of age).

The prevalence of PIU in our study sample of adolescents was 31.00% which is higher than reported in other studies (Durkee et al., 2012; Gámez-Guadix, 2014; Jelenchick et al., 2014).

The main findings in obtained subjective health complaints outcomes demonstrated that psychological health complaints were prevalent. Moreover, girls reported significantly higher rate of the eight symptoms than boys ($p < 0.05$) that was in line with recent study outcomes in Lithuania (Vaičunas and Smigelskas, 2019), Latvia (Pudule et al., 2020) and other international cross-sectional studies (Gobina et al., 2011). There are a number of possible explanations for this. Data were collected when some schools across country had temporary closings because of quarantine situation related to COVID 19 pandemic. During Spring – Summer 2020 in

TABLE 2 | Correlation of PRIUSS total scores with subjective health complaints and healthy lifestyle behaviors.

n = 396	PRIUSS	
Variables	**Correlation coefficient**	***p*- values**
Physical activities (times during week)	–0.238	0.000
Physical activities (hours per week)	–0.122	0.008
Headache	0.254	0.000
Abdominal pain	0.228	0.000
Back pain	0.307	0.000
Depression	0.407	0.000
Irritability or bad mood	0.435	0.000
Nervousness	0.430	0.000
Difficulty falling asleep	0.258	0.000
Dizziness	0.236	0.000
Eat breakfast	–0.061	0.115
Eat with family members	–0.261	0.000
Eat at the screen	0.348	0.000
Eat fruits and vegetables	–0.060	0.115
Drink carbonated or sweetened drinks	0.205	0.000
Use ready-to-use packaging	0.194	0.000
Screen time use on week days	0.222	0.000
Screen time use on holidays	0.364	0.000
Sleep duration on weekdays	–0.206	0.000
Sleep duration on holidays	–0.067	0.090

TABLE 3 | Stepwise multiple linear regression model examining associations with the PRIUSS.

Variables	Unstandardized Coefficients		Standardized coefficients	95% CI	Sig.
	B	Std.Error	Beta	B	p-value
Irritability or bad mood	1.068	0.455	0.139	0.174–1.963	0.019
Screen time use on weekend days	0.84	0.256	0.157	0.336–1.343	0.001
Depression	1.367	0.384	0.18	0.612–2.122	0.001
Drink carbonated or sweetened drinks	1.512	0.555	0.114	0.421–2.603	0.007
Eat fast food	1.28	0.583	0.093	0.133–2.426	0.029
Nervousness	1.049	0.41	0.146	0.244–1.854	0.011
Eat at the screen	1.396	0.534	0.124	0.346–2.446	0.009
Physical activities (times during week)	–0.71	0.32	-0.095	–1.339–0.08	0.027

F (8, 387) = 27.273. $P < 0.0001$. R^2 *(Adjusted* R^2*) = 0.361 (0.347).*
Dependent value: PRIUSS total.

Latvia there were very small numbers of new infections and lockdowns were not enforced. However, many restrictions regarding public events, travelling and social distancing were applied. Therefore, adolescents still experienced increased stress because of uncertainty threats and insecurity about future. According to Zhu et al. (2020), specifically, societal regulations that restricts personal freedom might undermine adolescents' sense of control (for example, limited possibilities to attend public events such as concerts, sport competitions, summer festivals etc.).

In this study majority of participants did not meet WHO guidelines (2020) of daily physical activities for adolescents (at least 60 min of moderate to- vigorous activity each day). Also, a large proportion of participants did not meet international recommendations of less than 3 h per day of screen time (Hoare et al., 2016). With the increasing use of information technologies in adolescents' lives and the greater role of digital tools in education and social activities, it may be challenging to increase the proportion of adolescents meeting the recommendations and guidelines of healthy lifestyle (Marques et al., 2019).

The study outcomes indicated consistent positive association between PIU and subjective health complaints. Although some of these relationships presented small magnitude, the consistency of results across the eight health complaints presents strong link between problematic internet use related psychosocial behaviors and health. These findings are in line with previous studies describing relationship between PIU and mental health in adolescents (Gámez-Guadix, 2014; Ciarrochi et al., 2016). With regard to negative relations, the findings for PIU indicated that adolescents with limited daily physical activities, less sleep duration on weekends and those who had fewer mealtimes with their family members had higher PIU scores. Other research studies have identified problems associated with problematic use of internet and sleep deprivation and lack of exercise (Morahan-Martin and Schumacker, 2000; Moreno et al., 2011). The significant relations between PIU and eating behaviours (for example, having less meals together with family members, consuming more fast-food and carbonated or sweetened drinks) was more complex to explain since eating habits in a family can be related to parental education, culture and socioeconomic variables (Hanson and Chen, 2007).

The outcomes of multiple regression demonstrated that psychological health complaints, such as irritability, depression, and nervousness were significant predictors of the PIU scores. As indicated above, previous studies conceptualized PIU in relation to psychological dependence and lack of control over the time spent online. Specifically, the links between PIU and anxiety, depression and general psychological distress have been examined mainly as predictors in adolescents (van Rooij et al., 2010; Gámez-Guadix et al., 2013; Gámez-Guadix, 2014; Kowert et al., 2015). Similar to our study, risk factors that have been implicated in the development of PIU have encompassed lifestyle such as limited physical activities, sedentary behaviors including excessive screen time and consuming unhealthy food (Zboralski et al., 2009; Li et al., 2014).

There are a number of limitations to interpretation of this study findings. The sample included in this study does not necessarily represent the entire population of that age. The results are based on self-reported survey outcomes. Therefore, any errors introduced due to self-report of subjective health complaints, healthy behaviors and PRIUSS might tend to mitigate the statistical associations, suggesting that the actual associations might be stronger. Furthermore, the part of data were collected during COVID 19 pandemic when some schools had remote education because of temporary quarantine situation. Therefore, screen time measures can be increased because of online education mode. However, observations and anecdotal notes during this study demonstrated that screen time during leisure was also prolonged, indicating that many adolescents engaged in long screen time for leisure.

CONCLUSION AND IMPLICATIONS FOR FUTURE RESEARCH

The reported data presented relationship between PIU, subjective health complaints and lifestyle factors in adolescents. The results of the present study should also be considered as an indicator to public health policies to be acknowledged and strengthened in the future

targeting health, education and healthy lifestyle early in adolescence. Further effective measures and interventions are needed to prevent development of psychosomatic health problems. Evidence indicates that individual health behaviors of children and adolescents are influenced by social networks (Asch and Rosin, 2016). The innovative technological approaches could be designed to motivate adolescents engage in healthy lifestyle behaviors (e.g., physical activities) and to deploy interventions based on their social connections. Social incentives motivate adolescents to adjust their behaviors based on social links, are comprehensive and could incorporate gamification interventions to provide a measurable, achievement directed and sustainable approach to increase engagement in healthy lifestyle behaviors.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Latvian Academy of Sport Education (approval date 28.02.2020.). Written informed consent to participate in this study was provided by the participants legal guardian.

AUTHOR CONTRIBUTIONS

AK devised the structure of the paper, drafted the manuscript. LF, AR, and AA contacted participants and collected data. VV analyzed the data and JP commented on the final version.

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Personal and Social Responsibility Development in a Volleyball Hybrid Positive Youth Development Program: A Mixed Methods Approach

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Positive Youth Development (PYD) programs are being used to foster holistic growth in children and adolescents. The hybridized application of two or more programs of this type has acquired special relevance in recent years. Although their application is common in the school context, there are few research studies that attempt their implementation in an extracurricular context. This study analyzed the effects of an intervention based on a hybrid PYD program on personal responsibility (PR) and social responsibility (SR) in youth volleyball players in an extracurricular context. A hybrid program was applied during the competitive season, with a total of 37 sessions with 30 girl students (15 experimental and 15 control) aged between 8 and 10 years ($M = 8.87$, $SD = 0.82$). A convergent mixed methods design was applied to integrate the following: (a) semi-structured interviews and field notes and (b) personal and social responsibility questionnaires. The results indicated that the implementation of the hybrid program appeared to yield a positive perception of learning in both the participants and the coach. Although there were no statistically significant intergroup or intragroup differences, the findings suggest that the hybrid program seems to be effective in fostering PR and SR in youth girl volleyball players.

Keywords: pedagogical model, teaching personal and social responsibility model, sport education model, mini-volleyball, competitive sport

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INTRODUCTION

The use of Positive Youth Development (PYD) programs is currently on the rise. PYD, which has its origins in positive psychology (Caballero, 2015), is a way of understanding development rather than a specific construct and is used as an umbrella term to refer to the ways in which youth accumulate optimal developmental experiences in organized activities (Holt and Neely, 2011). Among these organized activities, sports are the most widespread among young people (Larson and Verma, 1999) and are a privileged context for promoting PYD (Fraser-Thomas et al., 2005; Petitpas et al., 2005; Escartí et al., 2009).

There are many potential benefits of sport-based PYD (SBPYD) programs. On a physical level, there may be improvements in the cardiovascular system, muscular strength and resistance, flexibility, bone structure and weight control, and a lower risk of suffering from

cardiovascular diseases, diabetes, obesity, osteoporosis, stroke, depression, or cancer. On a psychological/emotional level, opportunities are offered to experience challenge, fun, and enjoyment. SBPYD programs can also increase self-esteem, satisfaction, and happiness and can also decrease stress. On a social level, such programs promote citizenship, social success, positive interrelationships, and the development of skills such as leadership, cooperation, responsibility, empathy, or self-control. On an intellectual level, there is a positive relationship between these programs and academic performance, class attendance, study time, and university attendance (Fraser-Thomas et al., 2005; Petitpas et al., 2005; Theokas et al., 2008; Weiss et al., 2013, 2020; Ivy et al., 2018). However, SBPYD programs may not always foster all of these benefits.

There are different factors that must be taken into account for the successful implementation of SBPYD programs. PYD study states that the elements needed to be present in a sports program to achieve PYD are as follows: the climate of the program and the contents to be taught (Escartí et al., 2009); a mastery-oriented and caring climate, peer/adult supportive relationships, and opportunities to learn life skills (Weiss and Wiese-Bjornstal, 2009); or the individual learner (internal and external assets and autobiographical experiences), the learning contexts (school, sport, family, vocational, and extracurricular), and the transfer contexts (factors, e.g., similarity of context, opportunities to use skills, support and rewards for transfer, and psychological processes influencing transfer, e.g., unconscious personal reconstructions, confidence, or level of engagement) (Pierce et al., 2017). Indeed, Petitpas et al. (2008) state that, to develop PYD, sports programs must present voluntary and motivating activities that require effort and commitment and have clear rules, which are used as a metaphor to teach life skills and their application in the lives of youths, all of which should occur within a caring and safe environment led by a respectful adult. On this matter, Holt et al. (2017) established a model of PYD through sport, stating that a program should include a PYD climate (based on relationships between athletes and peers, parents, and other adults) and a focus on life skills program (employing life skill-building and transfer activities) in order to achieve personal, social, and physical PYD outcomes. According to their model, enhancing these outcomes "will facilitate transfer and enable youth to thrive and contribute to their communities" (Holt et al., 2017, p. 38).

Within competitive youth sport, Santos and Martinek (2018) established four strategies for coaches to promote its educational potential: to assume the double objective of improving sports skills while learning life lessons and building a positive character, to convert PYD into specific, adapted behaviors, to integrate a PYD-based approach into training sessions, and to maintain a balance between winning expectations and the PYD intervention regardless of the seasonal demands.

At present, there are different intellectual currents derived from the PYD theoretical frameworks, related to how PYD can contribute to better sports experiences for youth that connect to their daily lives in current society. Some, like critical PYD (Gonzalez et al., 2020), are focused on adopting a critical perspective on PYD, recognizing the values of youth and their capacity to challenge inequities, and transforming society and its structures to erase oppression. Others reflect on the long-term implications of SBPYD programs and present solutions to support and promote positive individual behavioral changes in the long term, such as the MINDSPACE (Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment, and Ego) model (Whitley, 2021). One way to apply SBPYD programs is through pedagogical models. Two of the most utilized ones from the scientific studies that align with the guiding principles of PYD are the teaching personal and social responsibility model (TPSR; Hellison, 2011) and the sport education model (SE; Siedentop, 1998; Siedentop et al., 2004). These pedagogical models have been applied with positive results in different Spanish contexts and with different populations, ages, sports, and educational levels. They have become the pedagogical models that are most commonly used by researchers in Spain (Escartí et al., 2010a,b; Meroño et al., 2015, 2016; Fernández-Gavira et al., 2018; Camerino et al., 2019; Manzano-Sánchez and Valero-Valenzuela, 2019; Manzano-Sánchez et al., 2019, 2020; Valero-Valenzuela et al., 2020a; Carreres-Ponsoda et al., 2021).

The TPSR model is one of the most relevant models aligned with the PYD framework, owing to its implementation in different countries, the wide variety of research studies about it, and the ease of its hybridization with other models (Escartí et al., 2009; Caballero Blanco et al., 2013; Pozo et al., 2018; Baptista et al., 2020; Sánchez-Alcaraz et al., 2020). It is characterized by strong instructor-participant relationships through specific guidelines, along with empowerment and personal and group reflections, carried out gradually. These tools aim for those involved to take responsibility for their actions at a personal and social level (Hellison et al., 2008). A characteristic framework was, therefore, designed that included the core values of the model, premises, levels of responsibility, instructor responsibilities, application format, suggested strategies, problem-solving, and evaluation (Hellison, 2011).

The SE model was designed to provide authentic and enriching sports experiences (Siedentop, 1998). The basic characteristics of this model arise from the particularities of sports (Siedentop et al., 2004), which make it possible to pursue objectives beyond those of learning a given technical skill. For the creators of this model, a competent athlete will possess the necessary skills to participate satisfactorily in these and other activities that arise, understanding them, and are being able to apply and execute appropriate strategies depending on the complexity of the situation.

There is no pedagogical model that is effective in all contexts and contents (Lund and Tannehill, 2010). In the words of Martinek and Hellison (2016, p. 13), "One size does not fit all (…). Drawing on personal strengths and available resources and augmenting interpersonal processes between youth and staff will be essential for (…) successful implementation." To overcome these limitations, different pedagogical models have begun to be combined when implemented to adapt them to the intervention context, enhancing their educational effects, and reducing the limitations that may exist in the application of any given model in isolation (Haerens et al., 2011; González-Víllora

et al., 2019). According to González-Víllora et al. (2019, p. 13) "hybridizations could be considered a new and innovative trend that is necessary to increase the benefits and possibilities for the implementation of pedagogical models." A previous research study has shown that these benefits have a positive impact in two main areas—sports skills and psychosocial variables (psychological, social, and personal development)—as long as a logical and appropriate use of the intervention is carried out (Fernández-Río et al., 2016). The proposal presented in this study analyzes personal responsibility (PR) and social responsibility (SR), a variable that falls within the psychosocial field proposed by the previous authors.

Hybridizations of TPSR or SE with different pedagogical models are especially frequent. The separate combination of TPSR—or SE—with other models has obtained positive results when applied in educational contexts in sports (Hastie and Curtner-Smith, 2006; Pritchard and Mc-Collum, 2009; Mesquita et al., 2012; Caballero-Blanco, 2015; Araújo et al., 2016, 2019; Valero-Valenzuela et al., 2020b), which strengthens support for the usefulness of designing hybrid programs that combine the benefits of both models (Menéndez-Santurio and Fernández-Río, 2016a,b, 2017; Fernández-Río and Menéndez-Santurio, 2017; Muñoz-Llerena et al., 2019). In the previous research studies, the feasibility of hybridizing TPSR and SE has been analyzed, with different studies considering SE suitable to combine with TPSR as long as the implemented programs are designed to offer the opportunity to experience all five levels of responsibility, noting that "the pressure and perceived importance of competitive sports can be useful in testing the depth of commitment to, and engagement with, the learning outcomes of TPSR" (Gordon, 2009, p. 15). Such studies have also pointed out that these two models share a common theory of learning (the constructivist theory; Hastie and Buchanan, 2000).

However, Gordon (2009) considered that tensions might arise in the implementation of both models together in physical education (PE) classes when it comes to the use of games within sports practice and by the emphasis placed on internal (TPSR) vs. external (SE) sources of authority, as they have different purposes: SE aims to promote good sports skills, while TPSR aims to help youngsters become better people. In PE, a decision must, therefore, be made about which model should be prioritized, rather than attempting to meet the goals of both.

Outside the regulated context of PE classes, the application of hybrid programs has seldom been addressed in scientific studies (González-Víllora et al., 2019). Only Muñoz-Llerena et al. (2019) have proposed a design for a PYD program hybridizing TPSR and SE for application, especially in team sports in extracurricular competitive contexts: the Team Sports Positive Development Program (TESPODEP). This hybridization was carried out bearing in mind the greater possibilities offered by hybridized pedagogical models to adapt to the intervention context and increase their effects on the participants. Using TPSR as a way to promote psychosocial development, complemented with the specific strategies of SE, contributes to promoting sports development while reinforcing the psychosocial gains obtained. In addition, the hybridization of these models allows the intervention to be adapted to a competitive team sports structure, which makes it possible to achieve, with the same intervention, improvements in a large number of participants and in a context in which winning is usually more important than the holistic development of the players.

To verify the benefits of an implementation based on this program, this study analyzed the effects of this hybrid TESPODEP program on PR and SR in youth volleyball players in an extracurricular context. The rationale for this research study was to provide evidence for how the implementation of a hybrid TPSR+SE program might affect players in an out-of-school competitive team sports club, helping to fill the existing gap in the study while offering a flexible model specifically designed to be applied in team sports.

Volleyball was chosen because of its differentiating characteristics from other sports. Unlike most team sports, volleyball is conditioned by the impossibility of retaining the ball; thus, it can only be played by hitting. This limitation influences the importance of technique in ball control and, therefore, the dependence between the collective contacts to win the point. The collaboration between teammates is crucial for scoring, when compared to other sports where a single player could score. In volleyball, except for the serve, the rest of the actions are sequential and depend on the previous and following ones, so cooperation or teamwork is of special relevance. Furthermore, in the initial stages the technical quality is lower, so it becomes essential to emphasize cooperative tactical behaviors, which compensate the limited mechanical efficiency, to achieve continuity in the game. Finally, the fact of not being able to hold the ball increases the timing demands of the game, which reinforces the need to achieve an adequate emotional state that encourages cooperation, decision-making, and autonomy in favor of the aims of the team.

Competitive youth sport "can serve as an appropriate context conducive to PYD" (Ferreira dos Santos et al., 2018, p. 229), being a fertile platform that can lead to developments in life skills such as perseverance, respect, teamwork, or leadership (Santos and Martinek, 2018). It was chosen based on the need to increase the research field with more studies that employ rigorous methodology and the suitability of competition as a perfect setting to implement SBPYD models, due to the reduced number of participants and its voluntary access (Carreres-Ponsoda et al., 2021) and the focus on empowering personal and social strengths (Harwood and Johnston, 2016; Jørgensen et al., 2020). In addition, there is a need for more research studies to clarify our understanding of the development of life skills through competitive SBPYD programs (Jacobs and Wright, 2018).

The study was put into practice based on a series of research questions and hypotheses. The main hypothesis was that the proposed intervention would promote the development of PR and SR in the participants. The research questions considered were as follows: What are coaches' and athletes' perceptions concerning teaching and learning personal and social responsibility as a consequence of the intervention? What is the impact of the TESPODEP program on athletes' personal and social responsibility outcomes? To what extent do the quantitative responsibility data obtained agree with the findings

of the interviews and field notes on the development of personal and social responsibility perception in the players?

MATERIALS AND METHODS

Context

The main goal of the intervention program was to train participants to become enthusiastic, competent, literate, and responsible sportspersons and be capable of leading a team and making decisions that benefit the whole group. The intervention took place in two subsidized schools in Seville (Spain), which presented similar sociodemographic profiles and belonged to neighborhoods with an upper-middle socioeconomic level.

In Seville, federated sports clubs usually have a defined framework or guidelines for training programs. However, in clubs that are not part of a federated competition, it is common for each coach to work in his or her own way, and there is no consensus or guide on how to coach a team. In general, coaches tend to be focused on achieving victory rather than on the process of the personal development of each athlete. In the Catholic Schools Competition, where the intervention took place, they are somewhat more flexible and let the coach be the one who sets the model to follow. In this way, everything depends on the level of training and knowledge of the coach of this type of methodologies, far from those centered on execution models, typical of the courses of coaches.

Research Design

This study used a convergent mixed methods design (**Figure 1**), because this type of design acknowledges the inadequacy of qualitative or quantitative methods alone to capture trends and details in the context of the research studies (Creswell and Creswell, 2018), so the strengths of one approach cover the weaknesses of the other, thus providing more evidence for studying the research study problem and helping to answer questions that neither quantitative nor qualitative methods alone can (Creswell and Plano Clark, 2018).

In the qualitative section, a design based on descriptive phenomenology was used (Moustakas, 1994; Giorgi, 2009), in which the researchers sought to describe the experiences lived by individuals for a specific phenomenon (Creswell and Creswell, 2018). In the quantitative section, a quasi-experimental design was used, in which there was no random assignment of participants to the experimental or control groups. This study was carried out with a pragmatic worldview, in which the focus was on the consequences of the research study and the question asked rather than the methods, thus employing multiple methods of data collection to inform the problems analyzed (Creswell and Plano Clark, 2018). This worldview is perfectly suited to the mixed methods design carried out in this work, and its philosophical assumptions are shown in **Table 1**.

Sample

According to the coaches, students, and schools that showed interest in, and commitment to, participating in the research study, sample selection was convenient and non-probabilistic (Patton, 2015). A total of 30 girls participated in the experimental ($n = 15$, age $= 8.93 \pm 0.80$) and control groups ($n = 15$, age $= 8.80 \pm 0.86$) during the 2018/2019 school year. The coach for the experimental group was a 26-year-old man with experience of 4 years in managing volleyball youth teams. The coach for the control group was a 25-year-old woman with an experience of 5 years in coaching volleyball youth teams. Both coaches were graduates in Physical Activity and Sports Sciences and had a Level 2 Volleyball Coach qualification from the Andalusian Volleyball Federation.

Both schools competed in the U-10 category in the Catholic Schools Competition, organized by the Catholic Schools Association of Seville. Both groups were selected because of their homogeneity in terms of sport (volleyball), gender (women), age (between 8 and 9 years old), training structure (two training sessions/week, 1.5 h/session, plus the weekend game), and season expectations (qualifying for the final phase of the competition). The inclusion criteria were as follows: (a) participation in the extracurricular volleyball activity at their schools; (b) willingness to participate in the study; (c) written consent of the parents/guardians; (d) attendance for at least 85% of the sessions; and (e) adequate program implementation fidelity.

This study followed the ethical commitment guidelines defined by the Declaration of Helsinki regarding the consent, confidentiality, and anonymity of the participants through an agreement signed by the boards of the schools and the parents/guardians of the players. This study was also approved by the PhD Research Committee of the Pablo de Olavide University (internal code 2345-N-20).

Variables

The dependent variables analyzed were the two dimensions of responsibility: PR, which is the responsibility to assume the own actions of an individual and act in consideration of, and respect for, the value of people and things, and SR, which is defined as sensitivity toward the feelings and needs of colleagues, respecting their rights and cooperating and working together to achieve goals and negotiating conflicts (Jiménez and Durán, 2004). Both the objective perception of the level of each of the dimensions and the subjective perception of skills development in these dimensions throughout the intervention were analyzed.

The independent variable was the TESPODEP program (Muñoz-Llerena et al., 2019), which is a hybridization of the TPSR and SE models, and was focused on the development of values such as leadership, decision-making, and PR and SR through team sports. The program, following the recommendations of Gordon (2009), used the general structure of the TPSR as a basis, adding the sport-specific elements that come from the SE, while using methodological strategies that arise from both the TPSR and SE (**Table 2**). A total of 37 sessions of 90 min plus 14 competition games were carried out, implementing sports content and a concrete responsibility level (**Table 3**). It must be considered that level 5 (transference) was implemented in all sessions of the program through the group reflection and self-evaluation, and this level was also the focus during games.

A brief description of the characteristics of the TESPODEP program is included as **Supplementary Material**.

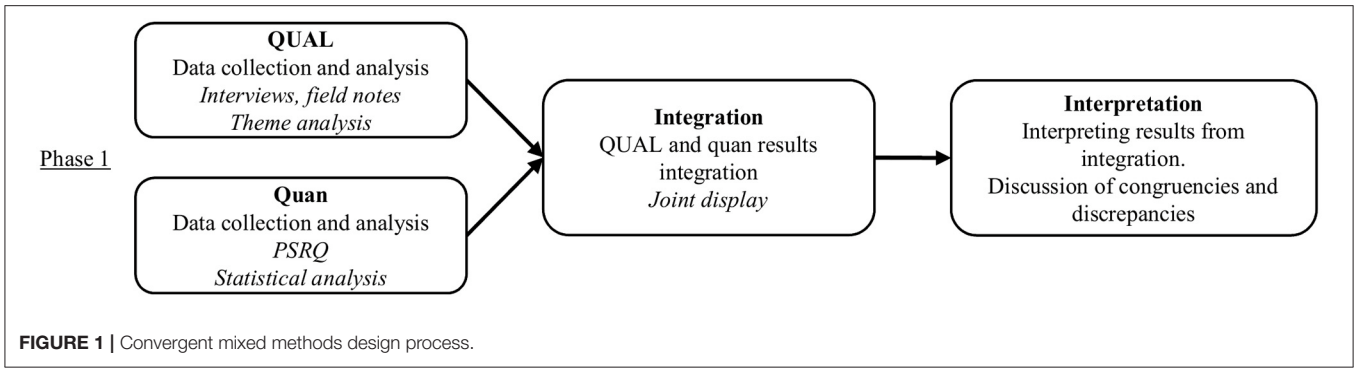

FIGURE 1 | Convergent mixed methods design process.

TABLE 1 | Philosophical assumptions of pragmatic worldview.

Ontology	Epistemology	Axiology	Methodology	Rhetoric
Singular and multiple realities	Practicality	Multiple stances	Combination	Formal or informal

TABLE 2 | Team Sports Positive Development Program (TESPODEP) characteristics.

E	Description	S
P	Educate participants to be players in the full meaning of the term, helping them to develop as competent, literate, enthusiastic, and responsible players, capable of leading the group and of making decisions that benefit the team.	TPSR/SE
MF	Embedding, transference, empowerment, and being relational with youngsters	TPSR
O	Develop volleyball-specific physical, technical, and tactical skills; participate at an appropriate level; share, be responsible, and lead the management of the athletic experiences; improve decision-making ability in sport; and apply the learned skills and abilities outside the program	TPSR/SE
RL	1- Establishing a positive group climate; 2- Participation and effort; 3 – Self-direction; 4- Help and leadership; 5- Transference	TPSR/SE
SS	Relational time, awareness talk, action time, group reflection, and self-evaluation	TPSR
SSE	Season, affiliation, formal competition, performance recording, festivity, and culmination event	SE
GM	Setting expectations, giving opportunities for success, fostering social interaction, setting roles and tasks, mastery-oriented learning, leadership, giving voice, role in the evaluation, respect model, and transference	TPSR
SM	Group control routines, guided practice, independent practice, conflict resolution, coach's portfolio, and team identity	SE

E, Element; S, source; P, purpose; MF, methodological foundations; O, objectives; RL, responsibility level; SS, session structure; SSE, sport-specific element; GM, general methodological strategies; SM, specific methodological strategies.

Instruments and Measures

Semi-structured Interviews

Semi-structured interviews were chosen and elaborated *ad hoc* from the adaptation of other interviews used in interventions based on the TPSR model (Patton, 2015; Manzano-Sánchez and Valero-Valenzuela, 2019); the interview structure was designed to determine the perception of the players about their PR and SR skills.

The questions asked were divided into four differentiated blocks. The first block aimed to assess the previous experience of the players in the practice of volleyball (e.g., "Had you practiced volleyball before starting this year?") and their participation in other extracurricular activities, athletic or not (e.g., "Do you do any other after-school activity besides volleyball?"). The second block was oriented toward the perception of the players of their skills development after participation in the intervention program (e.g., "Do you think that the training sessions have helped you to be more responsible in training and competitions? And in your life outside of sport? Why?"). The third block focused on determining the perception of the players about the intervention program itself (e.g., "What do you think about trying to take care of the group's positive climate?"). Finally, the fourth block focused on the perception of the players of the work of the coach (e.g., "Do you think the coach had a good relationship with the team? Have you felt comfortable with him/her?"). The full script of the interview is included as **Supplementary Material**.

Field Notes

Field notes were taken after each training session by the researcher, who also had the role of the coach in the team (full participation role). The structure of the field notes was elaborated *ad hoc* adapting a diary structure used in the previous research studies (Escartí et al., 2006), while aiming to recognize the implementation of the program in terms of objectives, contents, responsibility levels, and methodological strategies and documenting the perception of the researcher of PR and SR skills

TABLE 3 | Sessions, contents, and levels throughout the program.

S	Content	RL
1	Overhead pass-T; Underarm pass-T	I
C	Competition	5
2	Overhead pass-T; Underhand serve-Sec	1
3	Underarm pass-T; Underhand serve-Sec	1
C	Competition	5
4	Overhead pass-T+M; Underarm pass-T+M	1
5	Overhead pass-T+M; Underarm pass-T+M	1
6	Overhead pass-P+M; Underhand serve-Sec	2
7	Overhead pass-T+M; Underarm pass-T+M; Underhand serve-Sec	2
C	Competition	5
8	Overhead pass-P+M; Underarm pass-T+M; Underhand serve-Sec	2
C	Competition	5
9	Overhead pass-T; Underarm pass-T	1,2
10	Overhead pass-T; Underarm pass-T; Underhand serve-Sec	2
11	Overhead pass-T+M; Underarm pass-T+M	2
12	Overhead pass-T+M; Underarm pass-T+M; Underhand serve-Sec	2
C	Competition	5
C	Competition	5
13	Overhead pass-T+M; Underarm pass-T+M; Underhand serve-Sec	3
14	Overhead pass-T+M; Underarm pass-T+M; Underhand serve-Sec	3
C	Competition	5
15	Overhead pass-T+M; Underarm pass-T+M; Underhand serve-Sec	3
C	Competition	5
16	Overhead pass-P; Underarm pass-P; Underhand serve-Sec	3
17	Overhead pass-P; Underarm pass-P	3
18	Underarm pass-P; Underhand serve-Sec	3
19	Overhead pass-P; Underarm pass-P; Underhand serve-Sec	3
C	Competition	5
20	Overhead pass-P; Underarm pass-P; Underhand serve-Sec	3
21	Underarm pass-P; Underhand serve-Sec	3
C	Competition	5
22	Overhead pass-P; Underarm pass-P	3
23	Overhead pass-Setting; Underarm pass-P	3
24	Overhead pass-Setting; Underarm pass-P; Underhand serve-P	3
C	Competition	5
25	Overhead pass-Setting; Underarm pass-Receiving; Underhand serve-P	4
26	Overhead pass-Setting; Underarm pass-Receiving; Underhand serve-P	4
27	Overhead pass-Setting; Underarm pass-P	4
28	Overhead pass-Setting; Underarm pass-Receiving; Underhand serve-P	4
C	Competition	5
29	Overhead pass-Setting; Underarm pass-P	4
30	Underarm pass-Receiving; Underhand serve-P	4
31	Overhead pass-Setting; Underarm pass-P	4
32	Overhead pass-Setting; Underarm pass-Receiving; Underhand serve-P	4
C	Competition	5
33	Overhead pass-Setting+attack (jump); Underhand serve-P	4
34	Overhead pass-P; Underarm pass-P; Underhand serve-Sec	4
35	Overhead pass-P+attack (jump)	4
C	Competition	5
36	Underarm pass-Receiving+defense; Underhand serve-P	4
37	Overhead pass-P+attack (jump)	4

RL, Responsibility level; I, introduction; S, session; T, technique; M, movement; Sec, security; P, precision; C, competition.

of the participants. A model for the field notes is included as **Supplementary Material**.

Personal and Social Responsibility Questionnaire

To assess the responsibility variable in its PR and SR dimensions, the Personal and Social Responsibility Questionnaire (PSRQ; Li et al., 2008) was used and validated in the Spanish context by Escartí et al. (2011). The questionnaire consists of 14 items, seven each for PR (e.g., "I propose goals for myself") and SR (e.g., "Respect for others"). All items are answered through a 6-point Likert-type scale, ranging from 1, totally disagree, to 6, totally in agreement with the formulation of the question. Confirmatory factor analysis [$\chi^2_{76} = 161.36$, $p < 0.001$, comparative fit index (CFI) = 0.91, root mean square error of approximation (RMSEA) = 0.06, goodness of fit index (GFI) = 0.89, adjusted goodness of fit index (AGFI) = 0.88, standardized root mean square residual (SRMR) = 0.06.] and internal consistency (= 0.85 SR; = 0.74 PR) indicate that the PSRQ is a useful instrument for assessing PR and SR levels and their evolution throughout the program.

Procedure

For the sample selection, an informative meeting was held with the parents of all of the players in each school, explaining the characteristics of the program and the procedure to be followed for all groups (experimental and control). Subsequently, the same protocol was followed with the players and coaches from each group, with emphasis on the voluntary nature of participation. The program was implemented in groups where there were 10 or more interested players, the coach was willing to implement the program, and the parents agreed to carry it out.

The coach for the experimental group knew the fundamentals of the TPSR and SE programs and was the main person responsible for the design of the hybridization of the TESPODEP

program. However, following the indications of Escartí et al. (2009, 2010b) and Fernández-Gavira et al. (2018), 1 month before the intervention he received recycling training on the theoretical foundations, objectives, and methodological aspects of both the TPSR and the SE by experts in these programs (research coauthors of this study). After the training period, the design of the intervention program was revised, with minor modifications. Throughout the intervention (once a month), the coach of the experimental group met with experts in the program to continue with the training and to analyze the fidelity of the implementation (Manzano-Sánchez and Valero-Valenzuela, 2019). The fidelity of the program implementation was considered adequate after analyzing it and triangulating the data obtained from the TARE 2.0 observation instrument (Escartí et al., 2015; Manzano-Sánchez and Valero-Valenzuela, 2019), which assessed methodological strategies, participant behavior, and the field notes.

The interviews were carried out in the final 2 weeks of training, once the program intervention had finished. The interviews were conducted with the players at the end of the session, without having established a time limit for each of them, which made it possible to collect between three and four interviews daily. The interview protocol was based on that proposed by Creswell and Creswell (2018). Interviews were recorded and transcribed verbatim. Field notes were completed daily after the training session, between 30 and 90 min after the end (depending on the availability of the researcher). All data were recorded in writing on a record sheet using the Microsoft Word (Office 365) software.

The PSRQ was completed before the beginning of the training sessions, under the supervision of the main researcher, ensuring

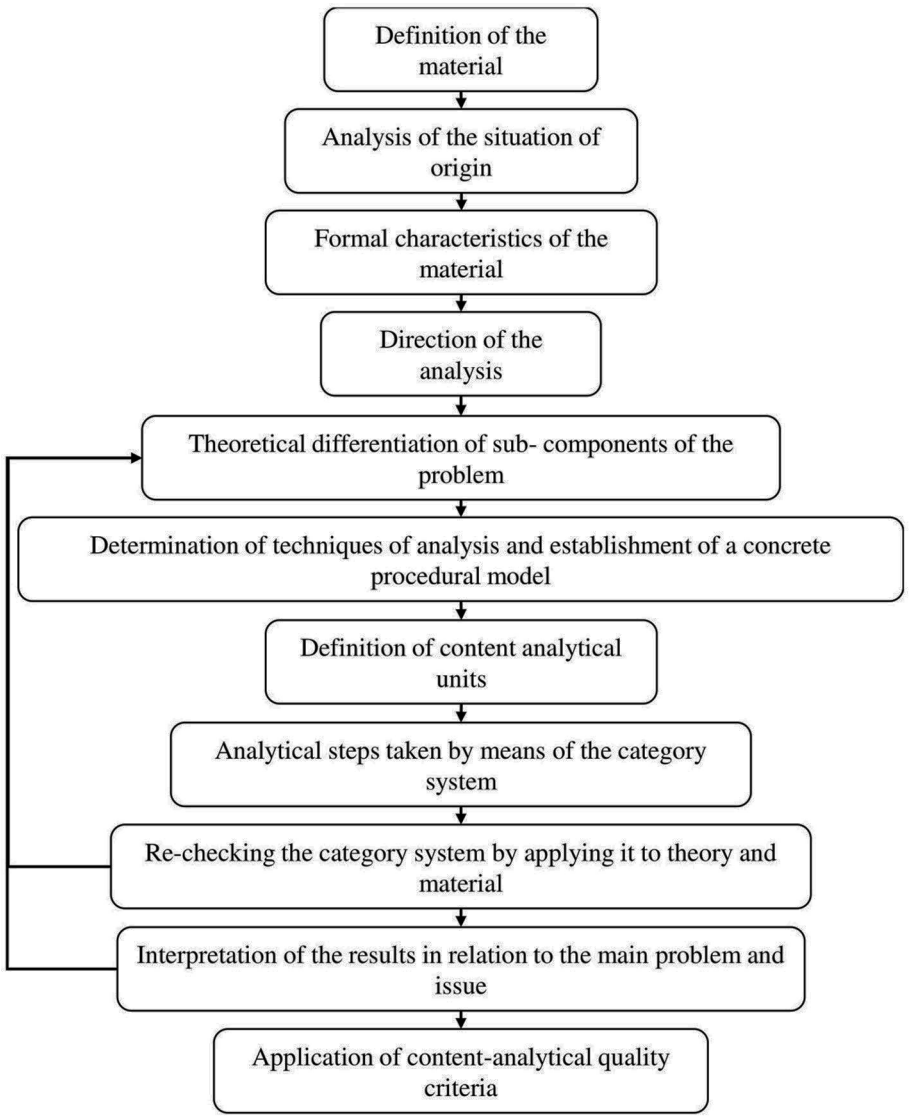

FIGURE 2 | Qualitative content analysis procedure.

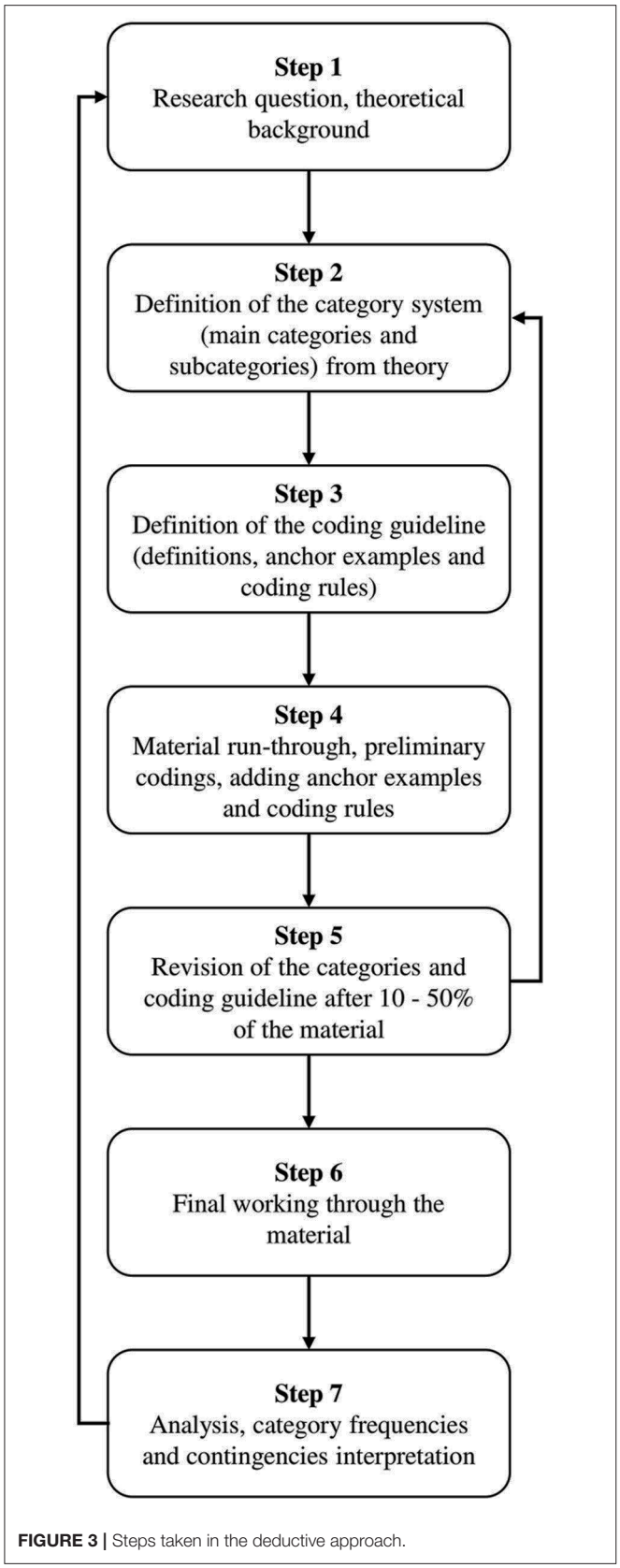

FIGURE 3 | Steps taken in the deductive approach.

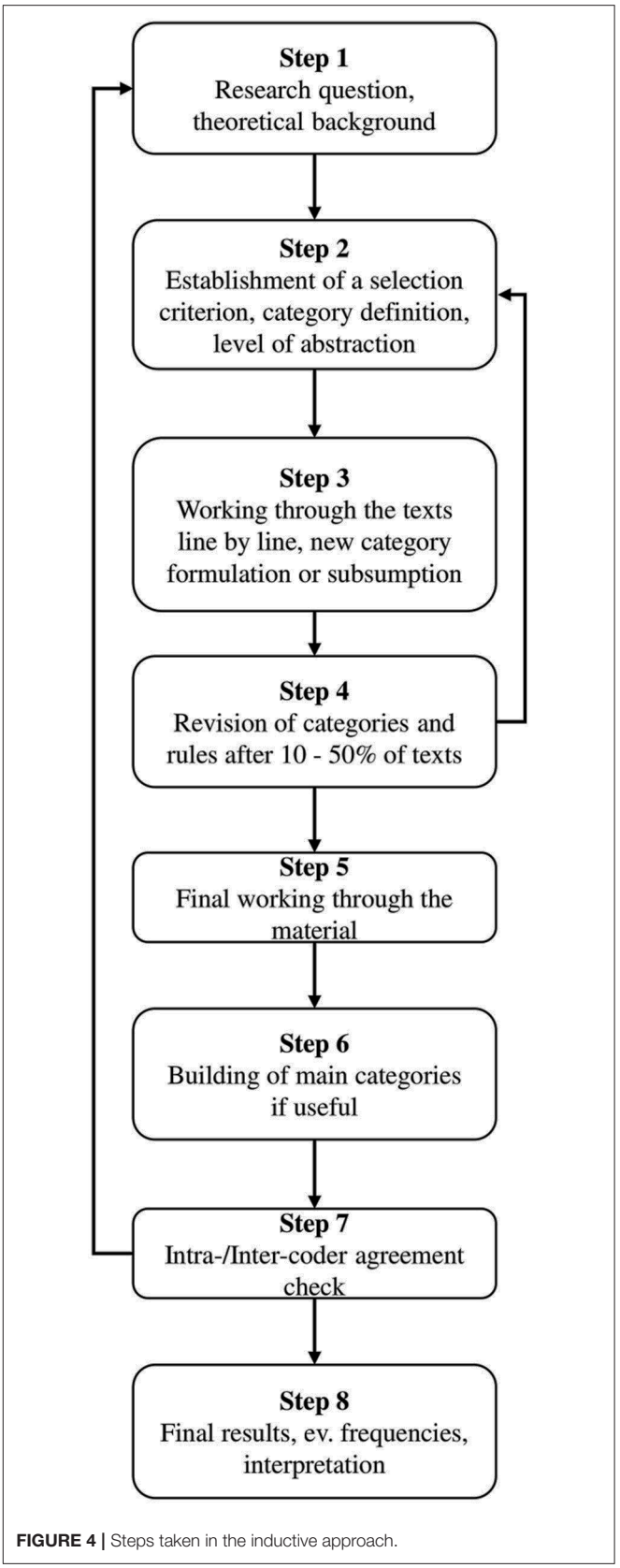

FIGURE 4 | Steps taken in the inductive approach.

the anonymity and sincerity of the responses, and answering any doubts that might arise during the process. Before starting, the instructions for correct completion of the PSRQ were explained and emphasis was placed on maintaining a relaxed atmosphere to promote concentration and maximum accuracy in the answers (Escartí et al., 2009, 2010a, 2011; Valero-Valenzuela et al., 2020a). The reliability in the pretest and posttest was 0.76 and 0.87 for SR and 0.83 and 0.86 for PR.

Data Analysis

Interviews and Field Notes

Qualitative content analysis (QCA) was the analysis strategy applied (**Figure 2**), utilizing the theme analysis technique, aiming to "retain the strengths of quantitative content analysis and against this background to develop techniques of systematic, qualitatively oriented text analysis" (Mayring, 2014, p. 39). Within the theme analysis technique of Mayring, a deductive approach was initially used to formulate the main categories of analysis based on the objectives of the study, semi-structured interview questions, and sections of the field diary (**Figure 3**); subsequently, the inductive approach was applied to formulate the secondary categories of analysis based on the emerging ideas of the participants about their perceptions on the development of PR and SR (**Figure 4**).

The quality criteria applied in the qualitative analysis were chosen based on the reflections of Smith and McGannon (2018). These criteria were as follows: (1) methodological integrity procedure (Levitt et al., 2017); (2) intervention of another researcher as a critical friend (Brewer and Sparkes, 2011); and (3) triangulation of analysts (inter-coder reliability) and sources (using multiple data sources) (Patton, 2015; Creswell and Creswell, 2018). **Table 4** shows the unification of all of these criteria within the methodological integrity procedure proposed by Levitt et al. (2017). This analysis process was carried out using the qualitative analysis software NVivo™ 12 Plus.

Personal and Social Responsibility Questionnaire

SPSS 21.0 software was used for the statistical analysis of the questionnaires and "psych" 1.4.2.3 of R 3.0.3 for the coefficient ω. For the PSRQ analysis, the main descriptive statistics were calculated, and normality tests were carried out. The asymmetry and kurtosis indicators of the variables were used for the univariate normality analyses, taking the limits of asymmetry and kurtosis in absolute values (Curran et al., 1996). Reliability analysis was carried out to check the internal consistency of the questionnaires. Cronbach's alpha (α) was used, equal to or> 0.70 (Nunnally, 1978; Nunnally and Bernstein, 1994), and the omega coefficient was used (ω; McDonald, 1999).

A repeated measures ANOVA was then carried out. A MANCOVA was used in the group factors (control group and experimental group) and two measurements (pretest and posttest), followed by the Bonferroni *post hoc* test to identify possible intragroup and intergroup differences and statistical power. Values of $p < 0.05$ and $p < 0.01$ were used for statistical significance.

Integration

The joint display technique was used for data integration (Guetterman et al., 2015; Creswell and Creswell, 2018; Creswell and Plano Clark, 2018), combining the data in a table and making interpretations based on the table. Four key aspects were followed (Creswell and Plano Clark, 2018) to evaluate the quality of the research as a study that uses mixed methods: (1) The authors collected and analyzed both qualitative and quantitative data rigorously, taking into account research questions and hypotheses; (2) they then intentionally integrated the two types of data and their results; (3) these procedures were organized into specific research designs so that the study was developed in a logical way; and (4) these procedures were framed within theory and philosophy. The joint display was carried out using the Microsoft Excel (Office 365) software.

RESULTS

Interviews

For the interview analysis, a first deductive coding was used on the basis of the existing studies and theory (Li et al., 2008; Escartí et al., 2011; Hellison, 2011) to determine the main categories of each dependent variable analyzed (PR and SR), establishing the categories of autonomy and effort (PR), and respect and caring and helping (SR). Once deductively encoded, inductive analysis of the coding was performed (Mayring, 2014). The coding frequencies for each category analyzed are shown in **Table 5**.

Personal Responsibility

Personal responsibility included the main categories of autonomy, effort, and responsibility for the equipment.

Autonomy

This category refers to the subjective perception of the player about her ability to be independent in tasks, without the need for coach supervision, and to set her own goals and develop an action plan to achieve them. This category included the secondary categories of self-confidence, goal setting, and autonomous work. *Self-confidence* is an abstract skill, and although several players considered that they had developed it, they nevertheless found it difficult to define why they thought they had improved. In particular, six players referred to having learned to trust themselves.

> P04: "I (have learned to) set my own goals and trust myself."
> P07: "Because I don't forget things."

In relation to *goal setting*, most of the players considered that they had acquired the ability to set goals, both in sport and in their daily lives, and that they were capable of acting to achieve those goals.

> P03: "I now make more decisions than before, because before I didn't make any decisions, but now I say, well now I'm going to try to do this just because, because it turns out badly or (…) just because I want."

TABLE 4 | Methodological integrity.

Fidelity		**Utility**	
Adequate data	Triangulation was carried out, collecting data from two main sources (players and coach)	Contextualization of data	Information regarding the characteristics of the participants and researchers who have been part of the study has been presented
Perspective management in data collection	The originating paradigm has been explained, in addition to the second author acting as a "critical friend" to avoid distorting the data	Catalyst for insight	Interviews and field notes have been used as a form of data collection, after reflection by the authors on the best way to generate information that allows in-depth analysis
Perspective management in data analysis	Analyst triangulation was used to ensure the fidelity of the analyzed results	Meaningful contributions	The study has had a positive impact on the development of the participants in the variables analyzed, in addition to showing the scientific community the effectiveness of the implemented program
Groundedness	The results obtained were analyzed and discussed, making reference to quotations and reflections	Coherence among findings	The data obtained are integrated to show the relationship between the different results, including reflection on the congruencies and discrepancies

TABLE 5 | Interview coding frequencies.

	1. Personal responsibility	**1.1. Self-direction**	**1.2. Effort**	**1.3. Responsible for the equipment**	**2. Social responsibility**	**2.1. Respect**	**2.2. Caring and helping**
Coding frequency	145	36	108	3	128	76	56

P14: "I don't set myself a lot of goals either, but at least, but I have set the goal of cleaning my room every day."

However, there were some players who considered that they had not been able to internalize the complete process or that they had learned it but were not able to carry it out on their own, as it depends on other circumstances such as mood.

P11: "It depends on what (the goal is). Because now I am a bit lazy."

Six players referred to *autonomous work* in the interviews. Of these, four claimed to have learned to act and decide on their own throughout the program, while the other two denied having acquired this ability (although they considered that they were capable of acting on their own in aspects relative to other categories).

P03: "It was very good for me, because in addition to the fact that I could do what I felt would be better—in my life apart from volleyball as well—I have also said: well, look, this can be better for others, so I'm going to do it."
P06: "Yes, I am (more) responsible. I make the bed, I set the table, I brush my teeth."

Effort

This category refers to the subjective perception of the player that she experiences the content of the program in a positive way, developing self-motivation and taking responsibility on her own, participating in the tasks/games proposed, trying to do the best in the games in which they participate, and conceiving success in terms of participation, improvement, and mastery, depending mainly on their own effort. The secondary categories of effort in tasks, motivation, and participation were included in this category.

Regarding *effort in tasks*, practically all of the players affirmed that they believed they had learned to try harder in the athletic context, although one of them believed that she did not always make the best effort and only did it halfway, while another two participants only felt they achieved this when they did not "act like a dummy."

P15: "I make an effort in training. (…) I am already trying my best. I can't try harder."
P14: "(I make an effort) but sometimes (…) in training, I don't know why, I start to act like a dummy."
P09: "Yes. Well, only if I don't act like a dummy."
P15: "In other words, effort—because I already make more of an effort (…) in games, I no longer treat it like a joke, because before I treated it like a joke."
P02: "My favorite game is Claret's second, because I passed a serve. And (in that game) I tried harder than in training."

Outside the athletic context, most of them considered that they had also learned to try harder, mainly in the school and family environments.

P14: "Yes, because now I do my homework every day—I study every day."
P02: "(Refers to her improvement in) Obeying my parents, studying...."

Regarding *motivation*, 10 players noted that they had learned to motivate themselves when carrying out a task or playing a game. Of these, two believed that they were capable of self-motivation only sometimes.

P14: "I have learned to motivate myself more. (…) I was (sad) before… and now, I'm happy all the time."
P01: "I do (motivate myself). Because in the game that we played, that I didn't want to go to, I went. And I played well."
P06: "I have to do it because I have (…) to achieve it. Myself."

Regarding *participation*, again 10 players affirmed that they had learned to participate more in tasks and games than before the program.

P10: "Yes, I didn't (participate) before."
P03: "(I have learned) not to stand still but to try (to participate). (…) Now I participate in everything. (…). (The program) Has also helped me to participate in everything in my life."
P15: "And participation, well... I try to participate in everything."
P06: "(I have learned to) Participate in all games."

In contrast, only one player believed that she had not learned to participate more in tasks and activities than before participating in the program (altogether with the effort, as seen previously). The rest of the players had nothing to say on the matter.

P11: "That just when we started level 2 (of the program), which was participation and effort, just on those days I neither made any effort nor participated because it was very hot. (…) When I'm hot I don't really want to learn."

Responsible for the Equipment

This category refers to the subjective perception of responsibility related to the treatment, care, and maintenance of the training equipment. Only two players referred to this category in the interviews. They had the perception that they had not learned to be fully responsible because they were not able to take care of their own equipment and, sometimes, the training equipment itself.

P02: "No, because I lose all of the sweatshirts. Have you seen me?"
P04: "First, (…) because I lose my sweatshirt a lot. And second, because when we are playing, when we are playing and all that in couples, I lose the ball. A lot of balls start to fall, okay, and now I hit another, I don't know what, and I'm not responsible for the ball. And then, with my backpack, I always forget my backpack, and that doesn't help me."

Social Responsibility

The main categories of respect and caring and helping were found in the SR perspective.

Respect

This main category refers to the subjective perception that the rights and feelings of others are respected, controlling the attitude and behavior of an individual in such a way that the rights and feelings of others are respected, resolving conflicts peacefully, and including everyone in the group in the tasks/games. This category included the secondary categories of cohabitation rules, interpersonal relationships, and conflict resolution.

Regarding *cohabitation rules*, most of the players referred to the fact that they had learned to respect and follow the rules of coexistence that were established at the beginning of the season by mutual consent of all team members.

P04: "(I have learned to) Respect the rules."
P07: "I have learned to… respect the rules… and that's it."
P05: "That next time I'm going to bring chewing gum, but for after training."

Some of them also showed an improvement in following the rules outside the team context, in the family environment.

P02: "(Referring to her improvement) Obeying my parents, studying..."
P05: "The yes (referring to what she has learned) is that I obey my parents more."

Regarding *interpersonal relationships*, several of the players referred to the fact that they had learned not to interrupt and to pay attention to the coach (either the main coach or the one with the role of coach). However, there were only a couple of players who admitted that they did not always pay attention to them.

P10: "(I have learned) To pay attention to the teacher."
P11: "That sometimes I listen to you, but other times I don't."

Some of the players also talked about how they applied what they had learned to their lives outside of volleyball, mainly in their family relationships. However, most of them believed that they had not become more responsible, as they kept fighting with their siblings.

P05: "Yes and no (I have learned). Because I keep bugging my brother. (Although already) I don't hit my brother. But if he hits me, I hit him."
P13: "Yes (I have learned), because I don't fight so much with my sister anymore."
P08: "Me sometimes, less than before. (But) No (I haven't learned). Because I keep hitting my sister."

In relation to *conflict resolution*, practically all of the players had learned to resolve conflicts peacefully. In the interviews, reference was made both to the learning of conflict resolution itself and to the knowledge of the specific steps to resolve conflicts, so participants were able to resolve them autonomously.

P14: "I think that I have learned to resolve conflicts. (…) Because now I get a bit into the fights of others, but now I at least resolve it, more or less."
P15: "Because you have taught us to resolve conflicts with the… with the list you gave us. (…) I know, now, that if we have a conflict, then we tell you 'We are going to solve the conflict,' and we solve it …"
P13: "Well, I've also learned to resolve conflicts, because (…) I didn't know before."
P08: "When there is a conflict with someone—knowing the steps."

There were also players who had begun to apply what they had learned about conflict resolution in other contexts outside the team, or they were able to resolve conflicts between other people, although one player thought that she had not learned anything in this regard.

> P03: "I have solved many conflicts (…), I get involved in everything. I have to know everything."
> P04: "(Outside of training I have learned) To pay more attention to others, to try to resolve more conflicts, to play more volleyball, and to help others when they are alone or something, to try to improve what happens to them."
> P11: "That I have resolved a lot of conflicts at school."
> P03: "Yes. I have solved a lot of problems. Too many. I mean, once, one day, everyone was crying. (…) And I went one by one trying to console them (…)."
> P07: "For example, P09 gets angry with P15. Then I go and tell them what happened, they tell me and (I help them solve it)."
> P14: "I don't. Not a single one. (…) What I did is tell them (the crying children) "cry at home all you want, be happy here," and that's it."

Caring and Helping

This category refers to the subjective perception of the player that the needs and feelings of others are recognized and that they are capable of putting themselves in the place of the other in an empathic and compassionate way, listening and responding without judging, helping without being arrogant, and understanding the importance of helping only when the other wants that help. This category includes helping others and effective interpersonal communication as secondary categories.

Regarding the secondary category *helping others*, most of the players claimed that they had learned to help other people when they needed it, to a greater or lesser extent. While some players found it more difficult than the others, most of them had adequately learned to help others.

> P10: "Yes (I am able to help my teammates when they get blocked), but I laugh a little."
> P04: "(I have learned) How to treat people, more or less in the ways that should or should not be—how you have to behave and how you should not behave and help others. (…) (And outside the program) To pay more attention to others, to try to resolve more conflicts, to play more volleyball, and to help others when they are alone or something, to try to improve what happens to them."
> P11: "Help children who cannot (do something)."
> P15: "What I (…) liked the most it's when we… taught, those of last year, to those who did not know, who had started, to help them learn the finger and forearm touch."

Several of the interviewees specifically described situations in which they had transferred this skill to their daily lives, mainly in helping at home or helping classmates or friends.

> P03: "I've never tidied up my room, unless my mother tells me off for tidying it up. (…) This weekend I got up and said come on, I'm going to take some work off my mother, and I make the bed. Then I take a shower and say well, I'm going to throw all the clothes... into the laundry."
> P14: "I... I started last week, because I said I'm going to make my mother happy and tidy up the room a little. Because everything was lying around (…) and what do I do? Well, I tidied it up."

Regarding *effective interpersonal communication*, approximately half of the players stated that they had developed their ability to communicate during the program, some referring to activities carried out that helped them improve their interpersonal communication, and others referring to the loss of shyness thanks to the program.

> P03: "(I have learned) To express myself. Before I was very shy. Now they call me a rascal (not shy)."
> P14: "I have learned to talk more with people. Before I was super shy and now I talk more."
> P06: "The… (communication). (…) We had minigames, too. (…) That we had to solve together to have more communication between us."

Several of the players expressed their learning and development in terms of behavior and treating others empathically and with compassion.

> P02: "I have learned how to behave and how I have to treat (…) people."
> P04: "(I have learned) How to treat people, more or less in the ways that can or cannot be, how you have to behave and how you should not behave and help others."
> P13: "I have learned to be more assertive."
> P05: "(I've learned to) Get less and less angry. (…) To be assertive with others."

Field Notes

The same process as with the interviews was followed for the analysis of the field notes, starting from a first deductive coding, establishing the main categories of autonomy and effort (PR) and respect and caring and helping (SR), and subsequently applying inductive analysis. The coding frequencies with respect to each category analyzed are shown in **Table 6**.

Personal Responsibility

The main categories of autonomy and effort were also found in PR.

Autonomy

This main category refers to the subjective perception of the coach of the ability of the players to be autonomous in tasks, without the need for coach supervision, and the establishment of their own goals and the development of an action plan to achieve them. The secondary categories of goal setting and autonomous work were included in this category.

Regarding *goal setting*, the perception of the coach was that, during training, in level 3 of the program (autonomy), the group had reflected on the usefulness that goal setting can have in the

TABLE 6 | Field note coding frequencies.

	1. Personal responsibility	1.1. Self-direction	1.2. Effort	2. Social responsibility	2.1. Respect	2.2. Caring and helping
Coding frequency	38	11	27	38	17	23

daily lives of the players and the need to decide their own goals to achieve during the next month of training.

> "In the final reflection, the usefulness of goal setting in different areas of life is explained to the players, and they are made to think (…) about a volleyball goal and another non-athletic goal that they want to achieve during next month, to focus on the training sessions to gradually reach them." (12th session)

The group progressed gradually during level 3 in its goal setting and learned to develop an action plan to achieve goals, dedicating numerous reflections during the training sessions to encouraging reflection and the acquisition of these skills.

> "In addition, they are looking together for a way to achieve the objectives that the players set themselves in the previous session." (13th session)
> "In the final reflection, how to use the 'checklist' is explained, as well as how important it is to develop one when setting a life goal, taking each of the elements that appear in it seriously." (14th session)

Regarding *autonomous work*, one of the points highlighted by the coach was the development of the autonomous work capacity of the players, which was chaotic at the beginning of level 3 (they were not able to train on their own without an attentive coach), but by the end, the coach perceived that the group was already capable of functioning on its own, without the need for a coach and without any danger of stopping the training due to the absence of the player with the role of coach.

> "In the final reflection, the conclusion is reached that, if at a specific moment the coaches have to attend to urgent things, the group cannot stop training and start to fall into chaos in training." (13th session)
> "Last session of level 3, this seems to be already mastered and I see players with the ability to function autonomously." (23rd session)

Effort

This category refers to the subjective perception of the coach of whether the players experienced the program content in a positive way, developed self-motivation and took responsibility for their own behavior, participated in the tasks/games proposed, tried to do their best in each task or game in which they participated, and conceived success in terms of participation, improvement, and mastery in a certain task, depending mainly on their own effort. The secondary categories of training, roles, and transference were included in this category.

Regarding *effort in training*, although it was worked on more consciously and intentionally in level 2 (participation and effort), it was a regular element of discussion throughout the program for the coach. The perception of the coach indicated that it was usual for the group to train properly in terms of effort, with the players experiencing the sessions positively and showing adequate effort and predisposition to do the tasks (as the program progressed, the level of effort and participation increased).

> "In the final reflection, the conclusion is reached that in this session there has been progress within level 2, and they have done their part (both players and coaches) to carry out the tasks with good participation and attitude." (6th session)
> "In general terms, the session developed satisfactorily, with the players engaging at a good level, except for a period of 5 min at the beginning of the second task, where there are several of them that are not sure of the groups that they have to make and they do not work on the task." (18th session)

However, the coach indicated that there were sessions in which the effort presented by the players left a lot to be desired and did not allow the development of proper training, or they simply did not make their best effort.

> "The players start the session well (warm-up and task 1), but the moment we advance to task 2 (somewhat more complex), they totally disconnect and each one begins to go on their own terms, to talk and stop training. I try to make them aware of the importance of level 2 when it comes to improving in sport and some of them get more involved, but others go their own way." (7th session)

The coach highlighted that, throughout the intervention, many reflections were made so that the players understood effort as something necessary for the proper development of both the training as a whole and themselves as players.

> "In the final reflection, they came to the conclusion of the importance of the coaches being aware of the group, correcting and helping the others, in addition to having, all of them, a feeling of being able to make a serious effort if they set out to do so." (9th session)
> "In the final reflection, I try to make them understand that if they do not train well there is no improvement, in addition to understanding how I feel as a coach when all my effort to prepare a productive session goes to waste because they don't want to work or train." (28th session)

Regarding *roles*, the coach referred to the effort that the players presented with respect to their own roles within the group in the training sessions. On most occasions, the effort made by a specific role was highlighted in a positive way or the improvement in her

performance (due to greater effort on the part of the player) from one session to another.

> "The coach (...) is not able to control the group and it is difficult for her to explain the tasks and for the others to understand them, but she puts in all her effort to achieve it." (3rd session)
> "In the final reflection, (…) in this session there was progress within level 2, and they have done their part (both players and coaches) to carry out the tasks with good participation and attitude." (6th session)

Finally, the coach also made the players think about the importance of showing a high effort in training by the players with roles, especially those with greater responsibility.

> "In the final reflection, a conclusion is reached about the importance of the coaches being aware of the group, correcting and helping others, in addition to having—all of them—a feeling of being able to make a serious effort if they decide to do so." (9th session)

Regarding *transference*, throughout the program, the coach tried to foster the learning of the player about the importance of effort in other areas of their lives through reflection, and not only in the sports context, perceiving that they were integrating this message and carrying out actions in their day-to-day activities where they have to strive.

> "In the final reflection, I lecture them on their attitude in the second half of the training, then highlighting the things they have done well throughout the training and the benefits they can get from working hard and participating to the best of their ability. The team mostly agrees and comes to the same conclusion (…)." (7th session)
> "They are made to think about the usefulness of this capacity for effort in other areas of life, giving them examples." (9th session)

Social Responsibility

The main categories of respect and caring and helping were found in SR.

Respect

This category refers to the subjective perception of the coach that players respect the rights and feelings of others, controlling their own attitudes and behaviors such that the rights and feelings of others are respected, resolving conflicts peacefully, and including everyone in the group in the tasks/games. The secondary categories of respect for others, respect for the decisions of the coach, and conflict resolution were included in this category.

Regarding *respect for others*, the coach stated that, although in general terms the players had maintained a high level of respect for others, sometimes this respect was conspicuous by its absence. At times, this resulted in not respecting the cohabitation rules set out in the group at the beginning of the season, which were chosen democratically, albeit in the first sessions they had not yet internalized the rules and it is normal that they were not capable of respecting all of them.

> "At the level of values within level 1, there is a good training environment, although not all the rules of coexistence are respected." (1st session)
> "The first part of the session proceeds normally, while in the second part I allow 5 min to drink water and the players arrive 15 min later, thus losing almost a quarter of the training time." (37th [last] session)

There were also occasions when the players did not respect the person in charge of the group, interrupting while (s)he spoke or not doing what they were told, especially in the first three levels of the program.

