PSYCHOLOGICAL AND BEHAVIORAL DETERMINANTS OF PHYSICAL ACTIVITY PARTICIPATION ACROSS THE LIFESPAN

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PSYCHOLOGICAL AND BEHAVIORAL DETERMINANTS OF PHYSICAL ACTIVITY PARTICIPATION ACROSS THE LIFESPAN

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Social-Ecological Analysis of the Factors Influencing Shanghai Adolescents' Table Tennis Skills: A Cross-Sectional Study

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The main purpose of this study was to explore the factors that affect adolescents' table tennis skills (ATTS) among adolescents in Shanghai from the social ecological perspective, including individual factors, social support, and physical environment. 1,526 students from Shanghai primary and secondary schools were included in this study (age = 12.31 ± 1.32 years). Participants completed a questionnaire based on social ecological theory after taking the ATTS test. A structural equation model was applied to test the relationships among the study variables. The relationship model incorporating individual factors, social support, physical environment, and ATTS test score fit the data well (χ^2 = 1415.754, χ^2/df = 4.96, $p < 0.001$; CFI = 0.914; IFI = 0.930; NFI = 0.921; RMSEA = 0.032). The investigation results showed that social support and physical environment promote adolescents' scores on the ATTS test. At all levels of social ecology, individual factors were the most important factors for the improvement of ATTS. The level impacting most significantly on ATTS was individual factors, followed by social support, and, finally, the physical environment. Therefore, cultivating intrinsic interest is an important way to facilitate the continuous activities of adolescents. In addition, friends should support each other, and parents should give adolescents appropriate encouragement regarding table tennis exercise. Schools should provide more table tennis facilities. PE teachers should respect adolescents' ideas, listen to students' opinions, and encourage them to participate in table tennis training.

Keywords: social support, self-efficacy, adolescents, physical activity, table tennis skills

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INTRODUCTION

Research has demonstrated that playing table tennis can increase adolescents' physical fitness, relieve learning pressure, prevent and improve myopia, enhance the body's sensitivity and coordination, promote learning efficiency and communication with other students, and cultivate adolescents' psychokinesis (He, 2012; Liu and Li, 2013). However, the number of minors taking part in China's table tennis is declining year by year, and only 10% of students have been contacted with

Abbreviations: ATTS, adolescents' table tennis skills; CFI, comparative fit index; IFI, incremental fit index; NFI, normed fit index; PE, physical education; RFI, relative fit index; RMSEA, root-mean-square error of approximation.

table tennis regularly (Yan, 2014). The reasons are as follows: adolescents' heavy study pressure; the increasing influence of other sports, such as badminton, in recent years; and adolescents' poor table tennis skills (Zhou et al., 2018; Qin, 2019). All of the above-mentioned factors lead to adolescents' lack of interest in table tennis. Therefore, possessing certain sport skills is necessary for cultivating adolescents' sports interest and adhering to life-long physical exercise (Wang, 2012).

The formation of ATTS not only requires adolescents to actively participate in table tennis and carefully practice basic table tennis skills under a PE teacher's guidance, but also is related to other individual factors such as age, sex, and previous sports experiences (Faber et al., 2016). Internal factors are the main factors that affect adolescents' table tennis participation, and external factors are also important (Shao, 2015; Condello et al., 2016). Dealing with the relationship between internal factors and external factors well can help adolescents better master table tennis skills (Faber et al., 2016). At present, the research on the teaching of table tennis in primary and middle schools mainly focuses on teaching methods, teaching content, and effect evaluation (Chen, 2015; Yu, 2016). The existing research is not deep enough and has not been extended to the specific research on the influencing factors of table tennis skills.

In addition, good table tennis skills are necessary for regular table tennis exercise participation, and regular table tennis exercise participation helps in enhancing table tennis sport skills in return (Faber et al., 2016). Table tennis skills test score was used to reflect adolescents' table tennis sport skills level and their table tennis exercise participation (China Table Tennis College, 2017). The implementation of the ATTS test can enrich daily table tennis activities, facilitate the mastery of table tennis skills, and improve adolescents' physical and mental health.

Social ecology investigates the relationship between an individual and the environment. In the context of health promotion, the socio-ecological framework emphasizes the influence of individual factors, social support, and physical environment on activity patterns, such as adequate sports facilities, verbal encouragement of teachers and friends, and physical participation of parents, all of which have an impact on individual physical activity (PA) (Golden and Earp, 2012).

Individual factors in this research included two parts: self-efficacy and motivation. Self-efficacy represents "trust [in] one's ability to organize and execute actions that can achieve a certain achievement" and has been always associated with adolescents' PA (Lee and Young, 2018). There are striking and positive relationships between self-efficacy and adolescents' initiation, participation, and self-regulation in PA (Cortis et al., 2017). Self-efficacy is a determinant of motivating new PA behaviors, how long individuals will persist when facing negative experiences, and how much effort they will put into physical activities (Bandura et al., 1999). Self-efficacy is of great importance in the adoption and the maintenance of different periods of exercise behavior (McAuley et al., 2003).