> "In the final reflection, the players are a bit agitated and are not able to remain calm and silent, interrupting me many times while I try to speak." (18th session)
> "In the final reflection, I ask them if it really compensates them for all the time they lost and wasted in speaking and not doing what the coaches asked, in addition to having a negative impact on not carrying out the final reduced/real game task." (22nd session)

In relation to *respect for the decisions of the coach*, the general perception of the coach was that the group adequately respected the decisions of the coach (player who has assumed the role of coach), although in the first sessions of the intervention they still did not grasp the concept that they were self-training and thus did not fully respect the instructions of the fellow trainers. As the program progressed, this aspect improved.

> "The group does not entirely respect the coach's instructions, and they barely make any self-criticisms in the personal reflection." (1st session)
> "In the final reflection, I ask them if it really compensates them for all the time they lost and wasted in speaking and not doing what the coaches asked, in addition to having a negative impact on not carrying out the final reduced/real game task." (22nd session)

Regarding *conflict resolution*, the coach referred to his perception that the group acquired and applied conflict resolution in training, all during level 1 of the program. Some references indicated that the players were learning and trying to apply the proposed conflict resolution mechanisms, and others exposed concrete cases in which some players (with responsible roles) applied them to solve problems among other group members. However, some performed better than others.

> "She has been able to resolve a conflict between three players autonomously, demonstrating her development in leadership, decision-making, and conflict resolution skills." (2nd session)
> "(Referring to the 2nd coach) Good role in conflict resolution." (30th session)
> "Trying to apply learned conflict resolution mechanisms when one arises." (1st session)
> "In the final reflection, conclusions are drawn about what has been learned, about how what has been learned can be applied when resolving conflicts autonomously outside of training, and occasional self-criticism of the leading players in the group begins to appear." (4th session)

Caring and Helping

This main category refers to the subjective perception of the coach that the players recognize the needs and feelings of others and are able to put themselves in the place of another in an empathic and compassionate way, listen and respond without judging the other, helping without being arrogant, and understand the importance of helping only when the other wants that help. This category includes the secondary categories of helping others and effective interpersonal communication.

Regarding *helping others*, the coach considered that the players were able to internalize the importance of helping others when they needed it, highlighting the help that the player with the role of coach gave the rest of the group when she directed them.

> "In the final reflection, a conclusion is reached about the importance of the coaches being aware of the group, correcting and helping the others, in addition to all of them having a feeling of being able to make a serious effort if they decide to do so." (9th session)

However, one of the players noted a lack of SR in this sense, because she left the coach alone (being 2nd coach) in one of the sessions to go to a birthday party.

> "The second coach (…) did not go to training because she has a birthday, which indicates a great lack of commitment and respect for her teammates." (25th session)

In relation to *effective interpersonal communication*, the perception of the coach was that the group seemed to have acquired knowledge about the concept of effective interpersonal communication, what it is, what it is for, or why it is necessary to learn it.

> "In the final reflection, I emphasize the need—both when they are coaches and when they need to communicate in their day to day—to know how to communicate effectively." (24th session)
> "In the final reflection we talked about the importance of styles when leading groups or communicating outside of sports, in their personal lives." (37th session)

It was observed that learning took place gradually throughout the application of level 4. At the beginning of the level, the girls did not control interpersonal communication at all; at the end of the program, they were able to communicate assertively while respecting the turn of each other.

> "This time they do begin to ask to speak and to speak when it is their turn, although sometimes I have to remind them and ignore them if they don't." (29th session)
> "In the final reflection, they are asked about their experience with the different styles, and which style they believe is the most important when dealing with other people, reaching the conclusion that it is the assertive style that best suits effective and adequate communication." (35th session)

Personal and Social Responsibility Questionnaire

The results obtained in the Kolmogorov-Smirnov normality test and the homogeneity of variances (Levene's test) showed a normal distribution of the data. The results referring to the descriptive analysis of the instruments used in the study were taken at two different moments (pretest and post-test; see **Table 7**). In the reliability test, some items had to be eliminated ($\alpha > 0.70$) so that the PR-Pre and SR-Post factors presented adequate reliability values ($\alpha > 0.70$; $\omega > 0.70$).

In the intergroup analysis, no significant differences were observed between groups in the PR and SR variables, the magnitude of the effect size being trivial ($\eta 2 < 0.20$). In the intragroup analysis, no significant improvements were observed in any group (**Table 8**).

Integration

The aim of the following integration was to develop integrated results and interpretations that could provide a more comprehensive understanding of the results analyzed and to validate and confirm the qualitative and quantitative results. **Table 9** shows the integration of results through a joint display.

DISCUSSION

The main objective of this study was to analyze the effects of an intervention based on the hybrid TESPODEP program on the PR and SR of youth girl volleyball players. The results obtained showed similarities with other research studies that exhibited the benefits that can be achieved in PR and SR and their different dimensions (autonomy, participation and effort, respect, and caring and helping) thanks to the implementation of TPSR, SE, or a hybridization of the two (Meroño et al., 2015; González-Víllora et al., 2019; Manzano-Sánchez and Valero-Valenzuela, 2019; Manzano-Sánchez et al., 2019; García-García et al., 2020; Valero-Valenzuela et al., 2020a).

Perceptions of the Players and the Coach About PR and SR Development

Concerning the perception of the players, practically all of them managed to develop their PR throughout the implementation. The greatest learning occurred in the effort applied to tasks and in autonomous goal setting, such that the majority perceived being able to try harder, participate more, set their own objectives and establish an action plan to achieve them, and motivate themselves in everything they do. At least half of them believed they had also learned to act autonomously and to trust themselves. These results are in line with those presented by other studies carried out with school-age participants (Stran et al., 2012; Meroño et al., 2015; Fernández-Río and Menéndez-Santurio, 2017; Antón-Candanedo and Fernández-Río, 2018) and might be caused by the methodological structure of the TESPODEP, which encourages autonomy and effort through the establishment of responsibility roles in the players, thus producing this personal development (Muñoz-Llerena et al., 2019).

TABLE 7 | Descriptive statistics and reliability analysis.

Variable	M		SD		α-Pre	α-Post	ω-Pre	ω-Post
	Pre	Post	Pre	Post				
PR	5.13	5.30	1.02	0.70	0.66	0.70	0.73	0.73
SR	5.24	5.15	0.54	0.74	0.70	0.60	0.80	0.71

M, Mean; SD, standard deviation.

TABLE 8 | Intergroup and intragroup analysis.

Variable	Group	Pre			Post		
		M	SD	p	M	SD	p
PR	Experimental	5.13	1.10	0.33	5.48	0.63	0.18
	Control	5.13	0.97		5.13	0.76	
	Comparative	5.13	1.02		5.30	0.70	
SR	Experimental	5.33	0.68	0.89	5.07	0.90	0.52
	Control	5.16	0.37		5.24	0.57	
	Comparative	5.24	0.54		5.15	0.74	

M, Mean; SD, standard deviation.

In terms of SR, it seems that practically all of them developed skills related to this dimension. The greatest perceived development was shown in conflict resolution, in respect for cohabitation rules, and in helping others, capacities that are mostly considered to be capable of transferring to other contexts. To a lesser extent, several participants also improved their knowledge about interpersonal communication and relationships. These results could be attributed to the implicit characteristics of the TPSR program, because, through various aspects such as group and personal reflections or the integration of the content of responsibility in the tasks, this type of social development was promoted (Hastie and Buchanan, 2000; Gutiérrez et al., 2014; Menéndez-Santurio and Fernández-Río, 2016b, 2017; Fernández-Río and Menéndez-Santurio, 2017).

Regarding the perception of the coach, the results are in line with the insights of the players. As the intervention progressed, positive learning was observed both in PR (through the fostering of the capacity for effort, goal setting and action plans, being autonomous in tasks, and being able to train without exhaustive supervision of those responsible for the group) and SR (developing their skills of respect for others, resolving conflicts autonomously, interpersonal communication, and ability to help others and learn the importance of respecting the feelings and rights of others, the cohabitation rules, and the decisions of the group leader).

From the perception of the coach, the internalization of content and prosocial skills through group and personal reflections and self-evaluations carried out at the end of the sessions seem to be a key aspect in the acquisition of these lessons. Results in line with these perceptions have been presented in previous research studies and have been related to the perception of the teacher of the usefulness of PYD programs (Casey and Dyson, 2009; Gutiérrez et al., 2014; Manzano-Sánchez and Valero-Valenzuela, 2019) and their effect on the increase in PR and SR (Fernández-Río and Menéndez-Santurio, 2017; Menéndez-Santurio and Fernández-Río, 2017). The importance of self-reflection and critical thinking to interiorize learning has also been highlighted in the study (Stran et al., 2012).

One of the fundamental aspects that can be deduced from this study is the achievement of transference by the participants. They seem to be capable of transferring those lessons mentioned above into their daily lives. This transference is an essential characteristic of PYD programs that use sports as a means to achieve this skill transfer (Fraser-Thomas et al., 2005; Hellison et al., 2008; Hellison, 2011; Turnnidge et al., 2014; Chinkov and Holt, 2016; Whitley et al., 2016; Weiss et al., 2020). It is possible that the nature of volleyball (team sport, cooperative, etc.), together with the structure of the task assignments used based on the SE model and the methodological structuring of the TPSR, made possible the achievement of good levels of transfer in these dimensions of responsibility.

However, not all perceptions were positive. Within the PR variable, reference was made to negative or incomplete aspects of learning with respect to goal setting, autonomy, effort, participation, responsibility for the equipment, and the performance of roles. In SR, negative perceptions of learning are indicated when resolving differences between others, in interpersonal relationships, in helping others, and in respect for others. This lack of development in PR and SR, although it differs from what was previously stated, also occurred in a study based on implementations of pedagogical models in school-age participants (Gutiérrez et al., 2014). However, these considerations must be interpreted with caution, because most of them refer to specific players and situations, and not to the group as a whole. Therefore, it would be more appropriate to affirm that not all of the players had learned everything that the program can offer. Other individual social or psychological traits, as well

TABLE 9 | Integration.

V		PR			SR	
PSRQ		**Pre 5.13 ± 1.02**	**Post 5.30 ± 0.70**	**Sig. 0.37**	**Pre 5.24 ± 0.54**	**Post 5.15 ± 0.74 Sig. 042**
MT		**Self-direction**	**Effort**	**Responsible for the equipment**	**Respect**	**Caring and helping**
I	Cg	P11: "It depends on what (the goal is). Because now I am a bit lazy."	P11: "That just when we started level 2 (of the program), which was participation and effort, just on those days I neither made any effort nor participated because it was very hot. (…) When I'm hot I don't really want to learn."	P04: "First, (…) because I lose my sweatshirt a lot. And second, because when we are playing, when we are playing and all that in couples, I lose the ball. A lot of balls start to fall, okay, and now I hit another, I don't know what, and I'm not responsible for the ball. And then, with my backpack, I always forget my backpack, and that doesn't help me."	P05: "Yes and no (I have learned). Because I keep bugging my brother. (Although already) I don't hit my brother. But if he hits me, I hit him."	No data available
	Ds	P03: "It was very good for me, because in addition to the fact that I could do what I felt would be better—in my life apart from volleyball as well—I have also said: well, look, this can be better for others, so I'm going to do it."	P15: "In other words, effort—because I already make more of an effort (…) in games, I no longer treat it like a joke, because before I treated it like a joke. (...) And participation, well... I try to participate in everything."	No data available	P15: "Because you have taught us to resolve conflicts with the… with the list you gave us. (…) I know, now, that if we have a conflict, then we tell you "We are going to solve the conflict," and we solve it …"	P04: "(I have learned) How to treat people, more or less in the ways that should or should not be—how you have to behave and how you should not behave and help others. (…) (And outside the program) To pay more attention to others, to try to resolve more conflicts, to play more volleyball, and to help others when they are alone or something, to try to improve what happens to them."
FN	Cg	"In the final reflection, the conclusion is reached that, if at a specific moment the coaches have to attend to urgent things, the group cannot stop training and start to fall into chaos in training." 13th session	"The players start the session well (warm-up and task 1), but the moment we advance to task 2 (somewhat more complex), they totally disconnect and each one begins to go on their own terms, to talk and stop training. I try to make them aware of the importance of level 2 when it comes to improving in sport and some of them get more involved, but others go their own way." 7th session	No data available	"The group does not entirely respect the coach's instructions, and they barely make any self-criticisms in the personal reflection." 1st session	"The second coach (…) did not go to training because she has a birthday, which indicates a great lack of commitment and respect for her teammates." 25th session
	Ds	"Last session of level 3, this seems to be already mastered and I see players with the ability to function autonomously." 23rd session	"In the final reflection, the conclusion is reached that in this session there has been progress within level 2, and they have done their part (both players and coaches) to carry out the tasks with good participation and attitude." 6th session	No data available	"She has been able to resolve a conflict between three players autonomously, demonstrating her development in leadership, decision-making, and conflict resolution skills." 2nd session	"In the final reflection, they are asked about their experience with the different styles, and which style they believe is the most important when dealing with other people, reaching the conclusion that it is the assertive style that best suits effective and adequate communication." 35th session

V, Variable; MT, main categories; I, interviews; FN, field notes; Cg, congruent; Ds, discrepant; Sig, significance.

as previous experiences practicing the sport, could have had an influence on these results.

Integrating the Data: How Personal Perceptions Relate to Statistical Results

Regarding the PSRQ, the results indicate that the intergroup (experimental and control) and intragroup (experimental) differences are not significant, and therefore, it is understood that there were no differences within or between the two groups in PR and SR when comparing before and after, although the α and ω values obtained are sufficient to accept the reliability of the instrument under the conditions used in this study (Nunnally, 1978; Campo-Arias and Oviedo, 2008). These results differ from those shown in the study (Menéndez-Santurio and Fernández-Río, 2016b; Escartí et al., 2018; Manzano-Sánchez and Valero-Valenzuela, 2019; Manzano-Sánchez et al., 2019; Valero-Valenzuela et al., 2020a), perhaps because, as a general rule, published studies always present statistically significant results. This non-significance in the data could be due to the small sample size, which might not be large enough to allow the appearance of differences between and within the groups.

In data integration, because no significant positive results were reported in the PSRQ, the results obtained at the quantitative and qualitative levels differ to a great extent. Although there are some congruent results, because not all of the players perceived improvements in all of the analyzed aspects of PR and SR, nor did the coach attribute significant development to all categories, we must be cautious in drawing conclusions due to the relativity of the results: The majority of the group seem to have developed their PR and SR, but not all of the players have developed all of the capabilities that PR and SR comprise, and not all of them are capable of using them in all the situations that might arise.

Ensuring that the integrated data are 100% congruent is a complex task (O'Cathain et al., 2007; Slonim-Nevo and Nevo, 2009). In this study, we started from a more general conception of the dimensions of PR and SR (PSRQ), and those dimensions were compared with participant learning in much more concrete and deeper aspects within those dimensions (main and secondary categories in interviews and field notes), which makes it difficult to achieve a majority of congruent results in the integration, especially if they differ so much. In this respect, the authors considered that there may be greater confidence in the results obtained at a qualitative level, because the small sample used may lead to the absence of significant results in the PSRQ, following what has been carried out in other investigations that used convergent mixed methods (Creswell and Plano Clark, 2018).

The data integration was carried out following the criteria to ensure the trustworthiness of the study. Following Creswell and Plano Clark (2018), it can be stated that both the qualitative and quantitative data were collected and analyzed rigorously, taking into account the research questions and hypotheses, because data of both types were collected based on the objectives and hypotheses raised in the study, following adequate procedures for their thematic and statistical analysis, respectively. The two types of data and their results were intentionally integrated, in line with the stated reasons for choosing a convergent mixed methods design for the study and integration of the results obtained through a joint display to later discuss the congruencies and discrepancies of the results and then draw a conclusion about them. These procedures were organized into specific research designs so that the study was undertaken in a logical way, and all elements fit together logically and consistently. These procedures were also framed within theory and philosophy, appropriately marrying the pragmatic paradigm and the PYD theory on which the study was based with the mixed methods designs used. These criteria have been taken into account in multiple studies that use mixed methods to ensure their reliability (Ames et al., 2009; Craig et al., 2019; Vázquez-Diz et al., 2019; Leiter et al., 2020; Valero-Valenzuela et al., 2020a; Weiss et al., 2020).

Theoretical and Practical Implications

This study helps to fill the gap in the study related to the effects of SBPYD programs in competitive settings by designing a hybrid program that could serve as a reference in team sports interventions based on PYD. Another strength of this research study is its contribution to the mixed methods research field, which is not widely used in competitive sports interventions.

From a practical view, this study may provide strategies for coaches and teachers in the design and implementation of training exercises that aim to enhance decision-making, leadership, and life skills, transferring them to the daily lives of the participants. At early ages, these improvements can be difficult to achieve, so the coach should create learning environments to improve these capabilities. TESPODEP is a well-structured intervention program that aims to overcome these limitations, providing useful guidelines for coaches. Some recommendations to coaches when intervening within the competitive sport could be as follows: (a) set two different types of goals, sportive goals, and life skill goals; (b) integrate PYD strategies into training tasks; (c) use the methodological strategies offered to facilitate fostering PYD and life skill learning; (d) make all players play all roles throughout the season and let them make their own decisions; and (e) keep a balance between sports results and PYD intervention.

This study has some limitations. The main limitation is the sample size, which, although it presents an adequate and sufficient size to obtain relevant information for the scientific community at a qualitative level, seems to be insufficient to obtain significant results at a quantitative level (Creswell and Creswell, 2018; Creswell and Plano Clark, 2018). It should also be noted that this study was carried out with only one experimental group, in a specific sociocultural and socioeconomic context, in a single sport, and in a single category (limited age range) and competitive level. In addition, all of the participants were girls. This means that it is not possible to determine whether there are differences between genders, ages, sports, levels of sports demand, or socioeconomic/sociocultural levels.

To alleviate the limitations of this study, the following lines for future research studies are recommended: (a) to increase the sample size to draw on statistical data that contribute to a better understanding of the research question; (b) to carry out the study in different team sports, ages, competitive levels, and/or socioeconomic/sociocultural levels to determine how

TESPODEP works in different samples and settings; and (c) to include both genders in the sample to determine differences between genders in terms of life skill acquisition.

CONCLUSIONS

Hybridizing TPSR and SE models made it possible to design a program adapted to the intervention context in which it was applied (competitive extracurricular sports) to foster PR and SR and teach volleyball technical/tactical aspects in grassroots sport. TESPODEP made adaption to the intervention context (extracurricular competitive youth mini-volleyball) possible, where the TPSR structure contributed to fostering PR and SR throughout the intervention, while SE helped to incorporate the key elements of team sports for transferring learning to competition and the daily lives of the participants. In general terms, the analysis and subsequent reflection on that analysis showed that the implementation of the hybrid program TESPODEP seemed to present positive effects in terms of the development of PR and SR in youth girl volleyball players in an extracurricular setting.

Regarding PR, both the perceptions of players and coach indicated that they developed skills related to autonomy, effort, and responsibility with respect to the equipment throughout the intervention program. Concerning SR, again, the perceptions of players and coach both indicated that they acquired skills related to respect and caring and helping others. The insights of both players and the coach seem to indicate that the group positively perceived their learning and development in the analyzed dimensions. Although the quantitative data do not agree with the findings of the interviews and field notes on the development of PR and SR, as there were no statistically significant differences between or within groups, the authors consider that the main reason for this lack of positive results may have been the limited sample, which was not sufficient to achieve significant differences, and thus, the qualitative results derived from the interviews and field notes are more reliable for drawing conclusions about this study.

This study can serve as a reference to promote the design and implementation of hybrid TPSR+SE intervention programs to foment PYD through competitive team sports. However, it is necessary to increase the research field about this type of program, incorporating successful strategies like MINDSCAPE (Whitley, 2021) to foster long-term behavioral changes and assess them through longitudinal studies (e.g., throughout a whole sports category). It is also essential to come to an understanding with the coach about the program design, in addition to providing prior training about its key elements, ensuring implementation fidelity. Furthermore, using triangulation is essential to enhance the validity and reliability of the data. In conclusion, the hybrid program TESPODEP seems to be effective to develop PR and SR in youth girl athletes in a competitive extracurricular youth sports context.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Pablo de Olavide University's Ph.D. Research Committee. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

AM-L, PC-B, and EH-H elaborated the conceptualization, the methodological framework, the data validation, and the original draft writing, including results, discussion, and conclusions. AM-L and EH-H carried out the data analysis. AG-d-A took charge of reviewing and editing the final manuscript. All authors have read and agreed to the published version of the manuscript.

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SUPPLEMENTARY MATERIAL

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BRIEF RESEARCH REPORT
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Training the Social-Emotional Skills of Youth School Students in Physical Education Classes

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This study aimed to examine the impact of implementing an innovative Social-Emotional Skills Training Program in physical education classes at youth schools. This study used two surveys: the Schutte Self-Report Inventory (otherwise known as the Emotional Intelligence Scale) and the Social Skills Rating System (student form). The analysis included 104 youth school students (Mage = 16.91; SD = 1.12), who were randomly selected from two youth schools in the Kaunas region. Four classes were randomly assigned into an experimental (n = 49) and a control (n = 55) group. The experimental group participated in the Social-Emotional Skills Training Program. The intervention was targeted at the following social-emotional skills: empathy, cooperation, assertion, self-control, optimism, ability to understand and analyze emotions, appraisal, and utilization of emotions. The modified physical education classes were conducted by the physical education teacher, who was instructed by the researcher. Repeated measures multivariate ANOVA was used to analyze the effects of the Social-Emotional Skills Training Program. During the experiment, the applied training procedures had a statistically significant effect on the social-emotional skills of the experimental group of youth school students. Thus, the findings demonstrate that this program (for enhancing social-emotional skills of youth school students) positively impacted the social-emotional skills of the students. These results highlight the need to consider social-emotional skills training factors when interpreting the level of social-emotional skills among youth school students.

Keywords: training program, youth schools, students, physical education classes, social-emotional skills

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INTRODUCTION

Recent scientific literature broadly supports the notion that social-emotional skills are important for personality development, the development of prosocial behavior, and positive emotional growth. Social-emotional skills have been described as a multidimensional construct that includes the abilities to manage emotions, feelings, and care and concern for others, as well as to solve problems and have positive peer relationships (Zins et al., 2004). Various reviews and meta-analyses have proven the effectiveness of implementing social-emotional skills training in the general education context (Durlak et al., 2011; Korpershoek et al., 2016; Taylor et al., 2017; Corcoran et al., 2018). However, only a few reviews have analyzed the effectiveness of social-emotional skills training in the sports or physical education context (Rasberry et al., 2011; Bessa et al., 2019, 2021). Meanwhile, a systematic review revealed that only 19 studies (37%) confirmed the fidelity of implementing the educational program, meaning "the authors performed the validation of the

model implementation and presented a detailed description of the program." (Bessa et al., 2019, p. 824)

Youth schools have been chosen for this study because they are designed to teach students who have dropped out of typical schools and characteristically lack strong social-emotional skills (Malinauskas, 2019). Although youth schools are "usually part of the middle or high school program offered to secondary-aged students" (Dunning-Lozano, 2016, p. 434), youth schools in Lithuania are the alternative schools established to meet the behavioral and educational needs of adolescents and adults that cannot be properly met in a traditional school setting. Many students in youth schools have substantial academic and behavioral problems (Foley and Pang, 2006), such as attendance problems, underachievement problems, and having insufficient credits to graduate (Dunning-Lozano, 2016). Many students at youth schools have been sent there to prevent them from interfering with other students after they were repeatedly suspended due to fighting or disrupting classes. Youth school students can have unique learning interests and learning barriers, and they can be potential perpetrators of crimes or misdemeanors, even participating in the juvenile detention system (Malinauskas and Saulius, 2019).

Training the social-emotional skills of youth school students in physical education classes is a viable proposition because physical education classes promote intense emotions and can foster a positive environment that promotes social-emotional learning (Gagnon, 2016; Escartí et al., 2018). Physical education can be considered a school subject where students and teachers can create positive experiences (Dyson et al., 2021). Notably, previous studies have confirmed the relationship between physical activity/education and improved social-emotional indicators (Fernandez-Rio and Menendez-Santurio, 2017; Cañabate et al., 2018). These studies have indicated improved social responsibility, cooperation, solidarity, self-control, and self-esteem, among other factors. Research evidence suggests that quality physical education contributes positively to the development of social-emotional skills of the students (Hunter, 2006) and that physical education classes develop social-emotional skills in the affective domain, for example, in the context of "controlling one's emotions during competitive game play…and demonstrating awareness of and support for other classmates' differences." (Ciotto and Gagnon, 2018, p. 28) With better-developed social-emotional skills, students are more likely to seek help when needed, can better control their emotions, and can solve problems more successfully in different situations (Romasz et al., 2004). Acquiring social-emotional skills provides an opportunity to be successful not only during physical education classes but also in the context of everyday life (Ciotto and Gagnon, 2018).

Given that implementing educational programs must be theoretically grounded, we chose the model-based practice of cooperative learning (Dyson and Casey, 2012) for this study because model-based practices have been posited as fundamental tools for helping students accomplish social-emotional learning outcomes (Jacobs and Wright, 2014). The theoretical cooperative learning model integrates the study variables and is effective for developing social-emotional and relationship skills "amongst mainstream students and students with moderate/special educational needs amongst elementary and middle school ages." (Dyson et al., 2021, p. 9).

There is a considerable need for in-depth research aimed at better understanding the particularities of training the social-emotional skills of youth school students in physical education classes. Youth school students have been exposed to different types of trauma, producing individual discrepancies in the need for social-emotional skills training. Better understanding the social-emotional skills of youth school students through physical education classes could help them transform their weaknesses into strengths and enable them to overcome the challenges they face.

To examine the effects of this educational program on the social-emotional skills of youth school students, we investigated the changes in the social-emotional skills of the youth school students following the implementation of the educational program in physical education classes. Given that previous studies have proven the effectiveness of training the social-emotional skills of secondary school students during physical education classes (Sklad et al., 2012; Akelaitis and Malinauskas, 2016; Escartí et al., 2018; Bartlett, 2019), we hypothesized that youth school students would demonstrate significantly improved social-emotional skills following the implementation of the program.

METHODS

Context and Participants

A random serial sampling method was used for the educational experiment: first, two youth schools were selected from the list of district schools; then, four classes were selected from the class lists of the selected schools. The analysis included 104 youth school students (Mage = 16.91; SD = 1.12), who were randomly selected from two youth schools in the Kaunas district. Four classes were randomly assigned into an experimental ($n = 49$) and a control ($n = 55$) group. The inclusion criteria for study participants were middle adolescence (15–18 years) and male or female, and the only exclusion criterion was refusing to give informed consent. The research used a two-group pretest and posttest study design. The experiment was conducted during the 2019–2020 academic year. There were no significant differences between the experimental (16.71 ± 1.17) and control (17.09 ± 1.06) groups in terms of age ($t\,(102) = -1.72$; $p > 0.05$) or gender (experimental group: 37 boys and 12 girls; control group: 36 boys and 19 girls) [$\chi^2\,(1) = 1.25$; $p > 0.05$ ($p = 0.26$)].

Instruments

We used two instruments to measure the social-emotional skills of youth school students. Emotional skills were measured using the Schutte Self-Report Inventory (SSRI), which was validated by Schutte et al. (1998). The SSRI, also known as the Emotional Intelligence Scale, the Self-Report Emotional Intelligence, and the Schutte Emotional Intelligence Scale, assesses emotional intelligence skills based on self-reported responses. This scale was designed to determine participant perceptions of their emotional skills at both intrapersonal and interpersonal levels. It comprises

33 items answered on a 5-point Likert scale (where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree) such as "I like to share my emotions with others," "I expect that I will do well on most things I try." Higher values represent a higher emotional skill level. Various authors have considered psychometric properties and concluded that this scale is useful as a brief measure of emotional intelligence (Petrides and Furnham, 2001). The instrument usefully divides emotional intelligence into four separate skills (Palmer, 2003): the ability to use his/her own positive emotional experiences (optimism), the ability to assess and express emotions (appraisal), the ability to understand and analyze emotions (emotional understanding), and the ability to manage emotions (utilization). The research demonstrated good internal consistency ($\alpha = 0.81$). The Lithuanian version of the SSRI demonstrated an internal consistency value of 0.79 for the overall questionnaire (Malinauskas and Sniras, 2010).

Meanwhile, the Social Skills Rating System (Student form) (SSRS-S; Gresham and Elliott, 1990) comprises a self-reported questionnaire for students in grades 7–12, which comprises 39 statements requiring each student to respond with how frequently they demonstrate the behavior described and their perception of the importance of that behavior, for instance, "I make friends easily (assertiveness)" and "I follow the teacher's directions (cooperation)." The assessment method was based on the four dimensions (skills) defined by Gresham and Elliott (1990): cooperation, assertiveness, empathy, and self-control. Each item was rated on a 3-point frequency scale (0 = never, 1 = sometimes, and 2 = many times). This study found a Cronbach's alpha of 0.63 for the total SSRS-S score. The Lithuanian version of the SSRS-S ranges from 0.66 to 0.76 (Griciute et al., 2008).

Intervention (Educational Program)

To verify the efficiency of the educational program, we used an educational experiment method. The experimental group participated in a Social-Emotional Skills Training Program that included 48 15-min sessions (total of 12 h) during modified physical education classes conducted before the COVID-19 pandemic (i.e., September 2019 until March 2020). We targeted the intervention at the following social-emotional skills: empathy, cooperation, assertion, self-control, optimism, ability to understand and analyze emotions, appraisal, and utilization of emotions. The same amount of development time was allocated to each social-emotional skill (90 min). All of the youth school students in the experimental group attended 15-min training sessions four times per month during the modified physical education classes. The control group did not partake in any training sessions. The modified physical education classes were conducted by the physical education teacher, who received instructions from the researcher. To implement the social-emotional skills training during physical education classes, five training stages were incorporated as follows: (1) skill description; (2) skill demonstration; (3) skill practice; (4) feedback; and (5) reinforcement of trained skill. **Table 1** provides details of the Social-Emotional Skills Training Program for youth school students in physical education classes.

The training methods applied by the Social-Emotional Skills Training Program included impulse control (autogenic training), post-activity discussion about the shared experiences, group learning (cooperative learning), role-play scenarios, watching the videos, and written worksheets of the students. For example, when the youth school students had to improve their emotional management skills, autogenic training methods were adopted, including relaxation and impulse control methods. When working on understanding and analyzing emotions, students watched real-life videos demonstrating the difficulties suffered by students during the communication process. Following the video demonstration, the youth school students had to answer questions (e.g., "If your friend is sad, and you would like to say something to your friend about their mood or feeling during physical education classes, what would you say?"). Then, students were grouped into pairs to practice emotional understanding better (group learning). Later, the students jointly considered their emotional experiences (discussion about their shared experiences). The analogous methods were utilized during each session.

After 3 months, students from the experimental group had accomplished the interventional aims of the educational program and had improved all of their social-emotional skills. The students from the experimental group wrote in a free-answer form that they had improved empathy, cooperation, assertion, self-control, optimism, the ability to understand and analyze emotions, appraisal, and utilization of emotions. Participants from the experimental group also assessed the Social-Emotional Skills Training Program in the context of this free-answer form, reporting that they were satisfied with the educational program and had improved their relationships with their classmates.

Data Collection

Before the data collection, ethical clearance was obtained from the Ethical Committee of the Lithuanian Sports University. The study was conducted in accordance with the Declaration of Helsinki. Parental consent was obtained prior to the experiment because the participants were aged between 15 and 18 years. Confidentiality was ensured because the questionnaires were distributed for completion in classrooms, and participant names were not recorded.

The data collection procedure was realized by providing students with sufficient time to answer the questions in the classroom. The physical education teacher administered the questionnaires in the classroom. The time participants took to complete the SSRI varied between 12 and 15 min. The time participants took to complete the SSRS-S varied between 15 and 18 min. The study was conducted in three stages: first, the pre-assessment of the variables for the experimental and control groups; second, the implementation of the educational program for the experimental group (with the control group continuing with their traditional training); and third, following the implementation of the intervention, the posttest assessment of variables was conducted for both groups.

Data Analysis

The experimental design of this study included a quantitative analysis of the data from the experimental (intervention) group and the control (comparison) group. We calculated

TABLE 1 | Description of social-emotional skills training program for youth school students in physical education classes.

Intervention	Number of sessions	Content	Goals	Training methods
Emotional skills				
	6	Utilization	Learn and practice to manage emotions	Method of impulse control (autogenic training), discussion, and group learning (formally termed cooperative learning)
	6	Appraisal	Learn and practice to assess and express emotions	Role play scenarios, discussion, and group learning
	6	Emotions' understanding	Learn and practice to understand and analyze emotions	Watching the video, discussion, group learning, and written worksheets
	6	Optimism	Learn and practice to use own positive emotional experience	Role play scenarios, discussion, group learning, and written worksheets
Social skills				
	6	Empathy	Learn and practice to understand thoughts and feelings of other students	Watching the video about youth school student in physical education classes, discussion, group learning, and written worksheets
	6	Cooperation	Learn and practice social skills, such as cooperation and compromise	Role play scenarios, discussion, and group learning
	6	Assertion	Learn and practice to communicate in an open and positive way without being either aggressive, or passively accepting "wrong"	Role play scenarios, discussion, group learning, and written worksheets
	6	Self-control	Learn and practice to demonstrate self-control and respect for others	Method of impulse control, discussion, and group learning

means (M) and SDs for each variable. Skewness and kurtosis coefficients were calculated to verify the assumption of the data normality using multivariate ANOVA (MANOVA). In general, skewness and kurtosis values between −1 and 1 reflect the data normality. Pearson's correlations (two-tailed) were calculated for all variables. A 2 (Group: experimental group and control group) × 2 (Time: before the experiment and after the experiment) repeated measures (RM) MANOVA followed by the one-way ANOVA was used to investigate differences between Group and Time interactions in terms of social-emotional skills. Preliminary assumption testing checked for multicollinearity, sphericity, homogeneity, and equality of variance/covariance matrices; no serious violations were noted.

Wilks' Lambda statistic was used to evaluate the significance of multivariate effects, and the alpha level was set to 0.05. The effect sizes for *F*-statistics were expressed as partial eta-squared (η_p^2). Statistical analyses were processed using SPSS software (version 21.0).

RESULTS

Table 2 illustrates the computed statistical notations (means, SDs, skewness and kurtosis, and SEs of skewness and kurtosis) for all examined variables. All measures were checked for skewness and kurtosis and were considered to have acceptable distributions because they were between −1 and 1. This indicated that the assumptions for the data normality were met and confirmed the viability of using the Student's *t*-test and the RM-MANOVA.

Pearson's bivariate correlation coefficients were calculated to investigate the relationships between all dependent variables and the absence of multicollinearity. Given that no correlation exceeded 0.85, the assumption of multicollinearity was not violated (Weston and Gore, 2006). Pearson's bivariate correlation coefficients between variables are presented separately for the Time before the experiment and the Time after the experiment in **Table 3**. As shown in **Table 3**, the social-emotional skills of the students were not very substantially correlated in the positive direction.

An important assumption for the univariate RM-MANOVA procedure is that of sphericity. The condition for Mauchly's test of sphericity was met because RM variables only feature two levels.

Using the Student's *t*-test for independent samples, we found that, before the experiment, the experimental and the control group did not differ significantly with respect to any of the social-emotional skills under consideration: utilization ($t_{(102)} = 1.16$; $p = 0.25$), appraisal ($t_{(102)} = 1.58$; $p = 0.12$), emotional understanding ($t_{(102)} = 0.80$; $p = 0.43$), optimism ($t_{(102)} = 0.22$; $p = 0.83$), total emotional skills ($t_{(102)} = 1.54$; $p = 0.13$), empathy ($t_{(102)} = 1.87$; $p = 0.06$), cooperation ($t_{(102)} = 1.89$; $p = 0.06$), assertion ($t_{(102)} = 1.92$; $p = 0.06$), self-control ($t_{(102)} = -0.83$; $p = 0.41$), and total social skills ($t_{(102)} = 1.57$; $p = 0.12$).

Meanwhile, the RM-MANOVA revealed significant effects of the Social-Emotional Skills Training Program on the social-emotional skills of youth school students, i.e., the influence of Group by Time interaction was significant (Wilks' Lambda = 0.67; $F_{(10,93)} = 4.51$; $p = 0.00$). The effect was large according to Cohen ($\eta_p^2 = 0.33$), with 33% of variance accounted for by this interaction effect. According to the study by Dimitrov and Rumrill (2003), "a significant Group by Time interaction indicated that the change from pre-test to post-testing was

TABLE 2 | Means (M), SD, and normality tests of the study variables ($N = 104$).

	Before experiment						After experiment					
	M	**SD**	**Sk**	**SkSE**	**Ku**	**KuSE**	**M**	**SD**	**Sk**	**SkSE**	**Ku**	**KuSE**
Utilization	3.23	0.52	0.40	0.24	0.15	0.47	3.60	0.56	0.12	0.24	0.01	0.47
Appraisal	3.37	0.35	0.26	0.24	−0.57	0.47	3.68	0.35	−0.10	0.24	0.09	0.47
Emotions' understanding	3.33	0.43	0.99	0.24	0.88	0.47	3.57	0.43	0.59	0.24	0.22	0.47
Optimism	3.34	0.28	0.28	0.24	0.15	0.47	3.78	0.35	0.15	0.24	0.27	0.47
Total emotional skills	3.24	0.26	0.40	0.24	−0.31	0.47	3.69	0.32	0.73	0.24	0.59	0.47
Empathy	12.40	1.19	−0.48	0.24	0.95	0.47	14.83	1.82	0.45	0.24	0.05	0.47
Cooperation	11.98	0.52	−0.03	0.24	0.81	0.47	14.85	1.72	−0.01	0.24	−0.88	0.47
Assertion	11.65	1.03	0.31	0.24	−0.31	0.47	13.64	1.90	−0.41	0.24	0.69	0.47
Self-control	12.68	1.05	−0.14	0.24	0.39	0.47	14.58	1.65	0.25	0.24	−0.48	0.47
Total social skills	48.71	2.66	0.28	0.24	0.32	0.47	57.88	5.13	0.34	0.24	0.21	0.47

Sk, Skewness; SkSE, Skewness SE; Ku, Kurtosis; KuSE, Kurtosis SE.

TABLE 3 | Correlations of dependent variables.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Utilization	1	0.35**	0.53**	0.46**	0.69**	0.32**	0.22*	0.20*	0.22*	0.33**
Appraisal	0.29**	1	0.45**	0.45**	0.64**	0.42**	0.39**	0.45**	0.40**	0.58**
Emotions' understanding	0.36**	0.39**	1	0.54**	0.82**	0.43**	0.38**	0.32**	0.28**	0.48**
Optimism	0.42**	0.27**	0.22*	1	0.85**	0.35**	0.40**	0.34**	0.39**	0.50**
Total emotional skills	0.68**	0.61**	0.71**	0.71**	1	0.48**	0.47**	0.39**	0.42**	0.60**
Empathy	0.40**	0.40**	0.20*	0.43**	0.49**	1	0.43**	0.48**	0.32**	0.78**
Cooperation	0.39**	0.24*	0.27**	0.29**	0.43**	0.20*	1	0.32**	0.24*	0.68**
Assertion	0.19*	0.42**	0.37**	0.39**	0.47**	0.34**	0.33**	1	0.39**	0.77**
Self-control	0.27**	0.33**	0.22*	0.25*	0.33**	0.30**	0.27**	0.35**	1	0.66**
Total social skills	0.44**	0.51**	0.38**	0.50**	0.62**	0.74**	0.52**	0.74**	0.72**	1

Correlations below the diagonal are for Time before the experiment.
Correlations above the diagonal are for Time after experiment. N = 104.
$^*p < 0.05$; $^{**}p < 0.01$.

different depending upon the treatment groups" (2003, p. 160). In plain terms, while no difference was observed between the control and experimental groups for the social-emotional skills pretest, there was a considerably sized divergence observable posttest.

Elsewhere, as shown in **Table 4**, the univariate RM-MANOVA testing proved the significant influence of the Social-Emotional Skills Training Program on the social-emotional skills, with effect sizes ranging from small to large. **Table 4** shows that, following the intervention, students from the experimental groups demonstrated better social-emotional skills in physical education classes than the control group students, reporting higher scores for utilization ($p = 0.000$), appraisal ($p = 0.045$), emotional understanding ($p = 0.019$), optimism ($p = 0.025$), total emotional skills ($p = 0.006$), empathy ($p = 0.004$), cooperation ($p = 0.008$), assertion ($p = 0.002$), self-control ($p = 0.034$), and total social skills ($p = 0.000$).

DISCUSSION

The findings of the educational experiment confirm our hypothesis that the social-emotional skills of youth school students would improve significantly following the educational program based on the observation of more developed social-emotional skills in physical education classes among students from the experimental group. Following the educational experiment, the experimental group students demonstrated better utilization (a medium effect: $\eta_p^2 = 0.124$), appraisal (a small effect: $\eta_p^2 = 0.039$), emotional understanding (a small effect: $\eta_p^2 = 0.052$), optimism (a small effect: $\eta_p^2 = 0.048$), total emotional skills (a small effect: $\eta_p^2 = 0.073$), empathy (a small effect: $\eta_p^2 = 0.076$), cooperation (a small effect: $\eta_p^2 = 0.066$), assertion (a medium effect: $\eta_p^2 = 0.093$), self-control (a small effect: $\eta_p^2 = 0.043$), and total social skills (a medium effect: $\eta_p^2 = 0.163$). All of these significant changes indicate the impact of the Social-Emotional Skills Training Program on social-emotional skills as expressed in physical education classes. These findings coincide with those of other studies, such as the studies by Durlak et al. (2015), Dusenbury and Weissberg (2017), and Taylor et al. (2017), whose investigations on the effectiveness of social-emotional skills interventions produced small effect sizes (ranging from Hedge's $g = 0.13$ to Hedge's $g = 0.23$). In addition, a meta-analysis by Durlak et al. (2011) established

TABLE 4 | Mean scores of social-emotional skills of youth school students in physical education classes before and after the educational experiment.

	Experimental group M (SD)		Control group M (SD)		Univariate tests of RM MANOVA Group × Time		
Social-emotional skills	**Before experiment**	**After experiment**	**Before experiment**	**After experiment**	$F_{1,102}$	p	η_p^2
Utilization	3.29 (0.49)	3.79 (0.48)	3.17 (0.55)	3.44 (0.58)	14.50**	0.000	0.124
Appraisal	3.42 (0.36)	3.79 (0.31)	3.32 (0.33)	3.58 (0.35)	4.11*	0.045	0.039
Emotions' understanding	3.37 (0.37)	3.66 (0.37)	3.30 (0.47)	3.48 (0.47)	5.64*	0.019	0.052
Optimism	3.35 (0.26)	3.87 (0.31)	3.34 (0.30)	3.70 (0.37)	5.15*	0.025	0.048
Total emotional skills	3.28 (0.23)	3.79 (0.28)	3.20 (0.27)	3.60 (0.32)	7.98**	0.006	0.073
Empathy	12.63 (1.36)	15.61 (1.75)	12.20 (0.99)	14.13 (1.59)	8.44**	0.004	0.076
Cooperation	12.08 (0.49)	15.41 (1.72)	11.89 (0.53)	14.35 (1.58)	7.22**	0.008	0.066
Assertion	11.86 (1.06)	14.49 (1.67)	11.47 (0.98)	12.89 (1.78)	10.46**	0.002	0.093
Self-control	12.59 (0.93)	14.90 (1.62)	12.76 (1.15)	14.29 (1.63)	4.61*	0.034	0.043
Total social skills	49.14 (2.72)	60.39 (4.70)	48.33 (2.57)	55.65 (4.45)	19.85**	0.000	0.163

*η_p^2, partial eta-squared; *$p < 0.05$; ** $p < 0.01$.*

that schoolchildren who participated in Social Emotional Skills Training Programs demonstrated significantly enhanced social and emotional skills (a small effect: Hedge's $g = 0.26$), attitudes toward school (a small effect: Hedge's $g = 0.11$), positive social behavior (a small effect: Hedge's $g = 0.17$), and academic performance (a small effect: Hedge's $g = 0.32$).

The results of this study are also consistent with various studies that have identified the significant effect of the educational programs on improvements to social-emotional skills or social self-efficacy. For instance, Malinauskas et al. (2018) evaluated the effectiveness of educational programs for enhancing social self-efficacy among basketball-playing students. The duration of the educational program (i.e., 8 months) was similar to that of this study. The results showed that the level of social self-efficacy significantly increased for the experimental group following participation in the program (medium effect size: Cohen's $d = 0.54$). Similar teaching methods were used for that educational program: "modeling [observational learning through modeling (i.e., watching others do a certain task)], rehearsing (practicing by repetition so as to improve performance; for instance, practicing an action, a play, a conversation, etc.), and verbal rewarding (e.g., verbal praise, positive feedback, realistic encouragement)" (Malinauskas et al., 2018, p. 167). Notably, this allows us to conclude that there is a difference in effectiveness between implementing an educational program in physical education classes and implementing it in the school sports (extracurricular) context.

Elsewhere, a study by Gorucu (2016) investigated the effects of physical education lessons planned in accordance with a cooperative learning approach designed to improve problem-solving skills in secondary school students and reported a large effect size for self-control (Cohen's $d = 2.14$). The study similarly used a model-based practice; however, it differed in the duration of the intervention (only 10 weeks). Meanwhile, the results of a study of 7th-grade students by Goudas et al. (2006) indicated that an experimental group partaking in lifeskills program reported greater personal goal-setting skills compared with the baseline assessment (medium effect size: Cohen's $d = 0.51$) but higher nonsignificant levels of positive-thinking skills (i.e., optimism) compared with the baseline assessment. The life skills program took place over a 1-month period (two sessions per week for 4 weeks) and was based on the school-based intervention designed by Danish et al. (1992) to teach life skills (social skills for life). The study similarly used a model-based practice, also similarly, the intervention included group learning (cooperative learning), post-activity discussion, and written worksheets, with 15-min sessions but different in terms of intervention duration.

Meanwhile, a study by Goudas and Magotsiou (2009) examined the effect of a cooperative physical education program on the social skills of students and their attitudes toward group work, with the results indicating significant increases in the social skills scores of the experimental group following participation in the program for all of the investigated social skills: cooperating skills, empathy, and quick-temperedness (large effect sizes ranging from $\eta_p^2 = 0.26$ to $\eta_p^2 = 0.52$). The study similarly selected cooperative learning activities (e.g., groups of four, feedback, reciprocal teaching, and alternative roles) but differed in terms of the duration of the intervention (only 5 weeks) and the duration of sessions (45 min).

In conclusion, various studies have found consistent evidence for the positive impacts on student social-emotional competencies and general behavior derived from the social-emotional educational programs in physical education classes. Our finding that youth school students demonstrate more developed social-emotional skills in physical education classes following the intervention could be explained by the Dyson and Casey (2012) model-based practice of cooperative learning, wherein social and affective learning outcomes are combined to develop social-emotional skills as recognized elements of a comprehensive educational program. The results of this study could also be explained by the positive youth development approach, which indicates how skill-building activities, such as possibilities for improving physical, social, and psychological skills in physical education contexts, can prepare students to

be competent and healthy (Ebbeck and Gibbons, 1998; Weiss, 2011).

For both the cooperative learning approach and the positive youth development approach, the concept of autonomy-supporting teacher behavior is relevant; this indicates that teacher-student relationships are cooperative, and students feel that behavior is self-determined rather than controlled (Weiss and Wiese-Bjornstal, 2009; Weiss, 2011). The results of a similar study (Papacharisis et al., 2005) show that when social-emotional skills training is properly integrated into physical education classes, trained social-emotional skills are not taught at the expense of motor skills training. These results might be explained by the participatory-learning methods applied, which included listening to instructions about the relevant skills, observing the skills in practice (modeling), practicing the skills in selected situations in a cooperative learning context, and receiving feedback about the individual performance of the skills. Thus, the learning of social-emotional skills was facilitated by the practice of motor skills (Papacharisis et al., 2005).

Contributions and Implications

First, there is a considerable need to more deeply understand the particularities of training the social-emotional skills of youth school students through physical education classes. Youth school students experienced varying types of risks, hence, the individual discrepancies in their need for social-emotional skills training. Better understanding the social-emotional skills of youth school students in the context of physical education classes can provide insights that can help those students to transform their weaknesses into strengths and overcome the challenges they face, thus further improving their social-emotional skills. Second, this study has demonstrated that a Social-Emotional Skills Training Program can be successfully implemented during physical education classes not only in mainstream secondary schools but also in youth schools.

In general, this study provides important cues for investigators wanting to better understand the importance of social-emotional skills training in youth schools. It has demonstrated that implementing a Social-Emotional Skills Training Program in physical education classes is a powerful factor that can help to enhance the social-emotional skills of youth school students.

Limitations and Future Research

One of the limitations of this study was that it only considered students of high school age (15–18); further study is needed to analyze the peculiarities of middle- and primary-school-age students in terms of developing social skills in physical education classes. It would also be useful to compare the data among students from different age groups. The self-reported measures used represent another limitation of this study. Further research could also explore the behavioral measures of the use of social-emotional skills of the students in settings other than physical education.

Another potential limitation is that we assigned intact classes to the experimental and the control replication conditions. However, this, in general, corresponds to the likely real situation: the program will usually be implemented within regular classes. In addition, the results showed that the experimental and control groups did not differ before the beginning of the program.

Finally, the lack of retention and transfer measures of social-emotional skills could represent a limitation. Future studies could employ follow-up measures to demonstrate retention.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethical Committee of the Lithuanian Sports University. The participants provided their written informed consent to participate in this study. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

RM: conceptualization and methodology. VM: data analysis. VM and RM: data collection, writing, original draft preparation, review and editing and visualization and supervision. Both authors contributed to the article and approved the submitted version.

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Social, Personal, and Innovative Competencies Effect of Service-Learning in Physical Education Teacher Education: A Mixed-Methods Analysis

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The purpose of this study was to compare the development of social entrepreneurship competency in physical education teacher education students (n = 89), through two modalities of intervention from the same service-learning program. The student teachers provided a direct service to children with motor functional diversity, promoting their motor skills and counteracting their lack of social attention. The study was conducted using mixed methods with methodological triangulation. Quantitative evidence was gathered through a quasi-experimental design of two non-equivalent experimental groups implementing the *Social Entrepreneurship Competency Scale*. Qualitative analysis was undertaken by elaborating 12 life histories of multiple crossed stories. Quantitative results provide significant evidence about the social entrepreneurship competency effect of service-learning on physical education teacher education students while qualitative interpretation complements this view, reflecting how this competency was developed. We provide original findings on promotion of personal, social, and innovative social entrepreneurship competency features as well as the promotion of moral and civic values.

Keywords: social entrepreneurship competency, physical education teacher education (PETE), scale, motor functional diversity, life histories

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INTRODUCTION

The competence-based approach to the training of future teachers promotes the implementation of active and experiential methodologies, allowing students to apply their learning in real conditions. In accordance with this view, service-learning (SL) is a teaching methodology that seeks to develop academic competencies while providing a community service to meet social needs (Yorio and Ye, 2012). Moreover, SL has the potential to encourage entrepreneurial and innovative learning experiences (Meaney et al., 2016), promote social justice (Jones and Kiser, 2014), enhance students' critical thinking (Mitchell, 2008), and foster educational transformations (Meidl and Sulentic, 2018). Thus, SL stands as a firm opportunity to develop the social entrepreneurship competency (SEC) through integral training that provides a melding of theory and practice (Wilkinson et al., 2013). For the purpose of this research, we considered the SEC as the ability

to initiate or embrace new projects of social entrepreneurship. As established in previous research, this competency comprises personal, social, and innovative personality features (Capella-Peris et al., 2020a).

Understanding the influence of SL in Physical Education (PE) is currently a topic of great interest (Chiva-Bartoll et al., 2020a, 2021a, 2021b; García-Rico et al., 2021; Pérez-Ordás et al., 2021; Valverde-Esteve et al., 2021). Even new theoretical proposals have been made (Chiva-Bartoll and Fernández-Rio, 2021). For this reason, following a similar approach of previous works, we analyzed the effects of SL in PE (Domangue and Carson, 2008; Wilkinson et al., 2013; Peralta et al., 2015; Ward et al., 2017; Webster et al., 2017; Whitley et al., 2017; Capella-Peris et al., 2020b). Previous research has already focused on the personal, civic, or social effects of this methodology, for example, investigating how a SL program shaped preservice teachers' cultural competency (Domangue and Carson, 2008), examining the influence of SL upon first-year PETE candidates' vocational call to teach (Miller, 2012), exploring preservice teachers' experiences of cognitive disequilibrium theory during a SL project in a study abroad experience (Ward et al., 2017), and conducting narrative inquiry regarding undergraduate students' experiences in a physical activity-based SL (Whitley et al., 2017). However, there is a lack of emphasis regarding the effects of SL on promoting the SEC of physical education teacher education students (PETEs). The promotion of this competency in teacher education is important not only because it increases social skills and moral values in future teachers, but it also leads society to improve global wealth, counteract social crises, and resolve community problems. Thus, this paper fills this gap in the research field.

Another significant contribution is made in our research design, based on a comparison of two modalities of intervention in the same SL program, since no similar comparisons have been performed in previous studies. The main difference between the two modalities lies in the duration and intensity of the service provided. Despite several prior recommendations (National Youth Leadership Council, 2004), there are no established parameters for SL programs regarding duration (i.e., how long does the intervention last) and intensity (i.e., effective amount of time invested in the intervention). A previous review analyses several studies about implementations of SL programs in physical education (PE) that varied from 5–20 h to 4–12 weeks (Cervantes and Meaney, 2013). However, the comparison of their effects is skewed by many individual differences, which makes it difficult to interpret the duration and intensity variables. Therefore, we try to shed light on this issue by comparing two intervention modalities of the same SL program with different and well-defined duration and intensity parameters.

Specifically, the purposes of this study are to: 1) investigate the effect of a service learning (SL) program on the SEC of PETEs, and 2) compare the difference between the SEC of PETEs exposed at different SL intervention modalities characterized by different levels of SL duration and intensity. Thus, the studied variables in this study are the SL program (in both intervention modalities) as independent variable, while the dependent variable refers to the SEC of the PETEs.

Moreover, the use of mixed methods represents a new trend in education (Gullo and Sperandio, 2020; Cheung and Ng, 2021; Raza et al., 2021), allowing us to analyze the research question from a double perspective. In addition, the implementation of our design differs from previous work related to SL (Domangue and Carson, 2008; Miller, 2012), since it performs a qualitative data transformation and combines three types of results in the discussion (Creswell and Plano Clark, 2007; Camerino et al., 2012).

MATERIALS AND METHODS

Research Settings

The study was performed in the Elementary Education Degree program of a public university in Spain. The PETEs had to organize, apply, and manage several sessions of motor skills and body language games, and to directly serve a total of 150 children with motor functional diversity caused mainly by Autism Spectrum Disorder, Down Syndrome, Cerebral Paralysis, Attention Deficit and Hyperactivity Disorder, and Rett's Syndrome. The term 'motor functional diversity' is an umbrella concept used to describe any alteration of motor behavior such as repetitive movements or hyperactivity; problems with balance or coordination; poor muscle control, reflexes, and posture; hypotonia; delayed development; and other alterations of motor function produced by several causes. This term proposes a shift towards non-negative, non-disparaging, and non-patronizing terms, aiming to replace the ones with pejorative semantics as special needs, disability, impairment, and handicap. The goal was to stimulate the motor skills of these children and to relieve their lack of social attention. These sessions could foster both the academic learning in PE and the SEC of the PETEs. The academic effect of this project was evidenced in a previous publication (Capella-Peris et al., 2020b).

The study used an incidental-type non-probabilistic sample, with the sample selection matched to the class-group. The total sample was 89 PETEs: 31.5% ($n = 28$) in the Experimental Group I (EGI), and 68.5% ($n = 61$) in the Experimental Group II (EGII). The same SL program was implemented on the two groups under study, but at varying degrees. Specifically, they worked jointly on the design and implementation of the game sessions, although there were important differences in their dedication in terms of duration and intensity (**Table 1** near here).

These characteristics led the researchers to hypothesize that the duration and intensity differences (among modalities) will

TABLE 1 | Dedication characteristics of the SL Program.

Characteristic	SL intervention modality	
	Experimental Group I	***Experimental Group II***
Subject dedication	150 h (100%)	45 h (30%)
Intervention sessions (1 h)	30	9
Implication period	9 months	2 months
Frequency	Weekly	Weekly
PETEs involved	28	61

impact the SEC outcomes of EGI and EGII students, with EGI recording higher SEC than EGII.

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by all institutions involved. All participants provided written informed consent before enrollment.

Design and Data Collection

This study combines quantitative and qualitative research methodologies; its design is located within mixed methods approaches and uses methodological triangulation. The use of this design has been previously supported in several context of education (Gullo and Sperandio, 2020; Cheung and Ng, 2021; Raza et al., 2021), as well as in the PE and sports field (Camerino et al., 2012).

Quantitative evidence was gathered through a quasi-experimental design using two non-equivalent experimental groups, performing pre-test and post-test measurements. To assess the dependent variable, the *Social Entrepreneurship Competency Scale* (SECS) instrument was used (Capella-Peris et al., 2020a). This scale specifically measures SEC development in higher education.

The qualitative segment was undertaken through a biographical design, elaborating 12 life histories of multiple crossed stories. Narrative inquiry was used to illustrate the students' SL intervention trajectory. Open questions were performed on interviews to retrieve or expand valuable information. Individual and collective effects on the SEC of PETEs were analyzed. Life histories allows the knowledge, experiences, feelings, beliefs, and values shared in a learning community to be investigated more deeply, as previous studies demonstrated in teaching PE (Sparkes et al., 1993). As SL was expected to produce a stronger impact on EGI students (due to their greater exposure to the SL program) only participants from this group were interviewed. All EGI members were interviewed to elaborate the life histories. From all interviews collected, four were selected to apply the qualitative analysis using quota sampling, considering the representativeness of the students. Eight additional interviews were selected, applying snowball sampling, regarding the suggestions of the students from quota sampling. Following common guidelines to perform life histories (Pamphilon, 1999; Hernández et al., 2011), students were requested to prepare themselves for the interviews as follows: 1) they should explain their experience as if they were telling a story to a friend (narrative exposition); 2) they could use any support file to illustrate their story (e.g., guides, reflections, comments, reminders, reports, etc.); 3) stories should be focused on academic and personal impacts as main objectives, including contextual and additional information for clarification (e.g., suggestions, opinions, interpretations, etc.); and stories should be organized in chronological order, from the very beginning until the end of their intervention of the SL program. Students were asked at any moment to retrieve or expand information regarding interesting issues. All interviews were open, so there were no questions decided beforehand. After displaying those instructions, any additional doubt regarding the interviews was resolved (e.g., assigned day for the interview, location of the interviews, duration of the interviews, etc.). All interviews were audio-recorded and transcribed verbatim to conduct a thematic analysis from an illustrative approach (Demazière and Dubar, 1997). Thematic areas to perform qualitative analysis were defined by the SECS (Capella-Peris et al., 2020a), allowing researchers to compare quantitative and qualitative results on discussion. In addition, researchers' interpretations were added while constructing life histories from biographical stories, as this was the main difference between both approaches (Denzin, 1989).

Finally, we transformed qualitative data into quantitative results (Capella-Peris et al., 2020b). While the qualitative study assessed the importance and depth of comments from the PETEs, the qualitative data transformation showed the frequency with which each category and aspect analyzed was cited in interviews. This quantitative analysis of the transcripts provides a complementary view of their discourse, offering a new perspective of the effects of SL.

Hypotheses and Research Question

The specific hypotheses to be tested were H_1: *The SL program will produce a significant improvement ($p < 0.05$) in the SECS results for the EGI*, H_2: *The SL program will produce a significant improvement ($p < 0.05$) in the SECS results for the EGII*, and H_3: *The SL program will produce a significant improvement ($p < 0.05$) in the SECS results for the EGI compared with the EGII*. Furthermore, the main question needing a response in this research is *How does the SL program affect the experiences and learnings of PETEs related to their SE?*.

RESULTS

Quantitative Analysis

This section shows the results of the statistical tests performed throughout the quantitative study. The IBM SPSS v.24 software package was used in this analysis.

Reliability test: a value of $\alpha = 0.832$ was obtained for the Cronbach's Alpha test, showing good internal consistency.

Initial equivalence: a value of t (58) = 0.017, $p > 0.05$ was obtained for the Levene's test, so the initial samples were considered equal.

Pre-test/Post-test comparison: the values obtained when applying the t test for paired samples were t (29) = 4.864, $p < 0.001$ for the EGI and t (29) = 2.606, $p = 0.014$ for the EGII, respectively. Hence, there were significant differences between the pre-test and post-test measures in the two cases. However, when analyzing categories, there were significant differences only in the EGI (**Table 2** near here).

Post-test/Post-test comparison: a value of t (58) = 1.110, $p > 0.05$ was obtained for the Levene's test. Therefore, despite the higher results in EGI ($x = 4.002$) compared with EGII ($x = 3.868$), there were no significant differences in the post-test results between both groups. This situation was reflected in the comparison by categories, where the two groups obtained similar results without significant differences between them. The results obtained were t (16) = 1.093, $p > 0.05$; t (20) = 0.882, $p > 0.05$; and t (18) = 0.945, $p > 0.05$, for the categories of personal,

TABLE 2 | Pre-test/Post-test categories comparison in each group.

Category	EGI (n = 28)		EGII (n = 61)	
	Pre-test	*Post-test*	*Pre-test*	*Post-test*
	Mean (SD)[a]	Mean (SD)[a]	Mean (SD)[a]	Mean (SD)[a]
Personal features	3.853 (0.3)	4.128 (0.311)[b]	3.903 (0.365)	3.977 (0.274)
Social features	4.246 (0.306)	4.336 (0.336)	4.17 (0.295)	4.22 (0.275)
Innovative features	3.26 (0.422)	3.522 (0.302)[b]	3.292 (0.438)	3.382 (0.358)

[a]*Mean and Standard Deviation values are displayed for each case.*
[b]*Significant differences between Pre-test and Post-test measurements (p< 0.05).*

social, and innovative features, respectively. In all these cases, the EGI registered higher results.

Correlations: three significant records out of three were found in the Pearson's Test; all were positive and had a significance level of $p < 0.01$. The degrees of correlation were moderate ($0.4 \leq rp<0.6$) for two cases, and low ($0.2 \leq rp < 0.4$) for one case. When analyzing categories, 92 significant records out of 136 were found; all were positive and had significance levels of $p < 0.01$ for 74 cases and $p < 0.05$ for 18 cases. The degrees of correlation were high ($0.6 \leq rp<0.8$) for one case, moderate ($0.4 \leq rp<0.6$) for five cases, low ($0.2 \leq rp < 0.4$) for 64 cases, and very low ($0 < rp<0.2$) for 22 cases.

Qualitative Analysis

Qualitative analysis was elaborated through life histories of multiple crossed stories. The interviews were analyzed following the categories and aspects of the SECS (Capella-Peris et al., 2020a). The analysis was embraced through a multiphase approach, based on an initial open-coding phase and a second axial coding phase (Flick, 2014). Open-coding was applied to identify personal, social, and innovative features of SEC which are of great interest to this study (e.g., PETEs' perceptions of the benefits and effects of service learning, overall satisfaction, promotion of ethical and moral values, improvements in diversity understanding, etc.). Axial coding was used to classify comments that could be associated to the SECS features (i.e., confidence, goal-oriented motivation, ability to take risks, ability to learn and evolve, creativity, social awareness, etc.). NVivo 10 software was used in this analysis.

All extracts used in this qualitative analysis included category and aspect name, researcher interpretation, textual transcript of the PETEs comments, and reference codes. This section offers the information for two extracts per category as an example. The selection of these quotations is related to its importance and depth, and to highlight the PETEs experiences in each case.

Personal features > *Goal-orient*ed motivation: the following student's appreciation of the training provided shows her desire to be prepared in advance for the SL program. This situation demonstrates that she is motivated to fulfil the service in the best way possible. It also contains a critique of the educational system, suggesting several learning elements that appear to be otherwise missing from her teacher education program. Additionally, the statement connects to the previous feature, confidence.

"I liked the preliminary theory sessions because people usually think that as elementary education teachers, we have plenty of knowledge about children. I have not had experience working with children before that. Hence, I liked that we didn't go directly. Come on with the children! That made me feel more confident as well".

Personal features > Ability to take risks: PETEs expressed concern about preparing an information session for parents, but this situation helped them to overcome their fear of communicating informally with the children's families. This is a common concern among those who begin to teach in elementary, primary, or secondary education for the first time. Therefore, this experience is of great value in their educational training.

" The Down Syndrome Foundation requested that we offer an information session for parents. At the beginning we were so nervous, but later we understood that it was an easy task. They are people like you, you only need to tell them what you are going to do with their children, that's it. Sincerely, I liked a lot".

Social features > *Social awareness:* this student showed her social awareness about gender equality and respect when facilitating a game activity. Such a situation is common in PE, mainly because of gender stereotypes related to sports and physical activities. Thus, promoting gender equality, no matter what activity or sport the group plays, is of great educational value, especially when working with children at formative stages.

" This day we created groups using two puzzles. The first one had a Superman image and the second one had a Supergirl picture. A man and a woman, because in the group we had boys and girls. Otherwise, they could say that working with superheroes was only for boys! No, games were for boys and girls equally".

Social features > *Coexist*ence and respect of public affairs: sharing their time with these children presented certain challenging situations because of the significant social contrasts arising due to the children's differences of experience, habit, and tradition. The PETEs came to recognize these differences with their professor's support, improving their understanding of the children's varying needs.

" During a break, the children went to take a drop of water. A boy saw the water touching a peer's face and he was afraid about that. The professor told us that . . . maybe cleaning your face is a routine for you, but for them could be something new, maybe they don't have this habit from home. You just don't know! . . . We usually have 10 minutes at the end of the sessions to promote their habit to clean their faces and hands with water".

Innovative features > *Leadership:* the following student speaks about playing a leadership role among her classmates during the

TABLE 3 | Global quotes of Social Entrepreneurship Competency.

Categories	Interviews																								Total[a]	
	C01		C02		C03		C04		C05		C06		C07		C08		C09		C10		C11		C12			
Personal features	27	*4.4%*	50	*8.2%*	69	*11.3%*	90	*14.7%*	74	*12.1%*	53	*8.7%*	32	*5.2%*	32	*5.2%*	49	*8.0%*	36	*5.9%*	47	*7.7%*	52	*8.5%*	611	*29.7%*
Social features	108	*6.8%*	93	*5.8%*	173	*10.8%*	186	*11.7%*	175	*11.0%*	129	*8.1%*	81	*5.1%*	111	*7.0%*	129	*8.1%*	123	*7.7%*	142	*8.9%*	146	*9.1%*	1,596	*41.3%*
Innovative features	83	*10.1%*	55	*6.7%*	71	*8.6%*	61	*7.4%*	85	*10.3%*	71	*8.6%*	46	*5.6%*	63	*7.7%*	57	*6.9%*	65	*7.9%*	84	*10.2%*	81	*9.9%*	822	*29.0%*

[a]*The total percentage was normalized to compare results between categories.*
Upright/roman values show number of citations; italic values show percentages.

TABLE 4 | *Personal features* quotes.

Features	Interview																								Total[a]	
	C01		C02		C03		C04		C05		C06		C07		C08		C09		C10		C11		C12			
Confidence	3	*3%*	17	*16.2%*	6	*5.7%*	12	*11.4%*	9	*8.6%*	9	*8.6%*	7	*6.7%*	9	*8.6%*	7	*6.7%*	4	*3.8%*	14	*13.3%*	8	*7.6%*	105	*19.7%*
Goal-oriented motivation	8	*3.6%*	10	*4.5%*	26	*11.7%*	34	*15.3%*	28	*12.6%*	19	*8.6%*	14	*6.3%*	7	*3.2%*	24	*10.8%*	13	*5.9%*	13	*5.9%*	26	*11.7%*	222	*41.6%*
Ability to take risks	4	*3.1%*	8	*6.2%*	12	*9.3%*	22	*17.1%*	22	*17.1%*	9	*7.0%*	6	*4.7%*	10	*7.8%*	7	*5.4%*	8	*6.2%*	9	*7.0%*	12	*9.3%*	129	*24.2%*
Ability to learn and evolve *(p)*	10	*8.1%*	14	*11.3%*	20	*16.1%*	15	*12.1%*	13	*10.5%*	13	*10.5%*	3	*2.4%*	4	*3.2%*	10	*8.1%*	9	*7.3%*	9	*7.3%*	4	*3.2%*	124	*11.6%*
Creativity *(p)*	2	*6.5%*	1	*3.2%*	5	*16.1%*	7	*22.6%*	2	*6.5%*	3	*9.7%*	2	*6.5%*	2	*6.5%*	1	*3.2%*	2	*6.5%*	2	*6.5%*	2	*6.5%*	31	*2.9%*

[a]*The total percentage was normalized to compare results between features.*
Upright/roman values show number of citations; italic values show percentages.

TABLE 5 | *Social features* quotes.

Features	Interview																								Total[a]	
	C01		C02		C03		C04		C05		C06		C07		C08		C09		C10		C11		C12			
Ability to learn and evolve (s)	10	*8%*	14	*11.3%*	20	*16.1%*	15	*12.1%*	13	*10.5%*	13	*10.5%*	3	*2.4%*	4	*3.2%*	10	*8.1%*	9	*7.3%*	9	*7.3%*	4	*3.2%*	124	*4.0%*
Giving help and cooperation	16	*5.7%*	10	*3.5%*	27	*9.6%*	17	*6.0%*	38	*13.5%*	14	*5.0%*	18	*6.4%*	28	*9.9%*	28	*9.9%*	33	*11.7%*	26	*9.2%*	27	*9.6%*	282	*18.4%*
Social awareness	12	*7.5%*	3	*1.9%*	15	*9.3%*	19	*11.8%*	19	*11.8%*	9	*5.6%*	4	*2.5%*	4	*2.5%*	13	*8.1%*	12	*7.5%*	25	*15.5%*	26	*16.1%*	161	*10.5%*
Coexistence and respect of public affairs	11	*4.2%*	5	*1.9%*	20	*7.7%*	20	*7.7%*	22	*8.5%*	23	*8.8%*	21	*8.1%*	23	*8.8%*	25	*9.6%*	30	*11.5%*	25	*9.6%*	35	*13.5%*	260	*16.9%*
Resilience	19	*8.1%*	27	*11.5%*	32	*13.6%*	31	*13.2%*	24	*10.2%*	18	*7.7%*	14	*6.0%*	23	*9.8%*	15	*6.4%*	12	*5.1%*	8	*3.4%*	12	*5.1%*	235	*15.3%*
Responsibility	4	*4.0%*	6	*5.9%*	13	*12.9%*	15	*14.9%*	14	*13.9%*	5	*5.0%*	6	*5.9%*	8	*7.9%*	6	*5.9%*	8	*7.9%*	6	*5.9%*	10	*9.9%*	101	*6.6%*
Commitment and coherence	15	*9.6%*	10	*6.4%*	24	*15.4%*	12	*7.7%*	16	*10.3%*	7	*4.5%*	7	*4.5%*	11	*7.1%*	18	*11.5%*	11	*7.1%*	9	*5.8%*	16	*10.3%*	156	*10.2%*
Ability to create ideas	21	*7.6%*	18	*6.5%*	22	*7.9%*	57	*20.6%*	29	*10.5%*	40	*14.4%*	8	*2.9%*	10	*3.6%*	14	*5.1%*	8	*2.9%*	34	*12.3%*	16	*5.8%*	277	*18.1%*

[a]*The total percentage was normalized to compare results between features.*
Upright/roman values show number of citations; italic values show percentages.

TABLE 6 | *Innovative features* quotes.

Features	Interview																								Total[a]	
	C01		C02		C03		C04		C05		C06		C07		C08		C09		C10		C11		C12			
Creativity *(i)*	2	*6.5%*	1	*3.2%*	5	*16.1%*	7	*22.6%*	2	*6.5%*	3	*9.7%*	2	*6.5%*	2	*6.5%*	1	*3.2%*	2	*6.5%*	2	*6.5%*	2	*6.5%*	31	*1.9%*
Leadership	10	*9.1%*	3	*2.7%*	10	*9.1%*	4	*3.6%*	19	*17.3%*	3	*2.7%*	5	*4.5%*	6	*5.5%*	6	*5.5%*	13	*11.8%*	13	*11.8%*	18	*16.4%*	110	*13.6%*
Initiative	7	*6.3%*	11	*9.8%*	11	*9.8%*	9	*8.0%*	8	*7.1%*	4	*3.6%*	9	*8.0%*	11	*9.8%*	14	*12.5%*	5	*4.5%*	4	*3.6%*	19	*17.0%*	112	*13.9%*
Ability to change	20	*12.3%*	6	*3.7%*	18	*11.0%*	11	*6.7%*	15	*9.2%*	15	*9.2%*	13	*8.0%*	12	*7.4%*	9	*5.5%*	20	*12.3%*	8	*4.9%*	16	*9.8%*	163	*20.2%*
Being part of social networks	40	*16.4%*	19	*7.8%*	22	*9.0%*	11	*4.5%*	27	*11.1%*	20	*8.2%*	7	*2.9%*	21	*8.6%*	20	*8.2%*	14	*5.7%*	30	*12.3%*	13	*5.3%*	244	*30.3%*
Ability to identify opportunities	4	*2.5%*	15	*9.3%*	5	*3.1%*	19	*11.7%*	14	*8.6%*	26	*16.0%*	10	*6.2%*	11	*6.8%*	7	*4.3%*	11	*6.8%*	27	*16.7%*	13	*8.0%*	162	*20.1%*

[a]*The total percentage was normalized to compare results between features.*
Upright/roman values show number of citations; italic values show percentages.

TABLE 7 | Quotes of Social Entrepreneurship features on interview C12.

Categories	Interview C12																				Total[a]	
Personal features	*Confidence*		*Goal-oriented motivation*		*Ability to take risks*		*Ability to learn and evolve (p)*		*Creativity (p)*													
	8	*15.4%*	26	*50.0%*	12	*23.1%*	4	*7.7%*	2	*3.8%*											52	*27.5%*
Social features	*Ability to learn and evolve (s)*		*Giving help and cooperation*		*Social awareness*		*Coexistence and respect of public affairs*		*Resilience*		*Responsibility*		*Commitment and coherence*		*Ability to create ideas*							
	4	*2.7%*	27	*18.5%*	26	*17.8%*	35	*24.0%*	12	*8.2%*	10	*6.8%*	16	*11.0%*	16	*11.0%*					146	*41.2%*
Innovative features	*Creativity (i)*		*Leadership*		*Initiative*		*Ability to change*		*Being part of social networks*		*Ability to identify opportunities*											
	2	*2.5%*	18	*22.2%*	19	*23.5%*	16	*19.8%*	13	*16.0%*	13	*16.0%*									81	*31.2%*

[a]*The total percentage was normalized to compare results between categories.*
Upright/roman values show number of citations; italic values show percentages.

SL activities. Her comment shows that this task is not as easy as it seems. Problems can often arise in following guidelines, in respecting rules, or in reaching agreements, especially when trying to lead a group of peers.

" We told them . . . you should do this, this, and this, right? It was supposed that they had a clear idea about what to do, but later when the session came, they had no idea. They were neither performing their roles nor following our directions . . . for example, someone who should be preparing next game but was playing the current one, or someone who should be managing an activity but was watching another game . . . they didn't play their roles. Hence, what did we learn? We learned how to lead them stablishing the initial rules more clearly".

Innovative features > Ability to identify opportunities: assessing the advantages and disadvantages of taking part in the SL program, the following student indicates that one of the most favorable aspects is the realism of the activity. This situation is very important in training PETEs, displaying one of the most valuable contributions of this methodology compared to other, more traditional ones. The recognition of these opportunities let students take full advantage of their participation in those educational experiences.

" When the professor told us that we could tackle the subject in a more practical way, at first, we did not want to, because we knew there would be more work to do. But, on the other hand, we think this could be better for our training because it meant no longer taking classes with our classmates. We could work directly with children. So, we chose the Service-Learning option. Besides, the fact that they were children with disabilities was a plus for us because we could help them as well. Then, we did not hesitate any longer about taking it".

Qualitative Data Transformation (Qualitative Data Quantitatively Expressed)

This section displays a frequency analysis of the excerpts from selected interviews, counting the number of citations related to the categories and aspects of the SECS (Capella-Peris et al., 2020a), as well as the percentage value of each. In this study, the procedure was performed globally, showing the number of excerpts per category in each interview (**Table 3** near here), by aspects, indicating the frequency of citations into each specific category (**Tables 4**, **5**, and **6** near here), and by interviews, presenting all records related to each interview individually (**Table 7** near here).

These tables reflect on the frequency to which each category and feature analyzed is cited in life histories. This data provides a complementary view of PETEs' discourse, offering a new perspective of AL effects. Additionally, the information displays analyses in global terms, by course, and by participant, showing three different approaches.

DISCUSSION

Globally, the results obtained in the quantitative analysis indicate that the two experimental groups improved their SEC significantly. Although EGI results tend to be higher than EGII, the post-test results reveal no significant differences between them. However, qualitative analysis shows an enormous impact on EGI students describing a substantial development of all personal, social, and innovative features. Similarly, the qualitative data transformation (qualitative results quantitatively expressed) reinforces this global assessment, since the interviews show so many references to social entrepreneurship—more than 2,400. Altogether, this evidence points to outstanding progress in the PETEs' SE, due to their participation in the SL program. This situation agrees with most theoretical works regarding the impact of SL on education (Butin, 2003; Seban, 2013), as well as several meta-analyses concerning SL effects (Conway et al., 2009; Celio et al., 2011; Yorio and Ye, 2012; Carson and Raguse, 2014). In addition, as there are no statistical differences between the post-test measures of both groups, new proposals of intervention with bigger differences between modalities should be analyzed in future research.

Moreover, the category-by-category analysis supports the global findings described above. The quantitative study reveals that EGI improved significantly in two out of three categories on the SECS, while EGII registered non-significant differences. Similarly, the post-test comparison indicates that EGI recorded superior results in all three categories and in 16 out of 17 features compared to EGII. Results are highest for the category of *social features*, followed by the categories of *personal* and *innovative features*, respectively. In addition, there are significant correlations between the categories of the SEC in all cases and between the individual features in 92 out of 136 cases, evidencing the strong relationship among the features analyzed. The qualitative data transformation shows a similar distribution with the *social features* category being the most important. However, in this case more of the comments addressed the *innovative features* than the *personal features*. These results are supported by the qualitative study, where the PETEs specifically emphasize their social experiences and learning (Conway et al., 2009; Celio et al., 2011; Yorio and Ye, 2012). Furthermore, it is important to highlight the impressive results obtained in all categories and features, both according to an analysis of the quantitative data and based on the qualitative data transformation analysis, which suggests a significant impact for the SL program in promoting the SEC on the PETEs.

Therefore, the results from the different analyses performed present highly coherent and complementary data. In addition, this situation indicated that the SL program had a very similar effect among the PETEs in this study. The next sections offer an analysis of the results obtained in the individual features of the SEC.

The first feature, *confidence*, registers high scores in both quantitative and qualitative data transformation analyses. In addition, the improvement in the pre-test/post-test score on EGI is one of the largest observed. Moreover, the qualitative evidence shows how the PETEs increased both their personal and professional confidence, specifically in relation to handling functionally diverse populations and teaching sessions of PE. Altogether, the data points

to a huge enhancement of the PETEs' *confidence* during the study (Miller, 2012; Robinson and Meyer, 2012).

Goal-oriented motivation presents one of the highest results in the quantitative analysis and is the most cited category within the qualitative data transformation. Indeed, this is the only feature that shows statistically significant improvement in the pre-test/post-test EGI comparison. The qualitative data relates the desires of PETEs to develop teaching competencies related to their academic fields (Wilkinson et al., 2013; Capella-Peris et al., 2020b). They also showed a strong intention to help the children, improving their behavior and offering a quality service experience.

Ability to take risks also shows impressive results in the quantitative study. Similarly, the qualitative data transformation represents almost 25% of references coded for personal features. The qualitative analysis reveals the tendency of PETEs to face unknown situations with a high degree of uncertainty. This is mainly related to their participation in the SL program and the benefits of dealing with children with special needs (Miller, 2012; Santiago et al., 2016).

Ability to learn and evolve reveals more moderate results in the qualitative data transformation analysis but still shows high scores in the quantitative data. Moreover, the qualitative analysis reveals how improvement in this feature is connected to enhanced personal, social, and professional competencies among PETEs. All of this suggests both personal and professional progress, enhancing social skills as well as citizen participation (Whitley et al., 2017).

Creativity received moderate results on quantitative and qualitative data transformation analyses. However, it does show one of the higher levels of improvement in the pre-test/post-test comparison for EGI. In addition, analysis of the qualitative data reveals great advances in preparing and implementing new practice activities and highlights the relationship between this feature and the *ability to create ideas*. Some authors associate both elements with the ability to "create differences" in the community through SL (Fleck et al., 2017).

Giving help and cooperation, was the most cited of the social features and received one of the highest post-tests results for both groups. In addition, the qualitative analysis suggests that it benefits from both the service provided and the improvement in communication skills (Lee et al., 2018a).

Social awareness feature obtained remarkable scores in the quantitative study. The qualitative analysis reveals how this feature was developed for the PETEs; basically, it resulted from taking care of the special educational needs of the children receiving the service (Covitt, 2002; Furco and Root, 2010; Himelein et al., 2010; Peralta et al., 2015; Santiago et al., 2016).

Coexistence and respect of public affairs represents the highest score in the quantitative analysis and holds third place in the qualitative data transformation. The qualitative study suggests that it developed alongside attitudes of understanding and deference among PETEs towards the child participants and through contact with other involved groups, including classmates, teachers, and family members of the children, neighborhood and community members, and the school itself as an educational organization (Furco and Root, 2010; Celio et al., 2011; Santiago et al., 2016; Lee et al., 2018a).

Resilience received a high number of comments in the interviews and remarkable scores in the quantitative analysis as well. Both results are reinforced by the qualitative study, which indicates that students improve their response significantly when they face conflicts and unfavorable situations while providing the service (Covitt, 2002).

Responsibility received outstanding quantitative response in both experimental groups. The qualitative data describes that PETEs had to deal with new and complicated experiences related to preparing and performing the service, developing their social, personal, citizen and civic responsibility (Celio et al., 2011; Fleck et al., 2017; Whitley et al., 2017; Iyer et al., 2018). The enhancement of social responsibility is especially interesting because it contrasts with previous research in PE (Chiva-Bartoll et al., 2020b).

Commitment and coherence was one of the features valued most strongly in the quantitative study. Qualitative data shows that the promotion of this social feature occurs due to experience of service provision, along with a desire to participate again in similar proposals. That improvement has been described in previous work in relation to different views of commitment: community, civic, academic, and social (Furco and Root, 2010; Celio et al., 2011; Capella-Peris et al., 2020b). Likewise, there is also precedent for the stimulation of this feature in PE (Robinson and Meyer, 2012).

Ability to create ideas obtained high quantitative records and sits second in frequency of interview mentions within the social features category. The qualitative study explains how this feature was improved due to the PETEs development of reflection skills. They analyzed questions not only about education in general, but also about practice implementation individually. All of this suggests an increase in critical and reflective thinking skills through SL (Yorio and Ye, 2012; Carrington et al., 2015; Barnes and Caprino, 2016; Lee et al., 2018b).

Leadership, received the lowest scores in the quantitative and qualitative data transformation analyses, which contrasts with previous results (Chiva-Bartoll et al., 2020b). However, the qualitative study described that the PETEs led multiple activities while working with the children and their university peers (Celio et al., 2011).

Initiative represents the best improvement between pre-test and post-test measurements in the quantitative analysis for both groups. The qualitative data indicates how the PETEs enhanced this feature through implementation of the service, especially by conducting sessions concerning motor and body language games; this points to a personal improvement in organizational and management competencies (National Youth Leadership Council, 2004; Carrington et al., 2015) regarding how to handle such aspects as children, materials, space, and time in the course of sessions (Webster et al., 2017; Capella-Peris et al., 2020b).

Ability to change received a high number of quotations in the qualitative data transformation analysis, with more than 20% of references coded for innovative features. The qualitative study indicates a positive disposition among PETEs to adjust their perceptions of service recipients and the implementation processes while performing the game sessions. These situations imply important modifications referring to teaching

competencies and preconceived stereotypes (Peralta et al., 2015; Santiago et al., 2016).

Being part of social networks is the most cited feature on interviews for the category of innovative features. The comments extracted in the qualitative study refer to the relationship between the SL students and several groups of others, such as professors, university mates, members of the institutions involved, and children receiving the service and their families, which is in line with previous SL effects on PETEs (Salter and Halbert, 2019).

The qualitative results explain how PETEs developed their *ability to identify opportunities* taking advantage of their participation in the SL program on personal, academic, and professional levels. For this reason, all of them valued the experience positively, signifying an improvement not only for them but also for society. Basically, the main focus was on their potential to develop personal, interpersonal, and citizen participation skills (Ward et al., 2017; Whitley et al., 2017).

In addition, the SL program stimulated several personal, social, and innovative features of great interest to this study. The most outstanding aspects reflect a change in PETEs' perceptions of the children (Baldwin et al., 2007; Conway et al., 2009; Wilkinson et al., 2013). Another remarkable feature is their overall satisfaction with the SL program (Miller, 2012; Fleck et al., 2017), even appreciating the opportunity to participate in the educational experience (Himelein et al., 2010). This situation had a direct impact on their attitudes towards the school and academic learning in general (Furco and Root, 2010; Celio et al., 2011; Barnes and Caprino, 2016). The promotion of ethical and moral values through SL represents another remarkable feature from an educational and social point of view (Yorio and Ye, 2012). Specifically, this highlights the development of empathy, which facilitated the change in PETEs' perceptions of the service recipients and a related improvement in care for their individual needs (Baldwin et al., 2007; Lee et al., 2018a).

More enhanced features to take into consideration are improvements in diversity understanding (Baldwin et al., 2007), the development of interpersonal skills (Ward et al., 2017; Whitley et al., 2017), overcoming the initial doubts and insecurities about classroom management, reinforcing feelings of effectiveness among students (Miller, 2012), the connection between practice skills and the context of preparation for lessons (Baldwin et al., 2007), as well as the promotion of teaching independence and activism that may encourage innovation and social change (Sharra, 2005; Meidl and Sulentic, 2018).

Finally, the complementarity among the various measurement strategies used in this mixed-methods analysis reveals a marked interrelation among the personal, social, and innovation-related features enhanced by the PETEs. This situation explains why the SEC was promoted broadly instead of addressing needed improvements in various individual features.

CONCLUSION

The approach of mixed-methods, using methodological triangulation, offers a great opportunity to analyze the promotion of social entrepreneurship in physical education teacher education students. Indeed, highly reinforcing and complementary records emerge among the different results observed in this study. From this data, service-learning fostered the SEC of the PETEs, signifying an educational experience that boosted their personal, social, and innovative features. Additionally, the qualitative results offer valuable information to help researchers understand how these learning outcomes were achieved.

Therefore, the H_1 and H_2 hypotheses are accepted as there are significant improvements ($p < 0.01$) in the SECS results for EGI and EGII, respectively. On the other hand, the H_3 hypothesis is rejected, as there is no significant difference ($p < 0.05$) in the SECS results for EGI compared with EGII. Meanwhile, the depth of experience and insight demonstrated by the PETEs, in terms of increasing their SE, offers a broader answer to the research question.

The fact that life histories were only elaborated with students from EGI is a main limitation in this study. Regarding future research, it would be necessary to contrast SL modalities with bigger differences in terms of duration and intensity. Similarly, it would be promising to develop new strategies to assess SL with greater applications in practice, to open lines of inquiry that analyze the effects of SL on service recipients and community members, and to study the impact of this methodology throughout the entire teaching-learning process, analyzing its long-term effects on students, recipients, and society.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

This study was led, designed and conducted by CC-P and MM-P. CS-G and MM-V played a major role in analyzing the results and presenting them appropriately. All authors participated in drafting and reviewing the manuscript.

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Examining the Impact of School Esports Program Participation on Student Health and Psychological Development

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This study examined the influence of 7 high school esports developmental programs on student self-regulation, growth mindset, positive youth development (PYD), perceived general health and physical activity (PA), and sport behaviour. A total of 188 students (male $n = 120$; female $n = 68$) originally participated (89 enrolled in an esports program in their school and 99 acted as aged-matched controls), with 58 participants ($n = 19$ esports group; $n = 39$ controls) completing both pre- and post-program information. At baseline, no significant differences were found between youth e-athletes and their aged-matched controls. The analysis for the observation period showed a significant interaction effect for the PYD confidence scale, with *post-hoc* comparisons showing a significant decrease in the control group from pre- to post assessment whereas the esports group remained the same. Time main effects showed a decrease in the self-regulation motivation factor, PYD connection factor and PA for all participants. Overall, this study showed that students enrolled in their respective school esports program did not differ from those who did not in self-regulation, growth mindset, PYD, perceived health and PA, and sport behaviour. It was likely that all participants showed a decrease in motivation, connection, and PA due to COVID19 lockdown during the study period. This study is the first to investigate the longitudinal impact of student involvement in high school esports and showed that esports participation did not have a negative impact on any health or psychological factors.

Keywords: competitive video games, self-regulation, positive youth development, health, sport, esports, growth mindset

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INTRODUCTION

Esports has become hugely popular with the number of players and spectators growing year on year (Newzoo, 2020). The esports industry has been valued at over 24 billion dollars (Ahn et al., 2020) and professional esports athletes (e-athletes) can earn as much (or more) than traditional athletes (Finance Monthly, 2018). The rapid growth in esports is mostly due to the high levels of engagement of young people. A recent industry report showed that almost half of all esports fans are aged between 13 and 24 years (Nielsen, 2019). There has also been a 500% increase in the number of high school esports developmental and grassroots programs and tournaments in

the USA between 2018 and 2019 (Hennick, 2019). The increased popularity in esports has been accompanied by several concerns regarding sedentary behaviour, psychological development, and physical and psychological wellbeing (e.g., Shum et al., 2021).

Many esports leagues and organisations operate similarly to other sports; universities have begun to include esports as part of their sports portfolios and, philosophically, esports meets nearly every criteria for traditional sport (Holden et al., 2017; QUT, 2021). Furthermore, researchers are increasingly accepting esports as a sport (Jang and Byon, 2019). In traditional sport, the activity itself, as well as the social structure of sport, has been shown to result in improved mental and physical well-being (e.g., Eime et al., 2015). These factors have also provided opportunities for self-regulatory skill development (e.g., Collins and Durand-Bush, 2014) and positive youth development (Holt, 2016). Early evidence in esports research suggests similar trends. For example, in a qualitative study of CS:GO players Nielsen and Hanghøj (2019) provided preliminary evidence that grassroots esports programs can result in psychological skills development, which have the potential to transfer to everyday life. Conversely, in a cross-sectional study of e-athletes Trotter et al. (2021) reported evidence that the organisational structure of esports provide less opportunities for the development of social support, self-regulatory skills, psychological skills, and physical activity (PA) behaviour. Overall, there is a need to examine the potential of community or school esports programs on psychological development, health, and PA behaviour, especially in adolescent populations.

Despite negative connotations about video gaming (Mihara and Higuchi, 2017) and esports (Shum et al., 2021), a review by Granic et al. (2014) suggested that playing video games was associated with cognitive, motivational, social, and health benefits. Similarly, it has been theorised that pedagogical supervision in adolescent esports programs can assist in identifying potential signs of problematic gaming (Wimmer et al., 2021). Such esports programs are becoming increasingly common in school curriculum in the USA (Hennick, 2019). Currently, there is limited empirical evidence on the associated benefits of participation in adolescent esports programs. However, research indicates that such programs have the potential to positively impact the development of communication, teamwork, and problem-solving skills (Rothwell and Shaffer, 2019), professional and academic skills, social and emotional learning (Reitman et al., 2020), social belonging and mental health (Tjønndal and Skauge, 2020). In addition, only a small proportion of students enrolled in these programs have report problematic gaming behaviours (e.g., gaming addiction; Ortiz de Gortari, 2019). Despite this evidence, no study examining youth esports have used a longitudinal research design. As such, it is not possible to draw conclusions about the causal relationship participation in such program has on student development.

Self-Regulation

Previous research has suggested that metacognitive functions may theoretically be important for preventing the development of problematic gaming behaviours from involvement in esports programs (Brevers et al., 2020). In a review, Brevers et al. (2020) suggested there is a need to identify markers (e.g., self-regulation) that delineate high involvement from problematic esports engagement, as well as a better understanding of how such self-regulatory processes unfold among esports athletes.

To date, no literature exists on the self-regulatory processes in adolescent e-athletes. Previous research with adult esports athletes suggests that developmental esports programs may offer an avenue for the development of self-regulation (Trotter et al., 2021). Moreover, studies on the development of self-regulation in traditional adolescent athletes report that modelling by parents and coaches is predictive of an adolescent athlete belonging to an elite group (Teques et al., 2019). Similarly, in a longitudinal study of elite youth soccer players Erikstad et al. (2018) showed that high self-regulated adolescent traditional athletes were more likely to be selected for national initiatives and that sports participation may contribute to differences in self-regulatory skills. Despite research indicating the relationship between sporting and academic performance and self-regulation (Jonker et al., 2010a), to date, it is unclear if self-regulation predicts performance in esports or if adolescent esports programs impact the development of self-regulation. This study seeks to extend previous work by examining the use of self-regulatory skills in adolescent e-athletes enrolled in a high school esports program.

Positive Youth Development

Previous research has suggested that sport is a globally recognised domain in which positive youth development (PYD) can be successfully promoted (Holt, 2016). PYD is conceptualised as a strength-based method of developing adolescents and children's personal resources, rather than seeing adolescents and children as problems to be solved (Bruner et al., 2021). A recent meta-analysis of 29 sport based PYD interventions found that these interventions can be effective at improving PYD outcomes (Bruner et al., 2021). With esports programs in schools on the rise, it is important to determine if similar youth esports programs will have the same effect on youth development as sporting programs. Understanding the impact of such esports programs is important, as previous research suggests that co-curricular video gaming could be linked with high time costs, physical injuries and problematic psychological functioning (Shum et al., 2021). Similarly, other critics of adolescent video game usage have raised concerns about poor nutrition, decreased PA levels, and potential behavioural disorders related to increased video game usage (Balatoni et al., 2020). Esports programs, on the other hand, might offer an opportunity to engage adolescents who may not be so interested in traditional sports clubs (Tjønndal and Skauge, 2020) and, thus, miss out on the important developmental opportunities available in traditional sports, such as a growth mindset (Lauer et al., 2018).

Growth Mindset

Previous research suggests that developing a growth mindset is critical to elite adolescent development strategies in sport (Lauer et al., 2018) and academia (Burnette et al., 2013). A growth mindset has been described as the belief that talent can be developed through hard work, good strategies, and input

from others (Dweck, 2016), and is not dissimilar to a task or mastery orientation (Gilbert et al., 2010)—both of which are associated with intrinsic motivation and effort (Kim and Gill, 1997). Himmelstein et al. (2017) suggested that a growth mindset is a strategy used by adult esports athletes for successful performance. Currently, no research has explored a growth mindset in adolescent esports athletes. This study will determine levels of a growth mindset among adolescent esports athletes enrolled in a high school esports program.

Physical Activity

Despite adult e-athletes reporting that PA behaviour was the least important factor contributing to their performance (Railsback and Caporusso, 2019), research has shown that increased PA behaviour is associated with higher in game ranking (Trotter et al., 2020). The research on PA behaviour in e-athletes is equivocal. The percentage of e-athletes who exercise to specifically increase their in-game performance is between 6 and 9% (Pereira et al., 2019). Adult e-athletes, instead, appear to be motivated to exercise to maintain their general health (Kari and Karhulahti, 2016). However, some League of Legends players have been reported to exercise 4.2 times per week, more than most Americans who exercise 3 times per week (Thomas et al., 2019). The perception among adult e-athletes that PA is not important for performance may be due to the previous lack of developmental esports programs. Current research suggests that PA is becoming a normal part of high school esports program, with high schools in Austria, Norway and the USA including regular PA as part of their esports programs (Rothwell and Shaffer, 2019; Tjønndal and Skauge, 2020; Wimmer et al., 2021). This study seeks to build on the findings of previous literature by exploring the frequency of which e-athletes enrolled in a high school esports program are physically active and compare their PA levels with an aged-matched control group.

Perceived General Health

There is currently little empirical research on the association between esports and health. One study in adult e-athletes showed that in game rank was not associated with ratings of self-perceived health (Trotter et al., 2020). There is some evidence from the gaming literature which showed that heavy video gaming in young adults was associated with not meeting World Health Organisation PA guidelines (World Health Organization, 2018) and lower scores on indicators of general health compared to the general population (King and Delfabbro, 2009). However, to date, no research has explored the relationship between perceived general health and adolescent e-athletes engaged in a school esports development program.

Study Aims

The current study was exploratory in nature and had two aims:

Study aim 1, to explore differences between student e-athletes enrolled in a school based esports programme and an aged-matched control group on self-regulation, growth mindset, PYD, PA behaviour, and self-perceived health.

Study aim 2, to explore the effect of the school esports programs on self-regulation, growth mindset, PYD, PA behaviour and self-perceived health.

Considering most esports psychology literature has focused on the performance or health of adult e-athletes (Poulus et al., 2020, 2021a,b; Trotter et al., 2020, 2021). This study therefore will investigate the psychology and health of adolescent e-athletes. The study was conducted with adolescent males and females aged 13–18 years old. There are important differences in maturation between males and females. This is reflected in gender differences in self-regulation (e.g., Silverman, 2003), PA behaviour (Corder et al., 2019), and self-reported health (Potrebny et al., 2017). In addition, esports is more likely to played be males than females (Andrews and Crawford, 2021). Similarly, calendar age in adolescence is associated with differences in self-regulation (Steinberg et al., 2018), PYD (Taylor et al., 2017), PA behaviour (Corder et al., 2019), and indirectly to health status (Granger et al., 2017). Therefore, this study controlled for both age and gender.

METHODS

Participants

A total of 188 high school students (male $n = 120$; 63.7%); female $n = 67$; 37.3%) aged between 13 and 18 years, from 7 private schools in Queensland, Australia, took part in this study. All students attended a school participating in a local high school esports tournament, with a dedicated esports training program. Of the 188 students, 89 (76 males, 13 females; Average age = 14.28 years) played esports for their school, and the remaining 99 (44 males, 55 females; Average age = 14.57 years) were included in a aged-matched control group. The control group in the present study consisted of participants of similar age but who did not participate in the esports program. In addition, control participants were recruited from all participating Schools.

Of the 188 participants, 58 male ($n = 22$; 37.9%) and female ($n = 36$; 62.1%) students completed both the pre-test and the post-test survey, representing 6 of the 7 schools. A 69.15% dropout rate was observed, primarily due to COVID-19 restrictions in the greater Brisbane area during the study period. Of the 58 remaining students, 19 played esports for their school and 39 were aged-matched controls.

Measures

Self-Regulation

Self-regulation was measured using the Trait Self-Regulation Questionnaire (TSRQ; Hong and O'Neil, 2001). The TSRQ has been used previously in adolescent sport to examine self-regulation (Toering et al., 2009, 2012; Jonker et al., 2010a; e.g., Jonker et al., 2010b) and consists of 32 items and two higher-order factors—metacognition and motivation. Metacognition is represented by two lower-order factors—planning and self-checking. Planning refers to behaviours related to the planning of goals and strategies involved in self-regulation (e.g., *"I determine how to solve a task before I begin"*). Self-checking refers to behaviours related to the monitoring and reflection phases of

self-regulation (e.g., *"I cheque my work while I am doing it"*). Motivation is also represented by two lower-order factors—effort and self-efficacy. Effort refers to the amount of effort expended on attaining desired goals (e.g., *"I am willing to do extra work on tasks to improve my knowledge."*). Self-efficacy refers to self-beliefs in one's ability to complete a task (e.g., *"I am confident I can understand the most complex material presented by the teacher in this course."*). The higher-order factors of metacognition and motivation load onto the overall factor of trait self-regulation. The TSRQ is scored on a 4-point Likert scale ranging from 1 (*almost never)* to 4 (*almost always*). In a study of Korean high school students Hong and O'Neil, (2001) provided evidence for the hierarchical structure of the TSRQ, whereas (Jonker et al., 2010a) provided evidence for its satisfactory construct validity.

The initial confirmatory factor analysis (CFA) of the 3rd order factorial structure did not provide an adequate fit for the TRSQ. Modification indices indicated to cross correlate the error term of item 26 with the error term of item 28 (both self-efficacy factor) and the error term of item 18 with the error terms of items 19 and 23 (all effort factor). The subsequent CFA provided an adequate fit for the model. ($\chi^2 = 742$; $P < 0.01$; RMSEA = 0.058; TLI = 0.91; CFI = 0.91; GFI = 0.81 and Pclose = 0.05), with all indices, except GF, meeting minimal fit requirements. Finally, the Cronbach alpha for the scale as a whole at baseline was excellent ($\alpha = 0.95$), as well as for the individual factors planning ($\alpha = 0.87$), self-checking ($\alpha = 0.86$), effort ($\alpha = 0.85$) and self-efficacy ($\alpha = 0.92$).

Growth Mindset

The Self-Theories Questionnaire (STQ) was used to measure participants' growth mindset (Dweck, 2000). Growth mindset is; an individual's beliefs that their talents can be developed through hard work, coaching, or good strategies (Dweck, 2016). The STQ has 6-items (e.g., *"You have a certain amount of intelligence, and you really can't do much to change it"*) and is scored on a 4-point scale, ranging from 1 (*disagree*) to 4 (*agree*).

The initial CFA did not provide an adequate fit for the STQ. Modification indices indicated to cross correlate the error term of item 5 with the error term of items 1, 4 and 6. The subsequent CFA provided an excellent fit for the model. ($\chi^2 = 4.09$; $P = 0.54$; RMSEA = 0.001; TLI = 1.00; CFI = 1.00; GFI = 0.99 and Pclose = 0.75), with all indices meeting fit requirements. Cronbach alpha for the scale for the baseline data was good ($\alpha = 0.89$).

PYD: The Very Short Measure of PYD (VSMPYD) was used to measure participants' positive youth development (Geldhof et al., 2014). The VSMPYD measures five factors of PYD (Caring, Competence, Confidence, connection, and Character). Côté and Erickson's (2016) theory of PYD in sport suggests that only four of the five PYD factors are relevant in sport (Competence, Confidence, connection, and Character), and recommended removing the items for the Caring factor from questionnaires. However, as PYD has not been explored in esports, all five factors of PYD were included in this study. The items were measured using several different 5-point Likert scales. The VSMPYD has demonstrated good reliability with video gamers (Hilliard et al., 2018) and high school students (Travers and Mahalik, 2019). Due to the different response sets in the VSMPYD, no CFA or reliability analysis were conducted.

PA and Sport Participation

Based on the Australian PA guidelines for children and adolescents aged 5–17 of at least 60 mins of daily PA (World Health Organization, 2018), the following one-item question was used using an 8 point likert scale: "How many days are you physically active for longer than 60 mins?". Participants were asked to indicate the number of days they were physically active on a scale ranging from 0 (none) to 7 (seven). In addition, the participants were asked about their sport engagement. Specifically, (i) Do you play sports; and (ii) if yes, on average, how many minutes of sport do you participate in per week?

General Health

The SF-1 (Avery et al., 2006) was used to measure general health. The SF-1 is the short form of the SF-36, which is a commonly used generic measure of people's general health status (Ware, 2000; Avery et al., 2006). The SF-1 has one item, where participants are asked to rate their health on a scale ranging from 1 (*poor*) to 5 (*excellent*). The SF-1 has been used previously by the South Australian Government (Avery et al., 2006) to measure perceived general health. The SF-1 has been shown to predict health behaviours, including PA and weight status (Segovia et al., 1989), and mortality and morbidity (Benyamini and Idler, 1999).

Procedure

This study was approved by a University's Research Ethics Committee (approval number 1900000790). A convenience sampling approach was used for data collection, a previous existing relationship between a member of the Anglican Schools Commission and the lead researcher allowed for introductions to participating schools. All participating schools were recruited through the Anglican Schools Commission Office, which coordinated the competition and program. Each participating school ran its own esports program independently, choosing how to organise training sessions and the time, frequency and duration of these sessions. Each school had one teacher who was responsible for coordinating all esports related activities. It was not possible to observe the specific training activities for each school individually. The coordination of competitions between schools was organised at the end of each term and held at the Queensland University of Technology over the course of a day.

Permission from each participating school was obtained from the school Principal and each student provided informed consent prior to undertaking the survey. The teacher responsible for coordinating the esports team at each school distributed the survey to all students and explained the process of consent. All students (including control participants) completed the survey during the time allocated for esports training at the participating schools, under the teacher's supervision. Once consent was granted, all students completed the survey online using school computer resources, which took ∼20–30 mins.

The competitive season ran from term 1 through to term 2 (i.e., late January to late June, 2020). Once the competitive season started, participants from the esports group took part in

training sessions run at the participating school. These training sessions occurred between 1 and 2 times per week, for 8 weeks, during terms 1 and 2 at each school. Training sessions typically involved the development of game-based strategies, team bonding, and playing practise games. In each school term, there was one live competition held at the Queensland University of Technology (QUT) esports arena facility. Competition days were run similarly to professional esports events, with live streaming, a dedicated competition space, and participating students and teachers as a live audience. Data collection occurred in two, two-week periods. Participants completed the pre-survey questionnaire prior to the beginning of the commencement of training, (between the 10th and 23rd of February) and the post-test survey after all competitions had ceased in term 2 (between the 8th and 22nd of June).

Analysis Strategy

Data was screened for outliers and any incomplete surveys were removed from the data set. Descriptive statistics were then obtained for all variables and Pearson product moment correlations were calculated between all study variables. When examining the study's first aim, to explore baseline differences between the e-athletes and controls, a multivariate analysis of co-variance (MANCOVA) was used for self-regulation and PYD, and an ANOVA for growth mindset, PA and self-reported health. Because of the potential influence in the developmental process in adolescence, both gender and age were used as co-variates.

To examine the effect of participation in the school esports program, repeated measures ANOVA was conducted. We examined the interaction effect of condition (esports program vs. control) and time (pre- vs. post-test). In addition, we examined the effect of condition (program vs. control) independent of time and time (pre- vs. post-test) independent of condition. Due to COVID-19, the number of individuals completing the post-test data was reduced by 69.15%. As such, age and gender were not included as covariates. In the instance of a significant interaction effect, t-tests were conducted to compare differences. Effect size for the ANOVA was explored using partial eta squared (η_p^2), with a small effect at 0.01–0.059, medium effect 0.06–0.139, and a large effect > 0.14 (Cohen, 1988).

CFA was conducted to explore the psychometric properties of the TSRQ and STQ, but not VSMPYD, using the maximum likelihood method of estimation in AMOS 27 (Arbuckle, 2005). To determine the appropriate fit of the models, the following indices were used: Chi-square statistic (χ^2), root mean square of approximation (RMSEA: Brown and Cudeck, 1993), Tucker-Lewis index (TLI), Goodness-of Fit Index (GFI), Comparative Fit Index (CFI: Bentler, 1990) and *P* of close fit (Pclose; Hu and Bentler, 1999). The χ^2 statistics gives an indication of the fit of the data to the model. When the *P* value for χ^2 is non-significant this indicates a good fit. For the RMSEA, a value of $\leq$0.06 indicates good fit and a value $\leq$0.08 as acceptable (Brown and Cudeck, 1993), when taken together with other indices (Kline, 2011). For the TLI, GFI and CFI, a value $\geq$0.95 indicates a good fit and $\geq$0.90 an adequate fit (Hu and Bentler, 1999). Pclose is required to be non-significant (Brown and Cudeck, 1993; Hooper et al., 2008). Finally, reliability analysis was conducted by calculating Cronbach alpha.

TABLE 1 | Means and standard deviation for the dependent variables at baseline for the e-athletes and control participants.

	E-athletes *N* = 89	Controls *N* = 99
TSRQ total	97.2 (13)	96.27 (15.32)
TSRQ meta cognition	47.8 (6.86)	47.27 (7.81)
TSRQ motivation	49.11 (8.67)	49 (8.56)
TSRQ planning	23.47 (4.08)	22.97 (4.32)
TSRQ self-checking	24.32 (3.25)	24.3 (4.8)
TSRQ effort	24.16 (4.54)	24.57 (4.37)
TSRQ self-efficacy	25.26 (4.6)	24.43 (4.79)
Growth mindset	18.05 (3.81)	18.19 (3.54)
PYD competence	8.21 (2.32)	8.89 (1.91)
PYD confidence	8.05 (2.7)	9.14 (2.42)
PYD character	16.05 (1.93)	15.46 (2.26)
PYD caring	12.95 (2.12)	13.38 (1.91)
PYD connection	16.11 (2.4)	15.65 (2.69)
SF1	3.47 (0.96)	3.62 (1.11)
Physical activity	3.94 (1.69)	3.78 (2.01)
Time played Sport (min per week)	253 (159)	351 (227)

RESULTS

Baseline Analysis

Means and standard deviations for participant demographics, self-regulation, growth mindset, PYD, PA and sport behaviour, and self-perceived general health are presented in **Table 1**. 80.1% Of the e-athletes and 70% of the controls indicated that they participated in sport (Chi square = 3.14; $P = 0.08$, Cramer V = 0.13).

The MANCOVA for the four self-regulation factors (Wilk's lambda = 0.98, $P = 0.57$; $\eta p^2 = 0.02$) and ANCOVA for the higher order factors were all not significant (see **Table 2**). Similarly, the MANCOVA for PYD (Wilk's lambda = 0.96, $P = 0.15$; $\eta p^2 = 0.04$) and ANCOVA for growth mindset, PA, and self-perceived general health (see **Table 2**) were not significant. However, the control group reported significant more minutes of sport participation per week compared to the esports group. Except for sport participation, the results indicate no differences between the students enrolled in the esports program versus the control participants at baseline.

Co-variates

There was a significant effect for gender for self-regulation (Wilk's lambda = 0.94, $P = 0.03$; $\eta p^2 = 0.06$); however, follow-up ANCOVA did not reveal any differences (see **Table 2**). Gender was also significant for PYD (Wilk's lambda = 0.86, $P < 0.001$; $\eta p^2 = 0.15$). Sidak *post-hoc* comparisons showed that females scored higher on caring (13.5 vs. 12.5) and the males higher on confidence (9.78 vs. 8.49). The gender effect for PA showed that males were physically active on 4.17 days of

TABLE 2 | Mean and standard deviation scores at baseline and post-test.

	Esports ($n = 19$)		Control ($n = 39$)	
	Pre	Post	Pre	Post
TSRQ total	97.2 (13)	94.8 (12)	96.3 (15)	97.2 (17)
TSRQ meta cognition	47.8 (6.9)	48.1 (6.2)	47.3 (7.8)	48.3 (8.5)
TSRQ motivation	49.4 (8.7)	46.7 (8.1)	49.0 (8.5)	48.9 (9.2)
TSRQ planning	23.5 (4.1)	24.2 (3.7)	23.0 (4.3)	23.2 (4.5)
TSRQ self-checking	24.3 (3.2)	23.9 (3.2)	24.3 (4.0)	25.1 (4.4)
TSRQ effort	24.2 (4.5)	22.9 (4.1)	24.6 (4.4)	24.4 (4.3)
TSRQ self-efficacy	25.3 (4.6)	23.7 (4.6)	24.4 (4.8)	24.5 (5.1)
Growth mindset	17.4 (3.7)	18.1 (3.8)	17.6 (3.7)	18.2 (3.5)
PYD competence	8.2 (2.3)	8.1 (1.6)	8.9 (1.9)	8.4 (2.2)
PYD confidence	8.1 (2.7)	8.5 (1.8)	9.1 (2.4)	8.6 (2.5)
PYD character	16.0 (1.9)	15.5 (1.8)	15.5 (2.3)	15.6 (2.2)
PYD caring	12.9 (2.1)	12.8 (2.2)	13.4 (1.9)	13.3 (1.9)
PYD connection	16.1 (2.4)	14.8 (3.3)	15.6 (2.7)	15.3 (3.0)
Health (SF1)	3.5 (0.9)	3.1 (0.8)	3.5 (1.1)	3.7 (1.1)
Physical activity	3.2 (1.6)	2.5 (1.8)	3.8 (2.2)	3.5 (2.1)
Time played Sport (min per week)	316 (149)	313 (234)	406 (285)	441 (489)

the week and females on 3.30, but there were no significant gender differences for growth mindset, sport participation or self-perceived general health.

In terms of age there was a significant effect for self-regulation (Wilk's lambda = 0.89, $P < 0.001$; $\eta p^2 = 0.11$). *Post-hoc* comparisons showed that the 13–14-year-old group scored higher on all 4 dimensions and higher order factors of self-regulation than the 15–16-year-old group and for the effort factor higher than the 17–18 year old group. The covariate age was also significant for PYD (Wilk's lambda = 0.92, $P = 0.01$; $\eta p^2 = 0.09$), with the 13–14 year old age group reporting significantly higher levels of competence, confidence and connection than the 15–16 year old group, and also higher competence than the 17–18 year old age group. *Post-hoc* comparisons for growth mindset showed that the youngest group (M = 19.84) scored significantly higher compared to the other two groups (M = 17.62 and M = 15.53, respectively). The 13–14-year old group was also more physically active compared to the other two groups ($P = 0.04$; M = 4.29, 3.58 and 3.06 respectively), but there was no difference for sport participation or self-perceived general health.

Repeated Measures Analysis

Table 3 provides the means and standard deviations for the dependent variables for those esports ($n = 19$) and control ($n = 39$) students who completed both pre- and post-test instruments, whereas **Table 4** provides the results of the repeated measures ANOVAs for the pre-post results of each factor. A significant time main effect was found for PYD connection and PA, indicating a decline for all participants. In addition, there was a significant interaction effect for PYD confidence and a near significant effect for health (medium effect size). For PYD confidence, a paired sample t-test did not show a significant change over time for the esports conditions ($t = -0.89$; $P = 0.39$), but the control group showed a significant decline ($t = 2.42$; $P = 0.02$). For health, the change from baseline to post-test was not significant for either group ($P > 0.10$).

DISCUSSION

This study aimed to (i) compare adolescent esports athletes with aged-matched controls on self-regulation, growth mindset, PYD, PA and sport participation, and self-perceived general health, and (ii) examine how these factors changed following participation in a school esports programme. The findings suggested that there were no differences between the e-athletes and controls on any of the variables at baseline, except for sport participation (higher in control participants). Both the e-athletes and control participants showed a decrease in PYD connection and PA behaviour over the program period. In addition, the control group showed a decline in PYD confidence, whereas the esports group did not.

Self-Regulation

Results indicated no significant differences between control participants and e-athletes at baseline or after involvement in the school esports program. Previous research, albeit in adults and using a different instrument, has shown that e-athletes had significantly lower levels of self-regulation compared to traditional sport athletes (Trotter et al., 2021). It is possible that the e-athletes developed similar self-regulatory skills compared to the control individuals in the school or sport settings. For example, prior to enrolment to the esports school program, 81.1% of the e-athletes were engaged in sport compared to 70% of the controls. As such, the co-regulation of psychological skills (e.g., goal setting, self-reflection) associated with self-regulatory behaviours might have been developed in the e-athletes prior to the esports program enrolment.

During the COVID-19 lockdown schools closed between the 26th of March, 2020 and the 25th May 2020 (Australian Broadcasting Commission, 2020). During the lockdown, interactions with coaches, teachers, or peers, often required for the development of self-regulatory skills (Collins and Durand-Bush, 2014), were not possible face-to-face, but only online. It is unclear whether online interactions have similar impact as those which happen face-to-face. Both the frequency and quality of interactions was likely influenced by the COVID19 lockdown during this period. Future research would need to explore the efficacy of online interactions on the development of self-regulatory skills.

Growth Mindset

No statistically significant difference between the e-athletes and control participants on growth mindset was found. Previous research from traditional sports literature has suggested that a growth mindset is important for elite athlete development alongside optimism and proactively seeking feedback from coaches (Lauer et al., 2018). Interventions have been shown to be an effective method for increasing the growth mindset of high school students (Yeager et al., 2020). However, to date, there has not been research determining if participation in traditional sports developmental programs innately develops

TABLE 3 | Results of the repeated measures analysis of variance.

	Time $F(1, 54)$	Condition $F(1, 54)$	Time × condition F (1, 54)
TSRQ total	0.23; $P = 0.64$; $\eta_p^2 < 0.01$	0.04; $P = 0.85$; $\eta_p^2 < 0.01$	1.23; $P = 0.27$; $\eta_p^2 = 0.02$
TSRQ meta cognition	0.51; $P = 0.48$; $\eta_p^2 = 0.01$	0.01; $P = 0.94$; $\eta_p^2 < 0.01$	0.15; $P = 0.70$; $\eta_p^2 < 0.01$
TSRQ motivation	3.26; $P = 0.08$; $\eta_p^2 = 0.06$	0.15; $P = 0.70$; $\eta_p^2 < 0.01$	2.81; $P = 0.10$; $\eta_p^2 = 0.05$
TSRQ planning	0.59; $P = 0.45$; $\eta_p^2 = 0.01$	0.48; $P = 0.49$; $\eta_p^2 = 0.01$	0.13; $P = 0.72$; $\eta_p^2 < 0.01$
TSRQ Self-checking	0.21; $P = 0.65$; $\eta_p^2 < 0.01$	0.33; $P = 0.57$; $\eta_p^2 = 0.01$	1.46; $P = 0.23$; $\eta_p^2 = 0.03$
TSRQ effort	2.35; $P = 0.13$; $\eta_p^2 = 0.04$	0.67; $P = 0.41$; $\eta_p^2 = 0.01$	1.50; $P = 0.23$; $\eta_p^2 = 0.03$
TSRQ Self-efficacy	2.41; $P = 0.13$; $\eta_p^2 = 0.04$	0.01; $P = 0.98$; $\eta_p^2 < 0.01$	2.77; $P = 0.10$; $\eta_p^2 = 0.05$
Growth MINDSET	1.38; $P = 0.25$; $\eta_p^2 = 0.03$	0.04; $P = 0.85$; $\eta_p^2 < 0.01$	0.01; $P = 0.96$; $\eta_p^2 < 0.01$
PYD competence	1.72; $P = 0.20$; $\eta_p^2 = 0.03$	0.98; $P = 33$; $\eta_p^2 = 0.02$	0.45; $P = 0.51$; $\eta_p^2 = 0.01$
PYD confidence	0.10; $P = 0.76$; $\eta_p^2 < 0.01$	0.84; $P = 0.36$; $\eta_p^2 = 0.02$	4.43; $P = 0.04$; $\eta_p^2 = 0.08$
PYD character	0.50; $P = 0.48$; $\eta_p^2 = 0.01$	0.19; $P = 0.67$; $\eta_p^2 < 0.01$	1.59; $P = 0.31$; $\eta_p^2 = 0.03$
PYD caring	0.12; $P = 0.73$; $\eta_p^2 < 0.01$	0.83; $P = 0.37$; $\eta_p^2 = 0.02$	0.01; $P = 0.99$; $\eta_p^2 < 0.01$
PYD connection	7.90; $P = 0.01$; $\eta_p^2 = 0.13$	0.01; $P = 0.97$; $\eta_p^2 < 0.01$	2.64; $P = 0.11$; $\eta_p^2 = 0.05$
Health: SF1	0.62; $P = 0.44$; $\eta_p^2 = 0.01$	1.55; $P = 0.22$; $\eta_p^2 = 0.03$	3.65; $P = 0.06$; $\eta_p^2 = 0.06$
Physical activity	3.86; $P = 0.05$; $\eta_p^2 = 0.06$	2.59; $P = 0.11$; $\eta_p^2 = 0.04$	0.56; $P = 0.46$; $\eta_p^2 = 0.01$
Sport played	0.08; $P = 0.78$; $\eta_p^2 < 0.01$	1.20; $P = 0.28$; $\eta_p^2 = 0.03$	0.11; $P = 0.74$; $\eta_p^2 < 0.01$

Time = pre vs. post; Condition = Control vs. Esports. The grey shaded areas highlight mean $P < 0.05$ or a medium effect size.

TABLE 4 | Results of the multivariate analysis of covariance (grey area indicate significant effect).

	ANCOVA: F value, *P* value and Effect Size	Covariate Gender: F value, *P* value and Effect Size	Covariate Age: F value, *P* value and Effect Size
TSRQ total	2.35; $P = 0.13$; $\eta_p^2 = 0.01$	0.05; $P = 0.82$; $\eta_p^2 < 0.001$	14.8; $P < 0.001$; $\eta_p^2 = 0.08$
TSRQ meta cognition	2.29; $P = 0.13$; $\eta_p^2 = 0.01$	0.01; $P = 0.98$; $\eta_p^2 < 0.001$	8.61; $P = 0.004$; $\eta_p^2 = 0.05$
TSRQ motivation	1.80; $P = 0.18$; $\eta_p^2 = 0.01$	0.14; $P = 0.71$; $\eta_p^2 = 0.01$	17.4; $P < 0.001$; $\eta_p^2 = 0.09$
TSRQ planning	1.77; $P = 0.19$; $\eta_p^2 = 0.01$	0.02; $P = 0.90$; $\eta_p^2 < 0.001$	8.32; $P = 0.004$; $\eta_p^2 = 0.04$
TSRQ self-checking	2.37; $P = 0.13$; $\eta_p^2 = 0.01$	0.03; $P = 0.85$; $\eta_p^2 < 0.001$	7.08; $P = 0.01$; $\eta_p^2 = 0.04$
TSRQ effort	1.13; $P = 0.29$; $\eta_p^2 = 0.01$	2.33; $P = 0.13$; $\eta_p^2 = 0.01$	21.6; $P < 0.001$; $\eta_p^2 = 0.11$
TSRQ self-efficacy	1.99; $P = 0.16$; $\eta_p^2 = 0.01$	0.44; $P = 0.51$; $\eta_p^2 = 0.002$	10.4; $P = 0.001$; $\eta_p^2 = 0.05$
Growth mindset	0.01; $P = 0.98$; $\eta_p^2 < 0.001$	0.79; $P = 0.38$; $\eta_p^2 = 0.004$	22.4; $P < 0.001$; $\eta_p^2 = 0.11$
PYD competence	0.13; $P = 0.72$; $\eta_p^2 = 0.001$	1.70; $P = 0.19$; $\eta_p^2 = 0.01$	12.1; $P < 0.001$; $\eta_p^2 = 0.06$
PYD confidence	2.01; $P = 0.16$; $\eta_p^2 = 0.01$	17.1; $P < 0.001$; $\eta_p^2 = 0.09$	6.41; $P = 0.01$; $\eta_p^2 = 0.03$
PYD character	1.49; $P = 0.22$; $\eta_p^2 = 0.01$	4.03; $P = 0.05$; $\eta_p^2 = 0.02$	1.83; $P = 0.18$; $\eta_p^2 = 0.01$
PYD caring	0.43; $P = 0.51$; $\eta_p^2 = 0.002$	4.46; $P = 0.04$; $\eta_p^2 = 0.02$	5.31; $P = 0.02$; $\eta_p^2 = 0.03$
PYD connection	0.41; $P = 0.53$; $\eta_p^2 = 0.002$	0.38; $P = 0.54$; $\eta_p^2 = 0.002$	7.05; $P = 0.01$; $\eta_p^2 = 0.04$
Health: SF1	3.22; $P = 0.07$; $\eta_p^2 = 0.02$	0.63; $P = 0.43$; $\eta_p^2 = 0.003$	0.01; $P = 0.95$; $\eta_p^2 < 0.001$
Physical activity	0.30; $P = 0.59$; $\eta_p^2 = 0.002$	8.93; $P = 0.003$; $\eta_p^2 = 0.05$	10.0; $P = 0.002$; $\eta_p^2 = 0.05$
Sport played	8.73; $P = 0.004$; $\eta_p^2 = 0.06$	2.52; $P = 0.12$; $\eta_p^2 = 0.02$	2.87; $P = 0.09$; $\eta_p^2 = 0.02$

a growth mindset. Similarly, there is no research in esports performance literature that has explored the role of esports developmental programs effectiveness of increasing participants' growth mindset. It is likely that more specific interventions are required to improve an e-athletes growth mindset to enhance self-confidence and development of in-game knowledge, as suggested in previous literature (Himmelstein et al., 2017).

Positive Youth Development

At baseline, no differences were found for PYD between the e-athletes and control participants. However, there was a time main effect for connection and interaction effect for confidence. Although playing video games has been shown to enhance a sense of belonging and increase relationships with family and friends (Vella et al., 2017), not surprisingly connection decreased in both groups likely because of the COVID-19 lockdown in Queensland during the study period. This allowed only for virtual meetings and prohibited face-to-face meetings with peers, teachers, family, or friends. Several studies have found that lockdowns resulted in increased isolation and loneliness (e.g., Burrai et al., 2021). Loneliness during the COVID-19 lockdown has been associated with several negative mental health outcomes, such as depression and suicide, and has remained elevated despite the easing of lockdowns (Killgore et al., 2020).

Despite this, it has been shown that social connection through technology (e.g., social media) is a protective factor of loneliness during lockdowns (Cauberghe et al., 2021; Okabe-Miyamoto and Lyubomirsky, 2021). The results from this study contradict previous studies that suggest technology is a protective factor to the negative psychological outcomes of lockdown (Cauberghe et al., 2021). This finding suggests that face-to-face esports training is possibly more important to increase connectedness than online training.

In terms of confidence, the control group showed a decline whereas the e-athletes remained at a similar level (despite a slight increase in confidence scores from 8.1 to 8.5). An explanation for the decline in the control group is the notion that their confidence levels were higher (albeit not significantly) at baseline. Ultimately, the esports and control groups had similar values for confidence at the post-test timepoint. An alternative explanation is that the COVID19 lockdown resulted in the reduction in confidence for both groups. This might have been due to a reduction in social interactions and engaging mainly in novel online learning environments.

Perceived General Health

The *post-hoc* comparisons for health did not reveal differences between the two groups. Overall, the score for perceived general health was only between fair and good at both baseline and post-test. At baseline, 43% of participants reported health to be poor, fair, or good. Previous research has suggested that an individual's perception of illness is directly associated with the likelihood of behaviour change (Champion and Skinner, 2008). A recent study has indicated that a lack of understanding how adolescents perceive their health is likely to lead to unsuccessful interventions (Ott et al., 2011). Previous research has indicated various health issues related to esports participation (Zwibel et al., 2019). Yet, the lack of a significant difference between the e-athletes and control participants may indicate that youth e-athletes do not perceive any negative health outcomes to be associated with esports participation, or that participation in esports do not have a significant impact on their health.

Physical Activity and Sport Participation

There was no baseline or post-test difference in PA behaviour between the e-athletes and controls. However, there was a significant decrease for both groups from baseline to post-test. This decrease in PA behaviour was likely due to the COVID-19 restrictions. Research investigating PA levels in Irish adolescents ($n = 1214$) during the COVID-19 lockdown showed that half of the adolescents reported being less physically active, compared to a third who did the same, and only a fifth who were more physically active (Ng et al., 2020). These findings were replicated by Stockwell et al. (2021) in a systematic review of PA and sedentary behaviour before and during the COVID-19 lockdown. They found that more than 50% of the population of both healthy adults and children's PA levels decreased, despite government organisations providing guidance on staying physically active during lockdown.

Although the percentage of e-athletes who participated in sport was higher than controls, the control group reported more minutes per week in sport. One possible explanation is that the e-athletes engaged in playing esports prior to enrolment in the school esports program, leaving less leisure time for engagement in organised sport. In future research, more detailed information is required on how adolescents use their leisure time. In addition, it was noticeable that there was significant variability in the minutes participated in sport each week in both the e-athletes and controls.

Previously, it has been suggested that a benefit of co-curricular esports programs could increase the PA levels, including sport participation, of students (Shum et al., 2021). This suggestion is supported by recent research which found that high school esports programs in Europe have been reported to include PA as part of regular training (Tjønndal and Skauge, 2020; Wimmer et al., 2021). Norwegian high schools have even included PA and physical conditioning as part of the learning objectives of their program, arguing that an understanding of nutrition, rest and recovery are important to youth e-athlete development. Similarly, teachers involved in the esports program, in the present study, included PA as part of regular training and as a reward for participation in esports tournaments. Of course, this was not implemented because of the COVID-19 restrictions. However, the promotion of PA or sport participation as part of adolescent developmental esports programs (Tjønndal and Skauge, 2020; Shum et al., 2021) might help to enhance physical fitness in e-athletes.

Role of Gender and Age

Despite no baseline differences being found, significant covariate effects were found for gender and age. In line with previous research, the males were more active (Gortmaker et al., 2012), scored higher on PYD confidence (O'Connor et al., 2020), but lower on PYD caring (Conway et al., 2015) compared to the females. The gender differences in PYD have been attributed to females providing increased social contributions (e.g., more support to friends and family) and higher school engagement (more perceived performance, less boredom) (Gomez-Baya et al., 2021).

The covariate age was significantly related to self-regulation, positive youth development, growth mindset and PA, but not sport participation or self-reported general health. The finding that self-regulations was highest in the younger group contradicts previous findings that self-regulation increases with age at the behavioural and neurological levels (Steinberg et al., 2008; Monahan et al., 2009; King et al., 2013). A possible explanation for this finding might be the suitability of the TSRQ for younger adolescents. Similarly, the young group scored higher on PYD confidence and connection compared to the 15–16-year-old group, and higher on competence compared to both older groups. In terms of connectedness, this finding is not surprising, since research has shown that social connectedness decreases with age (Cole and Kerns, 2001). In addition, developmental experiences and plasticity in

development might result in adolescents being pulled in different trajectories and having different developmental pathways (Larson and Tran, 2014).

The youngest group also had the highest score for growth mindset. This finding is in line with results suggesting that adolescents' growth mindset decreases as they age. Also, cognitive interventions to improve growth mindset are most effective when targeting young people and old people, but less effective with adolescents (Guye et al., 2017). Finally, as expected, PA levels decreased with age (Gordon-Larsen et al., 2004; Gortmaker et al., 2012).

Study Limitations and Future Research

This study has several limitations. The first limitation of this study was the unexpected COVID-19 virus and the lockdown and quarantine which resulted in significant participant drop-out. Due to the substantial dropout of participants, it not possible to determine the full extent of the COVID-19 lockdown on participants health, psychology and wellbeing. Future research should explore the impact of health, psychology, and wellbeing of adolescent e-athletes uninterrupted by a global pandemic. Secondly, this study was conducted using only self-report measures. Participants may have responded to questions in a way in which they believe is socially desirable. Furthermore, future research could employ more objective methods of measuring PA and sport behaviour using pedometers or accelerometers, as well as physical fitness measures (e.g., VO_2max). Additionally, the measures used in this study had different numbers of anchors in their Likert scales. Constantly switching between the numbers of anchors a scale might impact the cognitive effort required to complete surveys. Future studies might consider standardising Likert scales to reduce participant cognitive effort. Another limitation is the current state of organisation of high school esports programs in Australia. High school esports programs in Australia are still in their infancy and unregulated. The potential differences in the esports programs across the 7 schools also represents a limitation to this study. As different schools are at different stages of development, it is possible that students had different experiences. Future research should continue to evaluate the practises of high school esports programs. The consistency of the findings will improve as youth esports programs become more established.

CONCLUSION

This study investigated the influence of participation in an esports school program on the psychological (self-regulation, growth-mindset, and positive youth development) and health (PA, sport participation, self-perceived general health) factors of adolescent e-athletes and aged-matched control participants. A novel finding was that, at baseline, there were no differences between those enrolled in the esports program and controls, except for sport participation. Both conditions reported decreased PYD and PA behaviours. However, the control group showed a decrease in PYD confidence, while the esports group did not. These changes were most likely due to COVID19 lockdowns in Queensland during the study period. Overall, school esports programs appear to attract adolescents who are similar in their psychological functioning and health compared to their peers. In addition, the school esports programs have the potential to bring about positive psychological development and/or health behaviour change, if implemented appropriately (Polman et al., 2018).