There are three types of motivation, named intrinsic motivation, extrinsic motivation, and amotivation, to explain the different reasons why individuals engage in activities (Deci and Ryan, 2004). Intrinsic motivation was identified as the spontaneous engagement in activities for their own sake, such as the feelings of pleasure, interest, and satisfaction derived directly from participation. Extrinsic motivation, as opposed to intrinsic motivation, drives the participation of an individual in activities through external stimuli (e.g., threat, reward, punishment). Amotivation, stemming from a lack of competence, is the belief that an activity is unimportant, and/or when an individual does not perceive contingencies between her/his behavior and the desired outcome(s). Motivation is a major determinant of the issue on sports interest (Kondric et al., 2013).

Social support was identified as a source of motivation by many of the participants who were adult cancer survivors (Barber, 2013). A growing volume of literature has reported significant correlations between self-efficacy, social support, and PA in adults as well as other age groups (Lee and Young, 2018). More exercise social support leads to a stronger sense of exercise self-efficacy and more positive affective responses to exercise participation when a program is finished (Hagger et al., 2002; Wiltshire et al., 2017). Receiving encouragement from significant others and having a companion for PA were associated with higher PA in children and adolescents (Jaeschke et al., 2017). Peers and PE teachers played an extremely important role in generating PA behavior; weekly observations of PE classes have shown that more positive behavior can be inspired from PE teachers' interest and positive reinforcement, which is the same as small "cliques" (Daigle, 2003; Barber, 2013).

A previous study has indicated that children's participation in PA and environmental attributes were correlated (Davison and Lawson, 2006). The availability of physical exercise programs and equipment in schools and neighborhood characteristics such as pedestrian and cyclist safety structures were positively correlated with physical exercise for children and adolescents (Carlin et al., 2017). A community with more PA resources nearby may offer residents more opportunities to exercise with friends, and both neighborhood safety and device accessibility had significant correlations with PA in a population-based adolescent sample (Molnar et al., 2004; D'Angelo et al., 2017). School also plays an extremely important role in all levels for adolescents' PA (Ip et al., 2017).

In China, studies on ATTS are mainly from the perspective of pedagogy but rarely from the perspective of social ecology. Based on the perspective of social ecology, this study explored the factors that affect ATTS and built a social–ecological model to improve Shanghai ATTS. To learn the reasons for adolescents' poor skills and low participation in table tennis, this study analyzed the multiple factors affecting table tennis skills and put forward suggestions for further improving ATTS among Shanghai adolescents and promoting the popularization of table tennis among adolescents. Thus, this study contributes to the improvement of the ecological environment of adolescents' table tennis in Shanghai and the promotion of Shanghai adolescents' physical health.

It was hypothesized that: (1) individual factors (motivation, self-efficacy), social support (parent support, friend support, PE teacher support), and physical environment (school environment, community environment) have an impact on the performance of the ATTS test (Xiang, 2019); (2) among the

levels of social ecology, different levels have different degrees of impact on the improvement of ATTS (Xiang, 2019); and (3) in addition to the direct effect, the influence of individual factors on the performance of the ATTS test has a mediating effect. Social support and physical environment can indirectly influence the performance of the ATTS level test through individual factors.

MATERIALS AND METHODS

Participants

The study was approved by the university ethics committee in Shanghai. In this study, table tennis skills test score was used to reflect adolescents' table tennis sport skills level and their table tennis exercise participation. Participants were randomly recruited from 12 districts of Shanghai, with one primary and one secondary school per district, and about 70 students from each school, using the stratified sampling method. The sampling inclusion criteria were as follows: primary or secondary school students (ranging from grades 3 to 9), agreeing to take the ATTS test, and Shanghai residents. Finally, 1,823 students who met the inclusion criteria were invited to attend the study. Written consent forms were distributed to all 1,823 students and their parents prior to data collection. A total of 1,628 students from 12 districts agreed to participate in this study.

A total of 1,576 participants out of the 1,628 students voluntarily returned the survey. Of the 1,576 participants, 50 participants were subsequently excluded because their response to the questionnaires was not complete. The final analytic sample consisted of 1,526 students whose ages ranged from 9 to 16 years old (age = 12.31 $\pm$ 1.32 years). A total of 755 (49.48%) and 771 (50.52%) were primary and secondary students, respectively.

Procedure

Before data collection, the participants were given a full explanation about the purpose of the study, the potential benefits/risks, and their confidentiality and withdrawal rights. Then, they were directed to China Table Tennis College training hall to attend the ATTS test. After finishing the ATTS test, they were directed to complete the self-reported questionnaires. For participants under 16 years old, questionnaires were completed with the help of their parents. Participants spent approximately 20–30 min to complete the questionnaires.

Measures

Demographics

Self-reported personal information on age, sex, residential region, frequency, duration, and intensity of table tennis activities was obtained from the questionnaires.