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by QUT Human Ethics Advisory Team. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MT, RP and TC: methodology, investigation, and writing—original draft preparation. MT, RP, and DP: formal analysis and resources. RP: data curation. MT: writing—review and editing. TC, PD, and RP: supervision. TC, PD, and RP: project administration. All authors have read and agreed to the published version of the manuscript.

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BRIEF RESEARCH REPORT
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The Influence of Physical Exercise on Adolescent Personality Traits: The Mediating Role of Peer Relationship and the Moderating Role of Parent–Child Relationship

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Adolescence is the critical period of the formation for individual personality traits, which would be influenced by numerous factors such as the internal and external environment. In view of physical exercise as an important factor affecting the healthy development of adolescents, whether it would play an important role in the formation of adolescents' personality traits and how it would work deserve further investigation. Based on the Ecological Systems Theory, this study has explored the relationship between physical exercise and adolescents' personality traits, as well as the mediating effect of peer relationship and the moderating effect of parent–child relationship using 9,284 data samples. The regression results show that physical exercise has a significant positive impact on the development of personality traits such as neuroticism, conscientiousness, and agreeableness. Peer relationships exert the mediating effect between physical exercise and adolescents' personality traits. However, parent–child relationship only moderates the effect of physical exercise on conscientiousness and agreeableness.

Keywords: physical exercise, adolescent, personality traits, peer relationship, parent-child relationship

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INTRODUCTION

Personality trait is an inherent individual neuropsychological structure (McCrae and Costa, 1997), which refers to an individual's behavior tendency in a relatively consistent way at different times and in different situations (Simon et al., 2020). Personality trait could effectively predict individual behaviors, which is an important characteristic that distinguishes individuals from others. Since the 1980s, Five-Factor Model (FFM) has been largely accepted and adopted as a theoretical model of personality traits, that is, neuroticism, extroversion, openness, agreeableness, and conscientiousness (Hendriks et al., 1999). Among them, neuroticism reflects the degree of individual emotional stability and the behavioral tendencies toward negative emotions (Laursen et al., 2010); extroversion reflects the interaction degree of individual interpersonal communication (Mesurado et al., 2014); openness reflects an individual's own creativity and curiosity (Gjerde and Cardilla, 2009); agreeableness reflects the individual's attitude in the process of getting along with others (Laursen et al., 2010); conscientiousness reflects the individual's prudence and persistence degree in goal-directed behaviors (De Fruyt et al., 2017). Studies have shown that compared with adults, adolescents' personality traits tend to show greater volatility and plasticity and be more

susceptible to be influenced by the external environment such as family, parent–child relationship, and peer relationship (Roberts and DelVecchio, 2000; Roberts et al., 2006; Fishman et al., 2011; Childs et al., 2014; Tottenham and Galván, 2016).

Physical exercise, an important factor influencing adolescent's development, has attracted more and more attention of scholars to identify the effect on the development of adolescents' personality traits. It has been found that physical exercise could affect the development of personality traits (Allen and Laborde, 2014; De Fruyt and Van Leeuwen, 2014; Wilson and Dishman, 2015). Some studies have shown that participation in physical exercise has a positive impact on the development of individual personality traits (Kwon, 2018), which could help the individual to improve the stability of personality traits. For adolescents, physical exercise is an important way for social communication, and active participation in physical exercise could help them improve extroversion and agreeableness. Moreover, when individuals take part in physical exercise, complying with the certain required discipline and the sportsmanship of cooperation, regulations, fairness, fortitude, and so on (Eime et al., 2013; Stephan et al., 2014b) could effectively improve adolescents' self-confidence, self-esteem, sense of responsibility, self-management ability, and emotional regulation ability, as well as the stability of personality trait (Vukasović Hlupić and Bratko, 2015; Alkadhi, 2018). Based on the above analysis, hypothesis 1 has been proposed:

> Hypothesis 1: Physical exercise has a significant impact on adolescents' personality traits.
>
> Hypothesis 1a: Physical exercise has a significant impact on adolescents' neuroticism.
>
> Hypothesis 1b: Physical exercise has a significant impact on adolescents' conscientiousness.
>
> Hypothesis 1c: Physical exercise has a significant impact on adolescents' agreeableness.

What needs to be further discussed is the influencing mechanism between physical exercise and adolescents' personality traits. The existing studies have mainly used psychological mechanisms, such as self-efficacy and resilience, as mediating or moderating variables to explore the influencing mechanism. The social mechanism has seldom been discussed. However, Bronfenbrenner's Ecological Systems Theory (EST) has identified that personal growth is a complicated process, which is affected by many factors such as social factors and the environmental systems (Bronfenbrenner, 1979). In the process of personal growth, individuals would be connected closely with ecosystems and be affected by various ways. In EST, Bronfenbrenner has divided ecosystems into five categories, namely, microsystems, meso-systems, exosystems, macrosystems, and chronosystems (Bronfenbrenner, 1979). Among them, microsystems refer to the systems that individuals are directly exposed to in their social life, such as the family, peers, and school, which would exert an imperceptible influence on their behavioral styles and values. In the development of adolescents' personality traits, family and peers are two important microsystems with the development of individuals' personality traits. Peer and parent–child relationships have a positive effect in the development of adolescent's personality traits (Caires et al., 2009).

First, peer relationship plays an important role in physical exercise and the adolescent's personality traits (Koepke and Denissen, 2012; Klimstra et al., 2013). With the development of adolescents' independence and autonomy, the peer relationship plays a more irreplaceable role in adolescents' socialization and emotional development (Gorrese, 2015). The existing studies have shown that participation in physical exercise could effectively promote the development of individual peer relations, expand the individual's range of interpersonal interactions, and increase the number of friends (Smith, 2003; Jowett and Lavallee, 2007; Eime et al., 2013; Swanson et al., 2019). In addition, the studies have identified that peer relationship exerts the mediating effect in the relationship between physical exercise and output variables. Participation in physical exercise could further increase the levels of individuals' extraversion, agreeableness, and responsibility through peer effects (Konu et al., 2002; Lehto et al., 2012). Second, for the parent–child relationship, the attachment theory by Bowlby has stated that individuals would seek attachment objects to prevent danger and improve chances of survival by establishing emotional connection (Bowlby, 1969). In the process of interaction with parents, individuals could observe the sense of security, love, and trust, and learn to understand others. Parents are the important attachment figures for adolescents. The relationship between adolescents and parents is crucial in shaping adolescents' personality traits. Moreover, a good parent–child relationship plays an "incubator" role in the development of adolescents' personality traits (Davison, 2004; Craig et al., 2013), which could provide emotional support and make them more brave and confident in making friends (Freedson and Evenson, 1991; Davies and Cummings, 1994). On the contrary, low-quality or poor parent–child relationship would weaken the positive effect or even cause the negative effect on the development of personality traits (Strong et al., 2005; Kılınç and Sis Çelik, 2021). In addition, appropriate intervention of parents could effectively weaken the negative influence of peer on adolescents. Based on these facts, the study puts forward hypothesis 2 and hypothesis 3:

> Hypothesis 2: Peer relationship has a mediating effect on the relationship between physical exercise and adolescents' personality traits.
>
> Hypothesis 3: Parent–child relationship has a moderating effect on physical exercise and adolescents' personality traits. The direct effect of physical exercise and peer relationship on adolescents' personality traits is moderated by parent–child relationship.

Based on the above analysis, the theoretical model of the physical exercise on the adolescent's personality traits has been explored (see **Figure 1**), in order to identify the relationship

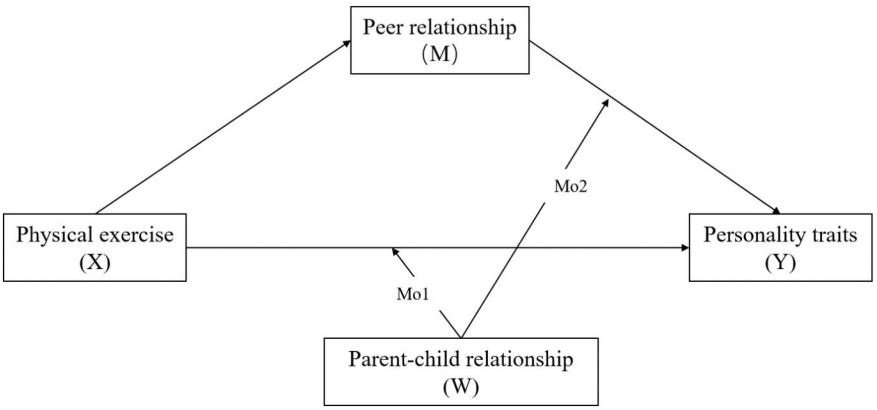

FIGURE 1 | Conceptual framework of the proposed moderated mediation model.

between physical exercise and adolescents' personality traits as well as the mediating role of peer relationship and moderating role of parent–child relationship based on the 9,284 adolescent's data samples. According to the EST, this study aims to further reveal the influencing mechanism of adolescent's personality traits from the perspective of social relationship, and provide the theoretical support and practical guidance for promoting adolescent's physical exercise and personality trait development.

MATERIALS AND METHODS

Material Source

The data were collected from the China Education Panel Survey (CEPS), which was designed and implemented by the National Survey Research Center (NSRC). This project took the seventh and ninth-grade middle school students in the 2013–2014 academic year as the baseline survey respondents through the probability proportionate to size sampling (PPS) method and 19,487 students from 438 classes in 112 schools in China have been investigated. In the follow-up survey in the academic year 2014–2015, 9,449 respondents in the first-round baseline survey have been monitored. The survey data were nationally representative and covered multi-dimensional information related to students, families, schools, and other fields. A total of 9,284 samples has been finally obtained by combining the first-round and follow-up survey data through excluding the data with missing values. The characteristics of selecting variables in this study have been summarized in **Table 1**.

Physical Exercise

The independent variable of the study was physical exercise. In the baseline survey, the two items of *"How long do you exercise on average from Monday to Friday," "How long do you exercise on weekends"* have been designed in CEPS to examine the situation of participation in physical exercise. The calculation of the duration time of physical exercise was "Exercise time = (physical exercise time from Monday to Friday + physical exercise time on weekends) /60."

Personality Traits

The dependent variable was personality traits. Variables have been measured by five dimensions in the CEPS questionnaire, which are neuroticism, extroversion, openness, agreeableness, and conscientiousness. The neuroticism dimension was measured by five items (Wang et al., 2020; Zhao and Chen, 2022), that is, *"you often feel "blue," "depressed," "unhappy," "not enjoying life," and "sad" in the past seven days,"* using five-point Likert scale ranging from 1 (never) to 5 (always), in which the Cronbach's α is 0.904. The extraversion dimension was measured by four items, that is, *"there are some adults I respect and admire" "I can easily talk to adults" "I apologize when I accidentally hurt or offend people" "If I handle things, the method is wrong and I will try to find another way to solve it,"* using four-point Likert scale ranging from 1 (completely agree) to 4 (completely disagree), in which the Cronbach's α is 0.680. The openness dimension was measured by 4 items, that is, *"I can express my opinions clearly" "I can respond quickly" "I can learn new knowledge quickly" "I am curious about new things,"* using four-point Likert scale ranging from 1 (completely agree) to 4 (completely disagree), in which the Cronbach's α is 0.714. The agreeableness dimension was measured by four items, that is, *"Most of my classmates are nice to me" "My class is in good atmosphere" "I often take part in school/class activities" "I feel close to people in this school,"* using four-point Likert scale ranging from 1 (completely agree) to 4 (completely disagree), in which the Cronbach's α is 0.773. The conscientiousness dimension was measured by four items, that is *"I would try my best to go to school even if I had any reasons to stay at home" "I would try my best to finish even the homework I dislike" "I would try my best to finish my homework, even if it would take me quite a long" "I would persist in my interests and hobbies,"* using four-point Likert scale ranging from 1 (completely agree) to 4 (completely disagree), in which the Cronbach's α is 0.805. The whole Cronbach's α is 0.814.

Personality traits are the unique psychological characteristics of individuals formed in the long-term living environment. Although they often show greater volatility and plasticity in adolescence, the impact of physical exercise on adolescents' personality traits may still take some time to have an impact.

TABLE 1 | Sample descriptive statistics information (N = 9,284).

	Variable	Mean/Ratio	S.D.	Min	Max
Independent variable	Physical exercise	0.37	0.40	0.00	5.00
Dependent variable	Neuroticism (time 1)	4.20	0.88	0.00	5.00
	Conscientiousness (time 1)	3.25	0.69	0.00	4.00
	Agreeableness (time 1)	3.50	0.71	0.00	4.00
	Neuroticism (time 2)	4.80[a]	0.81	0.00	5.00
	Conscientiousness (time 2)	3.67[a]	0.64	0.00	4.00
	Agreeableness (time 2)	3.49[b]	0.68	0.00	4.00
Control variables	Gender	0.52	0.45	0.00	1.00
	National	0.92	0.27	0.00	1.00
	Registered residence	0.52	0.50	0.00	1.00
	Health	0.58	0.49	0.00	1.00
	Cognitive ability	0.50	0.87	−2.03	2.33
	One child/Only child in family	0.45	0.49	0.00	1.00
	Parental education level	2.57	0.94	0.00	5.00
	Family cultural capital	3.25	1.22	1.00	5.00
	Family economic	0.79	0.41	0.00	1.00
	School infrastructure	2.08	0.40	1.20	3.00
	School type	0.94	0.24	0.00	1.00
	School ranking (Above average)	0.59	0.49	0.00	1.00
	School ranking (The best)	0.23	0.42	0.00	1.00
	School location (A combination of urban and rural areas)	0.26	0.44	0.00	1.00
	School location (City center)	0.34	0.47	0.00	1.00
Mediating variable	Peer relationship(time 1)	2.76	0.28	1.00	3.00
Moderating variable	Parent-child relationship(time 1)	2.10	0.47	0.00	3.33

[a]*Significantly lower than the baseline value.* [b]*Significantly higher than the baseline value.*

Therefore, to better illustrate these changes of personality traits, the longitudinal analysis to measure adolescent personality traits(Δt) based on the tracking data of personality traits in CEPS has been conducted. The specific calculation method is as follows: Δt = score t2-score t1 (where score t2 is the score on each dimension of adolescent personality traits in the first follow-up survey; score t1 is the score on each dimension of adolescent personality traits in the baseline follow-up survey). Considering the unreliability of difference scores, the overall variable of personality traits and a new regression model as the robustness test of regression analysis has been conducted (Stephan et al., 2014b). Due to the data acquisition of CEPS, the dimensions of neuroticism, conscientiousness, and humanity have been taken as an example.

Peer Relationships

The mediating variable was peer relationship. In the baseline survey in CEPS, this variable was measured by ten items about adolescent's peer relationship, that is, *"Do any of these things happen to your best friends: "Doing well in academic performance "Studying hard" "Expecting to go to college" "Skipping classes" "Criticized or punished for violating school rules" "Always fighting with others" "Smoking or drinking alcohol" "Always going to net bars or video arcade" "Having had or is having a romance" "Dropped out of school,""* using three-point Likert scale ranging from 1 (no) to 3 (many), in which the Cronbach's α is 0.831. The scores of items on negative peer influence were calculated in a reverse order. The whole score of peer relationship was calculated by averaging the values of the ten dimensions.

Parent–Child Relationship

The moderating variable was parent–child relationship. Three dimensions of parent–child communication, parent–child interaction, and parent–child trust were selected to measure the parent–child relationship (Zheng et al., 2020; Liu and Jiang, 2021). In the baseline survey in CEPS, parent–child communication was measured by ten items, that is, *"Do your mother (father) often discuss the following issues with you?: "Things happened at school" "The relationship between you and your friends" "The relationship between you and your teachers" "Your feelings" "Your worries and troubles,""* using three-point Likert scale ranging from 1 (never), 2 (sometimes) to 3 (often), in which the Cronbach's α is 0.868. The score was obtained by summing and averaging the 10 items with a value in the range of 1–3. Parent–child interaction was measured by six items in CEPS, that is, *"The frequency with which you and your parents do the following is approximately: "Having dinner" "Reading" "Watching TV" "Playing sports" "Visiting museums, zoos, science museums, etc." "Going out to watch movies, shows, sports games, etc.,""* using six-point Likert scale ranging from 1 to 6 (never, once a year, once every half year, once a month, once a week, more than once a week), in which the Cronbach's α is 0.773. The score was obtained by summing and averaging the six items with a value in the range of 1–3. Parent–child trust was measured by three items in CEPS, that is, *"Who will be the first one for you to turn to when you want to chat with someone?" "Who will be the first one for you to turn to when you are in trouble?" "Who will be the first one for you to turn to when you need help?"* in which the Cronbach's α is 0.704. The "parent" option was assigned to 1 and the other options to 0. After the virtualization processing, the score was obtained by summing and averaging the three items with a value in the range of 0–1. Finally, the score of the three dimensions was summed up and averaged to obtain the whole score of parent–child relationship. The whole Cronbach's α is 0.805.

Analytic Approach

Stata16.0 was used for descriptive statistical analysis and correlation analysis. In order to further investigate the relationship between physical exercise and personality traits, three models were constructed, and stratified regressions were conducted in each model. The dependent variables of model 1, model 2, and model 3 are neuroticism, conscientiousness, and agreeableness, respectively. In step 1, the study added variables at multiple levels, including the items related to the individual, the family and the school, and then included physical exercise

in step 2. Finally, SPSS PROCESS3.3 (Hayes, 2012) was used to test the mediating effect of peer relationship and the moderating effect of parent–child relationship between physical exercise and adolescents' neuroticism, conscientiousness, and agreeableness.

RESULTS

Descriptive Analysis and Correlation Analysis

Table 1 summarizes the results of descriptive statistics of the variables. In terms of personal characteristics, male adolescents accounted for 52.2% and female adolescents accounted for 41.8%; rural adolescents accounted for 47.6% and urban adolescents accounted for 52.4%; 74.7% of adolescents believed that their health was in a good condition; the average cognitive ability of adolescents was 22.956, showing a high overall cognitive level; 78.9% of families were in a good financial condition. In terms of school characteristics, 25.9% of adolescents were registered in schools in central urban areas, and 39.8% in urban-rural areas. From the descriptive statistical results of the sample survey, the data were relatively balanced in terms of gender, urban and rural areas, health status, school location, and other aspects.

In **Table 2**, Step 1 has shown the results of rank-order correlations of three personality domains between the baseline survey and the first follow-up. Spearman correlation results have shown that neuroticism, conscientiousness, and agreeableness were significantly positively correlated in the baseline survey and the follow-up survey. However, from the perspective of mutuality intensity, most of the correlation coefficients are less than 0.4, indicating that the three dimensions of personality traits are weakly correlated. Step 2 has shown the results of the correlation analysis between independent variables, dependent variables, mediating variables, and moderating variables. The results have shown that physical exercise was positively correlated with peer relations, parent–child relationship, and the dimensions of personality traits, including neuroticism, conscientiousness, and agreeableness. Neuroticism was positively correlated with conscientiousness, agreeableness, peer relations, and parent–child relationship. Conscientiousness was positively correlated with agreeableness, peer relations, and parent–child relationship. Agreeableness was positively correlated with peer relations and parent–child relationship. Peer relationship was positively correlated with parent–child relationship.

Regression Results

Table 3 summarizes the results of the stratified regression of physical exercise on the personality traits of adolescents. In Model 1, variables of three aspects, namely, individuals, families, and schools at multiple levels have been analyzed in the regression equation in Step 1, and then physical exercise was included in the regression equation in Step 2. Both regression equations were statistically significant. Comparing the R^2 of the two regression models revealed that the explanatory coefficient of the regression equation increased by 0.9% with the inclusion of physical exercise. The regression results of Step 2 indicated the significant positive effect of physical exercise on the development of neuroticism in adolescents.

In Model 2, the study has adopted the stratified regression to test the impact of physical exercise on adolescent conscientiousness. The regression results of the two regression equations showed that the regression equation was statistically significant. By comparing the R^2 of the two regression models, it was found that the explanatory coefficient of the regression equation increased by 0.3% with the inclusion of physical exercise. The Step 2 regression model showed that physical exercise had a significant positive effect on adolescents' conscientiousness.

In Model 3, the results of the two regression equations showed that the regression equation was statistically significant. Comparing the R^2 of the two regression models revealed that the explanatory coefficient of the regression equation increased by 1.1% with the inclusion of physical exercise. The Step 2 regression model showed that physical exercise has a significant positive effect on adolescents' agreeableness.

According to the regression results of model 4, it is clear that physical exercise has a robust effect on the development of adolescents' personality traits.

Moderated Mediation Analysis

Table 4 summarizes the results of the moderated mediation analysis. In Model 1 (shown in **Table 4**), the results showed that peer relationship played a mediating effect in the effect of physical exercise on adolescent neuroticism. However, the interaction term between physical exercise and parent–child relationship, peer relationship, and parent–child relationship was not significant, which indicated that the parent–child relationship did not have a moderating effect.

In Model 2 (shown in **Table 4**), the results showed that the peer relationship had a mediating effect on the impact of physical exercise on adolescent conscientiousness. In terms of moderating effect, the interaction term between peer relationship and parent–child relationship was significant, which suggested that the parent–child relationship moderated the effect of peer relationship on adolescents' conscientiousness. The simple slope plot of the moderating effect showed that physical exercise positively predicted adolescents' conscientiousness at high levels of parent–child relationship (shown in **Figure 2**). The moderating effect of high levels of parent–child relationship on physical exercise and adolescent conscientiousness was more significant than the effect of low levels of parent–child relationship. However, the interaction term between physical exercise and parent–child relationship was not significant, suggesting that the parent–child relationship did not have a moderating effect on the "physical exercise→ conscientiousness" (Mo1) pathway.

In Model 3 (shown in **Table 4**), the results showed that peer relationship had a mediating effect on the impact of physical exercise on adolescent agreeableness. In terms of moderating effects, the interaction between peer relations and parent–child relations was significant, indicating that the parent–child relationship moderated the effect of peer relations on adolescents' agreeableness. The simple slope plot of the

TABLE 2 | Correlations of variables (N = 9,284).

	1	2	3	4	5	6
Step 1 Spearman correlation						
1. Neuroticism[a]	–					
2. Neuroticism[b]	0.42** [0.40, 0.43]	–				
3. Conscientiousness[a]	0.19** [0.17, 0.21]	0.10** [0.07, 0.11]	–			
4. Conscientiousness[b]	0.15** [0.13, 0.17]	0.19** [0.16, 0.21]	0.28** [0.26, 0.30]	–		
5. Agreeableness[a]	0.28** [0.26,0.30]	0.17** [0.15,0.20]	0.27** [0.15, 0.19]	0.24** [0.22, 0.26]	–	
6. Agreeableness[b]	0.22** [0.19, 0.24]	0.27** [0.26, 0.29]	0.16** [0.14, 0.19]	0.34** [0.32, 0.36]	0.43** [0.41, 0.45]	–
Step 2 Pearson correlation						
1. Physical exercise	–					
2. Neuroticism[c]	0.07** [0.05, 0.10]	–				
3. Conscientiousness[c]	0.03** [0.01, 0.05]	0.16** [0.13, 0.18]	–			
4. Agreeableness[c]	0.16** [0.14, 0.18]	0.25** [0.23, 0.28]	0.22** [0.20, 0.24]	–		
5. Peer relationship	0.07** [0.04, 0.10]	0.19** [0.15, 0.20]	0.20** [0.18, 0.23]	0.26** [0.24, 0.28]	–	
6. Parent-child relationship	0.22** [0.20, 0.24]	0.23** [0.21, 0.25]	0.12** [0.10, 0.14]	0.36** [0.34, 0.38]	0.21** [0.17, 0.22]	–

***Correlations are significant at the 0.001 level (two-tailed); [,] is the 95% confidence interval. [a]Baseline survey data. [b]The follow-up survey data. [c]The difference between the two periods (Δt).*

moderating effect showed that peer relationships positively predicted adolescents' agreeableness at high levels of parent–child relationships (shown in **Figure 2**). The high-level parent–child relationship had a more significant regulatory effect on peer relationship and adolescents' agreeableness than the low-level parent–child relationship. The moderating effect of high levels of parent–child relationships on peer relationships and adolescent agreeableness was more significant than the effect of low levels of parent–child relationships. The interaction between physical exercise and parent–child relationship was significant, indicating that the parent–child relationship moderated the effect of physical exercise on adolescent agreeableness (shown in **Table 4**). The simple slope plot of the moderating effect showed that physical exercise positively predicted the level of adolescent agreeableness at high levels of parent–child relationship (shown in **Figure 2**). The moderating effect of high levels of parent–child relationship on physical exercise and adolescent agreeableness was more significant than the effect of low levels of parent–child relationship.

DISCUSSION

Based on the EST, this study has constructed a moderated mediation model with peer relationship as the mediating variable and parent–child relationship as the moderating variable, and discussed the influence of physical exercise on adolescents' personality traits as well as the joint effect of peer and family microsystems on the development of adolescent personality traits.

The results have shown that physical exercise could significantly predict adolescent neuroticism, conscientiousness, and agreeableness, which are consistent with the existing studies. In terms of influence effect, the research results have shown that physical exercise has a 4% influence effect on adolescent neuroticism, a 5% influence effect on adolescent conscientiousness, and an 11% influence effect on adolescent agreeableness. The results are consistent with the existing research (Allen and Laborde, 2014), but have the subtle differences of the specific value of influence effect. For example, research by Stephan has issued that the effect of physical exercise on adolescent neuroticism is 2%, the effect on conscientiousness is 4%, and the effect on appropriate agreeableness is 4% (Stephan et al., 2014b). Comparing the two studies, this study has shown a higher impact. Specifically, physical exercise could promote the release of beta-endorphins (Legey et al., 2017) and brain-derived neurotrophic factor (Donati et al., 2021), and help them maintain positive emotions and promote the stability of neuroticism. In addition, for adolescents, active participation in physical exercise could alleviate academic stress and help them release negative emotions and maintain mental health (Motl et al., 2004; Wiles et al., 2008; Jewett et al., 2014). In terms of adolescents' conscientiousness, it is mainly reflected that when taking physical exercise, it needs to overcome difficulties and enable students to experience the successful experience of completing goals and conscientiousness (de Bruijn et al., 2009; Eime et al., 2013).

TABLE 3 | Regression results of physical exercise and adolescent personality development (N = 9,284).

Variable	Step 1			Step 2		
	β	*t*	95% CI	β	*t*	95% CI
Model 1 Dependent variable: neuroticism						
Gender	0.02	−1.36	[−0.08, −0.02]	0.02	−1.11	[−0.08, −0.02]
National	0.02	1.42	[−0.02, 0.14]	0.02	1.29	[−0.03, 0.14]
Registered residence	0.04	2.27**	[0.01, 0.11]	0.04	2.25*	[0.09, 0.11]
Cognitive ability	0.08	5.59***	[0.05, 0.11]	0.08	5.53***	[0.05, 0.11]
Health	0.19	13.58***	[0.28, 0.37]	0.19	13.47***	[0.27, 0.37]
One child	0.02	1.25	[−0.02, 0.08]	0.02	1.22	[−0.02, 0.08]
Parental education level	−0.01	−0.80	[−0.04, 0.02]	−0.01	−0.83	[−0.04, 0.02]
Family economic	0.05	3.27***	[0.05, 0.16]	0.05	3.34***	[0.05, 0.16]
Family cultural capital	0.05	3.17***	[0.01, 0.06]	0.05	2.88**	[0.05, 0.16]
School infrastructure	−0.03	−1.71	[−0.11, 0.01]	−0.02	−1.64	[−0.11, 0.01]
School type	0.01	0.66	[−0.09, 0.11]	0.01	0.60	[−0.09, 0.10]
School quality (above average)	0.02	0.97	[−0.04, 0.08]	0.02	0.93	[−0.04, 0.08]
School quality (the best)	0.03	1.60	[−0.03, 0.13]	0.03	1.52	[−0.03, 0.13]
School location (a combination of urban and rural areas)	0.01	0.358	[−0.04, 0.08]	0.01	0.21	[−0.05, 0.08]
School location (city center)	0.05	2.41*	[0.02, 0.15]	0.04	2.32*	[0.02, 0.15]
Physical excise				0.04	2.40*	[0.02, 0.21]
Constant		15.22***	[1.22, 1.58]		15.18***	[1.21, 1.58]
Step 1: R^2 = 0.070; ΔR^2 = 0.067; F = 20.54; $p < 0.001$ Step 2: R^2 = 0.061; ΔR^2 = 0.059; F = 19.63; $p < 0.001$						
Model 2 Dependent variable: conscientiousness						
Gender	−0.10	−5.47***	[−0.14, −0.07]	−0.08	−5.80***	[−0.15, 0.07]
National	0.01	0.64	[−0.05, 0.09]	0.01	0.46	[−0.06, 0.08]
Registered residence	0.02	0.91	[−0.03, 0.07]	0.01	0.88	[−0.03, 0.06]
Cognitive ability	0.06	3.94***	[0.03, 0.07]	0.06	3.86***	[0.02, 0.07]
Health	0.04	2.87**	[0.02, 0.10]	0.04	2.72**	[0.02, 0.09]
One child	−0.01	−0.12	[−0.05, 0.03]	−0.01	−0.15	[−0.06, 0.03]
Parental education level	0.02	1.04	[−0.02, 0.03]	0.02	0.99	[−0.02, 0.03]
Family economic	0.05	3.06***	[0.03, 0.12]	0.05	2.97**	[0.03, 0.9]
Family cultural capital	0.09	5.55***	[0.04, 0.07]	0.09	5.12***	[0.03, 0.07]
School infrastructure	−0.01	−0.13	[−0.06, 0.04]	0.01	−0.03	[−0.05, 0.05]
School type	0.02	1.46	[−0.02, 0.14]	0.02	1.359	[0.01, 0.10]
School quality (above average)	0.02	1.03	[−0.03, 0.08]	0.02	0.973	[−0.04, 0.08]
School quality (the best)	0.06	2.77**	[0.03, 0.17]	0.05	2.64**	[0.03, 0.16]
School location (a combination of urban and rural areas)	0.01	0.43	[−0.04, 0.07]	0.01	0.21	[−0.04, 0.06]
School location (city center)	−0.01	−0.62	[−0.07, 0.03]	−0.02	−0.75	[0.07, 0.03]
Physical excise				0.05	3.55***	[0.02, 0.21]
Constant		11.78***	[0.77, 1.08]		11.73***	[0.77, 1.07]
Step 1: R^2 = 0.053; ΔR^2 = 0.050; F = 10.69; $p < 0.001$ Step 2: R^2 = 0.056; ΔR^2 = 0.053; F = 10.83; $p < 0.001$						
Model 3 Dependent variable: agreeableness						
Gender	−0.08	−5.77***	[−0.14, −0.07]	−0.09	−6.57***	[−0.15, −0.08]
National	0.10	6.88***	[0.16, 0.29]	0.09	6.49***	[0.15, 0.28]
Registered residence	0.01	0.30	[−0.03, 0.06]	0.01	0.25	[−0.03, 0.06]
Cognitive ability	0.13	8.73***	[0.01, 0.05]	0.12	8.59***	[0.01, 0.05]
Health	0.11	8.43***	[0.09, 0.16]	0.11	8.13***	[0.09, 0.16]
One child	0.07	4.26***	[0.02, 0.11]	0.06	4.20***	[0.02, 0.10]
Parental education level	0.04	2.19*	[0.01, 0.06]	0.03	2.09*	[0.01, 0.06]
Family economic	0.02	1.67	[−0.01, 0.08]	0.03	1.89	[−0.01, 0.09]
Family cultural capital	0.17	10.50***	[0.05, 0.09]	0.15	9.61***	[0.04, 0.08]
School infrastructure	0.07	5.08***	[0.02, 0.12]	0.07	4.88***	[0.02, 0.12]
School type	0.02	1.42	[0.02, 0.18]	0.02	1.21	[0.02, 0.17]
School quality (above average)	0.07	3.93***	[0.03, 0.13]	0.07	3.84***	[0.03, 0.12]
School quality (the best)	0.15	7.71***	[0.13, 0.25]	0.14	7.48***	[0.12, 0.25]
School location (a combination of urban and rural areas)	0.06	3.44***	[0.07, 0.17]	0.05	2.97**	[0.01, 0.11]
School location (city center)	0.06	3.48***	[0.11, 0.40]	0.06	3.20***	[0.06, 0.16]
Physical excise				0.11	8.08***	[0.21, 0.37]
Constant		3.84***	[0.13, 0.42]		3.51***	[0.11, 0.40]
Step 1: R^2 = 0.139; ΔR^2 = 0.136; F = 50.25; $p < 0.001$ Step 2: R^2 = 0.136; ΔR^2 = 0.133; F = 50.23; $p < 0.001$						

(Continued)

TABLE 3 | (Continued)

Variable	Step 1			Step 2		
	β	*t*	95% CI	β	*t*	95% CI
Model 4 Dependent variable: personality traits						
Gender	−0.06	−4.77***	[−0.09, −0.08]	−0.07	−5.40***	[−0.10, −0.04]
National	0.06	4.35***	[0.06, 0.14]	0.06	4.05***	[0.05, 0.14]
Registered residence	0.03	1.85	[−0.01, 0.06]	0.03	1.84	[−0.01, 0.06]
Cognitive ability	0.14	10.04***	[0.06, 0.10]	0.14	9.97***	[0.06, 0.09]
Health	0.18	13.58***	[0.15, 0.20]	0.18	13.38***	[0.15, 0.20]
One child	0.04	2.35**	[0.01, 0.06]	0.03	2.28*	[0.01, 0.06]
Parental education level	0.02	1.12	[−0.01, 0.03]	0.02	1.06	[−0.01, 0.03]
Family economic	0.02	1.46	[−0.01, 0.06]	0.02	1.63	[−0.01, 0.06]
Family cultural capital	0.15	9.54***	[0.04, 0.07]	0.14	8.80***	[0.04, 0.07]
School infrastructure	0.05	3.51***	[0.03, 0.10]	0.05	3.36***	[0.02, 0.09]
School type	0.03	2.08*	[0.01, 0.11]	0.03	1.96*	[0.01, 0.11]
School quality (above average)	0.05	2.69**	[0.01, 0.08]	0.05	2.62**	[0.01, 0.08]
School quality (the best)	0.11	6.10***	[0.10, 0.18]	0.11	5.92***	[0.10, 0.18]
School location (a combination of urban and rural areas)	0.04	2.38*	[0.01, 0.08]	0.03	2.03*	[0.01, 0.07]
School location (city center)	0.06	3.24***	[0.02, 0.08]	0.05	3.05**	[0.02, 0.09]
Physical excise				0.09	6.61***	[0.12, 0.23]
Constant		16.61***	[0.77, 0.98]		16.53***	[0.76, 0.97]
Step 1: R^2 = 0.128; ΔR^2 = 0.126; F = 52.70; $p < 0.001$ Step 2: R^2 = 0.150; ΔR^2 = 0.147; F = 53.55; $p < 0.001$						

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*

TABLE 4 | Standardized coefficients for the moderated mediation model.

Variable	Coeff	SE	*t*	*P*	LLCI	ULCI
Model 1 Dependent variable: neuroticism						
X(Physical exercise)	0.02	0.01	2.53	$P < 0.01$	0.01	0.04
M(Peer relationship)	0.10	0.01	11.58	$P < 0.001$	0.11	0.16
W(Parent-child relationship)	0.12	0.02	18.09	$P < 0.001$	0.34	0.43
M*W	0.02	0.03	1.23	$P > 0.05$	–0.02	0.05
X*W	0.03	0.02	1.41	$P > 0.05$	–0.02	0.05
Constant	0.02	0.01	2.83	$P < 0.01$	0.04	0.16
R^2 = 0.07; F = 148.10; $P < 0.001$; Cohen's f^2 0.75						
Model 2 Dependent variable: conscientiousness						
X(Physical exercise)	0.04	0.01	2.86	$P < 0.01$	0.01	0.07
M(Peer relationship)	0.16	0.02	14.84	$P < 0.001$	0.14	0.18
W(Parent-child relationship)	0.13	0.01	11.78	$P < 0.001$	0.11	0.15
M*W	0.03	0.02	2.07	$P < 0.05$	0.02	0.07
X*W	–0.01	0.01	–0.30	$P > 0.05$	–0.03	0.02
Constant	0.02	0.01	2.63	$P < 0.01$	0.03	0.16
R^2 = 0.08; F = 103.92; $P < 0.001$; Cohen's f^2 0.64						
Model 3 Dependent variable: agreeableness						
X(Physical exercise)	0.11	0.01	7.81	$P < 0.001$	0.08	0.14
M(Peer relationship)	0.13	0.03	8.83	$P < 0.001$	0.16	0.22
W(Parent-child relationship)	0.13	0.01	8.05	$P < 0.001$	0.15	0.21
M*W	0.12	0.05	2.37	$P < 0.01$	0.02	0.22
X*W	0.12	0.06	2.03	$P < 0.05$	0.02	0.06
Constant	0.02	0.01	2.34	$P < 0.05$	0.06	0.16
R^2 = 0.10; F = 196.54; $P < 0.001$; Cohen's f^2 0.11						

Long-term participation in physical exercise not only requires adolescents to have a high degree of self-discipline, but also may increase adolescents' conscientiousness (Gallagher et al., 2013). In terms of adolescents' agreeableness, actively participating in physical exercise could effectively improve adolescents' cognitive flexibility (Bhattacharyya et al., 2022) and social communication ability (Stephan et al., 2014a), promote adolescents' emotional acquisition, maintain adolescents' prosocial behavior, and

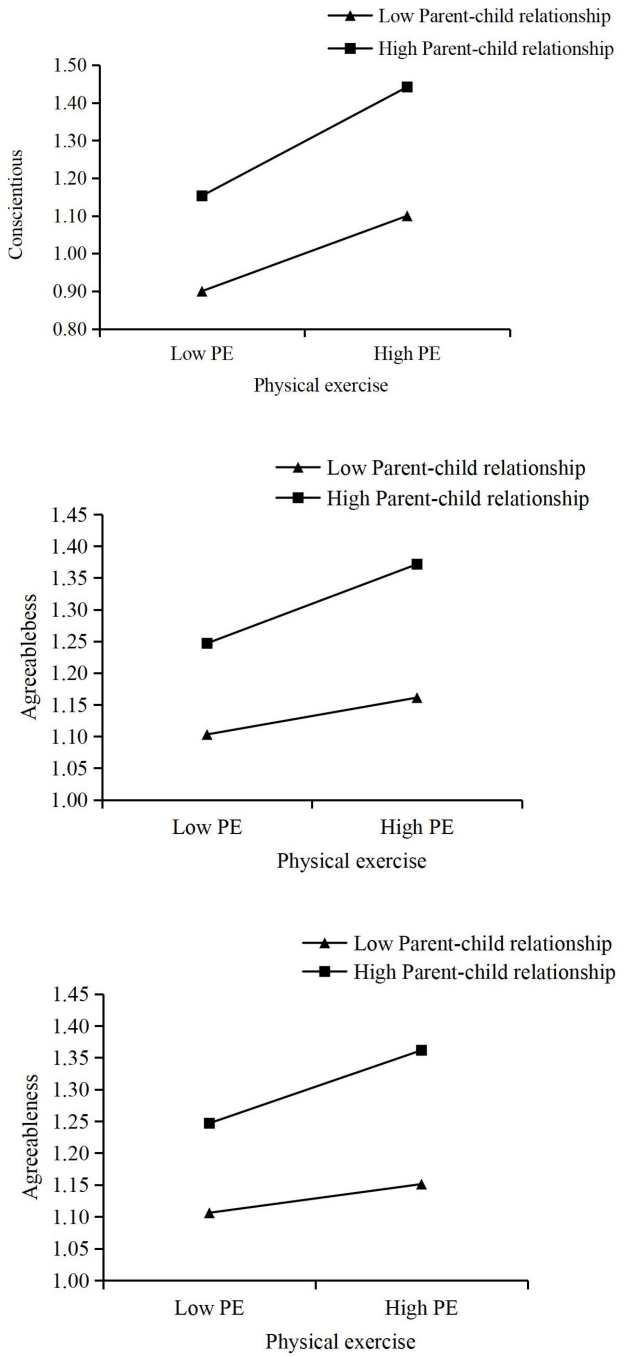

FIGURE 2 | The simple slope indicating the moderation effects. PR, peer relationship; PE, physical exercise.

then promote the development of adolescents' agreeableness (Stephan et al., 2014b).

The results of mediation effect show that peer relationship plays the mediating role between physical exercise and the development of personality traits such as neuroticism, conscientiousness, and agreeableness. Physical exercise could not only directly predict the development of adolescent's personality traits, but also significantly predict the development of adolescent personality traits through peer relationships. In adolescence, peer relationship has gradually become an important scene in adolescents' development. In the process of physical exercise, adolescents could enhance peer relationship, expand the scope of interpersonal communication, and develop the level of personality traits under the influence of peer effect through physical exercise (Smith, 2003). Meanwhile, participating in physical exercise could make young people feel better about peer acceptance and friendship connection, and show more positive behaviors and attitudes in the process of sports participation, thereby enhancing the sense of sports acquisition, satisfying their social needs, and emotional communication, and developing personality traits (Bandura, 1989; Eagleton et al., 2007; Zinchenko et al., 2018; Allen et al., 2020).

The results of the moderating effect show that the interaction of peer relationship and parent–child relationship jointly affects the development of adolescent' conscientiousness in the impact of physical exercise on adolescent conscientiousness. In terms of the impact of physical exercise on adolescent' agreeableness, the interaction between physical exercise and parent–child relationship and the interaction between parent–child relationship and peer relationship combined to influence the development of adolescent agreeableness. Based on the theory of human ecosystem, individual behavior is affected by the interaction with the environment. In the three-layer model of micro, medium, and macro, family and peers, as the main components of the microsystem, play an irreplaceable role in the growth and development of adolescents (Overton, 2013a,b). Parent–child relationship plays an important role in the construction of adolescent self-cognition. A high level of parent–child relationship would make adolescents form a safe world view (Greenberg, 1999), more inclined to get along with others and participate in physical exercise with a more positive attitude and behavior, reduce the occurrence of problem behaviors (Hutteman et al., 2014), and promote the development of adolescent personality traits to a greater extent, such as neuroticism, extroversion, and agreeableness (McCarthy, 2007; Clark et al., 2018). Meanwhile, a good parent–child relationship could effectively intervene and weaken the influence of negative peer behaviors on adolescents. Under the influence of good parent–child relationship and peer relationship, adolescents tend to show positive social behaviors in the process of communication with others, promote the acquisition of social emotion, and make teenagers have more affinity (Winefield et al., 2015; Raufelder et al., 2021).

CONCLUSION

This study has investigated the effect of physical exercise on the development of adolescents' personality traits, and the effect of mechanism of peer relationship and parent–child relationship on physical exercise and personality traits. It has been found that physical exercise has a significant positive

predictive effect on the development of personality traits such as neuroticism, conscientiousness, and agreeableness. Physical exercise could affect adolescents' neuroticism, conscientiousness, and agreeableness through peer relationship. In addition, parent–child relationships show differential moderating effects in different models. In the influential model of physical exercise on adolescents' neuroticism, the moderating effect of parent–child relationship is not significant. In the influential model of physical exercise on adolescents' conscientiousness, the parent–child relationship only exerts the direct effect of peer relationship on adolescents' conscientiousness. In the influential model of physical exercise on adolescents' agreeableness, the parent–child relationship regulates the direct effect of physical exercise on adolescents' agreeableness and the direct effect of peer relationship with adolescent agreeableness.

This study would give the enlightenment and guidance for intervention and development of adolescents' personality traits based on revealing the micro-level influencing mechanism of family and peer system. Moreover, the study includes the influencing factors of individuals, families, and schools in the regression analysis, which makes the model more explanatory, and provides important theoretical support and practical guidance for further scientific formulation of adolescent's physical exercise plan and promoting the development of adolescent's personality traits. Also, the study has fully considered the typical stability property of personality traits, and made the findings more convincing by using the differences in personality traits before and after the two periods of follow-up survey data as the dependent variable.

There are following limitations in the study. First, due to the particularity of data sources, the measurement of physical exercise only uses the exercise duration as the measurement index, and in the further research, the dimensions such as exercise intensity or events could be added. Second, the measurement of neuroticism in personality traits has some limitation. Although "International personality item pool" and "NEO personality inventory revised" include emotions such as anxiety and anger, it is insufficient only to use the emotional changes in the last 7 days to test neuroticism (Costa and Mccrae, 1992; Goldberg et al., 2006). Third, due to the data source of CEPS, the study could not completely obtain all the variables in the big five personality traits. Only the personality of neuroticism, conscientiousness, and agreeableness has been identified. Furthermore, the survey of parent–child relationship mainly comes from the subjective reports of adolescents, while the reports from the parents of adolescents have not been collected. A more objective and multidimensional measurement could be adopted in the follow-up study.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: http://ceps.ruc.edu.cn/.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/ participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

YL was mainly responsible for topic design, analysis, manuscript writing, and study revision. XC was mainly responsible for data analysis and manuscript writing. WC was mainly responsible for revision, proofreading, and supervision of studies. XP was mainly responsible for manuscript writing. All authors contributed to the article and approved the submitted version.

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SYSTEMATIC REVIEW
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What Drives Quality Physical Education? A Systematic Review and Meta-Analysis of Learning and Development Effects From Physical Education-Based Interventions

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Objective: To determine the effects of learning interventions aimed at optimizing the quality of physical education (PE) on psychomotor, cognitive, affective and social learning outcomes in children and adolescents.

Design: A systematic review and meta-analysis.

Data Sources: After searching PsycInfo, ERIC, and SportDiscus electronic databases, we identified 135 eligible studies published between January 1, 1995 to May 1, 2021.

Eligibility Criteria for Selecting Studies: We included randomized controlled trials, quasi-experimental studies, and controlled trials that assessed the effect of a PE-based intervention against one of the four identified learning domains in youth at school (aged 5–18 years).

Results: One hundred and thirty five (135) studies with over 42,500 participants and 193 calculated effect sizes were included in the study. The mean effect across all the learning and development outcomes was small to medium (Cohen's $d = 0.32$, 95% confidence interval [CI] (0.27–0.37). When adjusted for publication bias using the Duval and Tweedie Trim and Fill Method, this mean effect size increased to $d = 0.40$ (CI = 0.34–0.46). Effect sizes varied significantly based on learning and development outcomes. Interventions that consistently report above or below the mean $d = 0.40$ effect are identified based on learning outcome. The greatest effects across interventions were witnessed in psychomotor learning outcomes ($d = 0.52$) followed by affective ($d = 0.47$), social ($d = 0.32$), and cognitive ($d = 0.17$) learning outcomes. A minority (<10%) of PE interventions captured by this systematic review and meta-analysis reported having a negative effect on student learning and development.

Conclusion: The interventions with the greatest effects on student learning and development were dependant on the learning domains. Some PE interventions with a pedagogical focus such as games-based approaches, TARGET/Mastery Teaching, and

Sport Education were found to be strong investments across multiple domains. The evidence is limited however by consistency in intervention dosage, study design, and data collection instruments. The study received no internal or external funding and was not prospectively registered.

Keywords: physical education (PE), systematic review and meta-analysis, learning, child development, pedagogy

INTRODUCTION

Defining what constitutes "quality physical education" (QPE) has long been an arduous affair within the discipline of physical education (PE), and more broadly in the education, psychology, and public health sciences (Dudley et al., 2020). Indeed, Pate and Hohn (1995) described PE as suffering from a "muddled mission." Frequently, PE curricula and interventions around the world have been defined to achieve short, medium, or long term health effects including physical activity participation, body adiposity, and other fitness metrics. However, there is now a growing consensus that PE is also a potential mechanism for other aspects of development, with children and young people also needing to learn how to be confident, competent and knowledgeable in order to lead an active life as they age (Cairney et al., 2019; Barnett et al., 2021). Physical activity qua physical activity is not sufficient.

In the first review to consider the role of PE in promoting positive youth development, Bailey (2006) identified the possible benefits of PE curricula and pedagogy that occur across a number of domains: physical, lifestyle, affective, social, and cognitive. He suggested, based on the studies that were qualitatively analyzed, PE has the potential to make significant and distinctive contributions to development in each of these domains. However, the review also stressed that many of these benefits may be mediated by the nature of the instructional interactions between students and their teachers. Thus, the design of the PE lesson and activities is critical.

Nine years later, and after 3 years of consultation, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) released the Quality Physical Education Guidelines for Policymakers (McLennan and Thompson, 2015) which sought to provide further clarity to these claims. The document calls for QPE to drive broad academic achievement and health gains in youth around the world. It also states that growth should occur through fostering an inclusive environment for all students in PE, built upon the philosophical understandings of physical literacy. The inclusion of physical literacy as a central tenet of the QPE aligned with the benefits identified by Bailey (2006) in that it contends for the interconnected and holistic development of youth (Dudley, 2015; Whitehead, 2019). From a learning and pedagogical imperative, physical literacy is best understood as the lifelong learning that occurs across four domains of learning and development (psychomotor, cognitive, affective, and social) and is expressed through individual experiences of movement and physical activity (Keegan et al., 2019).

Recognizing that the psychomotor, cognitive, social, and affective domains are interconnected, and that they represent distinct aspects of a QPE program, it is important that research investigate the evidence for different PE lessons, instructional designs, and interventions which aim to address each domain systematically. In recent years, several systematic reviews and meta-analyses have attempted to make the case for QPE. For instance, one meta-analysis synthesized the effects of physical activity on academic achievement of youth (Alvarez-Bueno et al., 2017), one examined the effects of fundamental movement skill interventions on psychomotor development of youth (Logan et al., 2012), and one reported on the motivations of youth to be physically active (Knittle et al., 2018). Yet, no work to date has examined evidence for learning and development in the psychomotor, cognitive, social, and affective domains simultaneously. Furthermore, whilst Bailey (2006) and UNESCO each suggest that QPE programs should educate children across these domains, no research to date has attempted to capture the teaching and learning strategies that best support this goal.

Another layer of complexity when considering the educational impact of specific PE lessons, instructional designs, and interventions on our four domains of interest is the almost universal positive effect of school-based interventions. As detailed by Hattie (2009) in his seminal synthesis of over 800 meta-analyses on student achievement, almost everything in schools works in some capacity. Ninety percent of all intervention effect sizes are positive. This means that when teachers, schools, and their governing systems claim that they are having a positive effect on student achievement (and, potentially, other developmental outcomes), it becomes almost a trivial claim (Hattie, 2009). While no such research has been conducted in other domains of interest, including for psychomotor outcomes, affective outcomes, social outcomes, or for cognitive outcomes that extend beyond achievement (e.g., executive function, memory, attention), we consider it plausible that PE interventions designed with QPE principles in mind will be similarly beneficial. However, the degree to which they are effective, both between and within domains, remains a question of empirical and practical interest. For this reason, a "hinge point" of average effects across and within learning domains should be predetermined when sufficient evidence is available to determine what programs should receive educational investment and support.

To determine a satisfactory "hinge point," it is useful to compare intervention effect sizes using a common metric. When standardized, effect sizes allow researchers and policy-makers to compare results on different measures, between groups, over time, and across content of educational interventions (Glass et al., 1981; Hattie, 2009). In Hattie's synthesis of meta-analyses, for example, the average effect of all interventions on student

achievement using Cohen's *d*, a measure of the standardized difference between two means, was 0.4 (Hattie, 2009). Thus, in the case of student achievement, 0.4 becomes the relevant hinge-point for the assessment of whether an intervention has a greater or lesser than average impact. While hinge-points may vary across domains, we nonetheless adopt this approach when considering the role of different PE interventions on students' psychomotor, cognitive, affective, and social outcomes.

The aim of this systematic review and meta-analysis was to systematically capture and evaluate the impact of all published PE classes, instructional designs, and interventions on students' psychomotor, cognitive, affective, and social outcomes. Given that QPE must be driven by student outcomes, and drawing on the notion of an effect size "hinge-point" to determine which interventions should receive educational support, this systematic review and meta analyses is the first known study to articulate the PE-based interventions that are having a greater than average effect on cognitive, social, affective, and/or psychomotor learning and development.

METHODS

Protocol and Registration

To increase the rigor of reporting, we followed the PRISMA 2020 Checklist (Page et al., 2021) as pragmatically possible given this was a systematic review and meta-analysis of predominately educational literature (see **Supplementary Material**). As our study commenced as a rapid review but evolved into a more rigorous systematic review and meta-analysis, therefore, it was ineligible for registration with the International Prospective Register of Systematic Reviews. Covidence(TM) software, as reviewed by Babineau (2014), was used in the title and abstract screening, full-text review, and data extraction phases of the study.

Eligibility Criteria and Study Selection

To be eligible for inclusion in the review, studies needed to meet the following "PICOS" criteria: (1) **P**articipants: children and adolescents aged 5–18 years old (given prescribed PE usually commences in primary schools) enrolled in school but did not include participants with specific learning needs; (2) **I**ntervention characteristics included studies that used PE classes at school as the intervention medium; (3) **C**omparison: control group that received the regular PE instruction or no PE instruction; (4) **O**utcomes: psychomotor (e.g., gross motor skill, motor competence, fundamental movement skill acquisition), cognitive (e.g., executive function, memory, attention, academic scores); affective (e.g., motivation, self-esteem, self-efficacy, enjoyment, self-regulation), or social (e.g., prosocial behavior, teamwork, cooperation, social competence, self control) outcomes; (5) **S**tudy design: randomized controlled trials (RCTs), quasi experimental trials (QETs), and controlled trials (CTs).

Search Strategy

Searches of the PsycInfo, ERIC, and SportDiscus databases were conducted. To ensure a comprehensive overview of the field we limited our search to studies published between 1st January 1995 and 1st May 2021. The search was conducted between 1st May to 14th May 2021. Only peer-reviewed journal articles published in English were included. To identify relevant research, we combined three blocks of search terms. Our first group (Block 1) of search terms was used to identify relevant participants. These included variations of "adolescent" OR "child*" OR "youth" OR "teen*" WITH "primary school" AND/OR "elementary school" OR "middle school" OR "secondary school" OR "high school," respectively. Our second group of search terms (Block 2) was used to identify research on school-based PE classes. These included the terms "physical education" OR PDHPE OR PESS OR sport OR "health education." Our final group of search terms (Block 3) was used to identify research that implemented relevant study designs. These included variations of intervention, "randomis(z)ed control trial" OR quasi-experimental OR "control trial" OR "program" OR "comparison." All three blocked search terms were combined in order for Block 1 AND Block 2 AND Block 3 search terms to be applied concurrently. Given our outcomes of interest include four broad domains, each representing a large range of specific skills and capacities, we did not specify any outcome search terms. We instead used the screening process to identify studies with relevant outcomes falling into each domain.

To complement our database searches, the first author also conducted bi-directional screening of articles using previously published systematic reviews in physical activity, physical literacy, and movement skill development conducted in schools. Bi-directional screening is a method where a reviewer screens all references within an article and any articles that cited the article (Hinde and Spackman, 2015). This process aims to include relevant articles that may have been missed through traditional database searching.

Data Collection Process

We uploaded all articles captured in the initial database search and complementary bi-directional screening into the Covidence™ review management software library. Using this software, we then removed any duplicates. Two independent reviewers blindly screened titles and abstracts for inclusion or exclusion, with conflicts resolved by consensus by using a third reviewer (the lead author). Articles that were clearly out of scope were excluded, while those with the potential to be in-scope were retained. Next, two independent reviewers independently screened the full-text articles. Only those articles that met the inclusion criteria of the study were retained.

For each study, the following data were extracted: (1) authors' names, year of publication and country of the study; (2) number of participants; (3) characteristics of PE intervention (i.e., pedagogical model, instruction model, policy change); (4) psychomotor, cognitive, affective, and social learning information about instruments used; (5) targeted intervention site (i.e., primary or secondary school); and (6) results in all groups about the parameters of interest. **Table 1** provides a summary of the included studies based on learning outcome, study design, country, mode of intervention, and site of intervention. Meta analysis of these data are presented via a series of forest plots based on their level of analysis of the learning

TABLE 1 | An overview of the studies extracted from papers and included in the meta-analysis.

Author (Year)	Country	Study design	Sample size	Primary mode of PE intervention	Targeted learning domain(s)	Targeted level of schooling
Abós (2017)	Greece	QE	35	TARGET/Mastery motivational model	Aff, Psy, Soc	Secondary
Aguayo (2019)	Spain	RCT	157	(1) Games pedagogy; (2) Health-based PE	Cog	Primary
Almolda-Tomas (2014)	Spain	CT	113	TARGET/Mastery motivational model	Aff, Psy, Soc	Secondary
Andrade (2020)	Brazil	RCT	140	Exergaming	Aff	Primary
Ardoy (2014)	Spain	RCT	35	Increased PE frequency	Cog	Secondary
Bardaglio (2015)	Italy	CT	128	Team teaching	Psy	Primary
Barkoukis (2008)	Greece	CT	374	TARGET/Mastery motivational model	Aff	Secondary
Barzouka (2015)	Greece	CT	43	Teacher feedback	Psy, Aff	Secondary
Bechter (2019)	Australia	RCT	497	Student-centered	Aff, Psy	Secondary
Benítez-Sillero (2021)	Spain	QE	764	Cooperative games	Soc	Secondary
Bortoli (2015)	Italy	QE	108	TARGET/Mastery motivational model	Aff	Secondary
Boržíková (2020)	Slovakia	RCT	84	Games pedagogy	Psy	Primary
Boyle-Holmes (2010)	USA	QE	1,394	Developmental approach	Aff	Primary
Breslin (2012)	UK	CT	177	Direct instruction	Psy	Primary
Browne (2004)	Australia	CT	53	Sport education	Cog, Psy	Secondary
Carlson (2008)	USA	CT	5,316	Increased PE frequency	Cog	Primary
Cecchini (2007)	Spain	RCT	124	Teaching personal & social responsibility	Aff, Soc	Secondary
Cecchini (2020)	Spain	CT	830	TARGET/Mastery motivational model	Aff	Secondary
Chatoupis (2017)	Greece	RCT	75	(1) Direct instruction; (2) Student-centered	Psy	Primary
Chatzipanteli (2015)	Greece	CT	601	Student based with Mosston Teaching Styles	Cog, Aff	Secondary
Chen (2008)	USA	CT	199	Science-based PE	Aff	Primary
Cheon (2019)	South Korea	RCT	2,739	Autonomy-supported	Aff, Soc, Psy	Secondary
Coe (2006)	USA	QE	428	Health-based PE	Cog	Primary
Cohen (2012)	USA	CT	97	Aligned developmental feedback	Psy	Primary
Coimbra (2021)	Switzerland	RCT	143	Goal-setting	Aff	Secondary
Colella (2019)	Italy	RCT	84	Discovery/problem solving approach	Psy, Aff	Primary
Cöster (2018)	Sweden	CT	599	Daily PE	Cog	Primary
Costigan (2016)	Australia	RCT	44	Fitness-based	Cog, Aff	Secondary
Cuevas (2016)	Spain	QE	86	Sport education	Aff	Secondary
Dalziell (2015)	UK	CT	46	Specialist PE	Cog	Primary
Dalziell (2019)	UK	QE	139	Student-centered	Cog, Psy	Primary
De Bruijn (2020)	Netherlands	RCT	654	Increased PE frequency	Cog	Primary
Digelidis (2003)	Greece	CT	783	TARGET/Mastery motivational model	Aff	Secondary
Duncan (2019)	UK	RCT	92	Fitness/neuromuscular	Psy	Primary
Eather (2016)	Australia	RCT	21	Fitness-based	Aff	Secondary
Ellis (1995)	USA	CT	40	Integrated PE	Cog	Primary
Ericsson (2008)	Sweden	CT	152	Increased PE Frequency	Psy, Cog	Primary
Ericsson (2014)	Sweden	CT	220	Increased PE frequency	Psy, Cog	Primary
Escartí (2010)	Spain	CT	42	Teaching personal & social responsibility	Aff, Soc	Primary
Felver (2020)	USA	QE	21	Yoga	Soc	Primary
Fernandez-Rio (2017)	Spain	QE	249	Cooperative Learning	Aff, Soc	Secondary
Fisher (2011)	UK	RCT	57	Health-based PE	Cog	Primary
Font-Lladó (2020)	Spain	RCT	190	Direct instruction	Psy	Primary
Franco (2017)	Spain	QE	53	Self determination theory supported	Aff, Psy	Secondary
Fu (2016)	USA	CT	174	Health-based PE	Aff	Primary
García-Calvo (2016)	Spain	QE	835	(1) Positive behavior model; (2) Didactic	Soc	Secondary
Gibbons (1995)	Canada	RCT	286	(1) Increased PE frequency; (2) Social Learning (Bandura)	Soc	Primary
Gibbons (2010)	Canada	CT	72	Experiential learning	Aff, Soc	Primary/Secondary
Gil-Arias (2017)	Spain	QE	110	(1) Teaching games for understanding; (2) Sport Education	Aff	Secondary
Gråstén (2017)	Finland	CT	240	Constructive alignment	Psy	Secondary

(Continued)

TABLE 1 | Continued

Author (Year)	Country	Study design	Sample size	Primary mode of PE intervention	Targeted learning domain(s)	Targeted level of schooling
Grasten (2019)	Finland	QE	726	Creative PE	Soc	Primary
Gray (2011)	UK	QE	52	Teaching games for understanding	Psy, Cog	Secondary
Greco (2020)	Italy	CT	100	Health-based PE	Aff	Secondary
Gu (2018)	USA	CT	183	Fitness-based	Psy, Aff	Primary
Hagins (2016)	USA	RCT	104	Yoga	Cog	Secondary
Hartmann (2010)	Switzerland	RCT	231	Daily PE	Soc, Psy	Primary
Harvey (2017)	USA	QE	346	Teaching games for understanding	Aff, Psy, Soc	Primary/Secondary
Hernández (2020)	Spain	QE	102	Autonomy support/dialogic teaching	Psy, Aff, Soc	Primary
Hortz (2008)	USA	QE	240	Health promoting	Soc, Aff	Secondary
How (2013)	Australia	CT	143	Choice-based curriculum	Aff	Secondary
Ignico (2006)	USA	CT	86	Fitness infused	Psy	Primary
Ilker (2013)	Turkey	QE	54	Mastery teaching	Aff	Secondary
Jaakkola (2006)	Turkey	CT	461	TARGET/Mastery motivational model	Aff	Secondary
Jamner (2004)	USA	CT	47	Daily PE	Aff	Secondary
Jansen (2018)	Germany	QE	144	Increased PE frequency	Cog	Secondary
Jarani (2016)	Albania	RCT	1,024	(1) Health-based PE; (2) Games pedagogy	Psy	Primary
Kalaja (2012)	Finland	QE	446	Mastery teaching	Psy	Secondary
Karabourniotis (2002)	Greece	CT	45	Experiential Learning	Psy	Primary
Kliziene (2018)	Lithuania	CT	4028	Psychosocial/Kilaz	Aff	Secondary
Kokkonen (2019)	Finland	CT	382	Creative PE	Aff	Primary
Kouli (2009)	Greece	CT	57	Fitness-based	Aff	Primary
Kriellaars (2019)	Canada	QE	220	Circus arts	Psy	Primary
Krüger (2018)	Germany	QE	61	Sport pedagogy	Cog	Primary
Lakes (2004)	USA	RCT	193	Martial arts	Cog, Soc, Aff	Primary
Lander (2017)	Australia	RCT	190	Constructive alignment	Psy	Secondary
Leptokaridou (2014)	Greece	CT	54	Autonomy supported	Aff	Primary
Lima (2020)	Brazil	RCT	430	Increased PE frequency	Cog	Secondary
lisahunter (2014)	Australia	CT	107	Direct instruction	Cog	Primary
Lonsdale (2019)	Australia	RCT	998	Health-based PE	Aff	Secondary
Lopes (2017)	Portugal	RCT	40	Increased PE frequency	Psy	Primary
Lubans (2018)	Australia	RCT	1,164	Health-based PE	Cog	Secondary
Marshall (1997)	Canada	CT	110	Daily PE	Psy	Primary
Martin (2009)	USA	QE	54	Mastery	Psy	Primary
Martínez-López (2018)	Spain	RCT	184	Fitness-based	Cog	Secondary
Mathisen (2016)	Norway	QE	43	Dynamic systems approach	Psy	Primary
Mayorga-Vega (2012)	Spain	RCT	69	Fitness-based	Aff	Primary
McKenzie (1998)	USA	RCT	508	Health-based PE	Psy	Primary
Meijer (2020)	Netherlands	RCT	1,271	(1) Cognitively challenging; (2) Fitness-based	Cog	Primary
Miller (2016)	Australia	RCT	30	Teaching games for understanding	Cog, Psy, Aff	Primary
Moreno-Murcia (2019)	Spain	CT	20	Task-orientated	Soc, Aff, Psy	Primary
Morgan (2002)	UK/USA	QE	153	TARGET/Mastery motivational model	Aff	Secondary
Neumark-Sztainer (2010)	USA	RCT	336	Health-based PE	Psy, Aff	Secondary
Neville (2021)	UK	CT	40	Dance	Cog	Secondary
Noggle (2012)	USA	RCT	51	Yoga	Aff	Primary
O'Brien (2008)	Ireland	QE	85	Critical theorist PE	Aff	Secondary
Osterlie (2018)	Norway	QE	338	Flipped learning	Aff	Secondary
Pagona (2008)	Greece	CT	60	Metacognitive strategy	Psy	Secondary
Palmer (2018)	USA	CT	260	Meaningful PE	Aff	Primary
Pardo (2016)	Spain	QE	682	Health-based PE	Aff, Psy	Secondary

(Continued)

TABLE 1 | Continued

Author (Year)	Country	Study design	Sample size	Primary mode of PE intervention	Targeted learning domain(s)	Targeted level of schooling
Perlman (2010)	Australia	QE	78	Sport education	Aff	Secondary
Pesce (2012)	Italy	CT	125	Specialist PE	Soc, Psy	Secondary
Pesce (2016)	Italy	RCT	460	Deliberate play	Psy, Cog	Primary
Pesce (2021)	Italy	RCT	66	Socio-emotional PE	Cog, Soc	Primary
Pietsch (2017)	Germany	CT	46	Cognitive/Motor coordination	Cog	Primary
Platvoet (2016)	Netherlands	CT	244	Goal directed pedagogy	Psy	Primary
Polvi (2000)	Finland	CT	143	(1) Cooperative learning; (2) Direct instruction	Soc	Primary
Potdevin (2018)	France	CT	33	Video feedback	Aff	Primary
Prusak (2004)	USA	RCT	42	Self determination theory supported	Aff	Secondary
Reed (2013)	USA	CT	189	Daily PE	Cog	Primary/Secondary
Robertson (2018)	UK	RCT	136	Exergaming	Aff	Primary
Rubeli (2020)	Switzerland	CT	315	Reflexive pedagogy	Aff	Primary/Secondary
Sallis (1999)	USA	RCT	883	Health-based PE	Cog	Primary
Sánchez-Oliva (2017)	Spain	CT	836	Self determination theory supported	Aff	Secondary
Schmidt (2013)	Switzerland	CT	464	Health-based PE	Aff	Primary
Schmidt (2015)	Switzerland	RCT	124	Games pedagogy	Cog	Primary
Schmidt (2015a)	Switzerland	RCT	90	Cognitively challenging PE	Cog	Primary
Schnider (2021)	Switzerland	RCT	108	Behavioral skill approach	Aff	Secondary
Sgrò (2020)	Italy	QE	77	Teaching games for understanding	Aff, Soc	Secondary
Sharpe (1995)	Canada	CT	55	Cooperative learning	Soc	Primary
Sparks (2017)	Australia	RCT	382	SDT supported	Aff	Secondary
Spittle (2009)	Australia	CT	115	Sport education	Aff, Psy	Secondary
Stojadinović (2020)	Serbia	CT	162	Integrated PE	Psy	Primary
Sun (2012)	USA	RCT	79	Constructivist/ZPD	Cog	Primary
Telford (2012)	Australia	CT	620	Specialist PE	Cog	Primary
van Beurden (2003)	Australia	QE	1,045	Health-based PE	Psy	Primary
van der Fels (2020)	Netherlands	RCT	1,194	1) Fitness-based; (2) Cognitive/Fitness	Psy	Primary
Velez (2010)	USA	RCT	28	Fitness-based	Aff	Secondary
Viciana (2020)	Spain	RCT	109	Sport education	Aff, Psy, Soc	Secondary
Wallhead (2004)	UK	QE	51	Sport education	Aff, Psy	Secondary
Wallhead (2014)	USA	QE	538	Sport education	Aff	Secondary
Weiss (2015)	USA	QE	404	Fitness-based	Aff, Psy, Soc, Cog	Secondary
Yli-Piipari (2018)	USA	RCT	398	Autonomy supported	Aff	Secondary
You (2013)	USA	CT	61	Health-based PE	Aff	Secondary
Zhu (2016)	USA	CT	30	Technology supported PE	Aff	Primary
Zourbanos (2013)	Greece	CT	55	Self talk	Psy	Primary

RCT, Randomized Controlled Trial; CT, Controlled Trial; QE, Quasi-experimental; ZPD, Zone of Proximal Development; TARGET, Tasks, Authority, Recognition, Grouping, Evaluation, and Time; Aff, Affective Learning Domain; Cog, Cognitive Learning Domain; Psy, Psychomotor Learning Domain; Soc, Social Learning Domain.

domain targeted. A full reference list of studies included in the meta-analysis are provided in the **Supplementary Materials** attached to this paper.

Quality of Individual Studies

Included articles were assessed for methodological quality using a 10-item quality assessment scale derived from Van Sluijs et al. (2007) (see **Table 2**). This tool was designed to measure the methodological quality of the effectiveness of interventions to promote physical activity in children and adolescents. For each included article, two reviewers independently assessed whether the assessed item was present or absent. If an item was not described sufficiently it was allocated an absent score. For each article, when 100% agreement did not occur, the lead author reviewed the paper and determined the presence or absence of the item in dispute.

Risk of Publication Bias

We conducted two statistical tests to ascertain the degree of publication bias present in the studies. The first was the Classic Fail Safe N (Orwin, 1983) which describes the stability of a significant effect by calculating how many studies with an effect size of zero would need to be added to the meta-analysis before the reported effect lost statistical significance ($p < 0.05$).

TABLE 2 | Methodological quality assessment items (Adapted from Van Sluijs et al., 2007).

Item	Description
A	Key baseline characteristics are presented separately for treatment groups and for randomized controlled trials and controlled trials, positive if baseline outcomes were statistically tested and results of tests were provided.
B	Randomization procedure clearly and explicitly described and adequately carried out (generation of allocation sequence, allocation concealment and implementation)
C	Validated measures of learning (validation in same age group reported and/or cited)
D	Drop out reported and ≤20% for < 6-month follow-up or ≤30% for ≥6-month follow-up
E	Blinded outcome variable assessments
F	Learning assessed a minimum of 6 months after pre-test
G	Intention to treat analysis used (participants analyzed in group they were originally allocated to, and participants not excluded from analyses because of non-compliance to treatment or because of some missing data)
H	Potential confounders accounted for in outcome analysis (e.g., baseline score, group/cluster, age)
I	Summary results for each group + treatment effect (difference between groups) + its precision (e.g., 95% confidence interval)
J	Power calculation reported, and the study was adequately powered to detect hypothesized relationships

The second method was a Trim and Fill (Duval and Tweedie, 2000), which aims both to identify and correct for funnel plot asymmetry that is likely to occur from publication bias. The method involves three steps. The first step is to remove smaller studies causing funnel plot asymmetry. The second step is to deploy the trimmed funnel plot to estimate the true "center" of the funnel. Finally, the third step is to replace the trimmed studies and their missing "equivalents" around the center. As well as providing an estimate of the number of missing studies, an adjusted intervention effect is derived by performing a meta-analysis including the filled studies.

Data Synthesis and Analysis

All analyses were conducted using Comprehensive Meta Analysis (CMA) software (v3.3; USA). We analyzed effects using the random-effects model according to DerSimonian and Laird (2015). The effect sizes were expressed as a standardized effect size (Cohen's *d*) for comparison to broader educational research (Cohen et al., 2017).

It is important to clarify the following statistical aspects: (1) when two or more intervention groups using different strategies were included in a study, their data were analyzed as independent studies; (2) when a paper reported testing for more than one learning domain outcome, the data were analyzed as separate studies at the domain level only; (3) when two or more tests for measuring the same learning outcomes variable were included in the same study, they were calculated as a combined standardized effect size (Borenstein, 2021); (4) a random effects model was also applied to compare effect size differences between PE interventions based on learning outcome (i.e., cognitive, social, psychomotor, affective, or combined PE interventions) and the pedagogical (i.e., model of practice, teaching strategy) or intervention approach (i.e., teacher training, policy changes); (5) when two or more age cohorts were included in studies, their data were investigated as combined samples; and (6) when two or more follow-up measurements were reported, only the last measurement was considered.

Heterogeneity was assessed and reported across all the studies and at the learning domain level by using a series of complimentary statistical analyses. First, we calculated the Q-statistic (Q) which provided a test of the null hypothesis as to whether all studies in the model shared a common effect size. Second, we calculated an inconsistency index (I^2) statistic in order to report the proportion of the observed variance that were indicative of changes in true effect sizes rather than sampling error. Third, a Tau statistic (T^2) was calculated to determine the variance of true effect sizes; and finally, we calculated and reported a prediction interval to provide a range of true effect size for all samples observed within 95% confidence limits.

RESULTS

Study Selection

The database search strategy yielded 6,182 studies for possible inclusion. The bidirectional screening added an additional 46 studies, resulting in 6,228 studies that were imported for screening. After duplicates were removed by Covidence™, 5,037 papers were reviewed by title and abstract. 4,729 were deemed irrelevant by two reviewers based on their title and abstract resulting in 308 papers being subjected to a full-text review. At this stage, an additional 173 studies were excluded by consensus (as previously discussed) and their reasons for exclusion are detailed in the flowchart in **Figure 1**.

Study Characteristics

There were 135 studies extracted from the search strategy for final analysis (see **Table 1**). Studies came from primary (n = 60), secondary (n = 71) and a combination of primary and secondary (n = 4) school. They consisted of 47 randomized controlled trials, 54 controlled trials, and 34 quasi-experimental studies. The studies captured by the systematic review came from 23 different countries and included over 42,500 child and adolescent participants.

Risk of Bias Based on Quality of Individual Studies

The evaluation of methodological quality reported in **Table 3** revealed that the 135 studies included in the analysis varied considerably in their reporting. Approximately half (56%) of the papers met five or more of the quality assessment criteria (Van Sluijs et al., 2007). Only 16% (n = 21) of the collected studies met seven or more assessment criteria. The most infrequently reported quality assessment criteria reported in these studies were blinded assessments (9%; n = 12) and appropriate power calculations (16%; n = 22), and the most

FIGURE 1 | Flowchart of study selection.

frequently reported were a summary of key findings and the reporting of validated instruments (94%, $n = 127$; 81%, $n = 110$), respectively.

Summary of Evidence

From the 135 included studies, there were 193 effect sizes that examined a learning outcome or outcomes within at least one of the four learning domains of interest (cognitive, social, affective, and/or psychomotor). There were 57 different intervention strategies identified across the studies. Each of these intervention strategies are reported in forest-plots.

Combined Learning Effects

As above, all analyses were based on PE interventions targeting a learning variable of interest among students who were aged 5–18 years of age and attending primary and/or secondary schools. In each study, students were assigned to either (i) a new PE program or learning intervention (intervention condition), or (ii) their regular curricula (control condition). Researchers recorded student outcomes at either the conclusion of the intervention period or a later follow-up time point. The effect size was the standardized mean difference (Cohen's d) in each outcome variable between intervention and control groups.

The studies in this analysis were sampled from a universe of possible studies defined by the inclusion/exclusion criteria defined earlier in the paper. For this reason, a random-effects model was employed. The conclusion (below) applies to that universe.

Do Physical Education Interventions Improve Combined Student Outcomes?

When combined across domains, the PE interventions included in this meta-analysis had a significant positive effect on student outcomes across domains, $Z = 12.974$, $p < 0.001$. The standardized difference in means was $d = 0.32$ (95% CI [0.27, 0.37]), meaning that on average, students receiving a PE-based intervention improved their learning or development by a third of a standard deviation compared with those students who received their usual PE. Primary/elementary school interventions reported a slightly smaller average effect size of $d = 0.29$, whilst interventions conducted in secondary schools were slightly higher at $d = 0.34$.

TABLE 3 | Results of methodological quality assessment.

Paper No	Paper lead author (Year)	Methodological quality assessment items										No. of criteria met
		A	B	C	D	E	F	G	H	I	J	
1	Abós (2017)	✓		✓	✓					✓		4
2	Aguayo (2019)	✓	✓	✓						✓		4
3	Almonda-Tomas (2014)			✓				✓		✓		3
4	Andrade (2020)	✓	✓	✓					✓	✓	✓	6
5	Ardoy (2014)	✓	✓	✓		✓			✓	✓		6
6	Bardaglio (2015)	✓								✓		2
7	Barkoukis (2008)			✓			✓			✓		3
8	Barzouka (2015)	✓		✓						✓		3
9	Bechter (2019)	✓	✓	✓	✓	✓				✓	✓	7
10	Benitez-Sillero (2021)	✓		✓						✓		3
11	Bortoli (2015)	✓		✓	✓					✓		4
12	Borzikova (2020)	✓					✓			✓		3
13	Boyle-Holmes (2010)				✓		✓	✓	✓	✓		5
14	Breslin (2012)	✓		✓		✓	✓		✓	✓		6
15	Browne (2004)	✓								✓		2
16	Carlson (2008)	✓	✓	✓			✓		✓	✓		6
17	Cecchini (2007)	✓	✓	✓	✓					✓		5
18	Cecchini (2020)	✓		✓			✓	✓	✓	✓		6
19	Chatoupis (2017)	✓							✓	✓		3
20	Chatzipanteli (2015)	✓	✓	✓						✓		4
21	Chen (2008)	✓	✓	✓			✓	✓		✓		6
22	Cheon (2019)	✓	✓	✓	✓		✓	✓	✓	✓		8
23	Coe (2006)	✓	✓		✓		✓		✓	✓		6
24	Cohen (2012)	✓		✓						✓		3
25	Coimbra (2021)	✓	✓	✓	✓				✓	✓	✓	7
26	Colella (2019)	✓								✓		2
27	Coster (2018)	✓		✓			✓			✓		4
28	Costigan (2016)	✓	✓	✓	✓	✓		✓	✓	✓	✓	9
29	Cuevas (2016)	✓		✓						✓		3
30	Dalziell (2015)			✓						✓		2
31	Dalziell (2019)			✓	✓		✓			✓	✓	5
32	De Bruijn (2020)	✓	✓	✓	✓	✓			✓	✓	✓	8
33	Digelidis (2003)	✓		✓			✓			✓		4
34	Duncan (2019)	✓	✓	✓	✓				✓	✓	✓	7
35	Eather (2016)	✓	✓	✓	✓	✓			✓	✓	✓	8
36	Ellis (1995)									✓		1
37	Ericsson (2008)			✓			✓					2
38	Ericsson (2014)	✓		✓			✓			✓		4
39	Escarti (2010)			✓			✓			✓		3
40	Felver (2020)	✓		✓	✓					✓		4
41	Fernandez (2017)	✓		✓						✓		3
42	Fisher (2011)	✓	✓	✓	✓	✓			✓	✓		7
43	Font-Llado (2020)	✓	✓	✓	✓	✓			✓	✓		7
44	Franco (2017)	✓		✓	✓					✓		4
45	Fu (2016)	✓		✓	✓				✓	✓		5
46	Garcia-Calvo (2016)	✓		✓	✓				✓	✓		5
47	Gibbons (1995)		✓	✓	✓		✓			✓		5
48	Gibbons (2010)	✓		✓			✓		✓	✓		5
49	Gil-Arias (2017)	✓		✓						✓		3
50	Grasten (2017)	✓		✓			✓		✓	✓		5

(Continued)

TABLE 3 | Continued

Paper No	Paper lead author (Year)	Methodological quality assessment items										No. of criteria met
		A	B	C	D	E	F	G	H	I	J	
51	Grasten (2019)			✓				✓		✓		3
52	Gray (2011)	✓								✓		2
53	Greco (2020)	✓		✓	✓			✓		✓	✓	6
54	Gu (2018)	✓	✓	✓	✓				✓	✓		6
55	Hagins (2016)	✓	✓	✓	✓		✓	✓	✓	✓		8
56	Hartmann (2010)	✓	✓	✓	✓		✓		✓	✓		7
57	Harvey (2017)			✓					✓	✓		3
58	Hernandez (2020)	✓		✓			✓			✓		4
59	Hortz (2008)	✓		✓	✓				✓	✓	✓	6
60	How (2013)							✓	✓	✓		3
61	Ignico (2006)						✓		✓			2
62	Ilker (2013)			✓	✓				✓	✓		4
63	Jaakkola (2006)			✓	✓		✓		✓	✓		5
64	Jamner (2004)			✓	✓				✓	✓		4
65	Jansen (2018)	✓		✓					✓	✓	✓	5
66	Jarani (2015)	✓	✓		✓				✓	✓		5
67	Kalaja (2012)	✓		✓	✓		✓			✓		6
68	Karabourniotis (2002)			✓					✓			2
69	Kiliziene (2018)	✓	✓	✓	✓		✓			✓		6
70	Kokkonen (2019)	✓		✓	✓		✓		✓	✓		6
71	Kouli (2009)								✓	✓		2
72	Kriellaars (2019)			✓	✓		✓		✓	✓	✓	6
73	Kruger (2018)	✓		✓	✓			✓	✓	✓		6
74	Lakes (2004)	✓		✓	✓				✓	✓		5
75	Lander (2017)	✓	✓	✓	✓				✓	✓		6
76	Leptokaridou (2016)	✓		✓	✓			✓	✓	✓		6
77	Lima (2020)	✓	✓		✓		✓		✓	✓		6
78	lisahunter (2014)	✓		✓					✓	✓		4
79	Lonsdale (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	10
80	Lopes (2017)	✓			✓		✓	✓	✓	✓		6
81	Lubans (2018)	✓	✓	✓	✓	✓	✓		✓	✓	✓	9
82	Marshall (1997)			✓	✓				✓	✓		4
83	Martin (2009)	✓		✓					✓			3
84	Martinez-Lopez (2018)	✓	✓	✓	✓	✓			✓	✓		7
85	Mathisen (2016)	✓								✓		2
86	Mayorga-Vega (2012)		✓	✓	✓					✓		4
87	McKenzie (1998)	✓			✓		✓		✓	✓		5
88	Meijer (2021)	✓	✓	✓	✓				✓	✓	✓	7
89	Miller (2016)	✓	✓	✓	✓			✓	✓	✓	✓	8
90	Moreno-Murcia (2019)	✓		✓	✓					✓		4
91	Morgan (2002)			✓						✓		2
92	Neumark-Sztainer (2010)	✓		✓	✓		✓		✓	✓		6
93	Neville (2021)	✓		✓	✓			✓	✓	✓		6
94	Noggle (2012)	✓	✓	✓	✓			✓	✓	✓		7
95	O'Brien (2008)	✓		✓	✓				✓	✓		5
96	Osterlie (2018)	✓	✓	✓	✓					✓		5
97	Pagona (2008)	✓			✓		✓	✓		✓		5
98	Palmer (2018)	✓	✓	✓	✓				✓			5
99	Pardo (2016)	✓		✓	✓		✓		✓	✓		6

(Continued)

TABLE 3 | Continued

Paper No	Paper lead author (Year)	Methodological quality assessment items										No. of criteria met
		A	B	C	D	E	F	G	H	I	J	
100	Perlman (2010)	✓	✓	✓				✓		✓		5
101	Pesce (2012)				✓		✓		✓	✓		4
102	Pesce (2016)	✓	✓	✓	✓			✓	✓	✓	✓	8
103	Pesce (2020)	✓	✓	✓	✓		✓		✓	✓		7
104	Pietsch (2017)	✓	✓	✓					✓	✓		5
105	Platvoet (2016)			✓					✓	✓		3
106	Polvi (2000)			✓	✓		✓			✓		4
107	Potdevin (2018)				✓					✓		2
108	Prusak (2004)		✓	✓						✓		3
109	Reed (2013)			✓			✓		✓	✓		4
110	Robertson (2018)		✓	✓					✓	✓	✓	5
111	Rubeli (2020)	✓		✓			✓	✓	✓	✓		6
112	Sallis (1999)	✓	✓	✓			✓		✓	✓		6
113	Sánchez-Oliva (2017)	✓		✓	✓				✓	✓		5
114	Schmidt (2013)	✓		✓	✓			✓	✓	✓		6
115	Schmidt (2015)	✓	✓	✓	✓				✓	✓		6
116	Schmidt (2015a)	✓	✓	✓	✓			✓	✓	✓	✓	8
117	Schnider (2021)	✓	✓						✓	✓	✓	5
118	Sgro (2020)			✓	✓					✓		3
119	Sharpe (1995)						✓					1
120	Sparks (2017)	✓	✓	✓	✓	✓		✓	✓	✓	✓	9
121	Spittle (2009)			✓					✓	✓		3
122	Stodjadinovic (2020)	✓			✓				✓	✓		4
123	Sun (2012)		✓	✓	✓			✓	✓	✓		6
124	Telford (2012)	✓	✓	✓	✓		✓		✓			6
125	van Beurden (2003)		✓	✓			✓	✓	✓			5
126	van der Fels (2020)	✓	✓	✓					✓	✓	✓	6
127	Velez (2010)			✓	✓					✓		3
128	Viciana (2020)	✓		✓	✓				✓	✓		5
129	Wallhead (2004)	✓	✓	✓	✓		✓		✓	✓		7
130	Wallhead (2014)			✓	✓		✓			✓		4
131	Weiss (2015)			✓			✓		✓	✓		4
132	Yli-Piipari (2018)	✓		✓					✓			3
133	You (2013)			✓				✓		✓		3
134	Zhu (2016)							✓		✓		2
135	Zourbanos (2013)							✓	✓	✓		3
% of criteria present		70%	37%	81%	54%	9%	35%	21%	61%	94%	16%	

How Much Does the Effect Size Vary Across Studies (Heterogeneity)?

The Q-value is 2481.377 with 134 degrees of freedom and $p < 0.001$. Thus, we acknowledge that the true effect size is not identical in all studies. The I^2 is 94.600% representing the proportion of the observed variance that was indicative of changes in true effect sizes rather than sampling error. The T^2 is 0.069 representing the variance of true effect sizes and T is 0.262. The prediction interval is −0.198 to 0.846 therefore we would expect the true effect size for 95% of all students receiving the interventions to fall within this range.

To What Extent Would Publication Bias or the Small-Study Effect Alter These Findings?

The Classic fail-safe analysis showed that the incorporated data from the 135 observed studies yielded a z-value of 34.888 and corresponding 2-tailed $p < 0.0001$. The fail-safe N suggests that 12,641 "null" effects would need to be included for a combined 2-tailed $p > 0.05$ (i.e., for the reported effect to be nullified).

Duval and Tweedie (2000) "Trim and Fill" results suggest that 18 small studies should be trimmed from the right of the mean to determine the true "center" of the funnel plot and replace them with missing equivalents around the

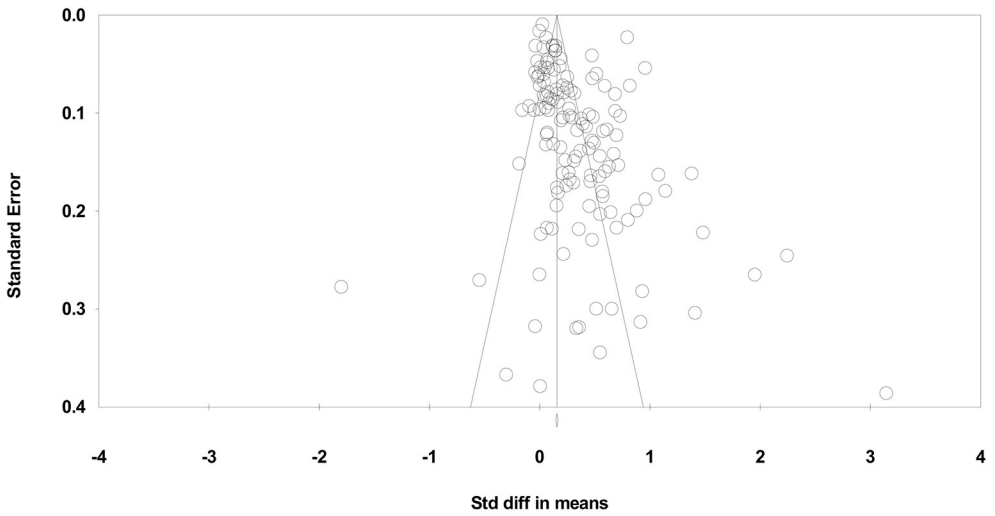

FIGURE 2 | Funnel plot of standard error by standardized difference in mean of combined learning effects.

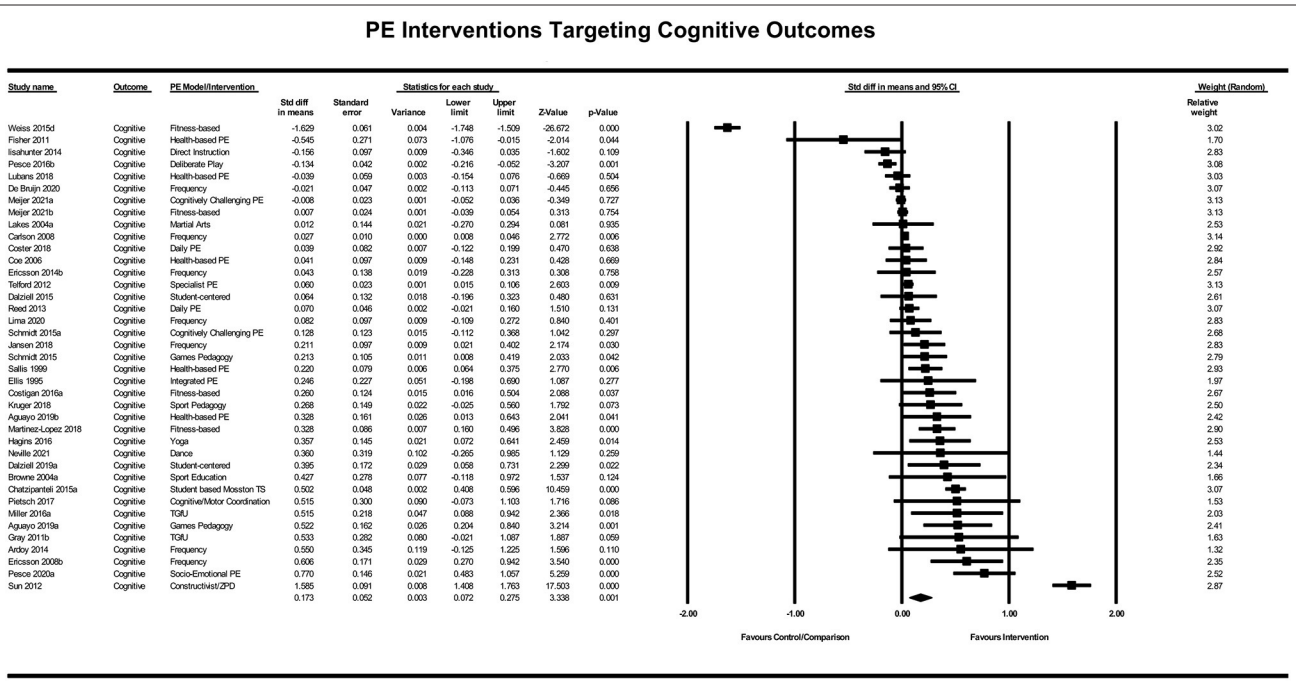

FIGURE 3 | Forrest plot of standardized difference in means of cognitive PE interventions.

center. The adjusted standardized effect size of the included PE interventions was increased from $d = 0.32$ to $d = 0.40$ (see **Figure 2**).

Cognitive Learning and Development

There were 37 studies employing 39 PE intervention strategies that sought to improve cognitive learning or development, therefore 39 effect sizes are captured in this meta-analysis. Of these 37 studies, 68% ($n = 25$) of the papers met five or more of the quality assessment criteria.

Which Physical Education Interventions Most Affect Students' Cognitive Learning and Development?

The included physical education interventions had a significant positive effect on cognitive outcomes, $Z = 3.338$, $p < 0.001$. The standardized difference in means for all cognitive interventions was $d = 0.17$ (95% CI [0.072, 0.275]; see **Figure 3**), meaning that on average, students receiving an intervention improved their cognitive learning or development by nearly a fifth of a standard deviation compared with those students who did not receive the same intervention.

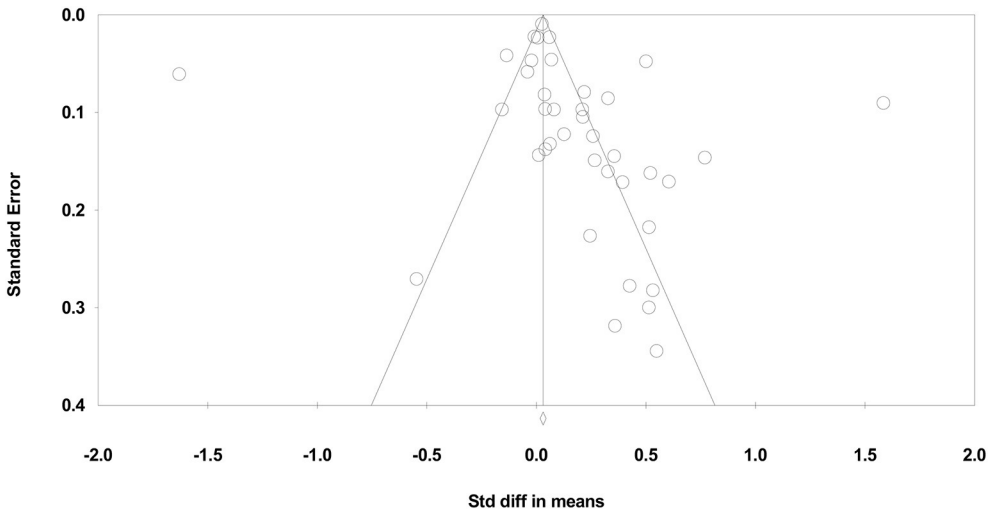

FIGURE 4 | Funnel plot of standard error by standardized difference in means of cognitive PE interventions.

Only one PE intervention strategy (represented by three or more studies) had an average effect size on cognitive learning and development that was higher than the domain average of $d = 0.17$. This strategy was to adopt games-based approaches (4 studies; $d = 0.38$), which included the Teaching Games for Understanding model (Bunker and Thorpe, 1983). Most strategies that were represented by three or more studies fell below the domain average of $d = 0.17$. These included (a) increased PE frequency (7 studies; $d = 0.10$); (b) health-based/PA promoting PE (5 studies; $d = 0.06$) and; (c) fitness-based PE (4 studies; $d = -0.26$).

Heterogeneity of Cognitive Effects

The Q-value for effects in the cognitive domain was 1269.249 with 38 degrees of freedom and $p < 0.001$. The I^2 is 97.006%, T^2 is 0.086 and T is 0.293. The prediction interval is −0.4310 to 0.7770 and therefore expect the true effect size for 95% of all students receiving a PE intervention to improve cognitive learning to fall within this range.

To What Extent Would Publication Bias Alter These Findings?

The results of the Classic fail-safe analysis showed that the incorporated data from 39 effects yielded a *z*-value of 7.793 and corresponding 2-tailed $p < 0.0001$. The fail-safe N in this case is 578 suggesting that this many "null" effects would need to be included for a combined 2-tailed $p > 0.05$ (i.e., for the effect to be nullified). According to the "Trim and Fill" analysis, 15 effects could be trimmed from the left of the mean to reduce the potential publication bias. The adjusted standardized effect size for PE interventions on cognitive learning in this case would be decreased to d=-0.02 (see **Figure 4**).

Social Learning and Development

There were 25 studies with 29 PE intervention strategies that examined social learning and development in PE. Of these 25 studies, 40% ($n = 10$) met five or more of the quality assessment criteria outlined by Van Sluijs et al. (2007).

Which Physical Education Interventions Most Affect Students' Social Outcomes?

The included PE interventions had a significant positive effect on social learning and development, $Z = 3.604$, $p < 0.001$. The standardized difference in means was $d = 0.32$ (95% CI [0.146, 0.493]; (see **Figure 5**), meaning that students receiving a new instructional design or intervention improved their social learning or development by just under a third of a standard deviation compared with those students who did not receive the intervention.

The PE intervention pedagogy (with three or more studies) that yielded a combined average effect above the domain average of d=0.32 were the cooperative learning strategies (4 studies; $d =$ 0.42). There were an insufficient number of studies employing a similar intervention strategy to analyse those that are likely to consistently fall below the hinge point for social learning and development.

Heterogeneity of Social Effects

The Q-value for these effects is 643.085 with 28 degrees of freedom and $p < 0.001$ ($I^2 = 95.646\%$; $T^2 = 0.193$; $T = 0.439$). The prediction interval is −0.6006 to 1.2386. We would expect the true effect size for 95% of all students receiving a social learning PE intervention to fall within this range.

To What Extent Would Publication Bias Alter These Findings?

The results of the Classic fail-safe analysis showed that the incorporated data from 29 effects yielded a z-value of 15.665 and corresponding 2-tailed $p < 0.0001$. The fail-safe N in this case is 1,824. The "Trim and Fill" analysis indicates no studies should be trimmed from the left or right of the mean to reduce the potential publication bias (see **Figure 6**).

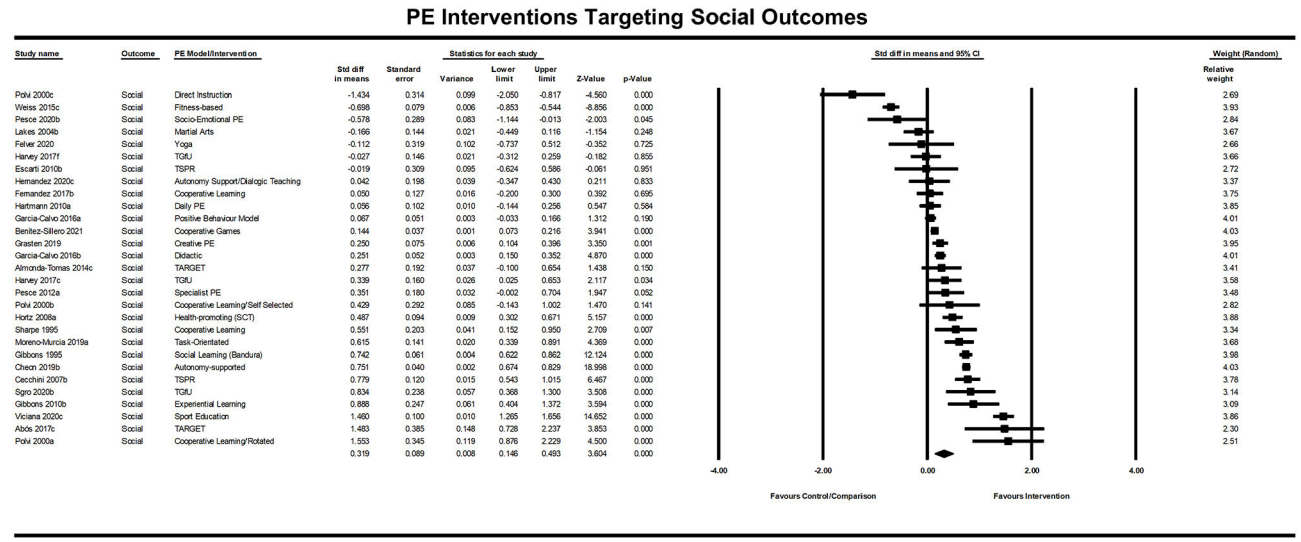

FIGURE 5 | Forrest plot of standardized difference in means of social PE interventions.

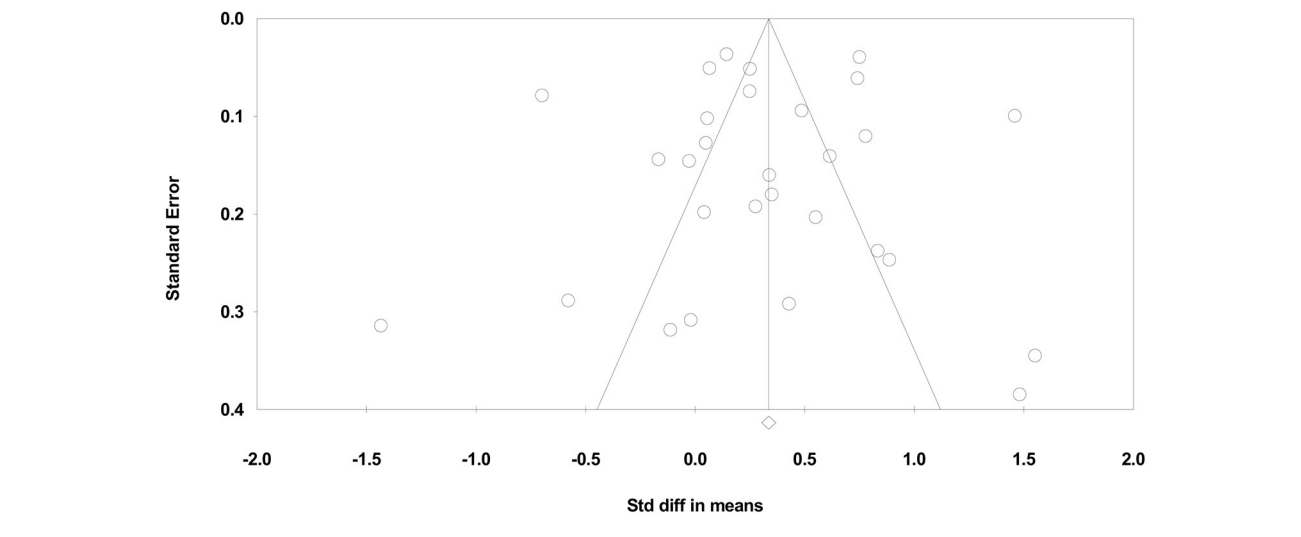

FIGURE 6 | Funnel plot of standard error by standardized difference in means of social PE interventions.

Psychomotor Learning and Development

There were 51 studies with 55 independent or combined effect sizes that examined psychomotor learning and development. 45% ($n = 23$) of these 51 papers met five or more of the quality assessment criteria.

Which Physical Education Interventions Most Affect Student Psychomotor Learning and Development?

The included PE interventions had a significant positive effect on psychomotor outcomes, $Z = 9.682$, $p < 0.001$. The standardized difference in means was $d = 0.52$ (95% CI [0.414, 0.624]), meaning that students receiving the intervention improved their psychomotor learning and development by just over a half of a standard deviation on average relative to those students who did not receive the intervention (see **Figure 7**).

The PE intervention strategies (represented by three or more studies) that yielded a combined average effect size on psychomotor learning or development above the domain average of $d = 0.52$ were (a) fitness-based/infused PE models (5 studies; $d = 0.56$); (b) Games-based and Teaching Games for Understanding approaches (5 studies; $d = 0.58$); (c) Mastery and TARGET (Epstein, 1987) PE models (4 studies; $d = 0.73$); (d) Sport Education (Siedentop, 1998) Model (4 studies; $d = 0.61$); and (e) increased frequency of PE (3 studies; $d = 0.61$). Interventions with three or more studies that had an average effect size below the domain-average "hinge point" were the health-based/PA promoting interventions (5 studies; $d = 0.13$).

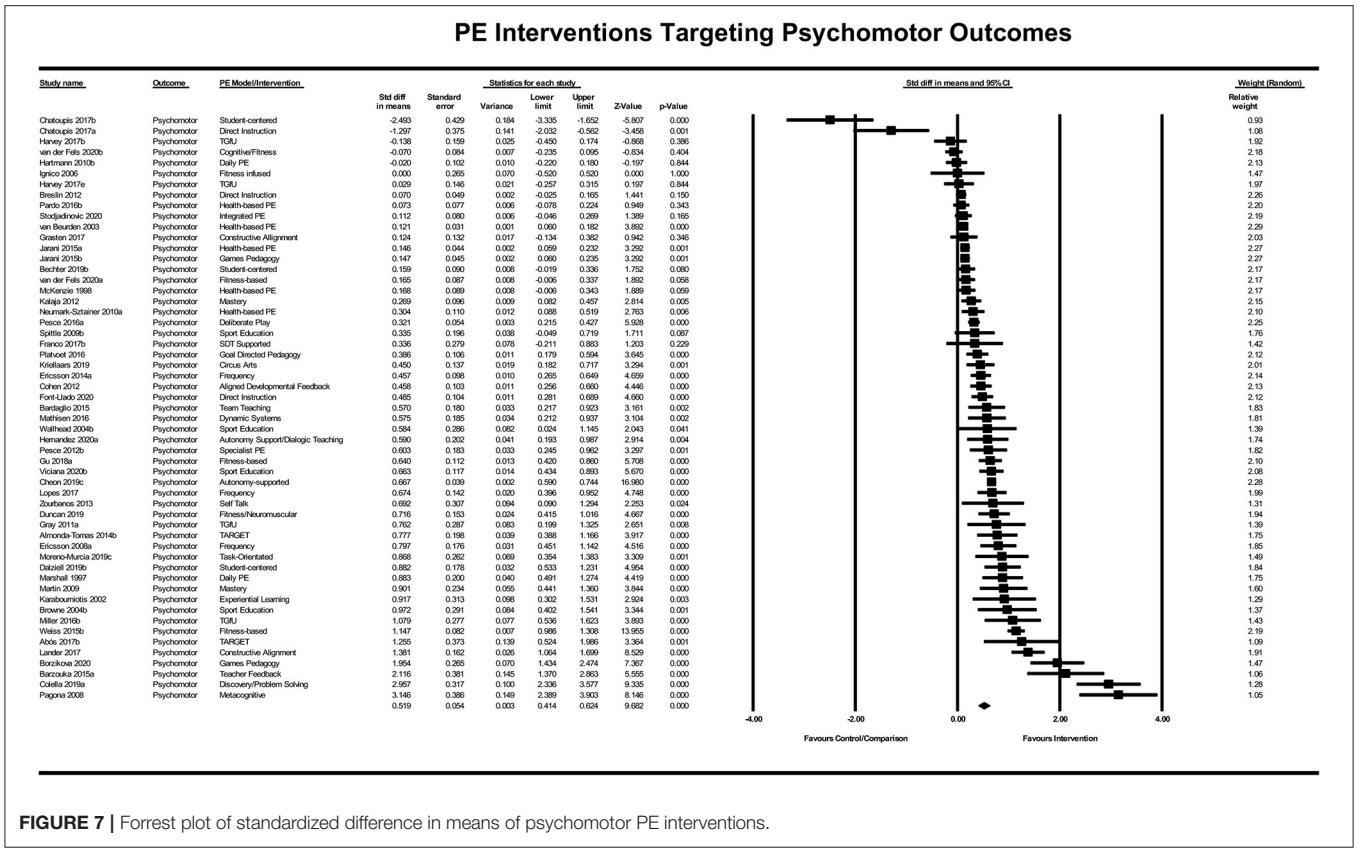

FIGURE 7 | Forrest plot of standardized difference in means of psychomotor PE interventions.

Heterogeneity of Psychomotor Effects

The Q-value for these effects was 753.063 with 54 degrees of freedom and $p < 0.001$ ($I^2 = 92.829\%$; $T^2 = 0.124$; $T = 0.353$). The prediction interval is −0.1954 to 1.2334 with the true effect size for 95% of all students receiving the interventions to fall within this range.

To What Extent Would Publication Bias Alter These Findings?

The results of the Classic fail-safe analysis showed that the incorporated data from 54 effects yielded a *z*-value of 26.085 and corresponding 2-tailed $p < 0.0001$. The fail-safe N in this case is 9688. The "Trim and Fill" analysis indicates no studies should be trimmed in the random effects model from either side of the mean to reduce the potential publication bias (see **Figure 8**).

Affective Learning and Development

There were 69 studies with 71 calculated effect sizes that examined affective learning. 54% ($n = 37$) of these papers met five or more of the methodological quality assessment criteria.

Which Physical Education Interventions Most Affect Student Affective Learning?

The included PE interventions had a significant positive effect on affective learning, $Z = 9.339$, $p < 0.001$. The standardized difference in means for all affective learning interventions was $d = 0.47$ (95% CI [0.370, 0.567]; see **Figure 9**), meaning that on average, students receiving the intervention improved their affective learning by just under a half of a standard deviation compared with those students who did not receive the intervention.

There were multiple PE intervention strategies focusing on affective learning that were represented by three or more studies and yielded a combined average effect size above the standardized mean effect for affective learning ($d = 0.47$). These included (a) Mastery and TARGET PE models (9 studies; $d = 0.54$); (b) Interventions based on autonomy support, student choice, or Self Determination Theory (8 studies; $d = 0.74$); and (c) Practices incorporating Sport Education (7 studies; $d = 0.67$). PE intervention with three or more studies had an average effect size below the standardized mean effect for this domain were (a) fitness-based PE models (7 studies; $d = 0.45$); (b) Practices incorporating Teaching Games for Understanding (4 studies; $d = 0.45$); and (c) health-based/PA promoting interventions (8 studies; $d = 0.11$).

Heterogeneity of Affective Effects

The *Q*-value for these effects is 1072.120 with 70 degrees of freedom and $p < 0.001$ ($I^2 = 93.471\%$; $T^2 = 0.149$; $T = 0.385$). The prediction interval is −0.309 to 1.245 with the true effect size for 95% of all students receiving the interventions to fall within this range.

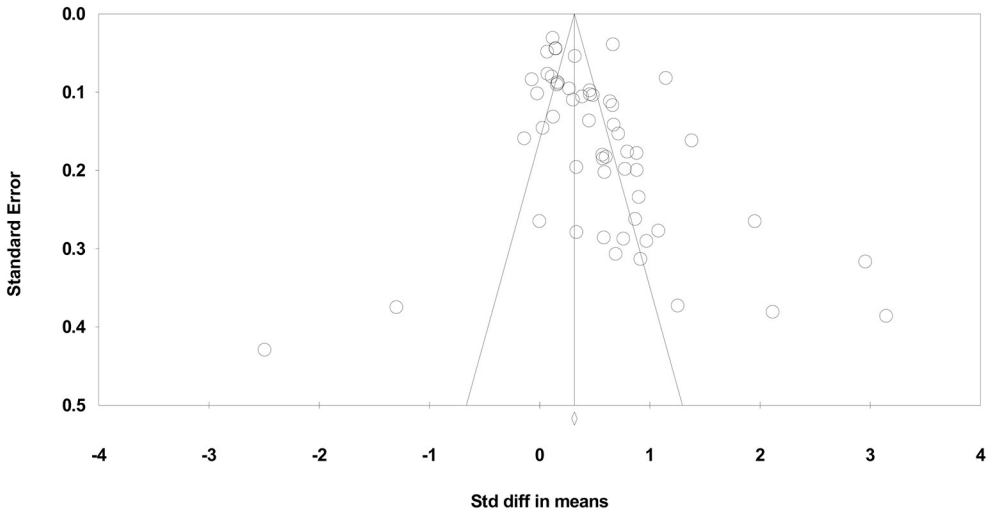

FIGURE 8 | Funnel plot of standard error by standardized difference in means of psychomotor PE interventions.

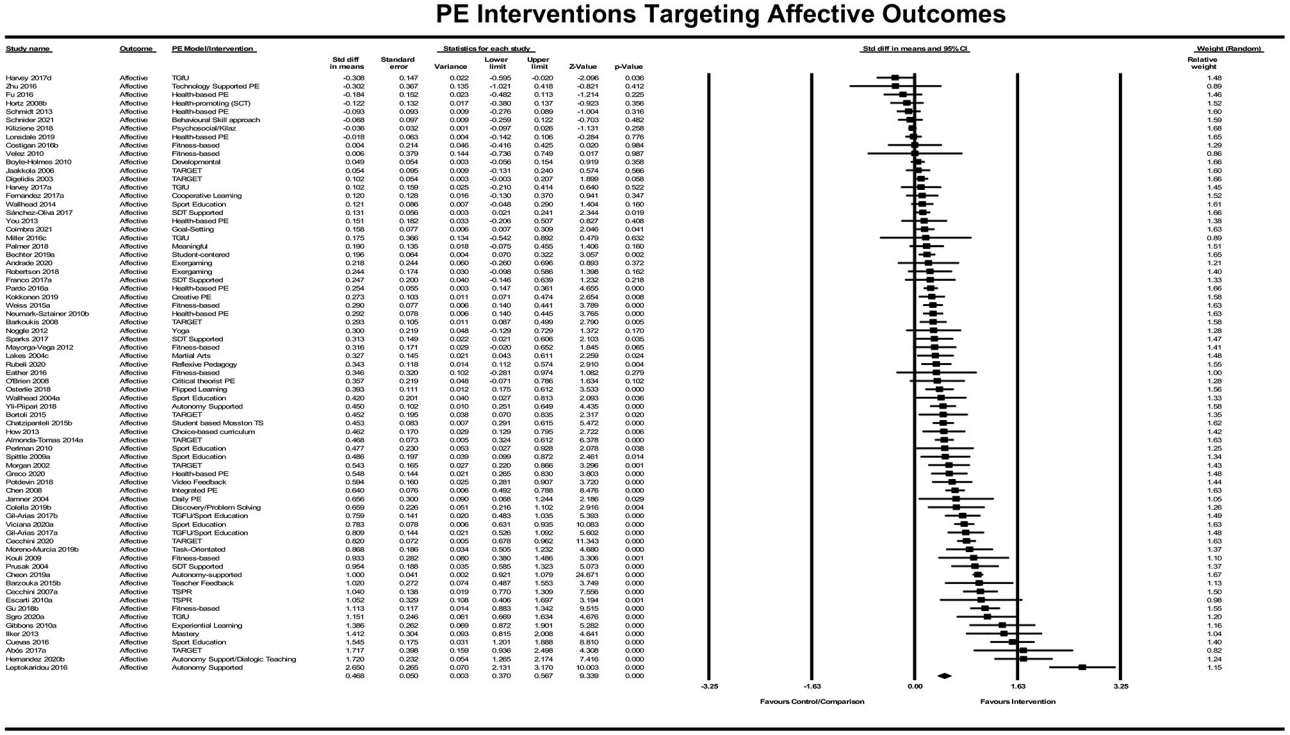

FIGURE 9 | Forrest plot of standardized difference in means of affective PE interventions.

To What Extent Would Publication Bias Alter These Findings?

The results of the Classic fail-safe analysis showed that the incorporated data from 71 effects yielded a z-value of 28.241 and corresponding 2-tailed $p < 0.0001$. The fail-safe N in this case is 4671. The "Trim and Fill" analysis indicates eight studies should be trimmed from the right of the mean to reduce the potential publication bias resulting in an increased adjusted standardized effect size of $d = 0.55$ (see **Figure 10**).

DISCUSSION

The aim of the systematic review and meta-analysis was to systematically evaluate the impact of different PE lessons,

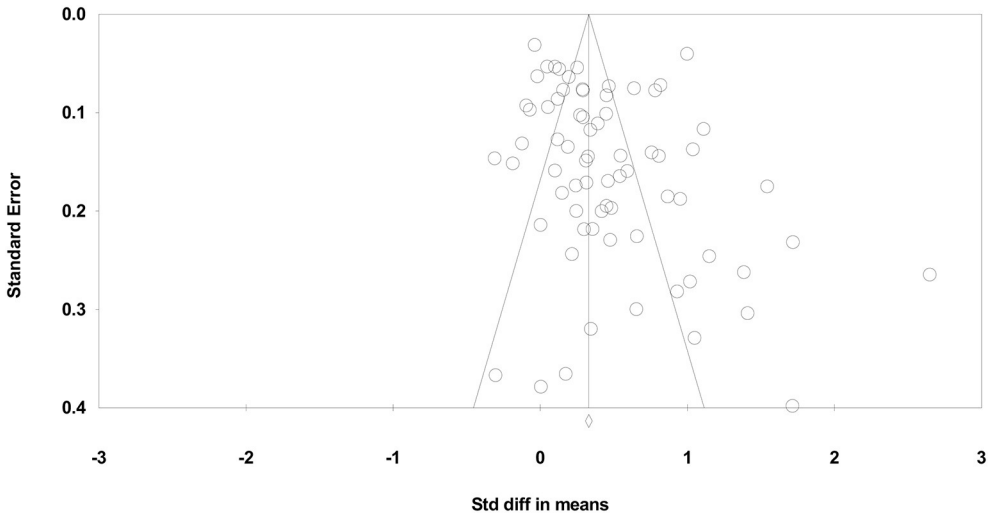

FIGURE 10 | Forrest plot of standardized difference in means of affective PE interventions.

instructional designs, and interventions on students' psychomotor, cognitive, affective, and social learning and development. Across the 135 studies found, there was a significant effect of PE interventions on all four domains of interest. Thus, not only can PE operate as a mechanism for enhancing learning and development broadly, specific interventions also have additive impacts over and above regular PE classes. These quantitative meta-analytic findings support the qualitative synthesis of Bailey (2006) in highlighting the multi-domain benefits of PE for development. Further, they also support claims from a range of researchers (e.g., Dudley, 2015; Cairney et al., 2019; Whitehead, 2019; Barnett et al., 2021) about the importance of the specific instructional techniques in supporting these learning and developmental outcomes to a stronger or weaker degree.

To extend our analysis of the role of PE in supporting students' learning and development, we considered the relative effect sizes between and within domains (psychomotor, cognitive, affective, and social). We note above the importance of effect sizes for comparing results across different measures, groups, and intervention designs (Glass et al., 1981; Hattie, 2009). For Hattie's (2009) analysis of the impacts related to student academic achievement, for example, the average effect equated to $d = 0.4$ (Hattie, 2009). While Hattie's (2009) analysis did not investigate PE interventions specifically, the fact that the current study finds a similar overall effect of $d = 0.4$ is important. PE interventions designed to improve student learning from a holistic multi-domain perspective are comparable to the plethora of educational studies around the world that have focused on academic achievement specifically.

An additional layer of complexity in our meta-analysis, missing from other meta-analyses of PE interventions to date, is that our data was of sufficient size and clarity to deaggregate by learning domain. Importantly, and notwithstanding our positive overall effects, we also found variation in the magnitude of specific interventions both between and within our domains of interest. Interventions for psychomotor and affective outcomes reported larger average effect sizes than for the standardized mean effect of all four domains combined ($d = 0.40$), for example, whereas cognitive and social learning interventions for cognitive and social outcomes frequently had effect sizes lower than this point.

There are two alternative explanations for this pattern of differences between domains. First, the disparities between domains may mean that QPE programs invest their time, money, and human resources in psychomotor and affective outcomes and not cognitive and social outcomes. Indeed, other subject areas and intervention sites within a broad school curriculum may be better placed to serve the cognitive and social learning needs of students. The effect sizes that we observed within each domain also appear comparable with the limited extant research on PE interventions, suggesting that these are relatively robust between-domain differences. For example, two recent reviews of PE reported medium to large positive effects on overall motor competence [i.e., $g = 0.69$ (Lorås, 2020) and ES = 0.52 (Jiménez-Díaz et al., 2019)], when compared against usual PE practice. Likewise, a recent meta-analysis of 26 studies investigating the effect of physical activity on cognitive achievement (Alvarez-Bueno et al., 2017), measured as language, mathematics, and overall performance, reported pooled effect sizes of between $d = 0.16$–0.30. Despite the robustness of our findings within domain, however, it is important to remember that effects *between* domains may not be directly comparable.

Second, and in contrast to our first explanation, the disparity in intervention effect size for psychomotor and affective development relative to cognitive and social development may simply suggest that some outcomes of interest develop more slowly than others. Observable changes in our cognitive and social outcomes of interest may emerge in smaller increments and across longer periods of time. Consistent with this explanation,

we note that non-PE interventions to enhance students' social skill have similarly small, but important, effects as observed in our study: we observed an average effect for PE interventions on social learning and development of 0.32, while January et al. (2011) meta-analysis of school-wide interventions showed an average effect size on social skill of just 0.15. When considered in this light, PE interventions that target social learning and development appear particularly strong. Given our robust evidence that growth in development following PE intervention is possible across all domains, we recommend that teachers and schools seek to nurture learning and development using interventions selected above the hinge point within each domain.

Perhaps the most important findings of our meta-analysis were those showing the heterogeneity of different PE interventions on learning and development within each of the four domains. Dudley et al. (2017) argue that agencies invested in QPE, need to evaluate where their contributions to lifelong physical activity participation lie. To date, however, no research has systematically considered which PE intervention strategies are the most effective mechanisms for learning and development of school-aged youth. Our findings are therefore valuable in highlighting which intervention approaches are most successful for what developmental and learning outcomes. Within the cognitive domain, for example, the most common interventions cited as having positive impacts on cognition in the existing literature focus on increasing the amount of PE students complete (Sattelmair and Ratey, 2009) or the amount of physical activity they engage in Erickson et al. (2019). In our meta-analysis, however, we discovered that physical activity-based strategies were consistently the weakest of the PE strategies employed. Instead, games-based approaches appear to have stronger impact in this domain. This finding is consistent with recent meta-analytic research by García-Hermoso et al. (2021), who also found very small to non-significant effects for quantity-based PE interventions, and offers evidence for educators about which types of intervention have greatest cognitive benefit.

Our finding in favor of games-based approaches for cognitive development is relevant given that PE itself may take different forms. A study of the history of PE shows evolutions from gymnastics, calisthenics and fitness to sport and games in the post-war years, where it was eventually integrated with other academic pursuits (Dudley et al., 2020). The 1990's saw PE take a marked shift toward health-promotion and physical activity, spurred on by the rise of non-communicable diseases, before moving again in the past 5–7 years to a focus on UNESCO's QPE model (Dudley et al., 2020). As noted previously, however, the mechanisms for best achieving the QPE agenda for the interconnected and holistic development of youth (Dudley, 2015; Whitehead, 2019) are not well-known. While we were unable to compare the influence of the various intervention strategies in our meta-analysis on specific cognitive outcomes, such as attention, executive function, or other cognitive processing outcomes vs. conceptual learning and academic performance outcomes, our findings nonetheless highlight the need for more nuanced conversations about where our PE intervention investments should lie. If PE is to serve as a mechanism for the development of cognitive processes and cognitive learning outcomes, among other outcomes, a renewed focus on games-based pedagogies should be considered as part of QPE instruction.

There were also a few pedagogically driven PE interventions that reported effect sizes consistently above the hinge point across more than one learning domain. Whilst games-based pedagogies reported and average of $d = 0.38$ in the cognitive domain (hinge point—$d = 0.17$) it also reported an average effect of $d = 0.58$ in the psychomotor domain (hinge point—$d = 0.52$). Likewise, Mastery Teaching/TARGET interventions based on Epstein (1987) reported effects sizes of $d = 0.94$ and $d = 0.73$ and Sport Education interventions based on Siedentop (1998) reported effects sizes of $d = 0.67$ and $d = 0.61$ in the affective (hinge point—$d = 0.47$) and psychomotor learning domains, respectively. Conversely, health-based/PA promoting PE interventions reported average effect sizes below the hinge point in the cognitive ($d = 0.06$), affective ($d = 0.11$), and psychomotor ($d = 0.13$) domains.

These findings are important as the field can no longer accept that PA participation in PE alone will drive sufficient learning and development of students. Furthermore, this study vindicates and extends Hattie's (2009) contention that the art of teaching (in this case, in PE) requires deliberate intervention to ensure there is cognitive (and affective, social, and psychomotor) change in the student. The key ingredients of which are awareness of the learning and development intentions of PE and knowing enough about the pathway a student must undertake to grow and make connections in their newly acquired learning (Hattie, 2009). Future research is needed however to identify whether these strategies are consistent across years of schooling (pre, primary, and secondary) and whether there are critical points in student development where they achieve optimal effect.

Identifying the intervention strategies that the improve psychomotor, cognitive, social, and affective domains in an interconnected fashion and yield greater than average growth is a necessary step forward in actualising a QPE agenda (McLennan and Thompson, 2015).

Limitations

While the present meta-analysis offered important insights regarding the role of specific PE interventions in supporting development within our domains of interest, there were four limitations of note. First, the study did not investigate dosage (that is, duration of interventions) for any of the intervention methods. For this reason, all comparisons should be considered a function not just of specific pedagogical approach but also potentially the way in which that program was implemented. Evidence to support the importance of dosage is mixed. While Lorås (2020), showed that duration of PE classes does not moderate the effect of specific intervention strategies on motor competence, Dudley and Burden's (2020) recent meta-analysis found a positive effect for increasing the frequency of classes. Across three learning domains (cognitive, psychomotor, and affective), with six included studies, the pooled effect-size of PE frequency on student outcomes was $d = 0.41$. While a similar focus on dosage was beyond the scope of the current study, we recommend that future research tease apart the effects of

PE instructional design and PE frequency to determine their independent and combined contributions of each to student learning and development.

Second, for studies with multiple longitudinal follow-up assessments, it was also necessary to adopt a single post-intervention measurement point: in this case, the last assessment completed. We recommend that future research also consider the trajectory of change over time following promising interventions to determine how well (and for how long) their effects are maintained within each of our four domains.

Third, we did not weigh our evidence according to any formal hierarchy (e.g., for randomized controlled trials, controlled trials, or quasi-experimental studies in turn), although our analysis of methodological quality nonetheless offers opportunities to consider the strength of the reported study details when interpreting results. We recommend that future research also consider separating these designs such that conclusions about each may be compared and sampling biases understood.

Also, as in any meta-analysis, it should be noted that the instruments used to collect data for all of the four domains differed between studies. Some studies used subjective instruments and some used objective instruments to measure the same constructs, for example, while constructs themselves also varied within each domain. Moreover, as discussed above, development in some domains is inherently harder or slower to shift than in others. Finally, specific outcome measures that are common within each domain may also be more or less sensitive than others. Discretion is required to interpret our broad statistical trends in light of these conceptual and experimental differences.

CONCLUSION

The rise of the UNESCO QPE agenda has important educational implications for student learning and development across four domains: cognitive, social, affective, and psychomotor. To date, however, no research has considered the impact of specific PE interventions within these domains. Such analysis is critical for determining how best to allocate the limited resources that are directed to PE globally, nationally, and locally, and for ensuring that our structural and pedagogical interventions yield the greatest potential benefits for students. Importantly, we found that almost all interventions in PE can stake a claim to making a positive difference to student learning and development. Moreover, these benefits extend across four domains: cognitive, affective, psychomotor, and social. If we continue to set the "efficacy" bar at zero, therefore, it is of little surprise that so many PE interventions claim victory in improving student outcomes. By instead considering interventions with greater than average effect within each domain, we highlight intervention approaches that are likely to enhance learning and development to the greatest extent. This is the first known study to provide clarity on where those structural and pedagogical investments lie.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

DD, EM, and PV conceptualised the study. DD designed, performed, and analyzed all the research. PV, EM, and JC screened articles and extracted data. JC provided critical feedback and manuscript input. LB assisted in the design of the study. DD, PV, EM, and LB wrote up the research whilst also critically reviewing and editing the manuscript. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.799330/full#supplementary-material

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The Influence of Shared Intentions With Others in Physical and Cognitive Tasks That Require Collaborative Solving in Elementary School

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Developing the competence to share intentions with others is an important role of elementary schools for the children's future well-being. We analyzed and clarified the relationship between physical and cognitive tasks that require collaborative solving to cultivate the skill of sharing intentions with others through human movement. As a physical task, we designed a tag game in which two defenders prevented three attackers from passing through to reach the goal line. We focused on the defenders' movement in the game and analyzed the efficiency of each defender's movement as an individual behavior and the interpersonal distance between these two defenders as a pair behavior. As a cognitive task, we examined pair activities when understanding concepts in math classes. We observed talking and listening behaviors during the pair activities and analyzed the responsive behavior as an individual behavior, which comprised responsive utterances and active listening from the listener's gaze direction. Role change during pair activities in math lessons was analyzed as a pair behavior. We then analyzed the relationship between behaviors in both tasks. The hypotheses were as follows: (1) task constraints lead to an interaction between individual and pair behaviors in both tasks and (2) individual and pair behaviors in the two tasks have similar characteristics. The results from both tasks support the first hypothesis that the efficiencies of individual movement and interpersonal distance in the tag game and the frequencies of responsive behavior and role changes in the pair activities in math classes are positively correlated. The results also support the second hypothesis that the individual and pair behaviors in the two tasks are significantly correlated. These results suggest that the competence to share intention with others is fundamental regardless of the task nature: physical or cognitive. The findings suggest that the task constraints of joint action in physical education lead to an understanding of the task goals and to exploring the solution for winning. These experiences might be generalized to all cognitive tasks for cultivating the competence to share intentions with others.

Keywords: tag game, pair activity, efficiency of individual movement, interpersonal distance, responsive behavior, role change

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INTRODUCTION

Cultivating the Competence to Share Intentions With Others in School Education

The Organization for Economic Co-operation and Development [Organisation for Economic Co-operation and Development [OECD], 2018] presents the OECD learning compass as a framework to achieve a desirable future for education. As its central concept, "agency" refers to the sense of responsibility to influence people, object, and the environment through social participation. To become an agent, one must collaborate with others to find and solve problems. Because people live in a dynamic and uncertain environment where they cannot understand everything, competence in inferring (Cohen, 1995) and in sharing (Tomasello, 1999, 2009) intentions are essential to finding and solving problems with others. Aside from the acquisition of scientific knowledge, the future of education calls for competence in inferring and sharing others' intentions.

The competence to infer and share the intentions of others has been examined in the learning sciences as collaborative problem-solving skills (Miyake, 1986; Shirouzu et al., 2015) and general classroom social norms (Cobb et al., 2001). Collaborative problem-solving skills improve in quality as they build on domain-specific learning experiences. General classroom social norms develop through interaction with "sociomathematical norms" (Yackel and Cobb, 1996). Both have commonly been examined in the process of solving domain-specific cognitive tasks. As such, current school education mainly depends on developing domain-general skills while exploring domain-specific or interdisciplinary cognitive tasks. Schools mainly adopt a cognitive approach. In fact, Battelle for Kids (2019) lists English, reading or language arts, world languages, arts, mathematics, economics, science, geography, history, government, and civics as subjects designed to foster 21st-century skills. Even in the arts, collaboration is assumed to develop through verbal communication (Dean et al., 2010).

Sharing Intentions With Others as the Foundation of the Sensorimotor System

The development of the sensorimotor system is fundamental to achieving competence in inferring or sharing the intentions of others. Mascolo and Fischer (2015) described the developmental tiers of empathy with others as beginning with reflexes shortly after birth, recognizing the relationship between one's own experience and that of others through sensorimotor actions, and developing representational concepts. In a more detailed overview of human development, we found that infants synchronize their rhythms with others shortly after birth (Kato et al., 1983; Provasi et al., 2014). Specifically, at the age of 6 months, infants show dyadic engagement in sharing behaviors and emotions. Individuals generally interact with others through emotional expression and turn-taking behaviors. At the age of 9–12 months, infants start showing triadic engagement in sharing goals and perceptions. At this stage, an infant may interact with a goal-directed agent toward a shared goal, and both may interact perceptually to monitor the goal-directed behavior and perceptions of their partner (Tomasello, 1999; Tomasello et al., 2005). In this developmental stage, infants understand others as intentional agents in goal-directed behavior by following the actions and attention of such agents. Moreover, cooperative engagement to select plans and share intentions becomes possible through the following three types of social cognition (Tomasello, 1999). The first is "joint attentional scenes," through which infants understand others' intentions and share context with others. The second is "communicated intentions," through which infants understand others' intentions toward their own state of attention. The third is "role-reversal," through which infants understand the roles of others and the self and can exchange roles when necessary. Even among young children, intentions can be shared because they can learn from watching and listening to others, as demonstrated by statistics, informal experiments, and Bayesian inference (Gopnik, 2012; Gopnik et al., 2017).

In other words, human development begins with empathetic identification through the physical synchronization and expression of emotions. The understanding and sharing of intentions with others emerge from physical information such as gaze direction and action based on the self–other distinction. This physical information then develops into domain-specific cognitive and physical tasks. In elementary school education, where the sensory-motor system is not sufficiently developed, it is important to have experiences of inferring and sharing the intentions of others through human movement interactions.

A Joint Action Requires the Sharing of a Goal and Intention

Recently, many studies have examined "joint action," which requires the sharing of intentions and goals with others. Knoblich et al. (2011) classified joint actions into "planned" and "emergent" coordination. Planned coordination involves intentional efforts to achieve a common goal, and consists of shared task representations and joint perceptions. Joint action is driven not only by action plans that specify individual contributions but also by action plans that specify joint action outcomes at the group level (Kourtis et al., 2019). In particular, complex tasks indicate that complementing rather than synchronizing actions may lead to superior task outcomes (Wallot et al., 2016). Meanwhile, emergent coordination refers to the spontaneous coordinated actions occurring through bottom-up perception–action coupling without a shared plan. This can be considered as the result of entrainment (Néda et al., 2000; Richardson M. J. et al., 2007), affordances (Gibson, 1977), perception–action matching (Calvo-Merino et al., 2005; Cross et al., 2006), or action simulation (Aglioti et al., 2008). Notably, many joint actions include both emergent and planned coordination to facilitate collective behavior (Richardson D. C. et al., 2007; Knoblich et al., 2011). Emergent cooperation within planned cooperation enables maintaining jointness and cooperation. Consequently, the cognitive effort to achieve a common task goal is reduced (Milward and Carpenter, 2018).

Tomasello (1999) suggested that "joint attentional scenes," "understanding [of] communicative intention," and "role

reversal" are the bases of social cognition in language acquisition. In a joint attentional scene, the purpose shared is perceived as "what we are doing," rather than merely looking at the same object. While the purpose is shared, planned coordination develops through the understanding of communicative intention, where pairs share what they are doing in order to direct attention to each other. In other words, the constraints of the task, which require sharing the task and coordinating, are essential to the establishment of a joint action, in contrast to performing the task separately.

Required Individual Behavior for Joint Action

One example of a joint action that requires a shared goal and intention is interpersonal sports. Because sports unfold continuously, the emergent movements are created through planned coordination. Kijima et al. (2012) examined the changes in strategies in repeated competitive situations in one-on-one "play-tag" by observing the movements of two players and interpersonal distances. They found that as the game was repeated, participants guessed the intentions of others and chose a not-to-lose strategy, resulting in a deadlock situation. This study demonstrates that an understanding of each other's intentions in competing joint actions is observable through interpersonal distance. In addition, Yokoyama and Yamamoto (2011) found that expert triad coordination requires sharing intentions with two other partners in a three vs. one ball-possession task. Yokoyama et al. (2018) quantified social forces consisting of spatial, avoiding, and cooperative forces, which were critical for successful triad coordination. In other words, in group sports, proficiency appears in individual movements (distance and angle, among others) within triad coordination. The authors suggested that sports skills include not only individual skills such as running and ball handling but also interpersonal skills to cooperate with others. In sports activities, quick decision-making and execution are necessary to respond to others' various movements. Thus, interpersonal coordination that is based on shared intention might help in achieving the team's goal. Successful interpersonal coordination in sports requires each individual to infer what information others perceive from the environment and then share their intentions with each other.

Another example of a joint action that requires the sharing of goals and intentions is a collaborative cognitive task. The listener must pay attention to the content of the conversation and understand the thoughts of the other person while listening. Meanwhile, the speaker must convey his or her thoughts to the listener while simultaneously choosing content that matches the other person's understanding. For example, one way to check whether the listener is interested in the dialog and is trying to understand what the speaker is saying is through nodding or the "back channel" (Yngve, 1970). The back channel is the listener's response to the speaker, but this is not established by the listener's efforts alone. Nodding and back channels are created when the speaker checks if the listener understands the message and encourages the listener to participate in a conversation. Particularly, in Japanese, the speaker's use of final particles such as "ne," "sa," and "yo" creates a context that encourages the listener to engage in dialog. Compared with English, Japanese is said to have more "in-progress" back channels. This is because the Japanese language is culturally characterized by harmony and cooperation, which often encourage engagement in conversation (Clancy et al., 1996; Kita and Ide, 2007). In other words, the conversation between two people is not a normative, static phenomenon but rather, a dynamic, context-dependent structure in which the conversation continuously develops through interactional routines, when viewed from a synergistic approach (Fusaroli et al., 2013). Through dialogic interactions, interlocutors jointly profile relevant content and distribute complementary (and often flexibly interchangeable) roles to meet the needs of the tasks at hand. In a collaborative cognitive task, participants are expected to obtain from others information about the cognitive task according to their roles and develop activities in response to the collected information.

The Possibility of Developing Competence in Sharing Intentions Through Human Movement

Abundant studies exist on the relationship between human movement and sociality based on entrainment or synchrony. Cirelli et al. (2016) clarified the effects of synchronous movement on the development of social relationships by showing that increased helpfulness after synchronous bouncing extends to affiliates of the bouncing partner, but not to people showing no specific affiliation to that person. Atherton et al. (2019) found a decrease in negative attitudes toward the Roma social group after participants walked synchronously with Roman participants. It has also been reported that intentional synchronization, such as dancing, tends to increase sociality compared with unintentional synchronization (Lakens and Stel, 2011; Reddish et al., 2013) and that the effects of synchronization on interpersonal relationships persist for 24 h (Cross et al., 2020). Synchronization and entrainment negate the self–other distinction, which can increase interpersonal empathy (Hove, 2008).

Sebanz et al. (2006) reviewed joint action research and identified future work to examine the common principles between non-verbal forms of joint action and language. Pezzulo et al. (2019) showed that the experience of sensorimotor communication can serve as scaffolding for more complex forms of communication such as mind reading and verbal communication. In interpersonal sports, it is necessary to integrate oneself and others based on entrainment or synchronization, separate the roles of self and others, infer others' intentions, share intentions with others, and cooperate in solving problems. Such experiences may help in developing the competence to share intentions with others, which can be generalized to everyday life. However, no quantitative studies based on actual behaviors of both cognitive activities and human movements in school education have been conducted. Therefore, this study analyzed and clarified the relationship between physical and cognitive tasks that require the sharing of intentions with others to develop competence in sharing intentions with others through human movement.

Tasks and Hypotheses for the Study

In this study, we observed two types of pair activities during physical education (PE) and mathematics lessons. In the PE lesson, the task was a 3-on-2 tag game where two-partner defenders prevented three attackers from passing through to reach the goal line. In the math lessons, to understand new mathematical concepts, two children were required to discuss the concepts with a partner. Both tasks required sharing the task goals and inferring the intentions of others during pair activities. In the tag game, to prevent the attackers from passing through, the defender must chase the attackers as an individual behavior (**Figures 1A-a1**) and coordinate with his/her partner's movement and infer and share the partner's attention to the attackers' movement as a pair behavior (**Figures 1A-a2**). In the mathematical discussion, two children had to express their own thoughts as an individual behavior (**Figures 1B-b1**) and infer the other's state of understanding as a pair behavior (**Figures 1B-b2**). It is predicted that the individual and pair behaviors would be reciprocally related because the task constraints in the two tasks are similar.

In the tag games, if the two-partner defenders share the task goal, they would move side by side to prevent the attackers from passing through. Therefore, the individual movement distance of the defender would be shortened in order to defend effectively, and the interpersonal distance between the two defenders would remain at a consistent length. Hence, in the physical task, we observed that the defenders' movements and analyzed the distance each defender traveled as an individual behavior and the interpersonal distance between the two defenders as a pair behavior. In the math discussion, if a pair shared a task goal, we would see a responsive behavior toward the other. Specifically, an individual would make utterances to confirm (1) the listener's understanding of their own thoughts, (2) the others' thoughts, and (3) the listener's attention to the object of the pair activity. In addition, a pair would show many role changes while sharing intentions with each other. Therefore, in the cognitive task, we observed the talking and listening behaviors during the pair activities and analyzed the content of the utterances at that time and the gaze direction of the listener as an individual behavior, and the frequency of the role changes as a pair behavior. In learning science for collaborative problem-solving ability, the analysis focused on conversational style and conceptual level as assessment for the deepening of understanding. Given that the conceptual level is domain-specific, this study focused only on conversational forms.

The study's hypotheses are summarized as follows.

1. The constraint of the task is that each person should not perform the task alone (**Figures 1a1,b1**); rather, two people should share the task (**Figures 1a2,b2**). Because of this constraint, individual and pair behaviors interact with each other.

   1.1 In the physical task, individual movement efficiency and interpersonal distance are positively correlated.
   1.2 In the cognitive task, individual responsive behaviors and the frequency of role changes are positively correlated.

2. Because the constraints and structure of the physical and cognitive tasks are similar, individual and pair behaviors in the two tasks are positively correlated.

MATERIALS AND METHODS

Participants

The participants were 32 third-grade elementary school children (10 boys and 22 girls), all of whom were in the same class. Their pair activities with the same partner were observed three times in one PE lesson and two math lessons. In the PE lesson, the task was a 3-on-2 tag game, for which the first lesson of six lessons was observed as one unit. In the math lessons, the task was to understand the concept of partitive division through pair

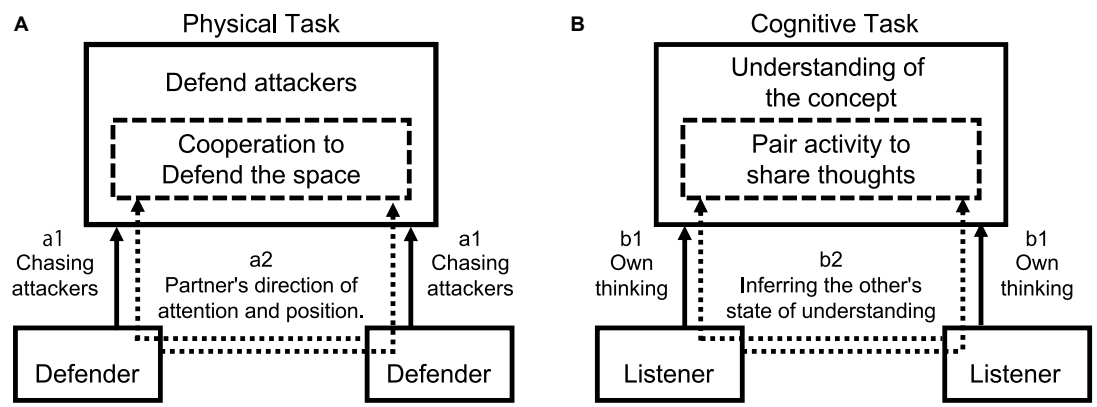

FIGURE 1 | Task structure of physical task **(A)** and cognitive task **(B)**. Panel **(A)** illustrates the task structure of a 3-on-2 tag game. The defender is required to defend the space in a coordinated way by chasing the attacker (a1) and inferring and sharing the partner's attention to the attackers' movement (a2). Panel **(B)** illustrates the task structure of the pair activity in the math class. Given that the pair activity task is to share each other's thoughts, the children need to express their thoughts (b1) and infer the other's state of understanding (b2). Solid lines denote individual behaviors and dotted lines denote pair behaviors.

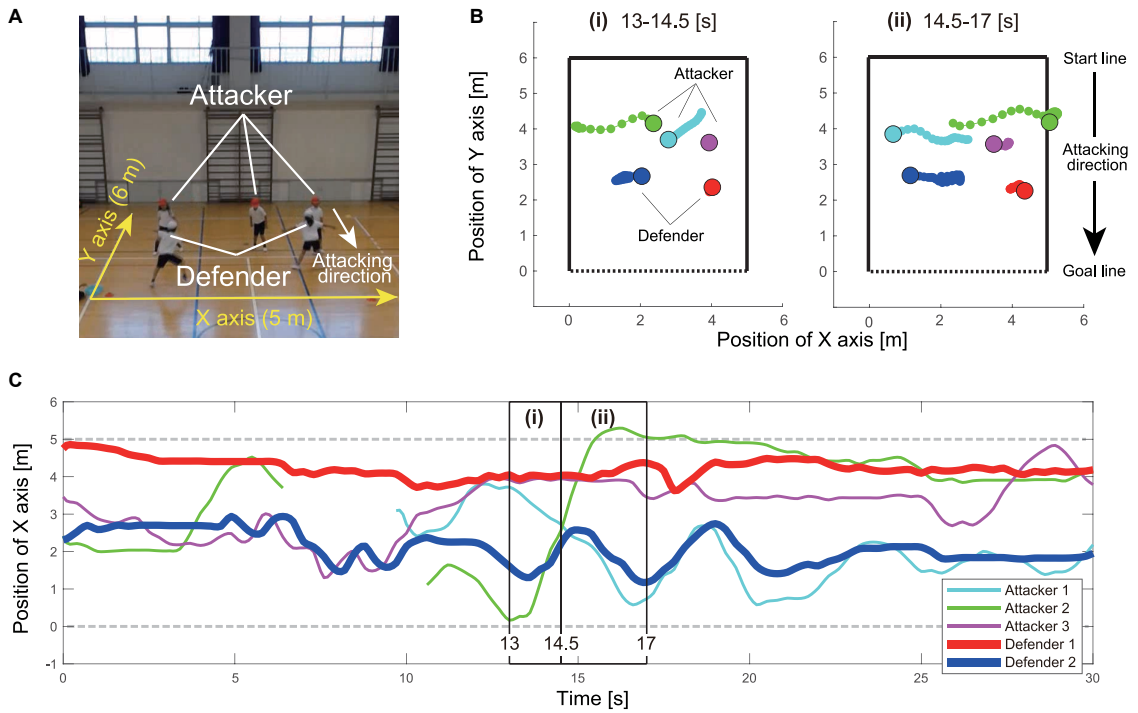

FIGURE 2 | Examples of recording and analysis of physical tasks. Panel **(A)** illustrates a part of the recording view for the physical task, 3-on-2 tag game, and the definition of the X-Y axis. Panel **(B)** provides examples of movements of two defenders (red and blue) and three attackers (cyan, green, and magenta) on the court corresponding to the two boxes (i,ii) in panel **(C)**. Panel **(C)** shows the time series in the position of the X-axis for the two defenders and three attackers. The red and blue bolded lines represent the two defenders and the cyan, green, and magenta shin lines represent the three attackers. The time when the shin line is broken is when the attacker reaches the goal line or is touched by the defender. The distance between the red and blue lines is calculated as X_IPD.

activities. The first math lesson was held before the first 3-on-2 tag game lesson, and the second math lesson was held after the third tag game lesson was observed. Of the 32 children, 16 children of 8 groups were selected for analysis; the other 16 children were excluded from the analysis as explained in the following. Two children were absent from both PE and math lessons and six children joined two groups of three children in the math class; therefore, these children were excluded. One pair (two children), including one child who observed the physical education class because of injury, and another pair (two children) who played only one game because they could not complete the game for lack of understanding of the rules and roles were also excluded. We also excluded two pairs (four children) who were unable to record their utterances for two lessons of the math classes.

Task

Physical Task: 3-on-2 Tag Game

For the 3-on-2 tag game, the goal was for two defenders to prevent three attackers from passing through to the goal line of a 6 m long by 5 m wide court (**Figure 2A**). An attacker scored one point if he/she could pass through the goal line without touching the defender. After scoring a goal, he/she should return to the start line and start all over. If the attacker is touched in court by the defender, they return to the start line and start all over. The task of the defenders was to prevent the attackers from passing through as much as possible. The teacher had informed the children of the rules and roles of the attacker and defender before the game started. Then, the 32 children were divided into three groups of six children and two groups of seven children for each court. Each group played 11 games (55 games in total) with the children switching roles as defenders and attackers. The playing time for each game was approximately 60 s. In the group of six children, when the children played the role of defender, they partnered with the same child in all the cases. In the group of seven children, two pairs of four children partnered with the same children when they played the role of a defender in all the games. The remaining three children partnered with other children as defenders. These pairs were excluded from the analysis.

Cognitive Task: Understanding Partitive Division in Math

The cognitive task was to understand the concept of partitive division through cooperative discussion between two children in the math classes. The two math lessons dealt with partitive division, and the children were asked one basic question and one applied question in each lesson. At first, each child worked on the basic problem on their own sheets by themselves, and then some children presented their own answers to all children. Subsequently, each pair discussed their presentations and understood and confirmed the solution method. In the basic task of the first lesson, Child A presented his solving

method to all children approximately 15 min after the first question was presented, and a pair activity to confirm his solving method was carried out for 180 s. In the application task of the first lesson, a pair activity to discuss the solution method with each other was carried out for 162 s approximately 10 min after the applied question was presented. In the basic task of the second lesson, Child B presented his solving method to all children approximately 20 min after the first problem was presented, and a pair activity to confirm this was carried out for 119 s. In the application task of the second lesson, Child C presented his answer to all children approximately 16 min after the problem was presented, and a pair activity to discuss his solving method was carried out for 65 s. Only the same eight pairs as in the physical task were analyzed for the four pairs of activities.

Analysis

Tag Game

All the tag games played in the five courts were recorded using two webcams (Logitech C922 Pro Stream Webcam, Japan) from the second floor of the gymnasium. One webcam recorded the tag games on three courts, and the other, on two courts. We analyzed only eight fixed pairs. Five pairs played four games each, and three pairs played three games each. The positions of three attackers and two defenders in 29 games were digitized at 10 Hz in each game using motion analysis software (Frame Dias V, DHK, Japan), and transformed to the actual coordinates using a two-dimensional direct linear transformation method. The player's position was defined as the midpoint between both feet. The X-axis was set directly along the goal line of the court, and the Y-axis was set perpendicular to the X-axis directed along the sideline of the court toward the reverse of the attack's direction (**Figure 2A**). **Figure 2B** shows an example of the movements of two defenders (red and blue) and three attackers (cyan, green, and magenta) on the court corresponding to the two boxes (i and ii) in **Figure 2C**.

Pair Activity in Math

In math lessons, we recorded the behavior of pair activities using two video cameras (Panasonic HC-VX990M, Japan) and a webcam (Logitech C922 Pro Stream Webcam, Japan) to observe all pairs in the class (**Figure 3A**). In addition, utterances in pair activities were recorded using 14 IC voice recorders (Olympus VN-541PC, Japan) for each pair. We then used video editing software (EDUIS9, Grass Valley, Canada) to synchronize the video recording of the camcorder with the audio recording of the IC recorder. Based on the recordings, we analyzed the utterance content and gaze direction every second (**Figures 3B,C**).

Dependent Variables

Table 1 provides the study's overview and dependent variables. The dependent variables in the tag game were the efficiency of individual movement and the interpersonal distance on the X-axis for individual and pair activities, respectively. In the Math classes, the responsive behavior, consisting of responsive utterances and active listening, was the dependent variable for individual activities, and the role change was the dependent variable for pair activities.

Efficiency of Individual Movement

We calculated the movement distance of each defender in each game, then calculated the mean velocity of each defender, and the reciprocal of the mean velocity was defined as the efficiency of individual movements. Because the game durations differed, the inverse of the mean velocity, which is the time taken to move a distance of 1 m, was considered to represent the efficiency of individual movement. As the movement length decreases, the efficiency of individual movement increases, and vice versa.

Interpersonal Distance as a Pair Behavior

Figure 2C shows the time series of the positions on the X-axis for two defenders and three attackers. As the variable of pair behavior, the average interpersonal distance of the two defenders in the X-axis [X_IPD (m)] direction in each game was calculated. In **Figure 2Bi** and the left box (i) in **Figure 2C**, the blue defender is shown chasing the green attacker; then the blue defender changes to chase the cyan attacker, as shown in **Figure 2Bii** and the right box (ii) in **Figure 2C**. In this case, two defenders are keeping constant interpersonal

TABLE 1 | The study's overview and dependent variables.

		Physical task	Cognitive task
Participants		8 pairs (16 children) of 3rd grade elementary school students	
Task		Defend attackers in the tag game	Pair activity in two math lessons
Analysis		Movements on the court in approximately 60 s × 29 games	Utterances and gaze directions in four pair activities
Dependent variables	Individual	Efficiency of individual movement	Responsive behavior (Responsive utterance and active listening)
	Pair	Interpersonal distance on X-axis	Role change

TABLE 2 | Categories and definitions of utterances.

Category	Definition
Assertive utterance	Independent of the previous context; transmits one's own thoughts and suggestions regarding the task to the partner
Responsive utterance	Inherits the previous context; shows interest and understanding for the partner's utterances, not only regarding the task but also the partner's utterances 1. An utterance in which turn-taking occurs; an individual accepts the partner's utterance, takes over the content, and conveys his/her thoughts to the partners 2. Non-vocabulary word format called "back channel"
Irrelevant utterance	Irrelevant to the task or expresses a refusal to respond to the partner's thoughts

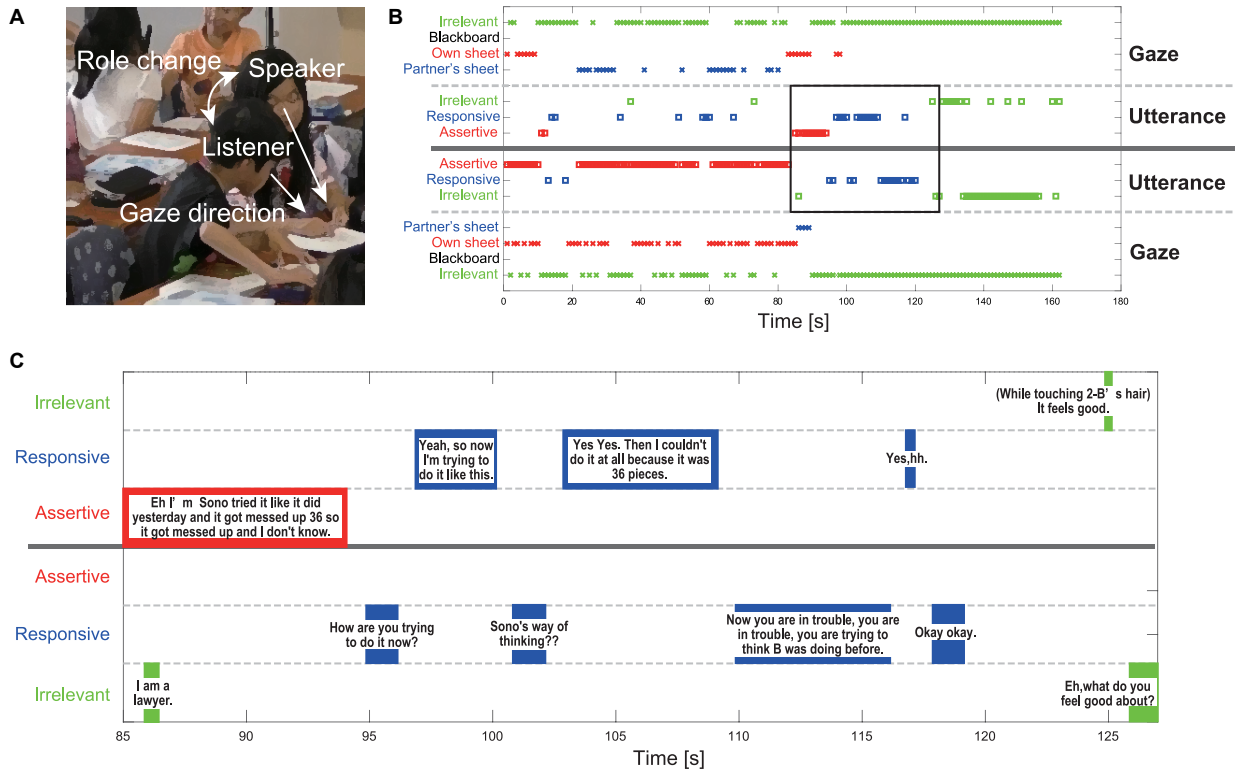

FIGURE 3 | Examples of recording and analysis of cognitive tasks. Panel **(A)** shows a part of the recording view for the cognitive task, which is the understanding of partitive division through pair activity in the math classes. Panel **(B)** illustrates the time series of the four types of gaze directions and three categories of utterances during the pair activity of two children. Panel **(C)** demonstrates three specific categories of utterances during a pair activity between two children corresponding to the box in panel **(B)**.

distance on the X-axis, not changing their positions to the right and left.

Responsive Behavior as Individual Activities

Responsive Utterance

Using utterance content analysis, the degree of shared intention with the partner was evaluated as an individual's responsive utterance during pair activities. The utterance content was classified into the following three categories (**Table 2** and **Figure 3C**). The first is "assertive utterance," which is characterized by transmitting one's own thoughts and suggestions regarding the task to the partner in the pair (**Figures 1B-b1**). An example is the following utterance: "Eh I'm Sono; tried it like it did yesterday and it got messed up 36 so it got messed up and I don't know" (**Figure 3C**, 85–94 s). The second is "responsive utterance" to the partner's utterance, showing interest and understanding not only for the task but also for the partner's utterance (**Figures 1B-b2**). This includes the following two types of "responsive utterances." The first is an utterance in which turn-taking occurs: the individual accepts the partner's utterance, takes over the content, and conveys one's thoughts to the partners (Schegloff and Sacks, 1973). An example is the following utterance: "How are you trying to do it now?" (**Figure 3C**, 95–96 s). The other is a non-vocabulary word format called "back channel" (Yngve, 1970). An example is the following utterance: "Yes,hh" (**Figure 3C**, 117 s). In addition, acts without a voice were considered back channels in agreement with the utterance and counted, such as nodding the head and pointing. The third is "irrelevant utterance," which refers to those that are irrelevant to the task or express refusal to respond to the partner's thoughts. An example is the following utterance: "(While touching 2-B's hair) It feels good" (**Figure 3C**, 124 s). When classifying utterances, we considered not only the meaning of the words but also the context and subtle nuances of the utterance. Taking the sentence "I don't understand" as an example, the child is confused because he/she cannot understand the partner's thoughts immediately. However, if he/she tried to understand it, the sentence was classified as a "responsive utterance." Meanwhile, if he/she gave up on understanding the task or the partner's thoughts, the sentence was classified as an "irrelevant utterance." Based on this classification, we calculated the ratio of "responsive utterance" duration for all three utterance durations for each child to evaluate the degree of intention-sharing with others.

Regarding the classification of utterances, three researchers classified them in the two pair activities independently and then decided on the evaluation criteria after a discussion among the three researchers. Subsequently, one researcher classified the utterances in the other scenes according to the evaluation criteria.

Active Listening

By analyzing the listener's gaze direction, the degree of joint attention or active listening was evaluated as an individual behavior during pair activities. The listeners' gaze direction was classified into four categories: "partner's sheet," "own sheet," "blackboard," and "irrelevant." When the gaze direction was toward the "partner's sheet," "own sheet," and "blackboard," it was judged that joint attention was established between the partners and active listening was performed. The gaze direction toward "own sheet" and "blackboard" were classified as "active listening." In all the scenes, the children looked at the partner's sheet after looking at their own and the blackboard to confirm their thoughts. The gaze direction classified as "irrelevant" included the child looking at the partner's face, other pairs, and so on. Regarding the gaze direction to the partner's face, it was judged that the child was "actively listening" when he/she looked at the partner's face for a moment. However, if the gaze direction to the partner's face continued for a long time, we did not classify it as "active listening" because of the possibility that this signified drifting from the task. Based on this classification, the ratio of "active listening" was calculated by dividing the "active listening" duration by the total time of the four categories of listening.

Responsive Behavior as Individual Activities

Finally, the mean of the ratio of "responsive utterance" and the ratio of "active listening" were used as the "responsive behavior" during pair activities and as an index showing the sharing of intentions with others. For example, in Pair 1, the frequency of "responsive utterance" was 0.32, and the frequency of "active listening" was 0.85. "Responsive behavior" was then calculated as $(0.32 + 0.85)/2 = 0.59$. A high ratio of "responsive behavior" indicates an attempt to share intentions with others as an individual behavior during pair activities.

Role Change as Pair Activities

The frequency of "role change" was calculated as an index of pair behavior. There are two types of role change in conversation. One is "turn taking" (Schegloff and Sacks, 1973), which indicates the initiative of the utterance. The other is "back channel" (Yngve, 1970), which does not change the turn but shows interest and understanding of the other's utterance. It is presumed that the high frequency of role change indicates that the conversation is interactive and that the interest in and the understanding of others' thoughts are high. For the frequency of role change, we defined the average number of role change occurrences by calculating the number of role changes in one 1 s based on the number of role changes in the total speaking time of the pair. A high frequency of role changes indicates more active interactions within pairs.

Statistical Analysis

For the physical task, to test Hypothesis 1.1, Pearson's correlation and Spearman's rank correlation coefficients were calculated to examine the relationship between the efficiency of individual movement as an individual behavior and interpersonal distance on the X-axis (X_IPD) as a pair behavior during the tag game. In this calculation, the mean efficiency of the individual movements in each pair was used. For the cognitive task, to test Hypothesis 1.2, Pearson's and Spearman's rank correlation coefficients were obtained to investigate the relationship between the mean ratio of responsive behavior in each pair as an individual behavior and the frequency of role change as a pair behavior during math lessons. Finally, we investigated the relationship between the behavior of defenders during tag games and pair activities in math lessons. To test Hypothesis 2, we calculated the Pearson's correlation and Spearman's rank correlation coefficients between the efficiency of individual movement during the tag game and the ratio of responsive behavior in math lessons as an individual behavior, and between the defenders' X_IPD during the tag game and frequency of role change in math lessons as pair behaviors. The significance level was set at $P < 0.05$.

Informed Consent

This study was conducted with the approval of the research ethics review committee of the university in accordance with the principles of the Declaration of Helsinki and with the written consent of the managers and teachers at the elementary school. Through the teacher-in-charge, we explained the study purpose and contents, permission for recording, protection of privacy, handling of data, and so on, to the participants and their parents and obtained their written consent.

RESULTS

Defender in the Tag Game

Figure 4A shows the means and standard deviations of the two defenders' X_IPDs (m) for each pair, rearranged in the order in which the pairs showed a longer X_IPD. Pair 1 participated in four games. The X_IPD in the first to the fourth games were 1.85 m, 1.84 m, 1.81 m, and 2.32 m, respectively. The average X_IPD for the four games was 1.95 ± 0.21 m, and Pair 1 showed the longest X_IPD. By contrast, Pair 8 participated in three games; the X_IPD in the first to the third games were 0.94 m, 1.14 m, and 1.52 m, respectively, and the average X_IPD for the three games was 1.20 ± 0.24 m, which was the shortest X_IPD. The average positions and standard deviations of the two defenders in all games in court are shown in **Supplementary Figure 1**. **Supplementary Table 1** shows the average X_IPD for each tag game and the means of the X_IPD for the pairs. **Figure 4B** shows the means and standard deviations of the individual defenders' movement efficiency. The order was arranged according to the order of the X_IPDs for each pair. Child A in pair 7 showed the most efficient movement (2.02 s/m), and Child B in pair 2 showed the worst (0.87 s/m). These results suggest that Child B in Pair 2 moved more than twice as much as Child A in Pair 7. **Supplementary Table 2** shows the individual defenders' movement efficiency for each tag game and the means of the individual and pair movement efficiency. **Figure 4C** shows the relationship between the defender's X_IPDs and the individual efficiency of movement. The results showed a significant Pearson's correlation coefficient ($r = 0.771$, $p = 0.026$) and marginally significant Spearman's rank correlation coefficient ($r = 0.667$, $p = 0.071$). A high positive correlation was found

between the X_IPDs of the two defenders as a pair behavior and the individual efficiency of movement in tag games. This means that the pair that maintains a certain distance from the partner has shorter individual movement distances during the game, and vice versa. The results suggest that long interpersonal distance as a pair behavior and short movement distance as an individual behavior interacted with each other, indicating shared task constraints and task goals. This finding supports Hypothesis 1.1.

Pair Activity in Math Lessons

Figure 5A shows the frequency of "role change" in each pair during pair activities, rearranged according to the order in which the pairs showed a longer X_IPD (**Figure 4A**). For Pair 1, a "role change" was observed to occur 9.01 ± 5.74 times per min. **Supplementary Table 3** shows the frequency of role change during each pair activity in the math lessons and the means of the role change for the four pair activities. **Figure 5B** shows the frequency of individual responsive behaviors for each individual during pair activities. **Supplementary Table 4** shows the individual responsive behavior frequency during each pair activity in the math lessons and the means of the individual and pair responsive behaviors. **Figure 5C** shows the relationship between the frequency of "role change" and "responsive behavior." The results showed a marginally significant positive Pearson correlation coefficient ($r = 0.705$, $p = 0.051$) and Spearman rank correlation coefficient ($r = 0.500$, $p = 0.207$). This means that the more frequently "role change" as a pair behavior occurred in each pair, the higher the "responsive behavior" frequency during the utterance duration as individual activities and vice versa. This finding suggests that many role changes in pair activities and individual responsive behaviors would interact and that the pairs had collaborated with each other, and shared task constraints and task goals. This result partially supports Hypothesis 1.2.

Relation Between Movement as a Defender in Tag Games and Pair Activities in Math Lessons

The relationship between individual and pair behaviors in tag games and math lessons was examined. **Figure 6A** shows the relationship between individual efficiency of movement in tag games and the ratio of individual responsive behavior in the pair activity of the math lessons. The results showed a significant positive Pearson's correlation coefficient ($r = 0.657$, $p = 0.005$) and Spearman's rank correlation coefficient ($r = 0.729$, $p = 0.007$). This means that children who showed higher efficiency of individual movement as a defender in the tag games had a higher frequency of "responsive behavior" during pair activities in the math lessons, while children who showed lower efficiency of individual movement in the tag games had a lower frequency of "response action" in the math lessons. In addition, in **Figure 6A**, the values for the two children in the same pair are connected by a line. Interestingly, the slope of the line in six out of the eight pairs was positive. The efficiency of individual movement as a defender in the tag game refers to understanding the task goal, which is how to cooperate with a partner to prevent attackers from passing through the goal line. Meanwhile, the higher "responsive behavior" in the pair activity during math lessons consisted of "responsive utterances" and "active listening." This means that the children who showed higher frequency of "responsive behavior" tried to understand the partner's thoughts. Both behaviors observed in the tag games and math lessons could be regarded as individuals in each pair understanding and sharing each task goal equally.

Figure 6B shows the relationship between the defenders' X_IPDs in the tag games and the frequency of role changes in the pair activities in the math lessons. There was a significant positive Pearson's correlation coefficient ($r = 0.765$, $p = 0.010$) and Spearman's rank correlation coefficient ($r = 0.833$, $p = 0.010$). These results indicate that the pair that maintained a certain distance and prevented attackers from passing through in the tag games frequently performed role changes in the math lessons, and vice versa. This result supports Hypothesis 2. Regardless of the type of task: cognitive or physical, the children could act as pairs according to the task demands because they could share task goals and others' intentions.

DISCUSSION

In this study, the targets of analysis were the movements of two children who shared a task requiring coordination skills in a PE class, and the communication between two children during a pair activity set as collaborative for problem-solving in a math class. We then focused on the relationship between the behaviors of individuals and pairs in each task.

First, a significant positive correlation was found between the X_IPD and the efficiency of the individual movements of the two defenders in the tag game (**Figure 4C**). The game was carried out on a court that was 6 m long and 5 m wide. If two defenders are positioned side by side and the space that the attacker can breakthrough is divided into equal parts, the X_IPD is 2.50 m, and the distance from one defender to the sideline of the court is 1.25 m. Therefore, the three pairs whose X_IPD mean are nearly 2 m adjusted their position and movement according to the position and movement of their partner (Pair 1, 1.96 m; Pair 4, 1.88 m; and Pair 7, 1.93 m). These three pairs also showed higher efficiency for the individual movement distance, as demonstrated by the lateral movements not overlapping, and the movements in the back-and-front positions being small (**Supplementary Figure 1**). The defenders move forward when chasing attackers before they try to pass through, or the defenders move backward when trying to follow the attacker even after the attackers have passed through. These two cases are considered movements that respond to one attacker where the defender tries to catch up only by oneself rather than movements that satisfy the task demands, which prevents pass through *via* collaborative movements.

Previous studies showed that experts could infer others' intentions from their movements, and consequently maintain a constant interpersonal distance between them to achieve their goals in interpersonal sports activities (Yokoyama and Yamamoto, 2011; Kijima et al., 2012;

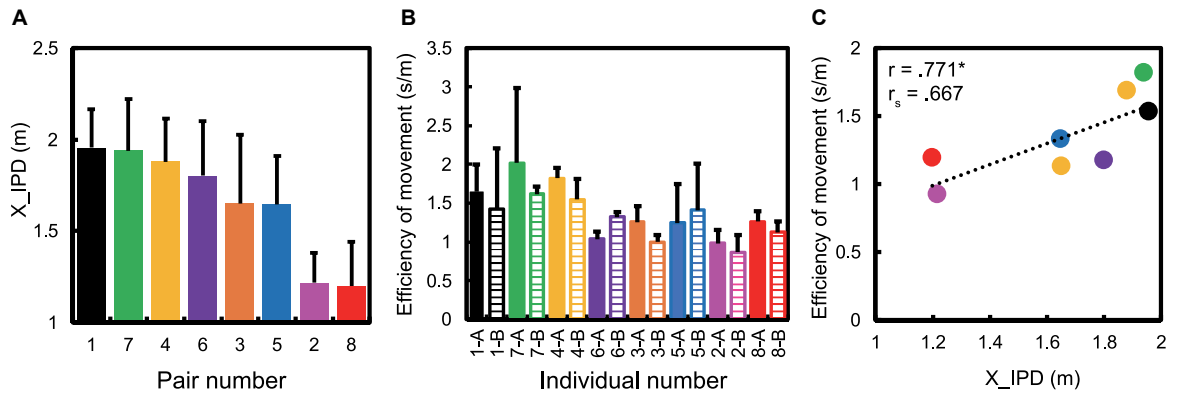

FIGURE 4 | Results of the tag games. Panel **(A)** shows the mean and standard deviations of X_IPDs in each pair. Panel **(B)** shows the mean and standard deviations of the efficiencies of individual movement for each child. Panel **(C)** shows the relationship between X_IPD and the mean efficiency of individual movement for each pair. *$P < 0.05$.

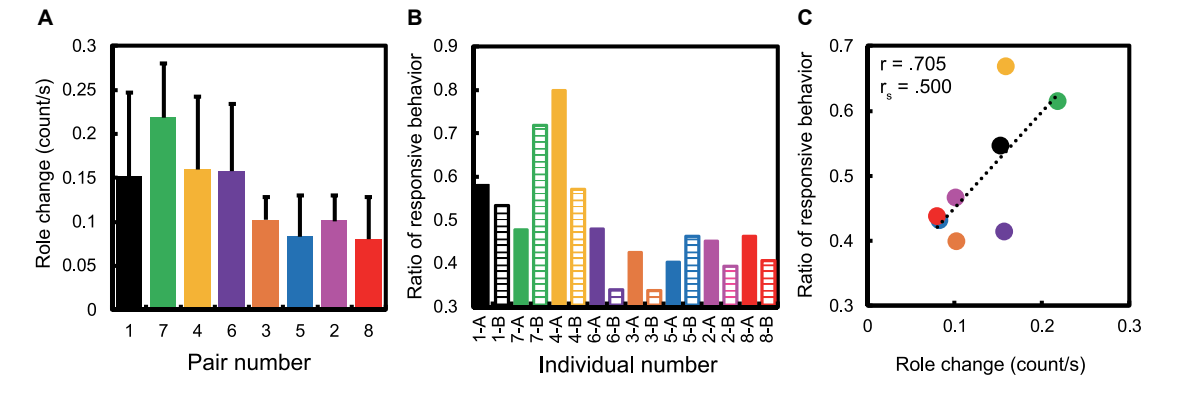

FIGURE 5 | Results of the pair activities in the math classes. Panel **(A)** illustrates the mean frequencies and standard deviations of the role changes for each pair. Panel **(B)** shows the ratio of the individual responsive behavior for each child. Panel **(C)** shows the relationship between role change and responsive behavior.

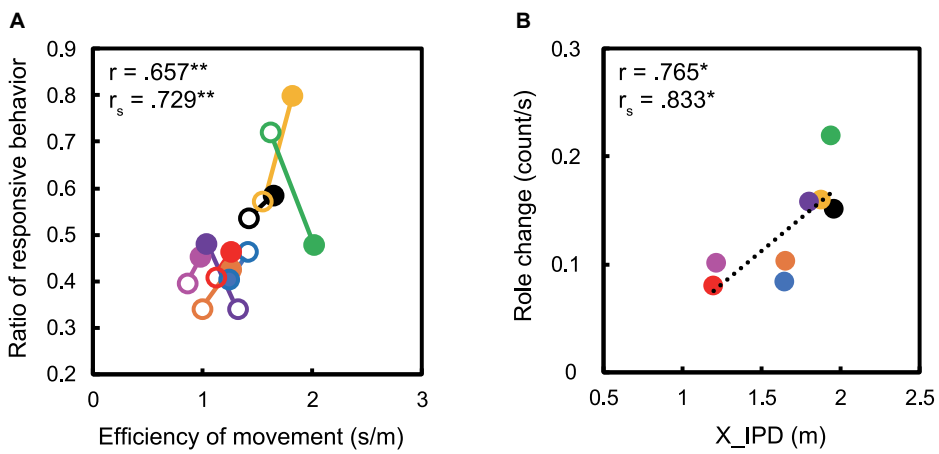

FIGURE 6 | Relationship of the individual and pair behavior indicators in the physical task with those in the cognitive task. Panel **(A)** shows the relationship between the individual behavior indicator in the 3-on-2 tag game and the pair activities in the math classes. The horizontal axis shows the time it takes to move 1 m of an individual's efficiency of movement in the 3-on-2 tag game. The vertical axis shows the ratio of responsive behavior in the pair activity. Panel **(B)** shows the relationship between the pair behavior indicator in the 3-on-2 tag game and the pair activities in the math classes. The horizontal axis shows the X_IPD of the game, and the vertical axis shows the role change in the pair activity. *$P < 0.05$, **$P < 0.01$.

Yokoyama et al., 2018). Meanwhile, this study showed that children with both shorter movement distances and constant X_IPD could understand the not-to-lose strategy in tag games and perceive the movement of teammates and adjust their relative positions accordingly. The results suggest that they could share task goals and others' intentions and consequently, could move while paying attention to the position and movement of each other to achieve the task.

Next, in the math class pair activity, a marginally significant positive correlation was found between responsive behavior and role change (**Figure 5C**). To share and understand each other's thoughts in pair activities, the speaker must construct an utterance such that the listener can understand it, rather than unilaterally communicating his or her own thoughts (Goodwin, 1999). Meanwhile, the listener has to listen to the speaker's thoughts by jointly paying attention to the same subject as the speaker's. It is necessary to prepare to continue the pair activity through "turn-taking" (Schegloff and Sacks, 1973) and "back channel" (Yngve, 1970). Pairs with low frequencies of role change and low-responsive behavior had longer utterance durations (see **Supplementary Figure 2**). Furthermore, in those pairs, the utterance content included more "argument utterance" and "irrelevant utterance" that showed one's thoughts and suggestions (**Figure 5C**). These results suggest that such pair activities were not activities to share thoughts with each other or develop thoughts through discussion, but to express one's selfish way of thinking on a task. Meanwhile, pairs that showed high frequencies of role change and responsive behavior had a shorter utterance duration in a single utterance. The results also showed that the utterances that responded to the previous content of the partner and the back channel showing interest and understanding in the partner's utterance were higher. The back channel signifies the listener's effort to pay attention to the speakers jointly and is triggered by the speaker's final particle, and both the final particle and the back channel produce a stable rhythm of conversation (Clancy et al., 1996). In addition, through the back channel, two people perform complementary roles, each depending on the needs of the task at hand (Fusaroli et al., 2013). In other words, pairs with higher frequencies of role change and responsive behavior can be regarded as signifying pair activities in which thoughts are shared with each other. Therefore, a speaker–listener interaction can be considered as an attempt to understand the task goal and share intentions if it is being carried out while guessing both the partner's thoughts and the partner's understanding of one's own thoughts. This suggests that responsive behavior as an individual behavior promotes role change as a pair behavior in cognitive tasks, and vice versa.

Finally, a significant positive correlation was found between the defender's efficiency of individual movement in the tag game and the responsive behavior in the math class pair activity (**Figure 6A**). A significant positive correlation was also found between the interpersonal distances between defenders in the tag game and the frequency of role change in the math class pair activity (**Figure 6B**). Children and pairs who could pay attention to the movement of both partners' defenders and attackers to achieve the task in the tag game could also follow the partner's utterance and take over the utterance content of the partner in the math classes. Meanwhile, children and pairs who tended to chase attackers according to their own selfish intention without being influenced by others' defenders in the tag games unilaterally conveyed their thoughts in the math classes. Moreover, there was a tendency not to listen to others' thoughts carefully.

Our research hypotheses were supported, suggesting that there is a common fundamental competence in sharing intentions with others. Despite the difference in task type: physical and cognitive, the relationship between the individual behavior and the behavior of the two in each task was found in the "joint attentional scene" and the "understanding [of] communicative intentions" for sharing the task goals and intentions of others (Tomasello, 1999). The defenders of a tag game are required to perceive that it is a game, that is, a joint attentional scene where two people cooperate to prevent attackers. In addition, defenders need an "understanding [of the] communicative intentions" to share who defends which attackers. In a pair activity in math classes, children need to recognize that the activity is about perceiving each other's information and sharing thoughts about the current problem. In addition, children are required to "understand communicative intentions" to infer how others understand their own thoughts. In other words, the two types of tasks in this study need to be perceived not only as the task itself but also as information about the behaviors of the "other" for the task. It is also necessary to understand the intentions of others regarding their state of attention and what they perceive themselves. Therefore, although the tasks in this study differ by type (i.e., physical vs. cognitive), the task structure is similar in that both require "planned coordination" (Knoblich et al., 2011) with others. As such, the correlation between the two tasks on an individual and a pair behavior level showed a common competence in sharing task goals and intentions, regardless of task type.

In this study, we showed the common competence between physical tasks in PE classes and cognitive tasks in math classes, but we could not describe the causal relationship between them. However, if the sharing of intentions with others is based on the perceptual-motor system, there is a possibility that such competence can be cultivated by performing tasks using the perceptual-motor system. Previous studies have shown that exercise promotes social cognition (e.g., Reddish et al., 2013; Cirelli et al., 2016) and that sharing intentions with others is necessary for physically planned coordination tasks with others (Yokoyama and Yamamoto, 2011; Kijima et al., 2012; Yokoyama et al., 2018). For the 3-on-2 tag game (the physical task in this study), coordinated movement is essential to achieve cooperation with others, and the process of cooperation is directly related to the results. Children develop scientific thought processes while exploring the world, for instance, the use of Bayesian inference methods to infer the cause from results (Gopnik, 2012; Gopnik et al., 2017). In fact, when the games were repeated, in the cases of Pairs 5, 6, 7, and 8, the two defenders were positioned side-by-side from back-and-front positioning, and Pair 2 also decreased back-and-front movement (see **Supplementary Figure 1**). This suggests that if sharing tasks and intentions with others is designed as a task constraint in physical tasks, participants may repeatedly search for causes of point loss. Meanwhile, the

cognitive task of understanding certain concepts in mathematics might not clarify whether a learner could understand it. It was argued that in the cognitive task, the repeated experience of searching for causes would be difficult, and the perceptual-motor system could not be used because of the relatively stable environment.

In other words, the results suggest the possibility of a new approach to cultivating the common fundamental competence of sharing task goals and intentions with others through human movement, especially in elementary school education, where the sensorimotor system is not sufficiently developed. In the future, empirical research should examine whether sharing tasks and intentions with others through physical exercise influences collaborative cognitive activities.

In this study, the interaction between individual and pair behavior was clarified, but the analysis was limited to 8 pairs of 16 participants. Therefore, it is necessary to increase the number of cases to confirm the results. Moreover, we estimated the shared intentions through behavioral observation. To evaluate the shared intentions more appropriately other perspectives are needed; this can be achieved by using qualitative methods such as interviews or questionnaire surveys of children and teachers. Furthermore, the relationship between the two individuals, that is, leader–follower relationship, should be analyzed. Studies have suggested that behavioral characteristics in daily life affect cooperative relationships (Schmidt et al., 1994; Fitzpatrick et al., 2016; Mukai et al., 2018). It is also a future task to investigate in detail the kind of interaction that occurs between the two parties and how these activities are developed.

CONCLUSION

In conclusion, children and their pair characterized as moving freely according to their own selfish intention in the tag games saw the pair activity in math classes as a "scene to convey their thoughts." Meanwhile, those who could move while paying attention to the position and movement of each other in order to achieve the task in the tag game regarded the pair activity in the math classes as a scene to share each other's thoughts and engage in behaviors to listen to each other's thoughts. This finding suggests that the sharing of intentions with others is a common fundamental competence in both physical and cognitive tasks for solving the task at hand cooperatively. A human being represents a complex system. The human movement of others cannot be understood entirely in the same way as their intentions. However, the task constraints of joint action in PE lead to an understanding of the task goals and exploration of the solution through trial and error. These experiences in PE might be generalized to cognitive tasks to cultivate the competence in sharing intentions with others.

DATA AVAILABILITY STATEMENT

The original datasets presented in this study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Research Promotion Committee, Faculty of Education, Mie University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

TK, KY, and YY conceived and designed the task and analyzed the data. TK recorded the lessons. All authors contributed to the study and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2022.863267/full#supplementary-material

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Aerobic Exercise Alleviates the Impairment of Cognitive Control Ability Induced by Sleep Deprivation in College Students: Research Based on Go/NoGo Task

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The purpose of this study was to observe whether aerobic exercise is able to alleviate the impairment of cognitive control ability in college students by sleep deprivation through cognitive control (Go-NoGo task) and blood-based markers. Taking 30 healthy college students (15 males and 15 females) as participants, using a random cross-over design within groups, respectively perform one night of sleep deprivation and one night of normal sleep (8 h). The exercise intervention modality was to complete a 30-min session of moderate-intensity aerobic exercise on a power bicycle. Change in cognitive control was assessed using the Go/NoGo task paradigm; 5-ht and blood glucose contentwere determined by enzyme-linked immuno sorbent assay and glucose oxidase electrode Measurement, respectively. The results showed that sleep deprivation could significantly reduce the response inhibition ability and response execution ability, and significantly reduce the blood 5-ht content ($p < 0.01$). Thirty minutes of moderate intensity aerobic exercise intervention significantly increased response inhibition ability and response execution ability, significantly increased blood 5-ht content ($p<0.01$), and did not change serum glucose levels. Conclusion: An acute aerobic exercise can alleviate the cognitive control impairment caused by sleep deprivation, and 5-ht may be one of the possible mechanisms by which aerobic exercise alleviates the cognitive control impairment caused by sleep deprivation.

Keywords: college students, aerobic exercise, sleep deprivation, cognitive control, Go/NoGo task

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INTRODUCTION

With the social progress, the acceleration of the rhythm of life, a more vibrant nightlife and the use of electronic networks and other products, sleep deprivation is a widespread problem in modern society, particularly among young people (Lissak, 2018; Becker et al., 2019). In a cross-sectional survey, more than 70% of young people reported sleeping less than recommended, about 60% of them suffered from severe sleep deficiency (Chaput et al., 2018). Researchers have found that, among young and middle-aged adults, short sleep duration is prevalent in 32% to 39% (Csipo et al., 2021). In addition to the increased risk of chronic somatic diseases (Schwartz et al., 2005; Kasasbeh et al., 2006; Knutson et al., 2006; Taheri, 2006; Zimmerman et al., 2006; Rahmani et al., 2020), short sleep duration is

strongly associated with decline in cognitive performance (Chaput et al., 2018; Cousins and Fernández, 2019). Csipo et al. (2021) studies have shown that, in healthy young adults, 24-h sleep deprivation can impair cognitive performance, this included a significant increase in reaction time and a significant decrease in scores on the rapid visual information processing test, which measures sustained attention. Cain et al. (2011) studies of healthy young people have shown that, stroop's task of naming colors, the response time is significantly increased by one night's sleep deprivation. Chan Kwong et al. (2020) studies have shown that, sleep deprivation for 24 h can significantly impair working memory (as determined by the n-back task and rapid visual processing test) in healthy volunteers, the N-back task showed a significant decrease in accuracy, for the rapid visual processing task assessment test, reaction times increased significantly. García et al. (2021) research on healthy college students has shown that, after 24 h of sleep deprivation, the subject's inherent tonic attention, selective and sustained attention (a component of attention) and in cognitive inhibition (a component of executive function) are markedly reduced. Grundgeiger et al. (2014) studies have shown that, sleep deprivation increases failures to carry out intended actions. Freshman in college who presented as subjects after 25 h of sleep deprivation, performance was lower after sleep deprivation and with a more resource- demanding prospective-memory task. Sleep deprivation resulted in slower reaction times and lower accuracy. Riontino and Cavallero (2022) evaluated the impact of one night of sleep deprivation on the efficiency of three attentional networks, following sleep deprivation, reaction times and accuracy were significantly slowed, executive control efficacy significan -tly decreased. Xu et al. (2022) studies have shown that, sleep deprivation for 36 h can significantly decrease working memory (pronunciation-related working memory) levels in healthy males, the accuracy of the articulation-related working memory task was significantly reduced, time to react significantly increased. These findings suggest that, Sleep deprivation appears to affect human cognition at both a global and a unspecific level, which should affect a variety of cognitive tasks.

In many industries such as medicine, transportation, and the military, people usually need to remain awake and perform cognitive tasks in the absence of sleep. Therefore, it is necessary to take measures to counteract the effects of sleep deprivation and to improve cognitive performance during sleep deprivation. Physical exercise involves the stretching of bones by muscles and the consumption of energy, and is a planned and repetitive physical activity designed to promote health, and improve motor skills (Eöry et al., 2021). Studies have shown that physical exercise is an important means to ensure physical and mental health, which can reduce the incidence of physical diseases (such as cardiovascular disease and obesity, etc.) and psychiatric diseases (such as depression and anxiety, etc.) (Mandolesi et al., 2018). In addition, behavioral studies have also shown that physical exercise is able to promote cognitive ability (Li et al., 2017; Elce et al., 2020; Morawietz and Muehlbauer, 2021). From the perspective of exercise groups, physical exercise can promote cognitive function in various groups including underage (Etnier et al., 2014), adult (Karssemeijer et al., 2017), and elderly (Yoon et al., 2018). From the perspective of exercise characteristics, different types (e.g., endurance training, coordination training, and stretching training), intensity, and duration of physical exercise can promote cognitive ability (Mollinedo Cardalda et al., 2019). From the perspective of training effect, physical exercise can also improve different types of cognitive function (such as visual memory, auditory memory, problem-solving ability and cognitive control ability, etc.), and the promoting effect can be maintained for a period of time after the end of exercise (Donnelly et al., 2016; Song et al., 2018; Zhou et al., 2022). Interestingly, not only long-term exercise, but even acute exercise has positive benefits on higher-order cognitive functions such as concentration, memory, and even executive function (Niedermeier et al., 2020; Cantelon and Giles, 2021). Animal studies have shown that exercise protects the memory from acute but not chronic sleep deprivation (Roig et al., 2022). Sahin et al. (2021) studied protective effects of mild treadmill exercise on acute sleep deprivation rats, the results indicate that, an acute sleep-deprivation period of 48 h impairs long-term spatial memory significantly. The adverse effects of acute sleep deprivation on memory can be mitigated by mild, regular treadmill exercise. Zagaar et al. (2012) studies have shown that, regular exercise program prevents the sleep deprivation induced impairments in short-term memory and early phase long-term potentiation (LTP) by preventing deleterious changes in the basal and post-stimulation levels of P-CaMKII and BDNF due to sleep deprivation. Saadati et al. (2015) investigate the effects of physical exercise on cognitive functions of female rats following paradoxical sleep deprivation, the results indicate that, 4 weeks of treadmill running alleviated the paradoxical sleep deprivation (PSD)—induced learning and memory impairments in both intact and ovariectomized groups. In humans, it is not known whether exercise can protect memory from the effects of sleep loss. Scott et al. (2006) researched the effect of a 30-h of sleep deprivation and intermittent physical exercise on cognitive, motor performance and mood, the results indicate that, when compared to those who are deprived of sleep alone, individuals that performed 5 h of intermittent moderate exercise during 30 h of sleep deprivation were more susceptible to negative. So, whether acute, a single bouts of exercise improve cognitive control impairment due to sleep deprivation? This needs to be confirmed by further studies.

A study compared older, poor memory rats without training to rats with improved memory after training, the expression of 5-ht and receptors associated with it differs significantly in the relevant brain tissues, this suggests that 5-ht and its receptors regulate learning and memory in the brain (Elmenhorst et al., 2012). As reviewed by Cools et al. (2008), in the OFC, serotonergic activity correlates with levels of response inhibition and performance in reversal learning. Marmosets with low levels of 5-ht were unable to inhibit prepotent responses (Walker et al., 2006). As well as disrupting inhibitory control, 5-ht depletion in the orbitofrontal cortex leads to substantial deficits in reversal learning in monkeys and rats (Clarke et al., 2007; Lapiz-Bluhm et al., 2009). When healthy volunteers are acutely depleted of tryptophan, the same effect is observed on human performance in reversal learning

tasks (Murphy et al., 2002). In this study, we investigated whether acute aerobic exercise can alleviate the cognitive impairment caused by sleep deprivation, and 5-ht may be one of the possible mechanisms by which acute aerobic exercise alleviates the cognitive control impairment caused by sleep deprivation.

STUDY SUBJECTS AND METHODS

Study Subjects

Thirty college students (15 males and 15 females), aged 19–24 years (mean age 22.3 ± 1.3 years; body mass index 22.5 ± 0.5 kg/m^2), were recruited from Lu Liang University by means of Internet and posting notices as study subjects. This study was reviewed and approved by the Ethics Committee of Luliang University. All study subjects were informed of the purpose of this study, volunteered to participate in the experiment, and signed an informed consent form.

Screening criteria for the study subjects:(1) Individuals with normal physical mobility in the Physical Activity Questionnaire (PAR-Q questionnaire) survey; (2) Individuals with normal intelligence as assessed by the Mini-Raven's Tweet Intelligence Scale; (3) Individuals with normal uncorrected or corrected visual acuity; (4) No physical, neurological, or psychiatric disorders, no recent medication; (5) Have good sleep habits, no staying up late recently; (6) score no more than 22 on the Morningness–Eveningness scale (Horne and Ostberg, 1976); (7) have no symptoms associated with sleep disorders; (8) have no history of any psychiatric or neurologic disorders; (9) No contraindications to exercise. In addition, individuals were excluded based on the following criteria: vegetarian, current efforts to lose weight (e.g., dieting), irregular meal timing habits, irregular sleep/wake habits, and habitual smoking, drinking and coffee.

Study Design and Procedure

According to the purpose of the study, all subjects needed to complete two parts of the experimental tasks of total sleep deprivation and aerobic exercise intervention. The former aims to investigate the changes in cognitive control ability of subjects in Go/NoGo task after sleep deprivation, and the latter aims to investigate the intervention effect of aerobic exercise on cognitive control ability of subjects after sleep deprivation.

Sleep Depravation

A randomized, balanced crossover design was used. Thirty subjects were randomly divided into sleep deprivation group (15 subjects) and normal sleep group. Each group had to participate in the experiment of sleep deprivation and normal sleep, with an interval of 2 weeks. The time span of both the normal sleep and sleep deprivation experiments ranged from 23:00 nights to 07:00 the next day (**Figure 1**). For each condition, participants came to the lab two evenings before the experimental morning, and stayed in the lab until the experiments were conducted, and got a standard meal. Participants were blinded to the experimental condition (i.e., Sleep vs. TSD) until being informed of the respective condition 90 min in advance of intervention onset. During normal sleep (23:00–07:00), the light of the laboratory was turned off, and the sleep status of the subjects was monitored using a polysomnography (Embla Flaga hf, Reykjavik, Iceland), and the sleep stages were distinguished according to the criteria determined by Hobson (Hobson, 1969). During sleep deprivation (23:00–07:00), all subjects had to remain awake at all times, and they could see a computer, book, play games, and walk freely in the laboratory, but could not eat any food and could not sleep. In the morning after the sleep intervention (07:00–08:00), the cognitive control ability of the subjects, as well as fasting glucose and 5-ht content, were measured, respectively (**Figure 1A**).

Aerobic Exercise

The aerobic exercise intervention experiment was started 2 weeks after the end of the total sleep deprivation experiment. In the experiment, 30 subjects were randomly divided into aerobic exercise intervention group (15 subjects) and sedentary rest group after completing a sleep deprivation treatment. In order to ensure that the order of exercise treatment and sedentary rest treatment is balanced between subjects, this part of the experiment, we are still using an intra-group crossover design, each subject is subjected to aerobic exercise and sedentary rest after sleep deprivation, with an interval of 2 weeks. Among them, the aerobic exercise group needed to complete a 30-min aerobic exercise intervention after sleep deprivation, and cognitive control ability was measured immediately after exercise, 30 min after exercise and 1 h after exercise, while venous blood was collected immediately after exercise and at 1 h after exercise to test fasting blood glucose and 5-ht. Cognitive function tests and blood sampling times in the sedentary rest group were consistent with those in the exercise group (see **Figure 1A**).

Aerobic exercise protocol Reference (Weinstock et al., 2012), 30 min of moderate- intensity aerobic exercise on a MONARK 834 power bicycle (Swedish). Exercise intensity was graded using the American College of Sports Medicine Aerobic Exercise Intensity Grading Criteria for Healthy Adults (American College of Sports Medicine, 2006). During exercise, the resistance range of the power bicycle was between 0 and 150 W, and the bicycle rhythm was ≥30 r/min. Before the formal exercise intervention, the subjects performed a warm-up exercise for 5 min in the power car, followed by continuous exercise for 30 min when the exercise load reached 60–69% of the individual's maximum heart rate, with a maximum heart rate = 220 – age. Exercise intensity was monitored using a Polar table and an RPE table throughout exercise (Borg, 1985), and heart rate and RPE were recorded every 2 min.

Cognitive Control Ability Tests

In this study, we used the Go/NoGo task paradigm associated with food pictures and non-food pictures to evaluate the cognitive control ability of the subjects (Verbruggen et al., 2014; Eöry et al., 2021). Non-food and food-related words represented Go and no-Go trials, respectively. The experimental program was written in E-prime, and at the beginning of the experiment, a black "+" sign with a duration of 1,000 ms was first presented in the center of the computer display screen as the fixation

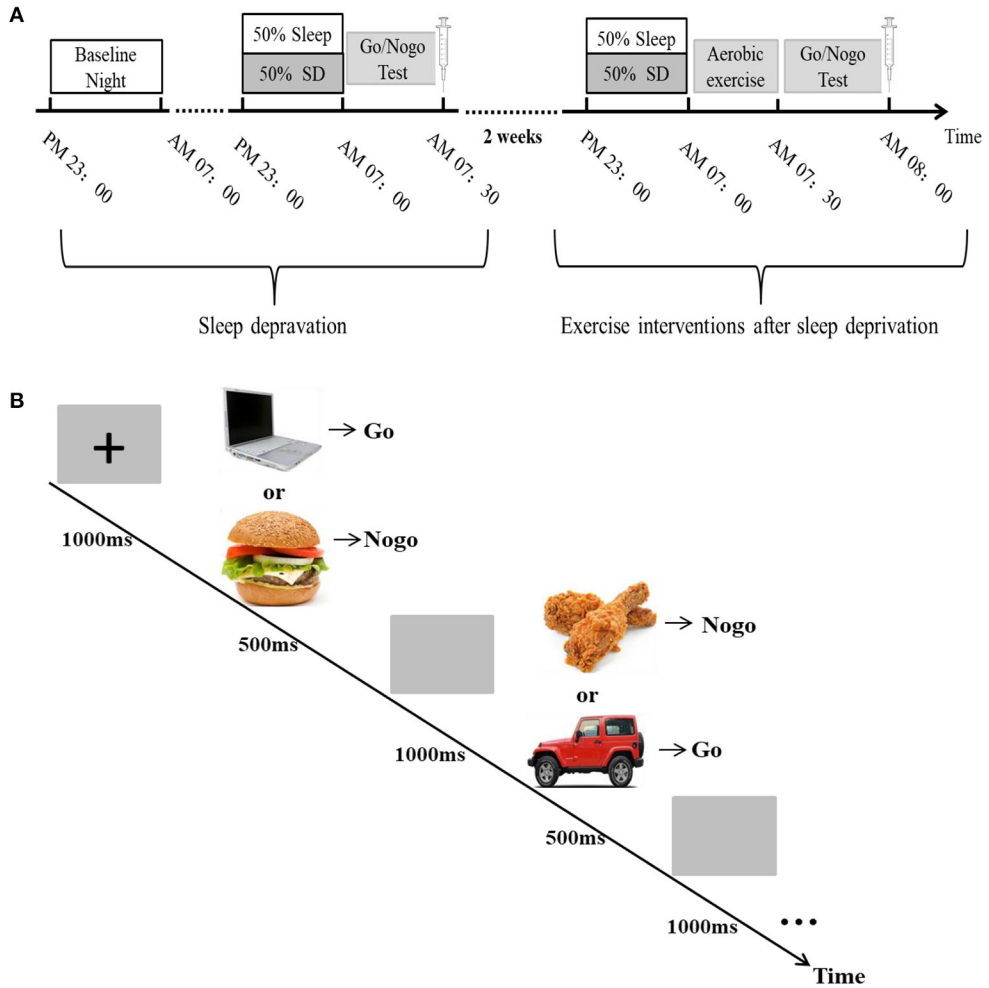

FIGURE 1 | Flow chart of test procedures. **(A)** A randomized crossover experimental design process. All subjects are required to participate in a sleep deprivation and a normal sleep experiment, with an interval of 2 weeks. The sleep intervention time is PM23:00-AM07:00. Sleep in the basal state (baseline night) was performed once before the experiment, and a Go/NoGo experiment and blood sample collection between 07:00 and 08:00 after the sleep intervention. **(B)** Go/NoGo experimental flowchart.

point, followed by a Go (appearance of a non-food related pichture) or Nogo (appearance of food-related word) trial, each trial presentation time was 500 ms. The subjects were required to respond to the Go trial of non-food and not to the food-related Nogo trial, and entered the next trial after a 1,000 ms gray screen, as shown in the experimental flow. A total of 160 pictures appeared in the 4-min task, where, food word occurrence constituted a quarter of the total words in the task, and these pictures are mainly composed of some foods they are familiar with (e.g., hamburgers, noodles, fried chicken legs, etc.), Non-food pictures are some items that subjects often see (e.g., tables, computers, cars, etc.). The subjects were asked to press the keyboard button using their dominant hand both quickly and accurately when the picture appeared. There are 5 mission versions available as balanced crossovers, and when one group uses one version of the task, the other uses another. A training session was performed to ensure that the participants understood the task. All of the participants had hit rates that were 90% or above before the formal test (**Figure 1B**).

Biochemical Analyses

Plasma glucose analysis carried out on a chemistry analyzer (Architect C16000, Abbott Laboratories). 5-ht content was detected by enzyme-linked immunosorbent assay, and the kits were from Tongwei Reagent (Shanghai) Co., Ltd.

Data Analysis

The outcome variables of Go/NoGo task performance included, the key accuracy rate (hit rate) of go trials, the no-key rate (omission errors) of go trials, the response time (RT) for responses and the intra-individual coefficient of variation (ICV), and the key rate of NoGo trials. Among them, hit rate, response time, ICV, and omission errors of go trials reflect response execution ability in cognitive control. Commission errors are

defined as the ratio of inhibition failures when subjects face NoGo stimuli (Cedernaes et al., 2014) and can reflect response inhibition ability. Response time was defined as the time between Go gignal appearance and correct key press response (Vainik et al., 2013). Intraindividual coefficient of variation (ICV) is the variability of subjects' reaction time in go trials (Castellanos et al., 2005; Chuah et al., 2006).

Statistical analysis of all data was performed using SPSS 17.0 software. In order to examine the effects of sleep deprivation on cognitive control ability and blood biochemical parameters of the subjects, first by independent sample *t*-test, after verifying that the sequential effect of the crossover design within the group was negative, the normal distribution of the data was examined using Kolmogorov–Smirnov's test of normality, and after verifying that the data were normally distributed, cognitive control ability (commission errors, response time, hit rate, and ICV) was analyzed using a 2-factor repeated measures analysis of variance with 2 (group: sleep and TSD) × 2 (gender: male and female) × 2 (task conditions: Go and Nogo conditions), and blood biochemical parameters (glucose and 5-ht) were analyzed using a 2-factor repeated measures analysis of variance with 2 (group: sleep and TSD) × 2 (gender: male and female). In order to verify the effect of exercise intervention on the cognitive control ability and blood biochemical indicators of the subjects after sleep deprivation, the processing factors (exercise and rest) were used as the variables within the group, and the repeated measures analysis of variance was further used to analyze the processing factors (exercise and rest), time factors (immediately after exercise, 30 min after exercise and 1 h after exercise) and their interaction effects on cognitive control (hit rate, reaction time, omission errors, commission errors and ICV). Throughout the analysis, the Greenhouse Geisser method was used to correct degrees of freedom and *p*-values for statistics that did not meet the spherical test, and Bonferroni was used for *post-hoc* comparisons. All data were expressed as mean and standard deviation, and the level of significance was set at $p < 0.05$.

RESULTS

Effect of Sleep Deprivation on Cognitive Control Ability of College Students

After using a 2 (group: sleep and TSD) × 2 (gender: male, female) 2-factor repeated measures analysis of variance on the sleep deprivation experimental data of the first part (**Figure 2**), it was found that compared with normal sleep, the subjects had a significantly lower hit rate in the face of Go signal stimuli after TSD (0.97 ± 0.01 vs. 0.93 ± 0.03% of non-food Pictures), the main effect of sleep was significant [$F_{(1, 58)} = 56.84$, $p = 0.0001$, $\eta^2 = 0.50$], the main effect of gender was not significant [$F_{(1, 58)} = 0.98$, $p = 0.33$], and the interaction between the two was also not significant [$F_{(1, 58)} = 1.22$, $p = 0.28$]. Compared with normal sleep, the response time (RT) of subjects tended to increase after TSD (613.29 ± 16.58 vs. 628.81 ± 20.72 ms, $p > 0.05$), but the main effect of sleep was not significant [$F_{(1, 58)} = 0.82$, $p = 0.19$], nor was the main effect of gender [$F_{(1, 58)} = 0.73$, $p = 0.31$], and the interaction between gender and sleep was not significant [$F_{(1, 58)} = 1.09$, $p = 0.07$]. The number of omission errors tended to increase, but did not change significantly (1.07 ± 0.17 vs. 1.14 ± 0.14% of total non-food Pictures, $p > 0.05$), the main effect of sleep was not significant [$F_{(1, 58)} = 1.10$, $p = 0.14$], nor was the main effect of gender [$F_{(1, 58)} = 0.26$, $p = 0.6138$], nor was the interaction between the two [$F_{(1, 58)} = 0.67$, $p = 0.841$]. The number of commission errors was significantly increased compared with the normal sleep group (15.86 ± 2.41% vs. 20.87 ± 2.49% of total food Pictures), the main effect of sleep was significant [$F_{(1, 58)} = 59.5$, $p < 0.0001$, $\eta^2 = 0.51$], the main effect of gender was not significant [$F_{(1, 58)} = 0.26$, $p = 0.6138$], and the interaction between the two was also not significant [$F_{(1, 58)} = 0.44$, $p = 0.9342$]. ICV significantly increased in subjects after TSD (0.21 ± 0.03 vs. 0.30 ± 0.02, $p < 0.05$), the main effect of sleep was significant [$F_{(1, 58)} = 192.99$, $p < 0.0001$, $\eta^2 = 0.77$], the main effect of sex was not significant [$F_{(1, 58)} = 0.12$, $p = 0.73$], and the interaction between sleep and sex was not significant [$F_{(1, 58)} = 0.04$, $P = 0.85$]. The above results showed that sleep deprivation could seriously impair the response inhibition ability of the subjects, and there was no difference in this impairment between genders.

Effect of Sleep Deprivation on Blood Glucose and 5-ht Levels in College Students

There was no significant change in glucose content in the peripheral blood of subjects in the TSD group compared with normal sleep status (5.47 ± 0.36 VS. 5.62 ± 0.54 mmol/L), no significant main effect of sleep [$F_{(1, 58)} = 0.99$, $p = 0.1633$], no significant main effect of gender [$F_{(1, 58)} = 0.16$, $p = 0.69$], and no significant interaction between gender and sleep processing [$F_{(1, 58)} = 0.09$, $p = 0.76$]. After TSD, 5-ht content was significantly reduced (1.03 ± 0.22 vs. 0.83 ± 0.17 μmol/L), the main effect of sleep was significant [$F_{(1, 58)} = 14.40$, $p < 0.01$, $\eta^2 = 0.2$], the main effect of gender was not significant [$F_{(1, 58)} = 0$, $p = 0.95$], and the interaction between gender and sleep processing was also not significant [$F_{(1, 58)} = 0.41$, $p = 0.53$]. As a result, TSD had no significant effect on fasting blood glucose content in subjects, but it could reduce 5-ht content in the blood, and there was no difference between genders in this effect (**Figure 3**).

Effect of Exercise Intervention on Response Inhibition Ability in College Students With Sleep Deprivation Time-Course Effect

The results of the first part of the experiment showed that TSD could indeed impair the cognitive control ability of the subjects in the face of food signals. On this basis, we further applied a 30-min aerobic exercise intervention to subjects with TSD, and compared the behavioral performance of subjects in the Go-Nogo task immediately after exercise (0 min), 30 min after exercise, and 1 h after exercise, and found that hit rate had a significant main effect of exercise processing immediately after exercise [F (1, 58) = 56.96, $P < 0.01$, η^2=0.5], 30 min after exercise [$F_{(1, 58)} = 50.48$, $p < 0.01$, $\eta^2 = 0.47$], and 1 h after exercise [$F_{(1, 58)} = 46.31$, $p < 0.01$, $\eta^2 = 0.44$], that is, 1 h after the end of aerobic

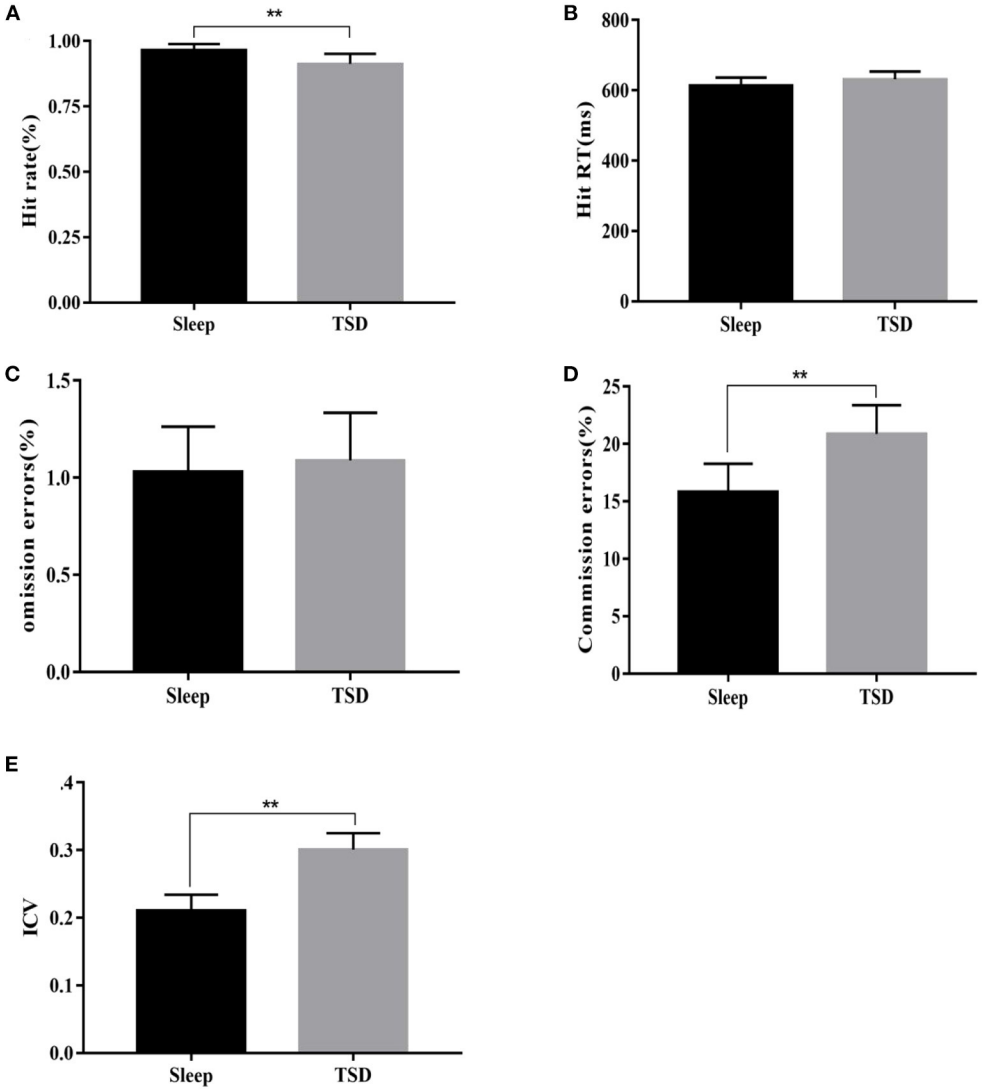

FIGURE 2 | Comparison of changes in various indicators of Go/Nogo task under sleep deprivation and normal sleep conditions. **(A)** Change in hit rate, **(B)** Change in RT, **(C)** Change in the number of omission errors, **(D)** Change in the number of commission errors, and **(E)** Change in ICV. $^{**}p < 0.01$.

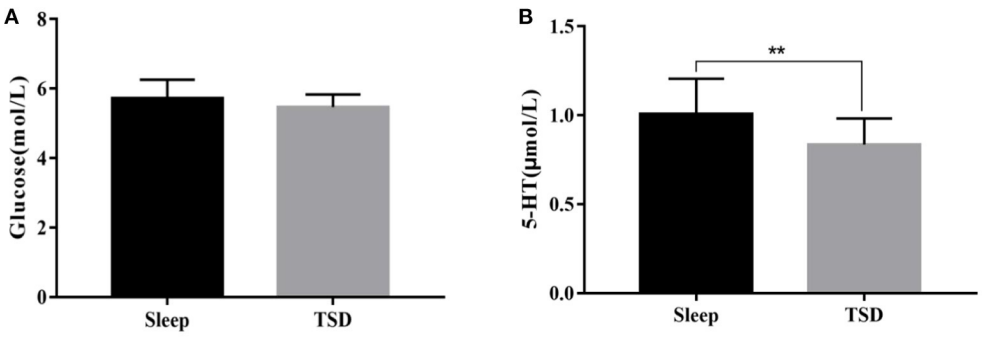

FIGURE 3 | Comparison of fasting blood glucose and 5-ht content changes under sleep deprivation and normal sleep conditions. **(A)** Change in the content of glucose and **(B)** Change in the content of 5-HT. $^{**}p < 0.01$.

exercise, the hit rate of exercise treatment was higher than that of sedentary rest treatment (0 min after exercise treatment−0 min after rest treatment = 9.51%, $p = 0.008$; 30 min after exercise treatment−30 min after rest treatment = 8.1%, $p = 0.008$; 1 h after exercise treatment−1 h after sedentary treatment = 6.51%, $p = 0.006$). The main effect of hit rate on time after movement processing was not significant [$F_{(2,177)} = 1.03$, $p = 0.46$].

RT had an exercise treatment effect on all three time periods: immediately after exercise [$F_{(1, 58)} = 58.98$, $p < 0.01$, η^2=0.5], 30 min after exercise [$F_{(1, 58)} = 40.13$, $p < 0.01$, $\eta^2 = 0.41$] and 1 h after exercise [$F_{(1, 58)} = 30.61$, $p = 0.0017$, $\eta^2 = 0.35$], that is, 1 h after the end of aerobic exercise, RT was lower than that in the sedentary rest group (0 min after exercise treatment−0 min after rest treatment = −52.21 ms, $p < 0.01$; 30 min after exercise treatment−30 min after rest treatment = −42.01 ms, $p < 0.01$; 1 h after exercise treatment−1 h after rest treatment = −30.1 ms, $p < 0.01$). There was also a time main effect of RT after exercise treatment [$F_{(2,177)} = 8.24$, $p < 0.01$, $\eta^2 = 0.09$], that is, RT immediately after exercise was shorter than that at 30 min and 1 h after exercise (0 min after exercise treatment = −17.28 ms, $p < 0.01$; 0 min after exercise treatment = −28.69 ms, $p < 0.01$), and there was also a significant difference at 30 min after exercise compared with 1 h after exercise (30 min after exercise treatment −1 h after exercise treatment = −12.06 ms, $p < 0.01$). There was no interaction between exercise processing and processing time [$F_{(2,177)} = 1.01$, $p = 0.225$]. The number of omission errors did not have an exercise treatment effect immediately after exercise [$F_{(1, 58)} = 1.09$, $p = 0.24$], 30 min after exercise [$F_{(1, 58)} = 0.89$, $p = 0.59$], and 1 h after exercise [$F_{(1, 58)} = 0.93$, $p = 0.36$]. The main effect of time after exercise treatment was also not significant [$F_{(2,177)} = 1.53$, $p = 0.26$], that is, omission errors did not change significantly during the three time periods immediately after exercise, 30 min after exercise, and 1 h after exercise (all $p > 0.05$). There was also no interaction between movement processing and processing time [$F_{(2,177)} = 0.87$, $p = 0.511$]. The number of commission errors had a main effect of exercise treatment immediately after exercise [$F_{(1, 58)} = 46.97$, $p < 0.01$, $\eta^2 = 0.45$], 30 min after exercise [$F_{(1, 58)} = 40.13$, $p < 0.01$, $\eta^2 = 0.41$], and 1 h after exercise [$F_{(1, 58)} = 38.61$, $p < 0.01$, $\eta^2 = 0.4$], that is, at 1 h after aerobic exercise, the errors in the exercise treatment group were lower than those in the sedentary rest treatment group (0 min after exercise treatment−0 min after rest treatment = −6.2%, $p < 0.01$; 30 min after exercise treatment−30 min after rest treatment = −6.17%, $p < 0.01$; 1 h after exercise treatment−1 h after rest treatment = −5.96%, $p < 0.01$). The commission also had a time main effect after exercise treatment [$F_{(2,177)} = 5.56$, $p < 0.01$, $\eta^2 = 0.06$], that is, the errors immediately after exercise were lower than those at 30 min after exercise and 1 h after exercise (0 min after exercise treatment−30 min after exercise treatment = −1.38%, $p < 0.05$; 0 min after exercise treatment−1 h after exercise treatment = −2.34%, $p < 0.01$), and there was no significant difference between 30 min after exercise and 1 h after exercise (30 min after exercise treatment−1 h after exercise treatment = −0.58%, $p = 0.374$). There was no interaction between movement processing and time Movement processing × time: [$F_{(2,177)} = 1.37$, $p = 0.2566$].

ICV had a main effect of exercise treatment at all three time points: immediately after exercise [$F_{(1, 58)} = 177.29$, $p < 0.01$, $\eta^2 = 0.75$], 30 min after exercise [$F_{(1, 58)} = 159.58$, $p < 0.01$, $\eta^2 = 0.73$] and 1 h after exercise [$F_{(1, 58)} = 148.69$, $p < 0.01$, $\eta^2 = 0.72$], that is, at 1 h after the end of exercise, ICV was lower than that in the sedentary rest treatment group (0 min after exercise treatment−0 min after rest treatment = −0.092, $p < 0.01$; 30 min after exercise treatment−30 min after rest treatment = −0.078, $p < 0.01$; 1 h after exercise treatment−1 h after rest treatment = −0.064, $p < 0.01$). There was a time main effect of ICV at three time points after exercise treatment [$F_{(2,177)} = 9.01$, $p < 0.01$, $\eta^2 = 0.09$], that is, ICV immediately after exercise was significantly lower than 30 min after exercise and 1 h after exercise (0 min after exercise treatment = −0.021, $p < 0.01$; 0 min after exercise treatment = −0.033, $p < 0.01$), and there was no significant difference between 30 min after exercise and 1 h after exercise (30 min after exercise treatment −1 h after exercise treatment = −0.009, $p = 0.079$). There was no interaction between exercise processing and processing time [$F_{(2,177)} = 1.28$, $p = 0.089$] (**Figure 4**).

Effect of Exercise Intervention on Blood Glucose and 5-ht in College Students With Sleep Capture Time-Course Effect

The results of repeated measures analysis of variance of fasting glucose content immediately after exercise and 1 h after exercise showed that there was no main effect of exercise treatment immediately after exercise [$F_{(1, 58)} = 0.99$, $p = 0.24$] and 1 h after exercise [$F_{(1, 58)} = 0.95$, $p = 0.19$], that is, there were no significant changes in fasting blood glucose content immediately after exercise and 1 h after exercise compared with the sedentary rest group (5.49 ± 0.33 vs. 5.33 ± 0.32 mmol/L, $p > 0.05$; 5.52 ± 0.53 VS. 5.42 ± 0.42 mmol/L, $p > 0.05$). In addition, there was also no time main effect on the fasting blood glucose content of the subjects after exercise [$F_{(1, 118)} = 2.91$, $p = 0.09$], that is, there was no significant change in the fasting blood glucose of the subjects immediately after exercise and 1 h after exercise (0 min after exercise treatment = −0.05 mmol/L, $p > 0.05$). There was no interaction between exercise processing and processing time [$F_{(1, 118)} = 0.99$, $p = 0.257$]. The results of repeated measures analysis of variance of 5-ht content in the peripheral blood of the subjects immediately after exercise and 1 h after exercise showed that there was a main effect of exercise treatment immediately after exercise [$F_{(1, 58)} = 25.53$, $p = 0.0004$, $\eta^2 = 0.31$] and 1 h after exercise [$F_{(1, 58)} = 26.89$, $p < 0.01$, $\eta^2 = 0.32$], that is, the 5-ht content of the subjects immediately after exercise and 1 h after exercise was significantly increased compared with the sedentary rest treatment group (0 min after exercise treatment = 0.37 μmol/L, $p < 0.01$; 1 h after exercise treatment−1 h after rest treatment = 0.24 μmol/L, $p < 0.01$). There was also a time main effect on 5-ht levels in subjects after exercise [$F_{(1, 118)} = 1.12$, $p = 0.2928$], that is, 5-TH content was significantly higher immediately after exercise treatment than 1 h after exercise (0 min after exercise treatment = 0.11, $p < 0.05$). There was no interaction between exercise processing and processing time [$F_{(1, 118)} = 1.14$, $p = 0.154$] (**Figure 5**).

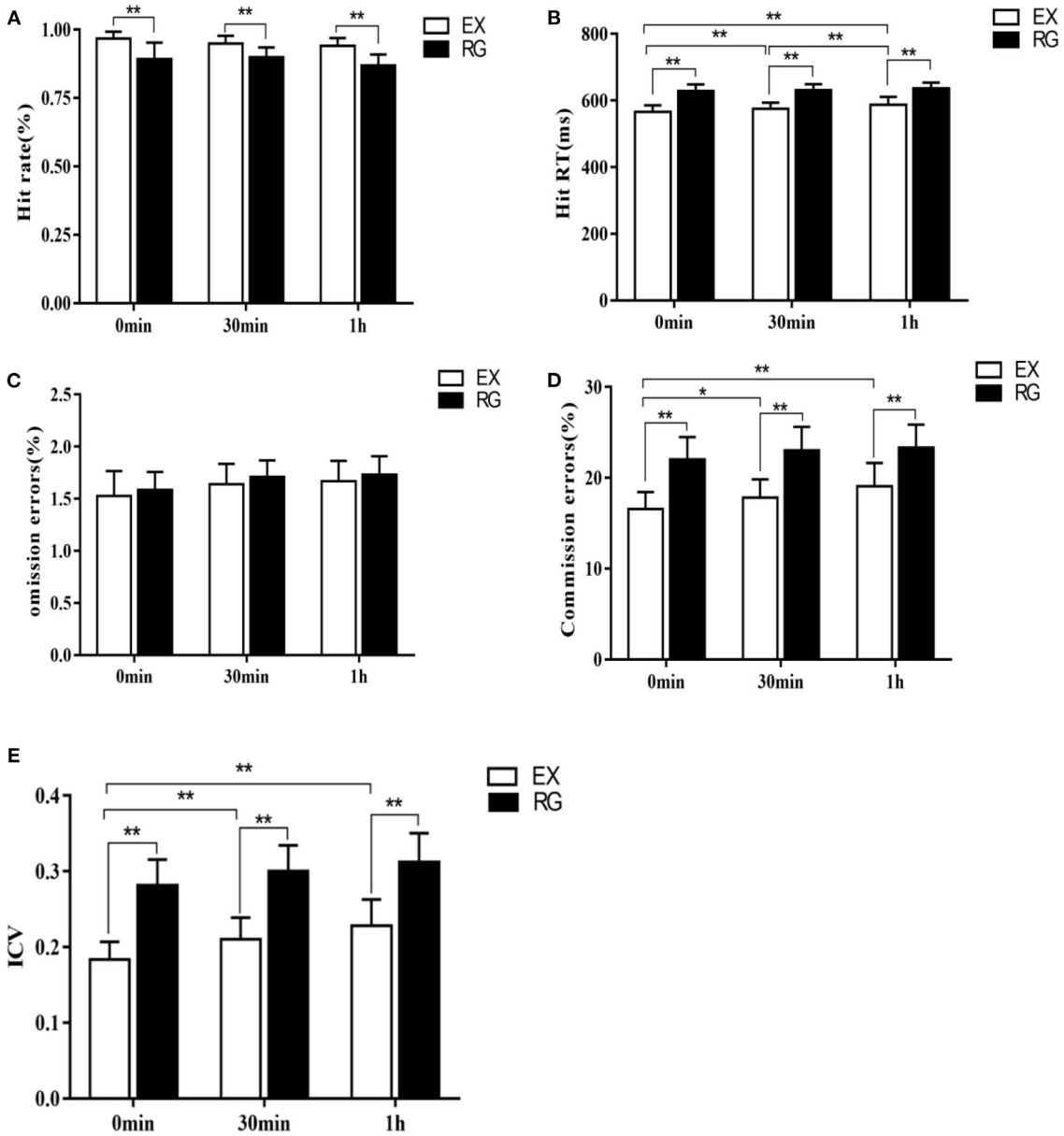

FIGURE 4 | Comparison of changes in each index of Go/Nogo task at different time points after exercise intervention. **(A)** Change in hit rate, **(B)** Change in RT, **(C)** Change in the number of omission errors, **(D)** Change in the number of commission errors, and **(E)** Change in ICV. $^{*}p < 0.05$, $^{**}p < 0.01$.

Correlation Analysis of Reactivity Inhibition Ability With Blood Glucose and 5-ht in College Students After Exercise Intervention

The results of Pearson's simple correlation analysis showed (**Table 1**) that there was no significant correlation between cognitive control function-related parameters and blood glucose changes in college students after exercise intervention ($p > 0.05$). The results of simple correlation analysis showed that commission errors and ICV showed a highly significant negative correlation with 5-ht content changes ($p < 0.01$). The results suggest that the decrease of 5-ht content after sleep deprivation may be an important factor leading to the loss of some cognitive control functions, while aerobic exercise intervention may reverse the loss of cognitive control caused by sleep deprivation by increasing 5-ht content in peripheral blood.

DISCUSSION

The study found that one night of sleep deprivation is sufficient to impair the execution of cognitive control and the inhibition of cognitive control in normal adults. This impairment of cognitive

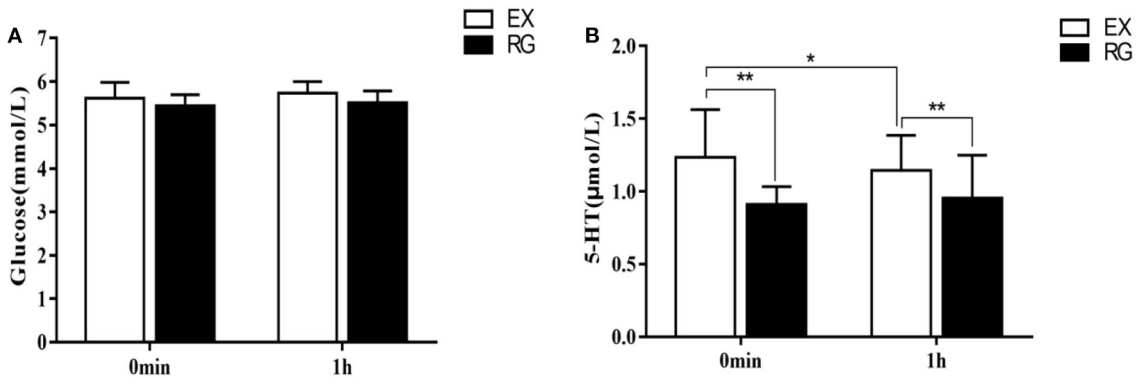

FIGURE 5 | Comparison of changes in fasting blood glucose and 5-ht content after exercise intervention. **(A)** Change in the content of glucose and **(B)** Change in the content of 5-HT. $^{*}p < 0.05$, $^{**}p < 0.01$.

TABLE 1 | Correlation analysis between cognitive control function and blood parameters.

	Hit rate	hit RT	Omissions errors	Commission errors	ICV
Glu	−0.107	0.124	−0.099	−0.134	0.144
5-ht	0.454**	0.104	−0.107	−0.521**	−0.475**

$^{**}p < 0.01$.

control ability was significantly alleviated by 30 min of aerobic exercise after sleep deprivation. This beneficial effect can last for about an hour after exercise.

Impaired Cognitive Control After Sleep Deprivation

Cognitive control is an ability to perform behavior according to rules, purposes, or intentions, two main parts are involved: execution and inhibition of reactions (Davranche and McMorris, 2009), this is a core component of cognitive function. In the first part of this study, the Go-Nogo task was used to assess the cognitive control function of 30 healthy adults after one night of complete sleep deprivation, findings revealed that, all subjects after total sleep deprivation, in the face of Nogo food picture stimuli, there was a significant increase in commission errors compared to the normal sleep group, the results indicate that sleep deprivation impairs the ability to inhibit response. In addition, compared with the normal sleep group, the sleep deprived group's Hit rate was significantly lower in response to go non-food picture stimulation, ICV increases significantly, the number of omission errors and RT tended to increase but there was no significant difference, suggesting that sleep deprivation can also impair the response execution ability of subjects to some extent. It has also been found that, sleep deprivation can increase impulsivity in response inhibition tasks, reduce response inhibition ability (Chuah et al., 2006), increase food intake (Herzog et al., 2012), and enhance rewarding effects in the central nervous system evoked by eating (Benedict et al., 2012). In this study, subjects' attention bias to food stimuli after sleep deprivation made them more likely (although inaccurate) to respond in the face of Nogo food picture stimuli, which in combination with lower executive function further weakened response inhibition, ultimately leading to an increase in commission errors. The velocity-correct rate theory suggests that increasing speed impairs the correct rate. However, this study found that there was no significant change in reaction time while the accuracy was reduced in the sleep deprivation state, and the results suggested that these two distinct automatic responses and stop responses may depend on different aspects of the attention system. In this study, after sleep deprivation, subjects made more commission errors, rather than omission errors, possibly because they sacrificed accuracy in pursuit of speed. Because the Go/NoGo commission task requires accurate inhibition of unrelated responses and continuous error monitoring, the commission errors were significantly increased in this experiment, which may also be related to the inability of subjects to effectively concentrate after sleep deprivation, resulting in reduced recognition of target stimuli (Koslowsky and Babkoff, 1992), and the difficulty in detecting Nogo stimuli or in inhibiting impulsivity caused by Nogo food image stimuli (Jin et al., 2015). Studies by Chee et al. (2006) and Mu et al. (2005) (also confirmed that changes in cognitive function after sleep deprivation have a significant neural basis, and there is a direct relationship between the degree of brain activation and the level of cognitive function. During waking at rest, the activity of the ventrolateral PFC, and the degree of reduced inhibition efficiency after sleep deprivation (Wager et al., 2005). Successful response inhibition (stop) requires activation of lateral prefrontal cortex regions (Konishi et al., 1998), errors of commission are associated with activation of the anterior cingulate cortex and medial frontal gyrus (Hester et al., 2004), the anterior cingulate gyrus plays an important role in conflict monitoring

(Braver et al., 2001), while the ventral part of the prefrontal cortex plays an important role in sustained attention control (Egner and Hirsch, 2005) and inhibition of unrelated response processes (Fujimoto et al., 2020). The response to food images in the anterior brain region of the right cingulate cortex is enhanced after total sleep deprivation (Benedict et al., 2012). The study by Chuah et al. (2006) also confirmed that after sleep deprivation, the variability (ICV) of the subjects in the Go/NoGo task was significantly increased, the correct rate (hit rate) was significantly reduced, and the reduced inhibition efficiency was related to the decreased activity in the ventral and anterior regions of the prefrontal cortex (Pfc). Therefore, the reduced cognitive control of the subjects after sleep deprivation found in this study may be caused by the reduction of top-down inhibitory control of the subjects after changes in the activity of the above brain regions, resulting in difficulty in overcoming the dominant response caused by Nogo-food image stimulation (Friedman et al., 2009).

Studies have found that reduced levels of available glucose (Gailliot and Baumeister, 2007; Cullen et al., 2020) and 5-ht (Zimmer et al., 2016) in the brain can impair cognitive control. Since glucose and 5-ht contents in blood are positively correlated with those in cerebrospinal fluid (Audhya et al., 2012), this study reflects changes in the central nervous system after sleep deprivation by detecting glucose and 5-ht contents in peripheral blood. The results showed that there was no significant change in fasting blood glucose content and the content of 5-ht decreased after sleep deprivation, indicating that the decrease of cognitive control ability after sleep deprivation was related to the decrease of central 5-ht content, while glucose may not be the main factor causing the decrease of cognitive control ability. However, the effect of reduced glucose sensitivity on cognitive control after sleep deprivation cannot be ruled out. It has been confirmed that sleep deprivation for one night can reduce insulin sensitivity in the blood (Cedernaes et al., 2016). However, whether reduced insulin sensitivity is the cause of reduced cognitive control in the subjects in this study needs to be further confirmed.

Physical Exercise Can Alleviate Impaired Cognitive Control After Sleep Deprivation

In this study, we applied a 30-min aerobic exercise to subjects who experienced a night of complete sleep deprivation, and the results showed that compared with the non-exercise group, the subjects had increased key accuracy and shortened response time, significantly decreased ICV, and no significant change in omission error immediately after exercise (0 min) in the face of non-food image stimuli, indicating that exercise improved the subjects' response execution ability. At the same time, commission error was significantly reduced immediately after exercise, indicating that the trend of reduced response inhibition ability of the subjects was reversed after sleep deprivation. In the face of Nogo food image stimulation, the subjects needed top-down inhibitory control to overcome the dominant response (Friedman et al., 2009), and the commission error in the exercise group was lower than that in the rest treatment group in this experiment, indicating that after acute aerobic exercise, the ability of the subjects to flexibly use top-down inhibitory control was improved, reflecting the promoting effect of acute aerobic exercise on inhibitory ability. In addition, the motor response time is also significantly reduced, which shows that the improvement of the correct rate is not at the expense of the response time, but the improvement of the potential inhibitory control ability. The results suggest that the improvement of inhibitory ability by aerobic exercise may inhibit impulsive responses from the time of early perceptual processing. The results are in line with the experimental expectations, and also further confirm the previous studies. The results of the study by Pontifex et al. (2013) showed that after exercise, it was accompanied by an increase in P3 amplitude and an increase in inhibitory control ability. Kashihara and Nakahara (2005) found that moderate-intensity aerobic exercise facilitates the improvement of the speed of selective response in exercisers. Drollette et al. (2014) demonstrated that a moderate intensity exercise could improve response accuracy in children with lower inhibitory control in the flanker task, but the reaction time did not change. Tomporowski (2003) also found that an aerobic exercise of 20–60 min at a time could improve exercisers' performance in cognitive tasks. There are various explanations for the reasons why short-term aerobic exercise improves cognitive control function. The awakening sleep hypothesis suggests that aerobic exercise can increase the awakening level of the body, increase its metabolic level, increase the blood flow level in brain regions related to executive function, and then improve the cognitive function of individuals (Kamijo et al., 2004); the brain-derived neurotrophic factor hypothesis suggests that short-term aerobic exercise increases the neuroendocrine level of the brain, leading to changes in neurotrophic factors in the brain and improving the cognitive function of individuals (Seifert and Secher, 2003). However, the above hypotheses need to be verified by more studies to comprehensively and clearly reveal the mechanism by which short-term aerobic exercise affects cognitive control function. Studies have found that changes in dopamine (Zoladz and Pilc, 2010) and 5-ht (Zimmer et al., 2016) neurotransmitter concentrations in the central nervous system can also affect cognitive function. The results of this experiment also confirmed that the 5-ht neurotransmitter content in the blood of the subjects increased after exercise. Because the prefrontal cortex has a very dense serotonergic innervation, and the prefrontal cortex plays an important role in regulating executive function including response inhibition (Sargin et al., 2019), the increased 5-ht content in the peripheral blood after exercise may increase the 5-ht content in the PFC through the 5-ht transporter (SERT) on the capillaries, which in turn enhances cognitive control (Morici et al., 2022) and reduces impulsivity.

By comparing the comprehensive performance of the subjects in the Go-Nogo task at two time points: 30 min and 1 h after exercise, it was found that exercise had a significant time-course benefit in promoting cognitive control function after sleep deprivation, including cognitive control advantages in both response execution and response inhibition that could be maintained until 1 h after the end of exercise. The reason for this time-course benefit may be that neurotransmitters such as dopamine (Longo et al., 2021) and 5-ht secreted during

exercise still play a role in neuromodulation after cessation of exercise, which is speculated to be partially confirmed in the detection of blood 5-ht after exercise. The results of correlation analysis also showed that there was a highly significant positive correlation between hit rate and 5-ht content changes, and a highly significant negative correlation between commission errors and ICV and 5-ht content changes in college students after exercise intervention. The reason for this may be because increased 5-ht content changes the activity of related brain regions such as the prefrontal cortex of the brain, ultimately changing the cognitive resource allocation function of the brain, which is that the response inhibition function and response execution of individuals are enhanced in the face of sensitive signal stimuli. However, this change in cognitive function was not significantly associated with changes in blood glucose content, which is inconsistent with previous studies. In addition, this study found that there was no gender main effect on the promotion of cognitive control ability by aerobic exercise. Because the degree of promotion and time-course benefit of cognitive control by moderate intensity aerobic exercise may be affected by factors such as exercise time, exercise intensity and physical fitness of subjects, therefore, future studies should use different cognitive task paradigms to comprehensively reveal the relationship between motor and cognitive control in terms of single factors, multiple factors and interactions.

CONCLUSIONS

One night of total sleep deprivation impaired cognitive control, including response inhibition and response executive function. Acute, a single bouts of aerobic exercise can alleviate the cognitive control impairment caused by sleep deprivation, and 5-ht may be one of the possible mechanisms by which acute, a single bouts of aerobic exercise alleviates the cognitive control impairment caused by sleep deprivation. This study suggests that aerobic exercise may be an effective emergency way to temporarily alleviate or restore impaired cognitive control ability in special occupations such as truck drivers, soldiers, and nurses who often engage in night shift work when effective sleep is not available.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by 2020 Educational Science Planning Project of Shanxi Province (Project Approval No.: J2021729). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SL: software, resources, and writing—original draft preparation. RZ: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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Exploration of Sports Participation and Curriculum Resource Utilization in Primary Schools Before and After the "Double Reduction"

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In order to eliminate capital chaos in the Education And Training (EAT) industry and ease parents' and students' excessive attention to subject achievements over physical quality, China government has launched the "Double Reduction" ("DR") policy which promotes students' Sports Participation (SP) in the Compulsory Education (CE) stage concerning students' physical and mental health. Firstly, based on the actual situation of students' SP before and after releasing the "DR" policy, this paper understands the exact needs of parents and children. Secondly, following empirical research and mathematical statistics, it analyzes the structure and characteristics of students' SP before and after the release of the "DR" policy. Mainly, the experiment focuses on the frequency, project types, and off-campus class expenditure. It also considers students' SP motivation in on-campus and off-campus sports classes before and after the "DR" policy proposal. Additionally the general curriculum resource utilization of PE teachers are surveyed in order to find out the current status of on-campus PE classes. Eventually, the strategies are put forward to optimize students' SP under the "DR" from the perspectives of family, school, and society. The results show that after the release of "DR", parents and schools gradually pay attention to student's physical health and better understand students' physical exercise in school. The consumption expenditure on sports off-campus classes has increased significantly. Meanwhile, family income and the father's occupation significantly impact the children's SP frequency in off-campus sports classes. Overall, "DR" is a protracted war. The existing difficulties need to be solved by families, schools, and the government. The research provides a practical basis for extending and managing on-campus sports classes and training. It helps timely uncover the problems in policy implementation. It guides the formulation of PE policy in the next stage of CE.

Keywords: Double Reduction policy, sports participation, students, empirical research, questionnaire survey

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INTRODUCTION

Since the founding of the People's Republic of China (PRC), the field of basic education in China has undergone five burden reduction orders to solve the physical and mental health problems of the primary and secondary school students in the stage of Compulsory Education (CE), in 1955, 2000, 2013, 2018, and 2021, respectively. Specifically, in 1955, educational reform reduced the burden thrice, followed by list reduction. Then, 2021 has seen a most thorough, rigorous, and explosive student burden reduction through root causes (Petrie et al., 2018; Zhang et al., 2020; Neville and Makopoulou, 2021). On May 21, 2021, at the 19th meeting of the Central Commission for

Comprehensively Deepening Reform, the Opinions On Double Reduction were formally adopted for deliberation. On July 24, the general office of the Communist Party of China (CPC) Central Committee and the general office of the State Council officially issued the opinions on further reducing the burden of homework and after-school training of students in the stage of CE. In this way, with high specification, short time, and fine content, the Double Reduction (DR) work has hammered into the field of education and pried the change in the education ecosystem. The document jointly issued by the CPC Central Committee and the State Council has also effectively proved the importance of "DR".

In order to strengthen the physical health education of primary school students and improve their comprehensive quality, on September 8, the Ministry of Education systematically held a series of press conferences on the golden autumn of 2021 education. The conference summarizes the existing problems in school Physical Education (PE) and discloses relevant data. About 22% of school PE and health courses in China are insufficient, and the cultural courses frequently occupy PE courses. In 2019, the excellent and good rate of physical health of students aged 6–12 was only 18.8% (Levinson et al., 2020). Therefore, the physical health level of teenagers in China needs to be improved (Goncharova, 2018; Lang, 2021; Papastergiou et al., 2021). The "DR" policy also highlights the importance of sports. The Ministry of Education promotes the "double increase" through the "DR" policy proposal. The "one increase" is to reduce the burden of schoolwork in the school and free up more time and opportunities for students to participate in outdoor activities, physical exercise, and artistic activities. The "other increase" lists sports and esthetic education training as non-discipline training. In essence, it increases students' time and opportunities to receive extra-curricular training in sports and aesthetic education (Moeijes et al., 2019; Bobrowski, 2021; Ilhan et al., 2021; Nathan et al., 2021). The "DR" policy has helped to develop physical education classes and students' Sports Participation (SP), but the real effectiveness of the policy lies in the effective implementation of PE, so this aspect of PE is particularly important. Among many contemporary theories of teaching and learning, the generative teaching theory conforms to the requirements of the development of the times for educational work, pays attention to students' differences, meets different needs and takes students as the main body, and emphasizes not only the development of students' physical health but also the strengthening of students' mental health development (Wang et al., 2020; Harvey and Smal, 2021; He et al., 2021). The Development And Utilization (DAU) of Generative Curriculum Resources (GCR) is the key link for teachers to carry out generative teaching. Teachers' active development of GCR can directly affect the overall development of students (Bosquet et al., 2020; Cárcamo et al., 2021). However, few studies utilize GCRorSports Participation (SP) in primary school PE.

Shenyang is one of the pilot cities for implementing the "DR" policy. What is the current status of on-campus PE activities? Do parents realize the importance of children's physique and sign up for off-campus sports training courses? What kinds of sports activities do parents tend to sign up for their children? These questions are all expounded on in the present work. First, this paper analyzes the GCR DAU of humanistic sports in primary schools and the actual situation of students' SP before and after introducing the "DR" policy. Then, it understands the actual needs of different parents and children and provides a certain practical basis for extending the role of on-campus sports and the management of extra-curricular sports training. The outcome points out the problems existing in implementing the policy in time and promotes and guides the formulation of PE policies in the next stage of CE.

METHODS

Research Object and Method

The formal questionnaire (QS) is distributed to the parents of students in five primary schools in the pilot city of Shenyang through convenience sampling from November 1 to November 18, 2021. The respondents are parents of students in grades 2–6 of primary school. The QS data are collected, screened, sorted, and analyzed by Excel and Statistical Science for Social Science (SPSS). A total of 1,240 QSs are distributed, 1,098 QSs are collected, with a recovery rate of 88%, 956 valid QSs, and an effective rate of 87%. Additionally, this work also interviews 38 PE teachers to understand the utilization of GCR in primary school before and after the "DR" policy.

QS Design and Preparation

The QS is designed. The aim is to understand the situation and changes in students' SP since implementing the "DR" policy and selecting sports items by students from families of different social classes under the current upsurge of off-campus sports training. QS includes a survey introduction, basic information about students and their families (namely, students' gender, number of family children, parents' age, income, occupation, and education level), frequency of students' SP in on-campus sports activities, types of sports activities, frequency of SP in off-campus physical education, cost of off-campus PE and motivation for admission. The respondents are parents of students in grades 2–6 of primary school (aged 6–12 years).

Statistics of Sample Frequency Distribution

The sample FD statistics are given in **Table 1**.

As manifested in **Table 1**, the QS sample is rich. The structure is reasonable, proving the good representativeness of the QS through the gender, one-child situation, and parents' educational background and occupational structures of the respondents.

RESULTS

Analysis of the DAU of GCR of Primary School PE

The Main Motivation of PE Teachers to Develop and Utilize GCR

This section investigates the respondents through direct questions and interviews. It analyzes the main motivation of PE teachers to develop and use GCR. **Table 2** lists the results. Q1: "what is your main motivation to develop and use GCR

TABLE 1 | Statistics of sample FD.

Variable	Category	Percentage/%
Gender	Male	55.4%
	Female	44.5%
Only-child situation	Only-child	67.9%
	Multi-children	32.1%
Maternal occupation	Workers or the unemployed	15.6%
	Service personnel or individual industrial and commercial households	34.4%
	Civil servants of Party and government organs, personnel of enterprises and institutions, or technicians	27.6%
	Teachers, engineers, doctors, and lawyers	19.7%
	Other	2.7%
Father's occupation	Workers or the unemployed	13.6%
	Service personnel or individual industrial and commercial households	34.8%
	Civil servants of Party and government organs, personnel of enterprises and institutions, or technicians	32.2%
	Teachers, engineers, doctors, and lawyers	16.6%
	Other	2.7%
Mother's education	Lower than high school	28.4%
	Diploma or undergraduate	62.2%
	Post-graduate	9.4%
Father's occupation	Lower than high school	29.3%
	Diploma or undergraduate	59.2%
	Post-graduate	11.5%

TABLE 2 | Interview data on the main motivation of PE teachers to develop and utilize GCR.

Questions	Teachers' answers	Proportion
Q1	To develop students' emotions, attitudes, and values	5.3%
	To develop students' thinking	7.9%
	To help students improve their movement skills	21.1%
	To achieve the preset teaching objectives	65.8%
Q2	Development of students' thinking ability	7.9%
	Students' emotions, attitudes, and value development	2.6%
	Mastery of students' skills	28.9%
	Completion of teaching plan	50.0%
	Classroom discipline	10.5%

in teaching?" Q2: "what do you think are the main factors to evaluate teachers' teaching ability?"

As listed in **Table 2**, 65.8% of teachers develop and utilize GCR to achieve the present teaching objectives. Regarding the main factors to evaluate teachers' teaching ability, 50% of teachers choose "the completion of the teaching plan", and 28.9% of teachers choose the "mastery of students' skills". Overall, in practice, most teachers always regard "the completion of teaching plans" as the purpose and destination of teaching activities, ignoring the needs of students' development of emotion, attitude, and values.

DAU of Different Types of GCR

Subsequently, to understand the DAU of different types of GCR by PE teachers, the results are obtained according to a series of questions in the interview, as illuminated in **Figures 1–5**.

As depicted in **Figure 1**, when facing students' error GCR, 71.1% of teachers directly correct errors through explanation or demonstration, and 15.8% of teachers help correct errors through other methods. Teachers seldom ignore students' errors GCR.

As shown in **Figure 2**, when facing students' individual differences, 47.3% of the teachers help those with low original level or poor learning ability, 31.5% of the teachers choose to ignore the difference, 13.2% of the teachers criticize and accuse students, and only 7.8% of the teachers select customized teaching according to the individual differences.

As outlined in **Figure 3**, when faced with students' different suggestions, Of this, 28.9% of teachers ignore them. About 39.5% of teachers judge, criticize, or immediately deny. And 28.9% of teachers respect students' views and lead students back to the standard answer. Additionally, a few teachers act according to the specific situation to decide whether to take students' suggestions.

As demonstrated in **Figure 4**, in the face of students' psychological changes, such as emotions, attitudes, and values, 28.9% of teachers criticize students or immediately deny their views. About 26.3% of teachers can pay attention to students and patiently help students solve problems, but many teachers ignore them.

As displayed in **Figure 5**, when facing the natural environmental changes in teaching (not strong enough to hinder the teaching), only 15.5% of teachers use the change to develop new teaching resources. Most teachers adhere to the original plan.

Before the "DR" policy, teachers' GCR DAU behaviors differ largely. However, on students' error-oriented GCR, no teachers choose the DAU method of ignoring. Most teachers will focus on criticism or ignore (bypass) when developing and utilizing resources other than students' errors and individual differences.

Problems in the DAU of GCR in Primary School PE

Figure 6 sketches teachers' interview results of the problems existing in the DAU of GCR in primary school PE. In the current teaching, teachers' DAU of GCR is often accidental. At the same time, the lack of understanding of GCR and related theories will also affect teachers' choice of DAU methods. At present, PE teachers mainly focus on the GCRDAU that can directly benefit students' sports skills. They ignore the GCR that may develop students' emotions, attitudes, and values. Specific DAU strategies can improve teachers' awareness of the GCR DAU and provide guiding ideas for teachers.

Descriptive Statistics

After the "DR" policy, schools have a rich choice of extra-curriculum classes. As enumerated in **Table 3**, science, calligraphy and painting, and sports rank among the top three in the number of choices. Since everyone can participate in multiple extra-curriculum classes, the proportional sum is

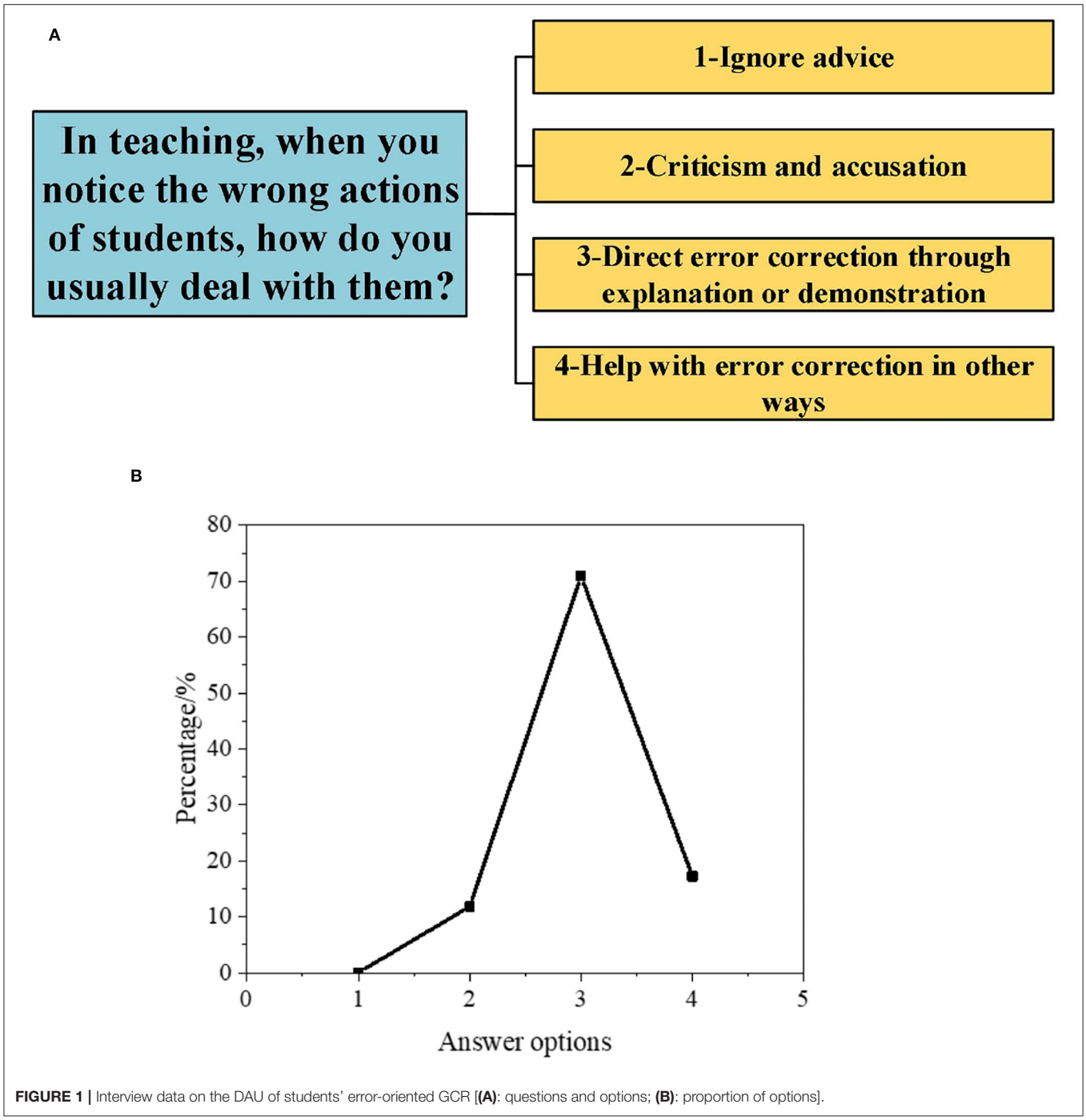

FIGURE 1 | Interview data on the DAU of students' error-oriented GCR [**(A)**: questions and options; **(B)**: proportion of options].

>1. According to the data survey, the students and parents who choose to participate in the off-campus sports class are more than those in the off-campus music class and slightly less than the off-campus science and painting class. The results reflect the students' and parents' preference for the extra-curriculum sports class and their attention to physical exercise.

Figure 7 compares the frequency of on-campus SP before and after "DR" (since a single class in primary school extends about 40 min, 40-min minimum organized sports activities are recorded as SP).

As revealed in **Figure 7**, after the "DR", the on-campus and off-campus SP frequency has increased. According to the interview with teacher W of T school, T school has adjusted the original sports class from 4 to 5 times a week. It aims to improve the students' physical exercise intensity. Additionally, as charted in **Figure 7**, the SP frequency of sports off-campus classes has also increased by 75%. The time and funds released

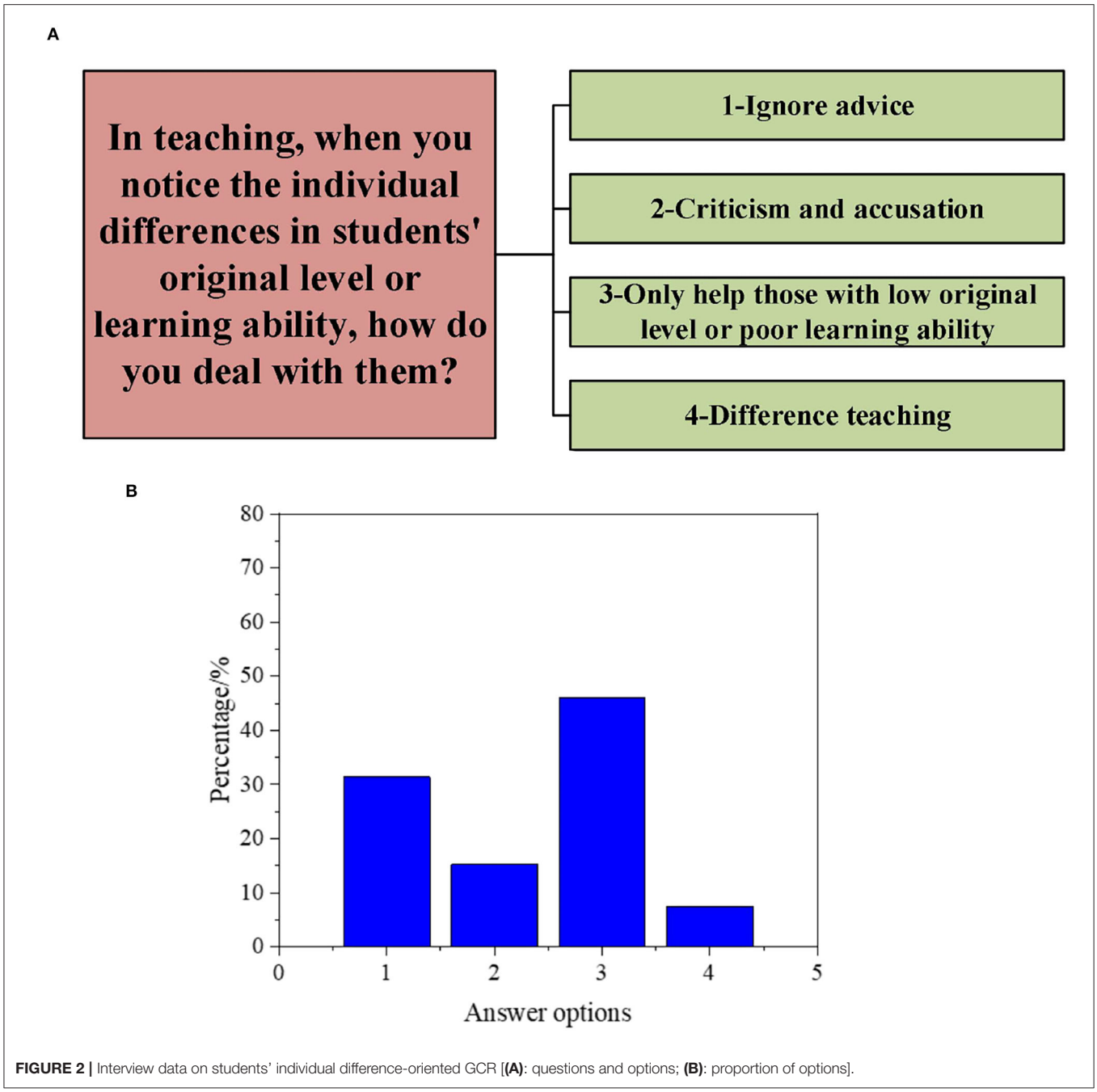

FIGURE 2 | Interview data on students' individual difference-oriented GCR [**(A)**: questions and options; **(B)**: proportion of options].

due to the cancellation of discipline training have also been used for off-campus sports training. In addition, the survey found that before and after the DR, 36 and 28% of parents said that they did not know their children's SP frequency. The results prove that the relationship between parents and the school needs to be strengthened. Thus, it shows that parents lack attention to their children's PE.

In the survey sample, the purpose of signing up for off-campus sports classes is expressed by numbers 1–7. The specific proportion is distributed in **Figure 8A**. No.1 represents that students thenselves require to enroll in the classes. No.2 represents that just follow surrounding students' choices. No.3 represents for increasing the interpersonal skill of kids. No.4 aims to improve physical health. No.5 means that preparing for high school or college entrance exam. No.6 means other reasons. No.7 aims to develop hobbies. In today's society, families have a deeper understanding of the overall development of children and the education of sports and art, on which they are more willing to spend on their children. The statistical results of the expenditure on off-campus sports classes are plotted in **Figure 8B**.

As charted in **Figure 8A**, the primary purpose of parents signing up for sports classes for their children is to exercise

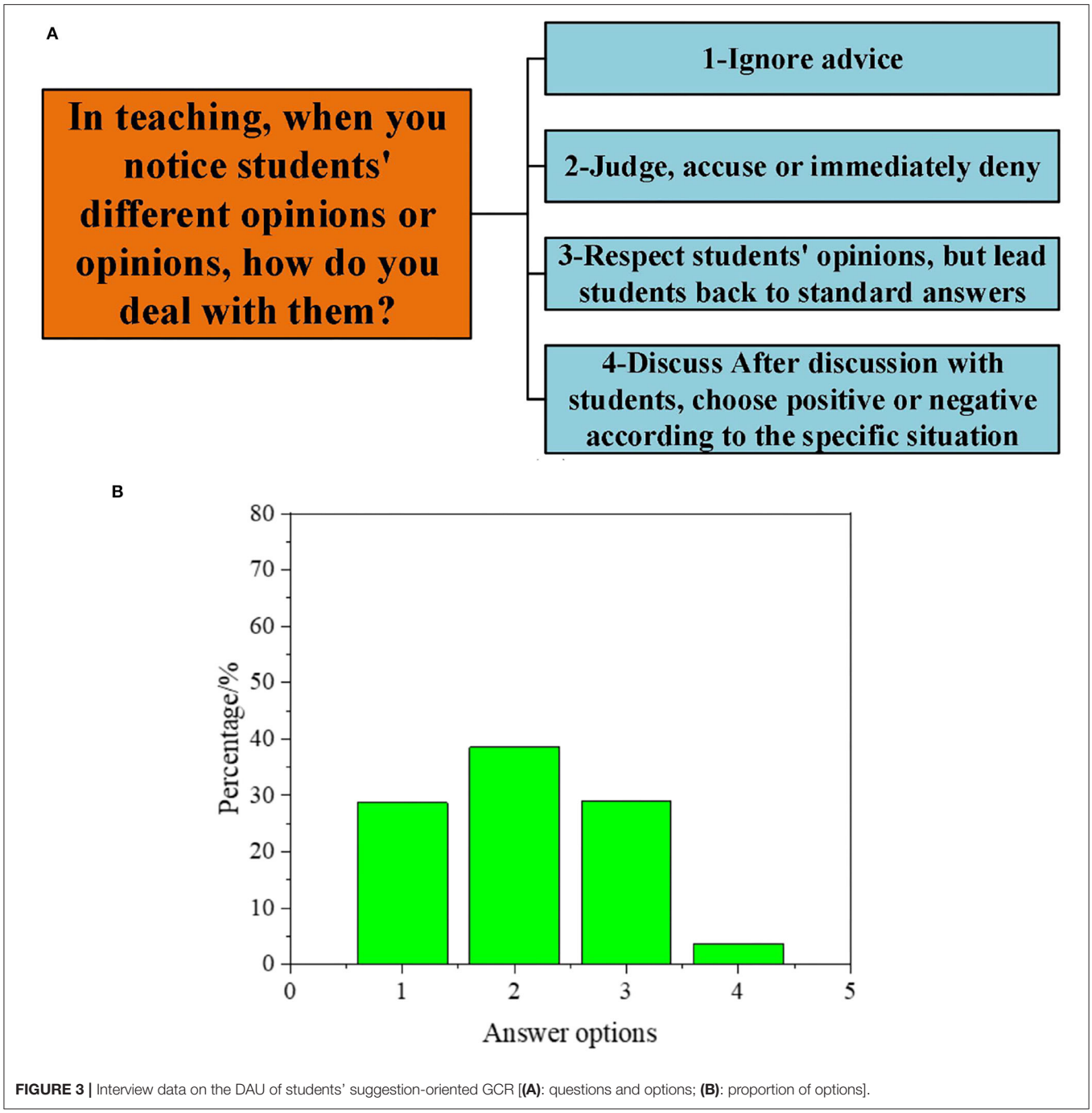

FIGURE 3 | Interview data on the DAU of students' suggestion-oriented GCR [**(A)**: questions and options; **(B)**: proportion of options].

their children's bodies and cultivate their interests and hobbies. Only 4% of parents sign up based on preparing for the sports evaluation of the College Entrance Examination (CEE; Gaokao). Hence, the score increase in sports in the CEE has not been as high as the discipline training before the "DR", which increases parents' anxiety. For example, the interviewed T school teachers have expressed that more parents have become anxious after implementing the "DR" policy. On the one hand, they are worried that their children's academic achievements will not be as well as others in CEE. On the other hand, given richer after-school time, parents have more reasons to worry about their children's possible addiction to the virtual world. Traditional ideas and the modern lifestyle are the main causes of parents' concerns. As suggested in **Figure 8B**, about the expenditure of off-campus sports classes, regardless of "DR", families' expenditure is mainly kept within 1,000 RMB per month. However, after the "DR", the number of families with an expenditure of 0–500 RMB decreases rapidly. The number of families with an expenditure of 501–1,000 RMB and 1,001–1,500 RMB per month is 2.6 times and

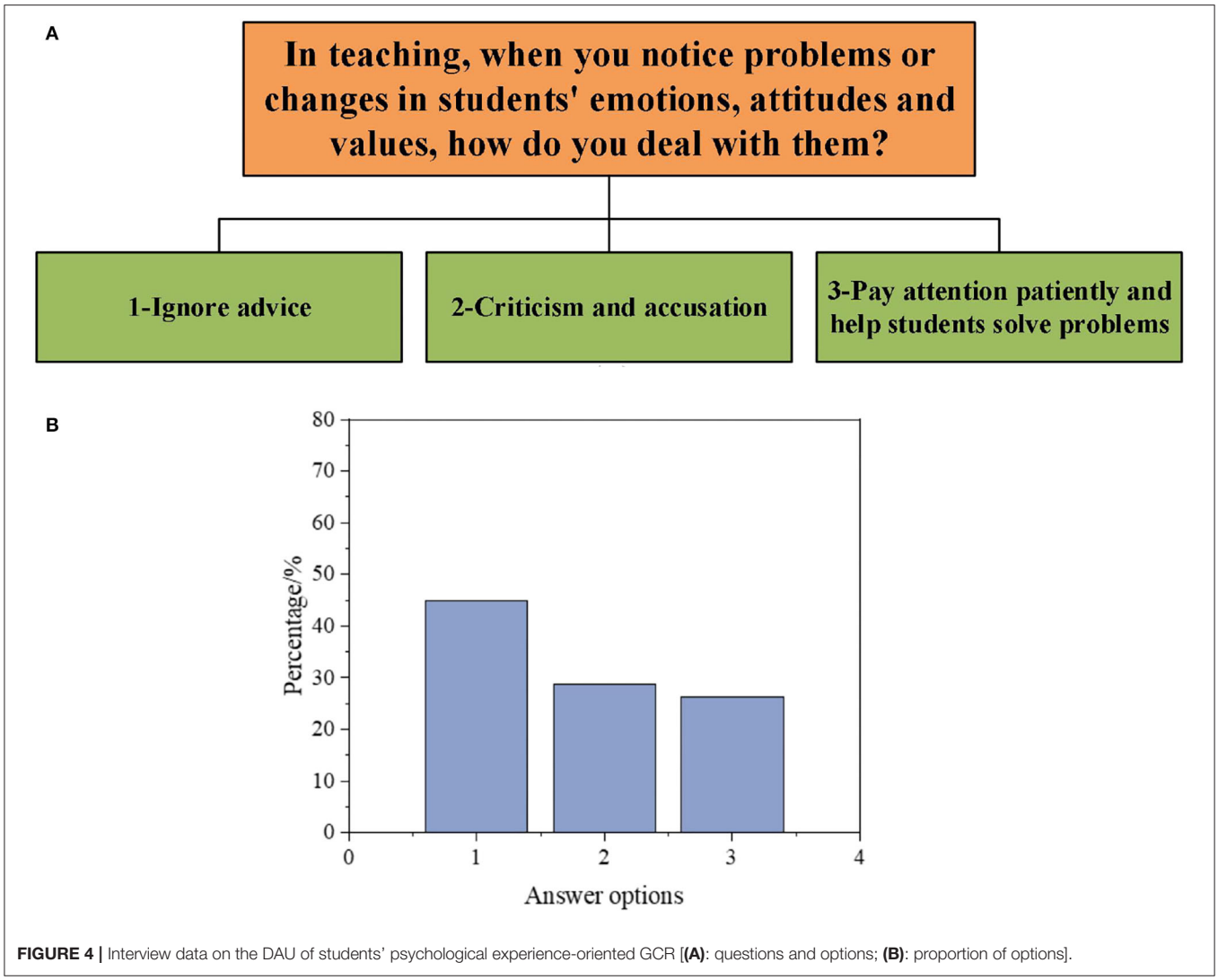

FIGURE 4 | Interview data on the DAU of students' psychological experience-oriented GCR [**(A)**: questions and options; **(B)**: proportion of options].

2.9 times the corresponding number of families before the "DR", respectively.

Although all the respondents live in Shenyang and are urban students, the sixth National Venue Survey data bulletin shows 962,700 sports venues in cities and towns, with a venue area of 1.337 billion square meters. In comparison, there are only 679,700 sports venues in villages, with a venue area of 612 million square meters. Thus, sports facilities in cities far exceed that in rural areas, and urban children enjoy more advantageous sports resources than rural students.

Influence of Family Background on Students' Participation in Off-Campus Sports

This section excludes the respondents who have no idea of off-campus SP frequency based on descriptive statistics. It implements a measurement model to deeply understand the impact of family background on participation in off-campus sports classes. Without specific classification, it takes students' SP frequency in off-campus sports classes. Based on this, a linear regression model is built for the situation before and after "DR". The classified variable and parental occupation are set as dummy variables. **Table 4** specifies the variables and results.

In terms of individual factors, students' gender significantly affects the off-campus SP frequency. Regardless of "DR", boys' off-campus SP frequency is higher than girls'. This is partly caused by boys' physical structure and interests. On the other hand, parents hope that sports can make boys more masculine. Additionally, the number of family children has a significant negative impact on students' off-campus SP frequency. The more children there are in a family, the less likely they will participate in off-campus sports.

Family income has a significant impact on the off-campus SP frequency. Regardless of "DR", the higher the family income is, the more students participate in off-campus

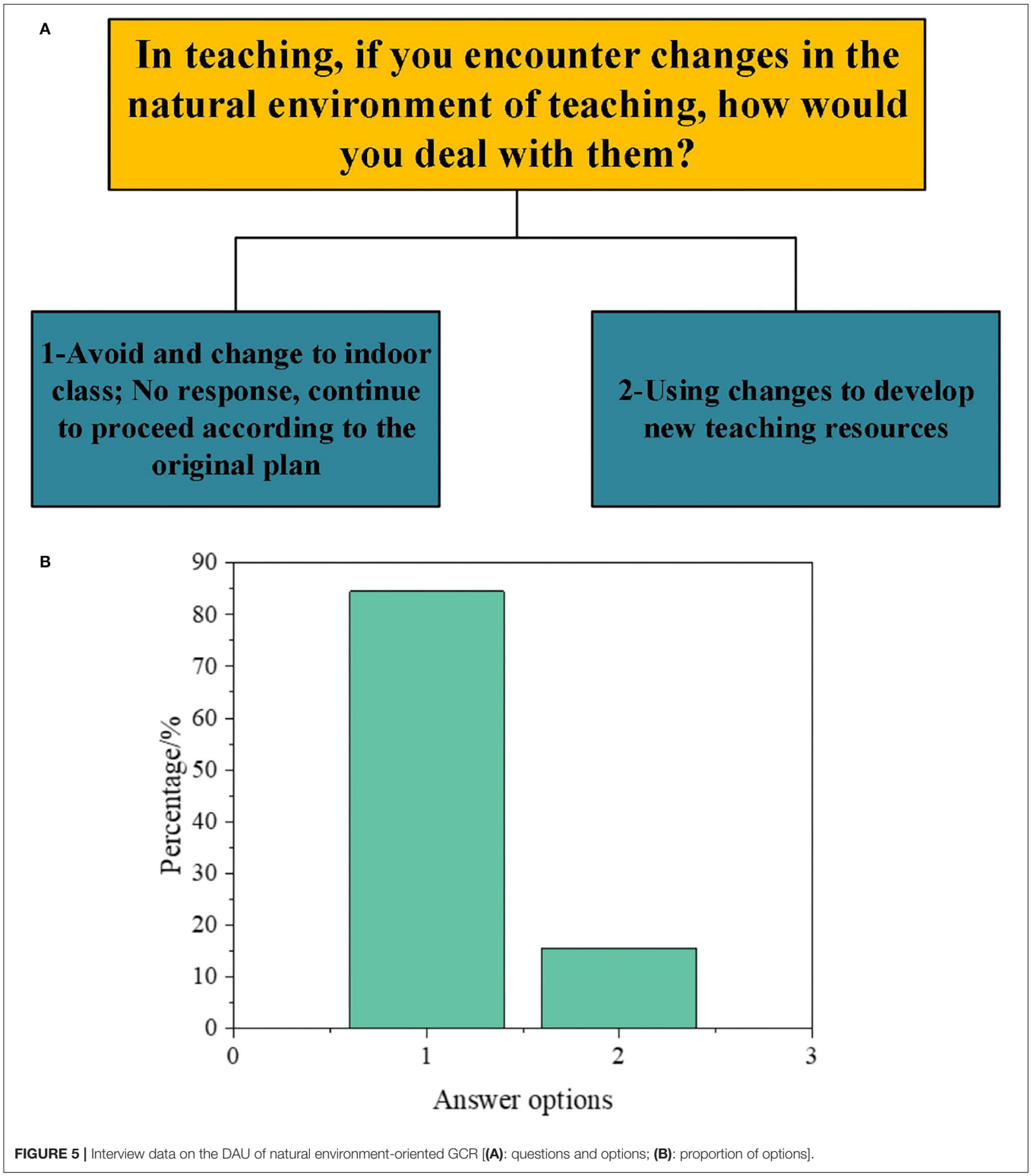

FIGURE 5 | Interview data on the DAU of natural environment-oriented GCR [**(A)**: questions and options; **(B)**: proportion of options].

sports. Off-campus sports classes can cultivate students' comprehensive quality. As shown in the statistics on parents' motivation to sign up for Off-campus sports classes for their children, parents are mainly intended to cultivate interests and hobbies and exercise their children's bodies. This off-campus counseling is considered an "icing on the cake" behavior. Therefore, family income has a great impact on the frequency of participation.

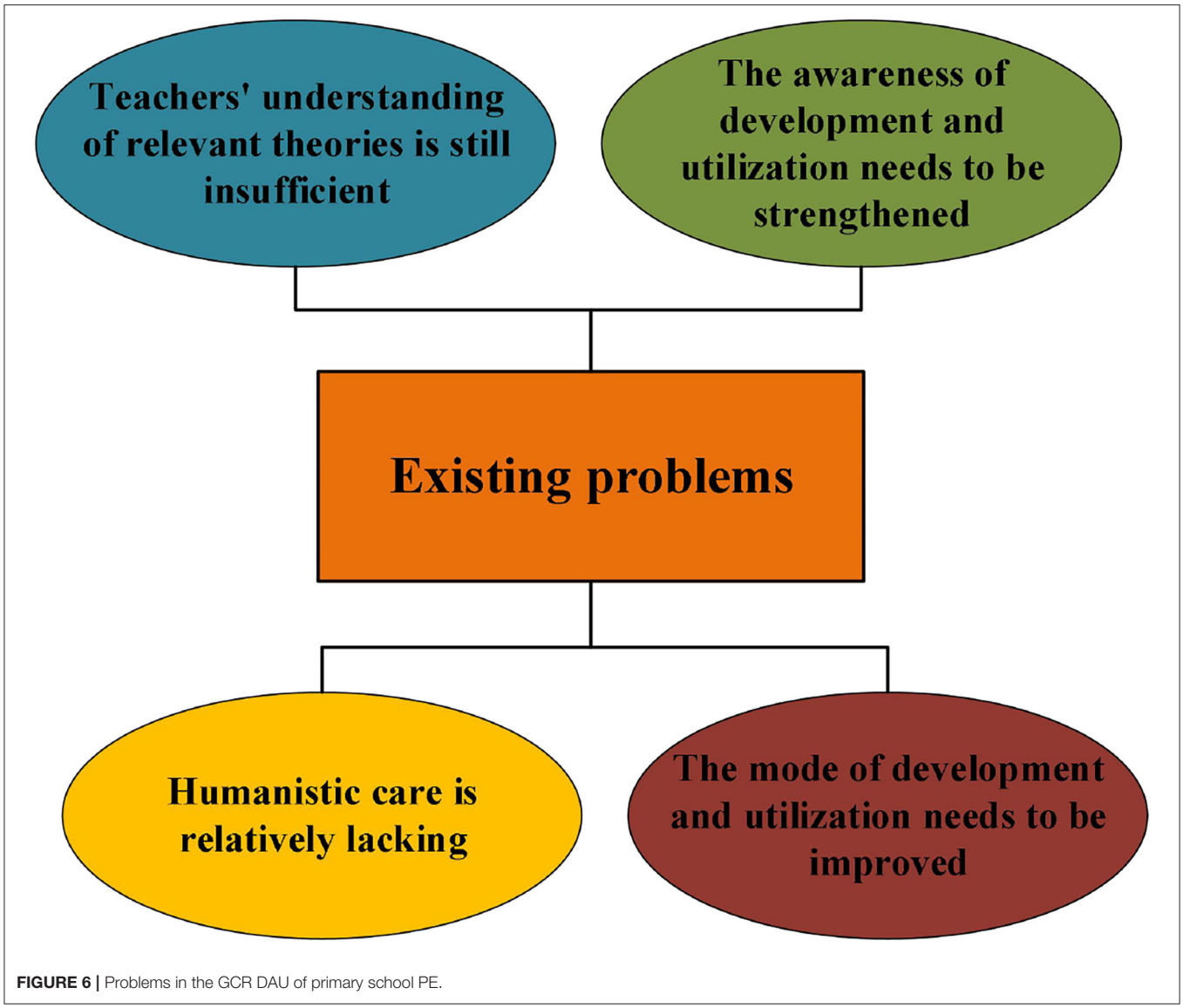

FIGURE 6 | Problems in the GCR DAU of primary school PE.

TABLE 3 | Participation in non-discipline extra-curriculum classes.

Variable	Category	Percentage/%
Participation in non-discipline off-campus classes (multiple choices)	Sports	18.9
	Calligraphy and painting	20.7
	Music	15.8
	Science	24.7
	Foreign language	11.3
	Brain development	7.2
	Other	10.4
	Non-participation	31.3

The parents' years of education have no significant effect on students' off-campus SP frequency. The empirical research reveals that the higher the family income and parents' education level are, the higher the children's off-campus SP frequency is. Possibly, previous studies have involved all sports activities, while the off-campus sports classes reported here only consider some charging items. Therefore, family income greatly impacts students' off-campus SP frequency, and the impact of parents' years of education can be ignored. Put differently, the impact of family income is too prominent, and the impact of parents' years of education is weak and no longer significant.

The father's occupation significantly affects students' off-campus SP frequency, while the mother's occupation has no significant effect. Children of CPC and government officials, employees of enterprises and institutions, and technicians have a significantly SP frequency than children of workers. Specifically, the gap is 1.53 and 1.83 units before and after the "DR", respectively. Meanwhile, children of teachers, engineers, doctors, and lawyers present a 1.25 and 2.15 higher off-campus SP

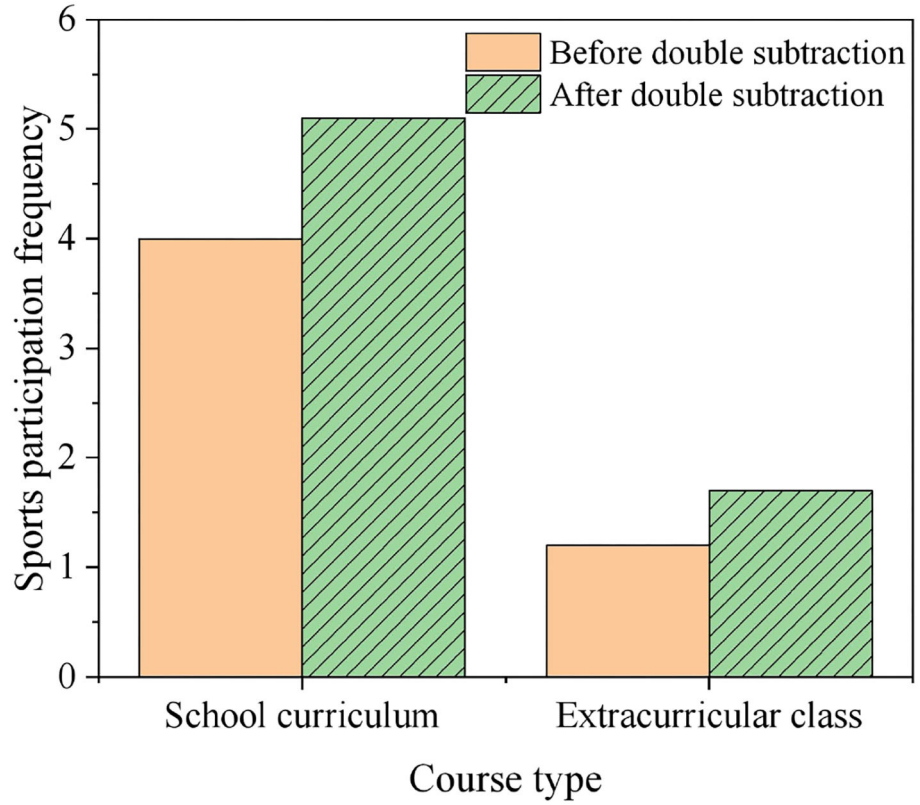

FIGURE 7 | SP frequency before and after "DR".

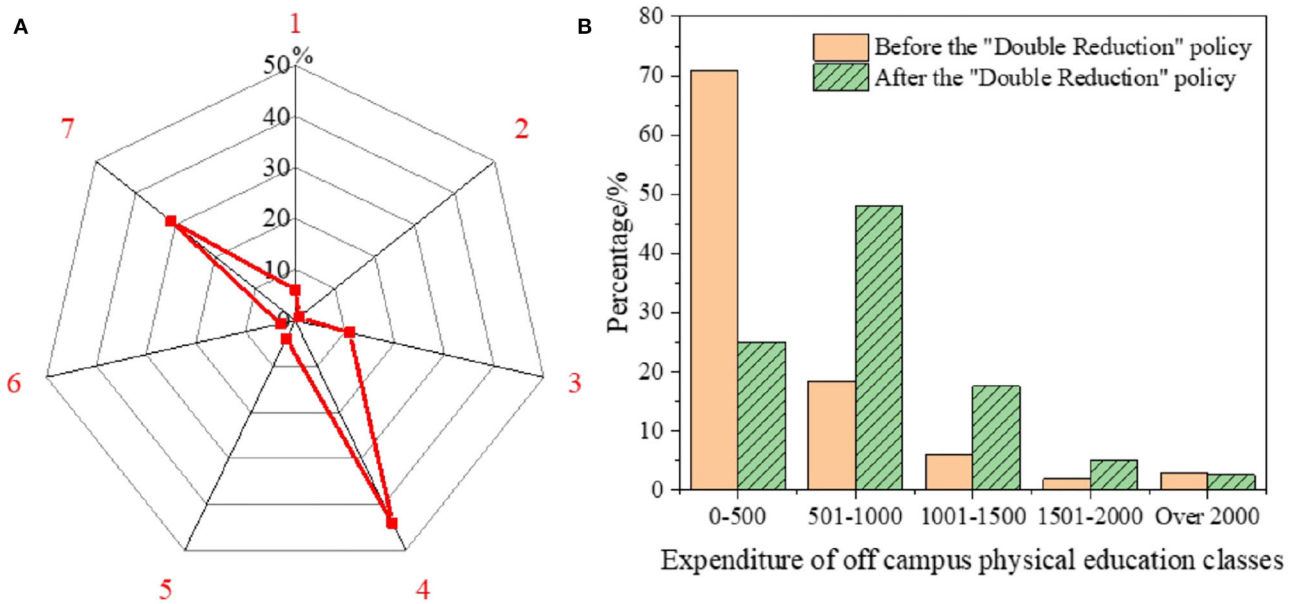

FIGURE 8 | Statistical results of registration purpose and cost of off-campus sport class [**(A)**: proportion distribution of registration purpose of off-campus sport class; **(B)**: cost expenditure of off-campus sport class].

TABLE 4 | Multiple regression analysis (MRA) results of off-campus class SP frequency.

Category	Variable	SP frequency of off-campus sports class before "DR"	SP frequency of off-campus sports class after "DR"
		Beta	Beta
	Gender (reference level is female)	−0.16***	−0.14***
	Number of children in the family (the reference level is the only child)	−0.13*	−0.14*
	Father's years of education	0.048	0.092
	Mother's years of education	0.043	0.036
	Annual household income	0.22***	0.33***
Father's occupation	Workers or the unemployed	0	0
	Service personnel or individual industrial and commercial households	1.03	2.01
	Civil servants of party and government organs, personnel of enterprises and institutions, or technicians	1.53*	1.83*
	Teachers, engineers, doctors, or lawyers	1.25*	2.15*
Mother's occupation	Workers or the unemployed	0	0
	Service personnel or individual industrial and commercial households	0.22	0.93
	Civil servants of party and government organs, personnel of enterprises and institutions, or technicians	0.60	0.73
	Teachers, engineers, doctors, or lawyers	0.24	0.96
	N	956	
	R^2	0.12	0.15

*Indicates significant at 0.05 level. **Means significant at 0.01 level. ***Represents significant at 0.001 level.

TABLE 5 | Distribution of off-campus sports class selection after "DR" under different family income.

Category		Football	Basketball	Tennis	Badminton	Indoor skating/ skiing	Fencing	Table tennis	Taekwondo	Dance	Other	Non
Family income	Maximum 25%	3.8%	25.6%	0.8%	13.5%	7.5%	0.8%	6.0%	4.5%	23.3%	5.6%	24.1%
	Upper middle 25%	5.0%	28.8%	1.4%	7.2%	8.6%	0.0%	9.4%	7.9%	17.3%	6.1%	20.9%
	Lower middle 25%	6.5%	30.6%	0.8%	5.6%	2.4%	0.0%	4.8%	11.3%	16.9%	4.7%	29.0%
	Minimum 25%	9.1%	21.7%	0.0%	4.3%	0.0%	0.0%	9.1%	3.5%	22.2%	5.5%	37.0%
	Chi square	4.7	6.1	2.6	8.35*	21.4*	4.7	1.2	3.7	2.7	-	91.1**

*Indicates significant at 0.05 level. **Means significant at 0.01 level. ***Represents significant at 0.001 level.

frequency than workers' children before and after the "DR", respectively. Probably, the income of intellectual occupations is relatively stable and rich in social resources. Signing up for off-campus sports classes is consumption behavior, so income is strong support. In addition, intellectuals have a high social status and pay more attention to their children's quality education.

Sports Category Selection Behavior

Further, to explore the opening and selection of on-campus and off-campus sports before and after the "DR", this section investigates students' SP by considering family incomes. Because the QS is designed with a multi-choice form for sports classes, the category selection of off-campus classes is repeated. **Table 5** lists the distribution of the proportion of students choosing different off-campus sports types. Because many people choose more than one sport, the sum is >1.

Table 5 uncovers the selection of sports types in off-campus sports classes. Basketball, dance, taekwondo, and football are very popular in families of all income levels. There is a large market demand in these areas. The overall participation rate of indoor skating/skiing, fencing, and tennis is meager, and they are concentrated in the class with high family income. Such projects belong to minority sports in China, with high-class fees, which is more suitable for families with high family income and attention to children's international education. The chi-square test between the four types of family income and each sport shows that badminton and indoor skating/skiing have significant differences among families with different incomes. There are significant differences among families without off-campus classes. Children from families with the top 50% of household income have more opportunities to participate in off-campus sports classes.

TABLE 6 | SPon-campus sports activities before and after "DR".

On-campus sports		Basic track and field	Football	Tennis	Badminton	Basketball	Table tennis	Taekwondo	Dance	Other
Before DR	Participant	532	94	6	25	268	135	18	73	29
	Proportion	55.6%	9.8%	0.6%	2.6%	28.0%	14.1%	1.9%	7.6%	3.0%
After DR	Participant	554	113	14	29	341	139	25	106	69
	Proportion	57.9%	11.8%	1.5%	3.0%	35.7%	14.5%	2.6%	11.1%	7.2%

Choice Behavior of On-Campus Sports Activities

Table 6 unveils that on-campus sports activities mainly involve common projects, without great innovation, such as basic track and field, football, basketball, badminton, and table tennis. However, after the "DR", various sports activities in the on-campus sports class involve a more comprehensive range of students. The school is encouraging students to experience more kinds of sports activities. Additionally, the number of students involved in other sports has increased. According to the QS results, after the "DR" policy, new sports are added to the "rope skipping" and "aerobics", such as "Spread Fight" and "Tai Chi Fan". The school actively promotes "DR" with sports empowerment. However, according to the interview with school teachers, the current sports projects are still relatively limited, and there are too few PE teachers. The school is currently discussing cooperation with off-campus PE training institutions to introduce more excellent and professional teachers and better hardware. The aim is to maximize the effectiveness of "school-enterprise cooperation". There is no regression analysis for the SP frequency of on-campus sports activities at the individual and family levels. It is because on-campus sports activities mainly involve PE and physical activity classes, which are compulsory and have little correlation with individual and family factors.

DISCUSSION

The "DR" is a protracted war. The existing difficulties need the joint efforts of families, schools, and the government. Parents are the first-hand teachers of their children. Parents need to change traditional ideas and avoid exam-oriented thinking. Besides, they should establish correct ideas, guide their children to exercise, invest in their children to participate in sports activities, and support and understand school sports. Moreover, parents should take the initiative to reduce their excessive concerns about academic performance. Physical exercise and subject performance are not contradictory but complement each other. A good physique guarantees long-term development, the evaluation of which has been included in the CEE. Still, parents should avoid short-term examination thinking (Otero-Saborido et al., 2021; Santos and Monteiro, 2021).

Therefore, schools should pay practical attention to cultivating students' physical fitness and sports quality and expand PE teaching projects. This can help avoid the expansion of inequality in SP caused by family status. Further, for projects with expensive venues or coaches, the government can give appropriate subsidies to encourage high-quality off-campus training to enter the campus. Lastly, an excellent physical education class in school can avoid the unfair phenomenon of educational resources brought by family class, which focuses on subject training (Meng et al., 2021).

The government should continue to reduce the burden through continuous policy guidance. Introducing sports scores in the education assessment can avoid the solid examination-oriented nature by strengthening the value-added evaluation and process evaluation of PE, rather than just the result evaluation. Additionally, there is a need to accelerate the homogeneity of PE in regional and school differences and promote educational equity. At the same time, the gap between urban and rural areas should be bridged. The differences in the frequency and quality of off-campus sports class participation caused by economic conditions should be further narrowed.

CONCLUSION

This study collects students' on-campus and off-campus SP in Shenyang through a QS and interviews under the background of "DR". Then, it explicitly analyzes the development and utilization of the Generative Resources in primary school sports. At the same time, it also focuses on the impact of family background on children's participation in off-campus sports classes under the control of personal factors and school factors. Based on this, the reality of the current difficulties is understood. After the "DR", parents and schools gradually pay attention to student's physical health and better understand their on-campus physical exercise. However, research findings also reveal some problems, such as in sufficient communication between parents and school. Regardless of "DR", some parents do not know the type and frequency of sports their children carry out in school. Some parents have anxiety, which is rooted in the traditional PE concept under the long-term exam-oriented education in China.

After "DR", the consumption expenditure of off-campus sports classes has increased significantly. The motivation of parents to sign up for sports off-campus classes for their children is mainly to exercise and cultivate interest. A few parents also sign up because of the increasing weight of PE in the college entrance examination. Students' on-campus and off-campus SP types and frequency have increased. Schools and parents have paid more attention to students' physical quality. Popular sports, such as football, basketball, table tennis, badminton, and taekwondo, maintain a high degree of participation both in on-campus and off-campus classes. After the "DR", although the number of participants in fencing, indoor skiing/skating, and other small and high-cost projects has increased slightly, the

participation is still low. The diversity of sports projects in the school is insufficient. Presumably, the policy landing time is still relatively short. There is not enough time to adjust the venue and teacher capital. The PE collaborative teaching with off-campus institutions has not been on the right track. Lastly, there is a slight shortage of teachers during the period of overweight PE. The boys' off-campus SP is significantly higher than the girls' at the individual level due to physical characteristics and natural hobbies.

In terms of family background, family income and the father's occupation significantly affect the children's off-campus SP frequency. The impact of parents' years of education is not significant. Due to the charging nature of off-campus classes, wealthy families are more likely to obtain counseling resources. PE is a part of quality education. As the driving force for the upward mobility of the lower class, education alleviates or changes the inequality caused by birth and shapes inequality. The survey shows that wealthy and stable-income families will take advantage of economic resources to ensure that their children have more physical training opportunities. The distribution of opportunities among families of different social classes is unequal, making sports off-campus training bend toward the rich. There is no doubt that the comprehensive quality of sports plays a vital role in individual development. The strong position of advantageous social strata in comprehensive quality training may further enhance their comprehensive competitive advantage. The shortcomings of this work are: first, the number of samples is relatively small. Secondly, the comparison is not very obvious because the implementation time of "DR" policy is relatively short. After the long-term implementation of the "DR" policy, the follow-up work needs to explore the frequency, project types, and off-campus activity expenditure of primary school students in combination with GCR utilization in primary schools in other cities. It is hoped to improve the SP of primary school students further.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

SL: design the questionnaire, conduct the survey, and write and revise the paper. GW: revise the questionnaire, conduct the survey, and design and revise the paper. Both authors contributed to the article and approved the submitted version.

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Dietary self-efficacy and social support interactions in junior athletes' acquisition of life skills

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Objective: According to the stages of change, this study identified the association between dietary control self-efficacy and social support for healthy diets as factors influencing life skills acquisition in dietary habits among adolescents in Japan.

Research design: This cross-sectional study was conducted between April and May 2018 among eight high school baseball teams in Japan.

Method: Participants included 180 Japanese high school baseball players. Survey items evaluated life skills (dependent variables), self-efficacy's influence on dietary control, social support (explanatory variables), and stages of change. Hierarchical multiple regression analysis was used to reveal the associations.

Results: In the pre-action stage, although there was no significant association between the interaction of self-efficacy and social support on total life skills ($\beta = 0.11$, $p = 0.158$), a significant association was observed in the action/maintenance stage ($\beta = 0.32$, $p < 0.05$). The interaction between self-efficacy and social support showed a significant association with goal setting in the pre-action stage ($\beta = 0.19$, $p < 0.05$) and with communicating in the action/maintenance stage ($\beta = 0.34$, $p < 0.05$).

Conclusion: The acquisition of life skills amidst dietary situations can be facilitated by providing social support that considers self-efficacy in relation to dietary control, according to the stages of change.

KEYWORDS

social skills (MeSH), self-efficacy, social support, adolescent, nutrition education

Introduction

Acquiring life skills is essential for promoting healthy development among children and adolescents (1). The World Health Organization (2) defines life skills as "abilities for adaptive and positive behavior that enable individuals to deal effectively with the demands and challenges of everyday life." In dietary habits, complex information (e.g., differences in nutritional value and safety of foods) should be analyzed and evaluated

when selecting what an individual needs from various foods (3). In this process, various life skills such as assertiveness, self-management, negotiation, and critical thinking are needed (3), and therefore, the dietary habits should contain enough elements for acquiring those skills. To our knowledge, however, empirical research on the relationship between diet and life skills is insufficient. Therefore, this study focused on the educational strategy of food and nutrition-related aspects in the context of sports to promote acquisition of life skills among adolescent athletes. The relationships among the factors involved in the acquisition of life skills through food and nutrition should be elucidated to develop life skills education related to dietary habits.

The theoretical framework of Social Cognitive Theory (SCT) helps consider these relationships. The SCT states that personal, environmental, and behavioral factors interact with each other (4). Most of the behavioral factors that comprise SCT are controlled through self-regulatory functions (4), including life skills concepts such as goal setting. In this study, we used self-efficacy on dietary control (hereafter "DSE") as a personal factor and social support on healthy diets (hereafter "DSS") as an environmental factor to clarify the relationship between these factors (DSE and DSS) and life skills as a behavioral factor. In terms of the relationship between life skills and self-efficacy (hereafter "SE"), Bandura and Wood (5) states that SE has a strong influence on personal goal setting. Furthermore, Sheard and Golby (6) reported that training in psychological skills, including goal setting, contributes to increased SE. In a study, the group whose DSE improved through nutrition education also showed greater improvement in life skills (7). Thus, life skills and DSE are expected to be interrelated. A study (8) demonstrating the relationship between life skills and social support (hereafter "SS") found that for athletes, building relationship with their coaches and development of their life skills were related. More specifically, athletes, perceiving that higher levels of coaching behaviors were related to life skills including goal setting, had a positive rapport with their coaches and viewed their experiences of sports positively. On the other hand, those who reported negative rapport with their coaches, experienced stress through their sports participation. These results suggest that building positive SS rapports with coaches is important for athletes' life skills development.

While targeting adolescents who are in the developmental stages both mentally and physically, an individual's stage of behavioral change should be considered. Therefore, the relationship between the factors also needs to be clarified according to the stage of behavioral change. In this study, the Transtheoretical Model (TTM) (9) based on time dimension, was used to understand the stages of change. The five stages of change are defined as: precontemplation i.e., "not intending to take action in the foreseeable future, usually measured as the next 6 months;" contemplation i.e., "intending to change in the next 6 months;" preparation i.e., "intending to take action in the immediate future, usually measured as the next month;" action i.e., having "made specific overt modifications in their life styles within the past 6 months;" and maintenance i.e., "working to prevent relapse," with this stage continuing between ∼6 months and 5 years (9). The model states that because the stages of readiness to change health behaviors differs across individuals, the components and processes that move them to act are qualitatively different (10). Specifically, in the early stages, individuals rely on cognitive, emotional, and appreciative processes (10). In contrast, in action-oriented stages, individuals increasingly draw upon commitments, conditioning, coincidences, environmental management, and support to move toward maintenance or termination of behavior (10). In other words, while personal factors are the main elements of the process in the early stages, environmental factors are considered main in the action-oriented stages. In this study, the early stage is described as the "pre-action stage" (precontemplation, contemplation and preparation) and the action-oriented stage as the "action/maintenance stage" (action and maintenance). A comparative study using the stages of change of TTM in dietary habits showed that those in the action stage have higher self-efficacy of eating behaviors than those in the pre-action stage (11). Benight et al. (12) states that high SE helps in effectively managing SS, suggesting that, during the action/maintenance stage, the effective use of SS may depend on SE. In dietary habits, studies examining psychosocial factors or dietary behaviors based on the stages of change have focused on foods and dietary behaviors such as promoting increased vegetable and fruit intake (13–15) or decreasing obesity (16–18), indicating the importance of DSE and support from those around the person. Regarding dietary habits, a study using the SCT as a theoretical framework in adults (19) found that social support indirectly predicted dietary behavior through self-regulation and self-efficacy, while self-efficacy indirectly affected dietary behavior through self-regulation. However, insufficient studies have been conducted to identify the relationships among these variables by stages of change to develop life skills in adolescents. Since life skill acquisition is particularly important during childhood and adolescence (1), there is a strong need to clarify the relationship among factors affecting life skills at different stages of change. Therefore, this study aimed to examine the association between DSE and DSS as factors influencing adolescents' life skills acquisition in dietary situations according to the stages of change.

We formulated two hypotheses:

Hypothesis 1: DSE and DSS are associated with and affect life skills acquisition.

Hypothesis 2: Depending on the stages of change, DSE will be the key factor associated with the pre-action stage, whereas DSS will be the main influence during the action/maintenance stage, for life skills acquisition.

Materials and methods

Research design

This cross-sectional study was conducted during April–May 2018 among high school baseball players in Japan.

Setting and participants

Participants were 180 first-year high school baseball players from eight high school baseball teams. Seven of these eight teams belonged to public schools, and one team was from a private school. All participants were day scholars. To recruit the participants, we approached the target teams' teachers, who then informed the respective players. We then, in writing, clarified our research objectives, investigation details, and the potential disadvantages to the prospective participants and their legal guardians, after which only those who were willing to participate and provide their consent were included in the study. More specifically, they were apprised that participation was optional and could be withdrawn, even after providing consent, through a written withdrawal of consent. Those who agreed to participate provided written informed consent. Notably, no school provided nutrition education to participants between admission and the time of the survey. The survey was self-administered, and the study ultimately involved 179 participants (15.1 ± 0.3 years old), excluding one who did not respond to the stages of change component. The study protocol was approved by the Ritsumeikan University Ethics Review Committee for Medical and Health Research Involving Human Subjects and was conducted per the Declaration of Helsinki.

Questionnaire

The survey items were related to life skills as the dependent variables, and DSE and DSS as explanatory variables. The stages of change helped identify the dietary behavior change process. The scales used to assess life skills and DSE were developed for college student-athletes, and the life skills scale has also been used with high school student-athletes (20). Thus, these scales were used for the high school student-athletes in this study.

First, we evaluated life skills using a scale for athletes (21) previously found reliable and valid. Responses to each question were scored from 1 (not applicable at all) to 8 (very applicable). A confirmatory factor analysis (CFA) was performed with 40 items (e.g., I communicate with every member of my team) and 10 subscales. Convergent validity was assessed using the means of composite reliability (CR), factor loading (FL), and average variance extracted (AVE). All the CRs for each construct were greater than the recommended value of 0.60 (22), except that for "Maintaining physical health and wellbeing," which was 0.57. The FLs of all the subscales were >0.5 (23), except that for "Maintaining physical health and wellbeing," which was 0.499. Moreover, all the AVEs were greater than the recommended value of 0.5 (24), except those for "Thinking carefully," "Taking responsibility for one's own behavior," and "Maintaining physical health and wellbeing," which were 0.44, 0.49, and 0.26, respectively. These three subscales were judged to have low convergent validity but were validated otherwise. Internal consistencies of the life skills scales were examined by computing the Cronbach's alpha coefficient for each subscale; the results reported that except for "Maintaining physical health and wellbeing" (alpha = 0.58), all the other nine subscales had alpha values of 0.70 or higher. The goodness of fit: χ^2 =1087.08, df = 695, $p < 0.001$, GFI = 0.78, AGFI = 0.74, RMSEA = 0.06, AIC = 1,337.08. As some scale items did not meet all the validity and reliability criteria, it may have been necessary to either delete those items or synthesize them with items on other similar scales, as is commonly done, in order to improve them. However, as pointed out by Haebara (25), the deletion or synthesis of items may reduce the generalizability of the scale measurements for use in subsequent related studies. Therefore, although we recognize that some of the scales we tested may not meet our validity and reliability criteria, we opted to retain them in recognition of their generalizability for future studies in various populations.

Second, DSE was evaluated through a self-efficacy scale on dietary control (26), comprising 19 items (e.g., I can eat a well-rounded diet with staple food, main dishes, and side dishes even when I am alone) structured under five subscales. The scale has been found to be reliable and valid (26). Responses were scored from 1 (not confident) to 8 (confident). The total DSE score was used in this study to examine the relationship between comprehensive DSE and life skills. The CFA results for this subject confirmed that the CR was 0.94, which exceeds the minimum requirement of 0.60 for consistency (22). The FL was 0.67, which was >0.5 (23). The AVE, at 0.47, was close to 0.5 (24). The Cronbach's alpha coefficient for the DSE scale was 0.85, which reflects adequate internal consistency. The goodness of fit: χ^2 = 275.13, df = 142, $p < 0.001$, GFI = 0.86, AGFI = 0.82, RMSEA = 0.07, AIC = 371.13. Although we find it problematic that the DSE scale did not fully meet the reliability and validity criteria, we chose, as with the life skills scale, to retain this instrument.

Third, DSS was evaluated through items based on the Functional Social Support for Healthy Diets scale (27). Its reliability and validity have been confirmed (27). The scale comprises a total of 12 items (three for each function, e.g., I have someone close to me who cooks healthy meals). The wording in one item was changed to fit the target population (from work environment to team environment). Each question was scored from 1 (*not applicable at all*) to 5 (*very applicable*). The CFA results for this subject confirmed that the CR was **0**.93, which exceeds the minimum requirement of 0.60 for consistency (22). The FL was 0.71 which was >0.5 (23). Moreover, the AVE was

0.54, which is deemed acceptable when >0.5 (24). The goodness of fit: χ^2 =114.54, df = 48, $p < 0.001$, GFI = 0.91, AGFI = 0.85, RMSEA = 0.09, AIC = 174.54. To examine the relationship between comprehensive DSS and life skills, this study used the total score for DSS. The Cronbach's alpha coefficient for the DSS scale was 0.88, which reflects adequate internal consistency. All these assessments showed that this scale was appropriate for further analysis.

Fourth, the stages of change were evaluated through the TTM (9, 10). It includes five stages of change: precontemplation, contemplation, preparation, action, and maintenance. Since the present study used self-efficacy on dietary control, we used the question item on dietary-related stages of change (28). Respondents were asked to choose which of the five stages of change most applied to their current situation.

Statistical analysis

Since some subscales of life skills were not normally distributed, Spearman's rank correlation coefficient was used to calculate the bivariate association between life skills, DSE, and DSS. Hierarchical regression analysis was performed using the forced input method. This procedure examined the degree to which DSE and DSS (and the interaction terms of both scales) predict the dependent variables, total life skills, and the subscale scores. Initially, DSE and DSS were added to Model 1. Subsequently, interactions between DSE and DSS were added to Model 2. A simple slope analysis was used to visualize the interaction term at one standard deviation above and below the mean and determine whether the standard partial regression coefficient in the interaction term was significant. Prior to the regression analysis, the variables in the model were standardized. We conducted the Breusch-Pagan test and the White test to assess homoscedasticity of the residuals. We conducted multiple analyses according to the combination of explanatory variables; thus, we conducted the two tests for each analysis. When the null hypothesis of homoscedasticity was rejected for either test with a 5% significance level, we adopted robust *t*-values to check the significance levels of the parameters. Otherwise, we adopted standard *t*-values. As a result, of the 11 analyses in each stage, only two showed heteroscedasticity in the pre-action stage (the cases of appreciating others and being humble) and one in the action/maintenance stages (the case of communicating). Consequently, heteroscedasticity was not considered to be a problem overall. The reason for the presence of heteroscedasticity is that our samples might be influenced by the characteristics of the eight targeted schools; however, the reason cannot be specified. Nonetheless, the estimated parameters are unbiased; thus, we believe that heteroscedasticity is not a serious problem for the purpose of this study as we explore only the signs of the estimated parameters. However, to assess the significance levels of the estimated parameters, we need to use robust *t*-values for the heteroscedasticity cases.

Notably, Prochaska et al. (10) outlined two types of stages—(a) the early stages, which exist before action, and (b) the action-oriented stages—that continuously emerge in the context of the relationship between stages and processes of change. Accordingly, this study divided the stage of change, depending on whether the action was performed continuously, into the following two stages: the pre-action stage (precontemplation, contemplation, preparation; $n = 115$) and the action/maintenance stage (action, maintenance; $n = 64$) and the relationships between the factors were examined. The threshold for significance was $p < 0.05$. Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Tokyo, Japan, 2013).

Results

Descriptive statistics

The means, standard deviations, reliability coefficients, and correlations for DSE, DSS, life skills, and the 10 life skills subscales are described in Table 1. The Spearman's rank correlation coefficient revealed that DSE was positively associated with total life skills and all 10 life skills subscales (r range = 0.20–0.62, $p < 0.01$). The correlations revealed that DSS was positively associated with eight life skills and total life skills, excluding the skills of maintaining etiquette and manners and being humble (r range = 0.19–0.39, $p < 0.05$). Confirmed by the stages of change, the pre-action stage showed the same correlation as the overall result ($p < 0.05$). In the action/maintenance stage, DSE was significantly correlated with life skills, excluding maintaining etiquette and manners ($p < 0.05$), but DSS was not significantly correlated with total life skills or any subscales.

Factors related to life skills in the pre-action stage

Table 2 presents the results of a hierarchical multiple regression analysis model examining the impact of DSE and DSS on life skills and its subscales during the pre-action stage. In Model 1, adding DSS and DSE resulted in a significant coefficient of determination ($R^2 = 0.42$, $p < 0.001$); DSE and DSS were significantly positively associated with total life skills (DSE: $\beta = 0.54$, $p < 0.001$, DSS: $\beta = 0.25$, $p < 0.01$). In Model 2, adding the DSE and DSS interaction led to no increment in R^2, and the interaction was not statistically significant. Upon performing the same steps with each subscale with life skills as the dependent variables, the increment in R^2 in Model 2 was significant only for the goal-setting subscale ($\Delta R^2 = 0.03$,

TABLE 1 Summary of intercorrelations, means, standard deviations, and reliability estimates.

		Mean	SD	Cronbach's alpha	1	2	3	4	5	6	7	8	9	10	11	12
1	Self-efficacy	99.5	18.2	0.86	–											
2	Social support	40.3	7.6	0.89	0.421***											
3	Life skills	243.2	27.6	0.91	0.624***	0.390***										
4	Stress management	22.3	5.8	0.89	0.384***	0.333***	0.560***									
5	Goal setting	17.8	6.6	0.84	0.326***	0.261***	0.517***	0.170*								
6	Thinking carefully	23.2	3.5	0.76	0.394***	0.187*	0.537***	0.372***	0.232**							
7	Appreciating others	27.0	4.4	0.85	0.359***	0.242**	0.679***	0.441***	0.243**	0.354***						
8	Communicating	24.2	5.0	0.83	0.285***	0.304***	0.581***	0.385***	0.122	0.279***	0.429***					
9	Maintaining etiquette and manners	29.3	4.9	0.93	0.203**	0.062	0.417***	0.106	0.135	−0.017	0.204**	0.127				
10	Always making one's best effort	24.4	4.3	0.86	0.531***	0.243**	0.769***	0.267***	0.328***	0.441***	0.474***	0.357***	0.351***			
11	Taking responsibility for one's own behavior	27.4	3.5	0.79	0.408***	0.248***	0.727***	0.343***	0.239**	0.424***	0.521***	0.448***	0.274***	0.608***		
12	Being humble	24.6	4.3	0.81	0.353***	0.086	0.602***	0.117	0.171*	0.307***	0.381***	0.214**	0.405***	0.594***	0.501***	
13	Maintaining physical health and wellbeing	22.7	4.8	0.59	0.483***	0.288***	0.574***	0.217**	0.215**	0.157*	0.379***	0.219**	0.353***	0.381***	0.349***	0.266***

*$p < 0.05$.
**$p < 0.01$.
***$p < 0.001$.

$p < 0.05$). The interaction term between DSE and DSS was also significant ($\beta = 0.19$, $p < 0.05$). To further examine the identified interaction effect, a simple slope analysis was used to depict the association between DSS and DSE in relation to goal setting. Results indicated that the goal-setting score was significantly higher at high DSE than at low DSE in situations of high DSS (1 standard deviation above the mean; $p < 0.01$). Conversely, in situations of low DSS (1 standard deviation below the mean), there was no significant difference between goal-setting scores at high and low DSE ($p = 0.195$; Figure 1). Additionally, the goal-setting score in high DSS situations was significantly greater than in low DSS situations only when DSE was high ($p < 0.01$; Figure 1).

Factors related to life skills in the action/maintenance stage

Table 3 presents the results of the hierarchical multiple regression analysis models performed to determine DSE and DSS's impact on the association with life skills during the action/maintenance stage. The same factors found in the pre-action stage were added to each model. After adding DSS and DSE to Model 1, the coefficient of determination was significant ($R^2 = 0.24$, $p < \mathbf{0.0}01$). Total life skills had a significant positive association only with DSE (β =0.52, $p < 0.001$). In Model 2, when the interaction between DSE and DSS was added, an increment in R^2 was observed ($\Delta R^2 = 0.06$, $p < 0.05$); the interaction term was significantly positively associated with total life skills ($\beta = 0.32$, $p < 0.05$). A simple slope analysis was used to examine the identified interaction effect.

Figure 2 shows the regression slope for DSS and DSE's influence on total life skills. The slope analysis results indicated that the total life skills score at high DSE was significantly higher than at low DSE in high DSS situations ($p < 0.001$). Upon performing the same steps with life skills subscales as the dependent variables, the increment in R^2 in Model 2 was significant only for the communicating subscale ($\Delta R^2 = 0.06$, $p < 0.05$). The interaction term between DSE and DSS was also significant ($\beta = 0.34$, $p < 0.05$). To examine the identified interaction effect, a simple slope analysis was used to compare DSS's impact on DSE in relation to communicating. The results of the slope analysis indicated that the communicating score at high DSE was significantly higher than that at low DSE in situations of high DSS ($p < 0.01$). Conversely, there was no significant difference between the communicating scores in high and low DSE conditions in situations of low DSS ($p = 0.853$; Figure 3). Moreover, the communicating score in high DSS situations was significantly lower than in low DSS situations only when DSE was low ($p < 0.05$; Figure 3).

TABLE 2 Hierarchical regression results of total life skills and subscales in the pre-action stage.

		Total life skills score					Stress management					Goal setting					Thinking carefully				
		β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value
Step1	DSS	0.25**	3.37	0.42***	0.43***	40.60***	0.36***	4.20	0.24***	0.25***	18.37***	0.23*	2.56	0.13***	0.14***	9.16***	0.07	0.77	0.12***	0.14***	8.78***
	DSE	0.54***	7.28				0.27**	3.23				0.25**	2.71				0.35***	3.80			
Step2	DSS	0.27***	3.58	0.42***	0.01	27.99***	0.36***	4.22	0.23***	0.00	12.27***	0.27**	2.92	0.15***	0.03*	7.66***	0.07	0.80	0.11**	0.00	5.83**
	DSE	0.58***	7.42				0.29**	3.25				0.30**	3.20				0.35***	3.71			
	DSS × DSE	0.11	1.42				0.05	0.55				0.19*	2.04				0.03	0.26			

		Appreciating others					Communicating					Maintaining etiquette and manners					Always making one's best effort				
		β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value
Step1	DSS	0.10	1.09	0.22***	0.23***	16.91***	0.26**	2.87	0.10**	0.12**	7.20**	0.05	0.46	0.01	0.02	1.34	0.02	0.27	0.25***	0.26***	19.67***
	DSE	0.45***	4.47				0.16	1.72				0.14	1.42				0.51***	6.02			
Step2	DSS	0.11	1.33	0.22***	0.00	11.37***	0.28**	2.94	0.10**	0.00	4.94**	0.05	0.52	0.00	0.00	0.94	0.03	0.40	0.25***	0.00	13.25***
	DSE	0.47***	3.87				0.18	1.84				0.15	1.47				0.52***	5.99			
	DSS × DSE	0.06	0.47				0.07	0.71				0.04	0.40				0.07	0.75			

		Taking responsibility for one's own behavior					Being humble					Maintaining physical health and wellbeing				
		β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value	β	t-value	R^{2adj}	ΔR^2	F-value
Step1	DSS	0.14	1.57	0.17***	0.19***	12.72***	−0.11	−0.94	0.11***	0.13***	8.21***	0.13	1.55	0.25***	0.26***	19.50***
	DSE	0.38***	4.28				0.37***	3.44				0.46***	5.50			
Step2	DSS	0.14	1.56	0.16***	0.00	8.41***	−0.09	−0.80	0.11**	0.01	5.81**	0.13	1.51	0.24***	0.00	12.88***
	DSE	0.38***	4.14				0.40***	3.40				0.46***	5.25			
	DSS × DSE	0.01	0.15				0.10	0.67				−0.01	−0.07			

*p < 0.05.
**p < 0.01.
***p < 0.001.
In Appreciating others and Being humble, robust t-values were adopted check the significance levels of the parameters because the null hypothesis of homoscedasticity was rejected for either test with a 5% significance level. Otherwise, standard t-values were adopted.

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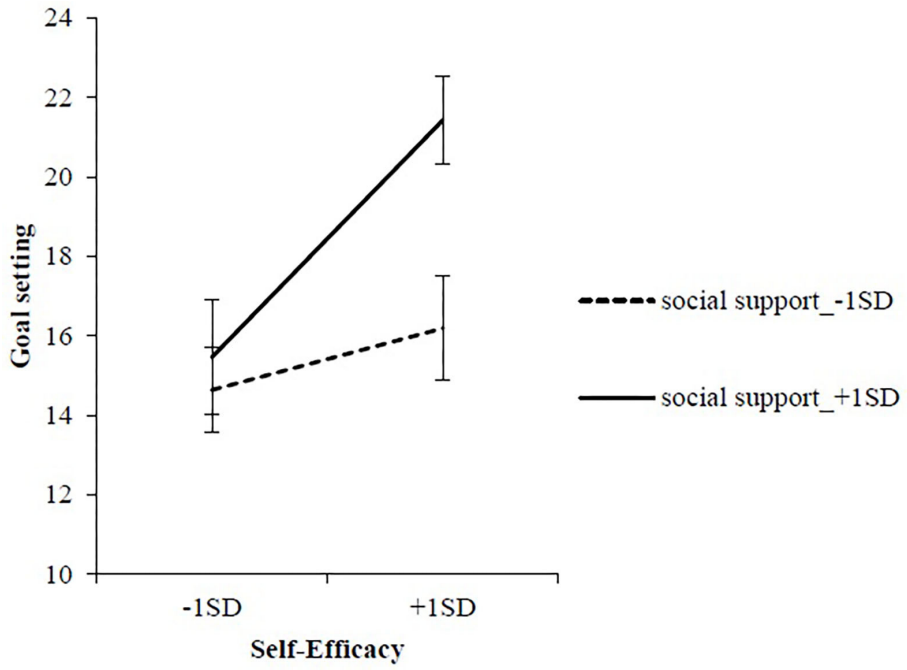

FIGURE 1
The interaction between self-efficacy and social support related to goal setting in the pre-action stage.

Discussion

Based on the stages of change, this study determined the extent to which the association between DSE and DSS impacts life skills acquisition in high school baseball players. Each variable of DSS and DSE independently explained total life skills in the pre-action stage. However, no significant association was found in the interaction terms that combined these explanatory variables.

Contrastingly, there was no significant association between DSS and total life skills among participants in the action/maintenance stage. However, DSE independently explained total life skills, furthermore, the interaction between DSE and DSS were observed. The interaction showed that the total life skills scores for participants with high DSE were significantly higher than the life skills scores for participants with low DSE during instances of high DSS. Thus, while DSS and DSE are independently related to total life skills in the pre-action stage, the combination of DSE and DSS may be related to acquiring total life skills in the action/maintenance stages. Particularly, SE contributes to the operation of the other agentic elements, such as self-regulation through goal setting (29). As DSE explained life skills at both stages of change, it may play a key role in life skills acquisition through dietary behavior, regardless of the stage of change.

In the pre-action stage, no significant association was found between the interaction of DSE and DSS and participants' total life skills. However, the interaction between DSE and DSS did significantly influence the goal-setting subscale. When DSS was high, goal setting at high DSE was significantly higher than at low DSE. Goal setting works to promote dietary change in participants in the nutrition education program (30). In the context of dietary habits, goals are set to manage one's weight and food intake quantity and frequency. Goal setting, required for behavior change or taking initiative, is similar to the self-liberation process of TTM (31). In the TTM, self-liberation is one of the processes of change in the pre-action stages (9). Thus, goal setting may be considered an important skill at this stage.

Additionally, according to the "General guidelines for applying stages and processes of change to adoption of healthful diets," encouraging an individual to set specific and achievable goals is effective in the preparation stage (32). The importance of receiving feedback from authority figures, along with planning proximal feedback goals is evident (33). Hence, in this stage, it is presumed that DSS is necessary to set food and nutrition-related goals and improve the quality of those goals. Notably, Bandura (34) and Bandura (35) states that efficacy beliefs influence individuals' goalsetting, commitment, and sustaining power of goals in the face of difficulties. This suggests that those with high DSE set challenging goals and develop effective analytical strategies. This study, too, found that with high DSS, the goal-setting score at high DSE was greater than at low DSE. This shows that when DSE is high, the influence of DSS may

TABLE 3 Hierarchical regression results of total life skills and subscales in the action/maintenance stage.

		Total life skills score					Stress management					Goal setting					Thinking carefully				
		β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value
Step1	DSS	−0.01	−0.05	0.24***	0.26***	10.89***	0.05	0.38	0.14**	0.17**	6.23**	0.09	0.65	0.02	0.05	1.69	0.05	0.34	0.12**	0.15**	5.35**
	DSE	0.52***	4.21				0.39**	2.98				0.17	1.26				0.36**	2.77			
Step2	DSS	−0.19	−1.29	0.28***	0.06*	9.31***	0.07	0.46	0.13*	0.00	4.11*	−0.07	−0.40	0.05	0.04	2.09	0.03	0.20	0.11*	0.00	3.52*
	DSE	0.44***	3.55				0.40**	2.92				0.11	0.75				0.36*	2.60			
	DSS × DSE	0.32*	2.19				−0.04	−0.27				0.28	1.67				0.02	0.14			

		Appreciating others					Communicating					Maintaining etiquette and manners					Always making one's best effort				
		β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value
Step1	DSS	0.11	0.77	0.01	0.04	1.21	−0.06	−0.44	0.06	0.09	3.09	−0.10	−0.71	−0.02	0.01	0.37	−0.06	−0.44	0.12**	0.15**	5.19**
	DSE	0.12	0.87				0.33	1.98				0.11	0.74				0.40**	3.06			
Step2	DSS	−0.05	−0.29	0.03	0.04	1.72	−0.25	−1.47	0.11*	0.06*	3.61*	−0.18	−1.03	−0.03	0.01	0.45	−0.22	−1.41	0.15**	0.05	4.72**
	DSE	0.06	0.38				0.24	1.58				0.07	0.49				0.33*	2.47			
	DSS × DSE	0.28	1.64				0.34*	2.20				0.14	0.78				0.30	1.84			

		Taking responsibility for one's own behavior					Being humble					Maintaining physical health and wellbeing				
		β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value	β	*t*-value	R^{2adj}	ΔR^2	*F*-value
Step1	DSS	0.02	0.17	0.04	0.07	2.21	−0.14	−1.11	0.16**	0.18**	6.87**	−0.03	−0.24	0.11*	0.14*	4.89*
	DSE	0.25	1.81				0.47**	3.66				0.39**	2.90			
Step2	DSS	−0.05	−0.31	0.03	0.01	1.67	−0.28	−1.84	0.18**	0.03	5.57**	−0.13	−0.78	0.11*	0.02	3.62*
	DSE	0.22	1.51				0.41**	3.10				0.34*	2.49			
	DSS × DSE	0.14	0.79				0.26	1.62				0.17	1.04			

*p < 0.05.
**p < 0.01.
***p < 0.001.
In communicating, robust t-values were adopted check the significance levels of the parameters because the null hypothesis of homoscedasticity was rejected for either test with a 5% significance level. Otherwise, standard t-values were adopted.

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deepen the analytical thinking component of the participant's goal setting.

Conversely, people who report low SE underestimate their own SE because of the difficulty in acquiring skills owing to their passive attitude toward learning (36). Another possibility is that individuals are actively engaged in learning, but due to their cognitive characteristics, such as high anxiety, they may underestimate their SE because they lack confidence in their ability to accomplish learning tasks (36). Although it is not clear what circumstances apply to the target individual, the results suggest that low SE may inhibit the acquisition of goal setting in either case.

In the action/maintenance stage, no significant association was found between DSS and total life skills. However, when DSS was high, the total life skills score at high DSE was significantly higher than at low DSE. In the action-oriented phase, people increasingly use environmental management and support with the aim of maintaining or terminating behavior (9, 10). In fact, one process encouraging change in the action/maintenance stage of the TTM is "Helping relationships," including social support for healthy behavior change (9, 10). Notably, there is a demonstrated need for environmental factors in this stage. Self-regulation is also used to sustain behavior: Bandura (4) observes that self-regulatory processes enable people to actively process and transform the environment, rather than simply reacting to them. In other words, at this stage, people do not simply receive SS passively. Instead, they require skills to effectively use SS to improve eating habits and manage their behavior.

The influence of such SS is determined by the recognition of SE, and those with higher SE may be enabled to efficiently manage present internal and external resources (12). Furthermore, active use of feedback positively influences SE (37). Accordingly, individuals with high SE and significant SS can effectively manage this support and increasingly improve their SE. It is presumed that the high score for life skills (including self-regulatory skills) reflects this. Contrastingly, lower SE makes it more difficult to access external measures, including SS (12). Thus, we conclude that when SE is low, SS cannot be employed, and life skills score poorly. This reasoning suggests that the degree of DSE affects the utilization effect of DSS during the action/maintenance stages and that this association between DSE and DSS is possibly related to acquisition of life skills.

In the action/maintenance stage, the interaction between DSE and DSS was not significantly related to goal setting, unlike in the pre-action stage. This means that DSS is not always necessary to set goals at this stage when one is ready for action. Instead of goal setting, the effective interaction of DSE and DSS was observed to influence communication. Furthermore, in situations where a lot of DSS existed, communication was significantly greater at high DSE than at low DSE. Communication skills comprise various factors, including self-control and assertiveness (38). Regarding dietary habits, it is expected that there will be an opportunity to exercise communication and undertake assertive negotiation (such as communicating a meal request to a meal preparer). Although the supporters may encourage such exchanges, it may be necessary for the subjects to work on the external environment themselves. Therefore, repeated practice exchanges with individuals and organizations are necessary to acquire communication skills in dietary situations for those who have dietary DSE to communicate their knowledge and ideas about food to another party.

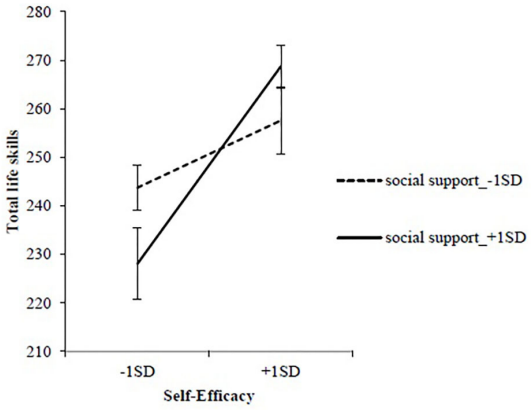

FIGURE 2
The interaction between self-efficacy and social support related to total life skills in the action/maintenance stage.

In contrast, when DSE was low, communication skills were lower when DSS was higher. This reasoning suggests that high DSS may negatively affect the acquisition of communication skills when DSE is low. This observed effect on communication, which requires interpersonal relationship skills among life skills, can be explained by the fact that SS involves relationships with various aspects of the external environment. Since lower SE makes utilization of external resources difficult (12), it is possible that the acquisition of communication skills may be hampered by over-support with extensive interaction in the context of SS. This suggests the need to first consider the degree of DSE when providing DSS—even at the action/maintenance stage.

This study's findings indicate that, among life skills, the acquisition of goal setting (in the pre-action stage) and communicating (in the action/maintenance stage) may be related to adjusting the action of DSS according to the degree of DSE. In conclusion, the acquisition of life skills in dietary situations can be fostered by providing DSS that considers DSE in dietary control according to the stages of change. We recommend that DSS must be appropriate for individuals' degree of DSE when implementing nutrition education.

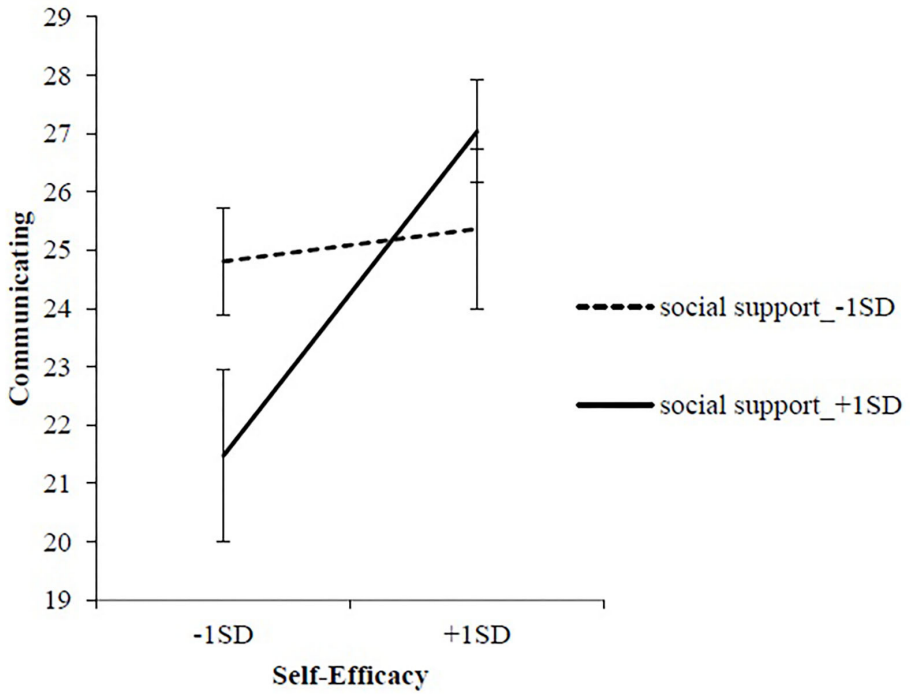

FIGURE 3
The interaction between self-efficacy and social support related to communicating in the action/maintenance stage.

Limitations

Since behavioral change was evaluated at the stages of change instead of the behavior itself, it was impossible to know the participants' actual behaviors. Hence, it is necessary to confirm behavioral changes at the behavioral level by focusing on dietary behavior, such as food intake. Baseball is one of the most popular club-sport activities among Japanese high school students (39). Additionally, as of 2021, there are 3,890 teams for boys (40) but only 43 teams for girls (41) in the baseball federation in Japan. Thus, we selected boys as the subjects of this study because there is a greater need for research on male players. Since this study was conducted in a male-dominated sport, high school baseball, only male players were considered, and comparisons with female players could not be made. While the results of this study may also apply to females, we did not examine gender differences in DSE for improving dietary habits in the athlete population. Although a previous study reported that the total DSE scores for improving dietary habits among Japanese high school students, not athletes, did not differ by gender (42), further studies are still needed.

Another potential limitation is that seven of the eight target teams belonged to public schools, and only one team was from a private school. Therefore, it is possible that these results were affected by the socio-economic status of the school. However, this study did not account for the socio-economic status of the individuals and their subsequent results. In addition, the association with communication in the action/maintenance stage may have been recognized because the participants were baseball players. Baseball is a team sport and has the characteristic of being excellently cooperative compared to some other sports (43). Thus, we presumed that the communicative relationships were already clearly present in the team. Therefore, to clarify that the functions of DSS and DSE within communicating are life skills originating in the action/maintenance stage, it is necessary to verify whether similar results can be obtained for sports other than baseball and among adolescents with various backgrounds.

When the validity and reliability of the scale were confirmed, some items did not meet the criteria. However, we decided to retain those items for the sake of generalizability in future studies. Therefore, the validity and reliability of these scale items should be considered while interpreting our results.

Implications for research and practice

We demonstrated that the degree of DSE and the function of DSS might be related to acquiring life skills that differ depending on the participant's stage of change; for instance, goal setting in the pre-action stage and communicating in the

action/maintenance stages. Results indicate that, in the pre-action stage, it is effective to provide DSS associated with goal setting, which motivates individuals with high DSE to commence the action. Therefore, it is necessary to provide DSS, such as by setting an action goal, to inspire behavioral awareness. It is also necessary to promote decision-making that leads to a heightened awareness of the decision to change behavior. Conversely, it may be helpful for those with low SE to first determine the underlying reason for low SE (44), then find a way to strengthen DSE according to the participant's characteristics, and finally, provide DSS for goal setting.

In the action/maintenance stage, it is necessary to provide information about what kind of DSS is available and help people find it, thereby increasing the chances that those with high DSE will receive it. Moreover, participants need to enhance DSS by strengthening their existing social networks or by developing new social network linkages through support groups (3). To this end, one may educate close supporters of participants, such as parents, and create opportunities to engender a new social network in which participants with similar goals can share information. However, when DSE was low, we observed that extensive DSS might negatively affect the acquisition of communication-related life skills. Therefore, we recommend providing DSS that considers the degree of DSE, even in the action/maintenance stage.

Given the cross-sectional design, the relationships between factors related to life skills can only be determined at a single point in time. Accordingly, a longitudinal study is needed to verify causal relationships between DSS efforts and DSE in life skills acquisition.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Ritsumeikan University Ethics Review Committee for Medical and Health Research Involving Human Subjects. Written informed consent to participate in this study was provided by the participants and the participants' legal guardian/next of kin.

Author contributions

YS and KY performed the statistical analysis. YS, KY, and KE contributed to the conception and design of this study. KY, JY, AS, and KE reviewed and edited the manuscript for important intellectual content. All authors have read and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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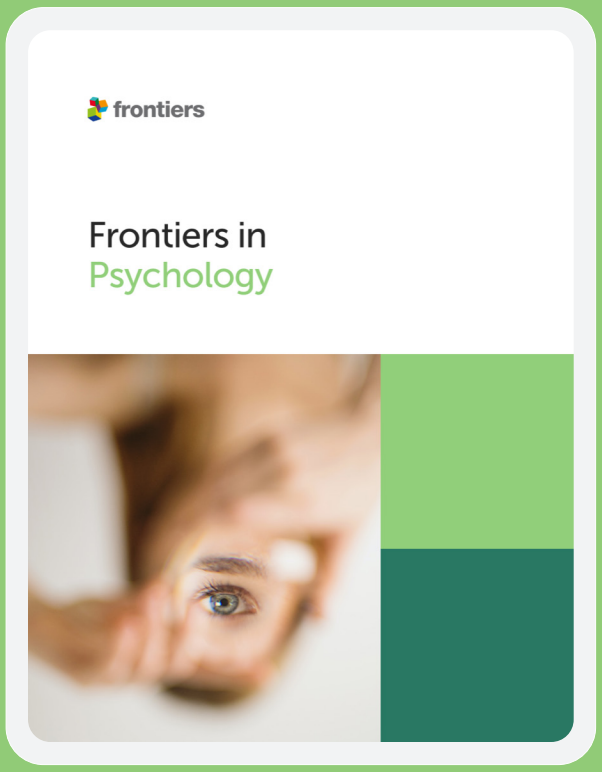

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