There were four programs tested through exercises in ATTS evaluation. ATTS test score = a*0.25 + b*2*0.25 + c + 25/40*d (National Youth Sports Skills Standards Development Group, 2017). Here, a represents the valid number of times the ball was bounced on the racket, b represents the valid number of times the ball was bounced against the wall, c represents the score of balancing the ball while walking around the table, and d represents the number of times a ball was caught when the serving machine served 40 balls to the participant.

Individual Factors

Self-efficacy

Adolescents' self-efficacy was assessed by an eight-item scale. The content of this scale pertained to students' confidence in their ability to be physically active (Motl et al., 2005). Each item was rated on a five-point Likert-type response scale. Mean was obtained from each item. The internal consistency of efficacy measurements based on the Cronbach coefficient α was 0.853.

Motivation

The scale used to assess different types of motivation was developed by Goudas et al. (1994). Five subscales need to be answered by participants, which were Intrinsic Motivation, Identified Rules, Introjected Regulation, External Regulations, and Amotivation (Standage et al., 2005). Mean score was obtained from each item, and the Cronbach coefficient α was 0.887.

Social Support

Social support in this study included three dimensions: parent support, friend support, and PE teacher support.

Social support from parents

A parental support scale was developed for Amherst Health and Activity Research. Adolescents and assessed parents completed five parental support scales together (Prochaska et al., 2002). Each item was rated on a five-point Likert-type response scale. Those responses were ranging from 1 (strongly disagree) to 5 (strongly agree), and then the mean score of all items was calculated to represent that scale. The Cronbach coefficient α was 0.927.

Social support from friends

The four-item friend support scale was developed by Prochaska et al. (2002). The scale included the following: encourage, participate, praise, and encourage friends to participate. Each item was rated on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree), and then the mean score of all items was calculated. The Cronbach coefficient α was 0.868.

Social support from PE teachers

A six-item scale was used to assess perceived social support about PE teachers. The scale's response options were ranging from 1 (strongly disagree) to 5 (strongly agree) (Daigle, 2003). There were two items included in the stem "In my PE class" to indicate the teacher support: "my teacher really listens to what I want to say" and "my teacher encourages me to do the best I can." Finally, the mean score was obtained from each item. The Cronbach coefficient α was 0.892.

Physical Environment

The method of environmental assessment was to quantify the extent to which the environment contains resources that promote or hinder PA.

Community environment

A scale developed by Motl et al. (2005) was used to evaluate equipment accessibility and perceived safety. The metric for

perceived environment consisted of four items, each with a score range of 5, from 1 (strongly disagree) to 5 (strongly agree). The means of these items were used as an overall indication of the magnitude of equipment accessibility and perceived safety. The Cronbach coefficient α was 0.797.

School environment

Robertson-Wilson et al. (2007) developed 12 items to assess the school's physical environment. Each item was rated on a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree), and the means of these items were used as an overall indication of the magnitude of school PA environment. The Cronbach coefficient α was 0.890.

The Chinese versions of those scales were translated back into English to test language validity. The Chinese scales had been found to exhibit a good value for reliability and validity and had been widely used in Chinese populations.

Data Analysis

Date analysis was performed using SPSS 22.0. Participants' demographic variables were summarized using descriptive statistics. Internal consistency reliability for each scale was assessed by Cronbach's alpha. Pearson correlation matrix analyses were employed to explore the relationship among social support, individual factors, physical environment, and the ATTS test score. Hierarchical regressions were conducted to separately examine the strength of associations of social support, individual factors, and physical environment with the ATTS test score. To test the R^2 change at each step, individual factors, including self-efficacy and motivation, were entered first; social support from parents, friends, and PE teachers was entered in the second block; and the school and community environmental factors were entered in the third block (Gu et al., 2014). Independent-samples *T*-test was used to analyze the effect of different age and sex on the ATTS test score. ANOVA was applied to examine the effect of the frequency of participating in table tennis per week and the duration of each table tennis exercise on the ATTS test score. Structural equation modeling (SEM) was employed to check the proposed model and to test the impact of individual factors, social support, and physical environmental variables on the ATTS test scores. Various indices for model-data fit, including the χ^2, CFI, RFI, IFI, NFI, and RMSEA were used to assess the model fit to the data. The alpha level in the multiple regression analyses was 0.05. The SEM was assessed using AMOS 22.0.

RESULTS

The ATTS test score was positively related to motivation, self-efficacy, social support from parents, friends, and PE teachers, community environment, and school environment (*r*'s ranging from 0.490 to 0.862, all $p < 0.01$) (**Table 1**). Among all study variables, motivation, social support from friends, and self-efficacy were highly correlated with the ATTS test score ($r = 0.862$, $r = 0.852$, and $r = 0.829$, respectively). Among individual factor variables, motivation had a higher correlation with the ATTS test score than did self-efficacy ($r = 0.862$ and $r = 0.829$, respectively). Among social support variables, friends' support showed greater correlation with the ATTS test score than parents' support, and the weakest factor was PE teachers' support ($r = 0.852$, $r = 0.739$, and $r = 0.650$, respectively). Among physical environment variables, the effect of school environment on the ATTS test score was higher than that of community environment ($r = 0.590$ and $r = 0.490$, respectively). In addition, self-efficacy and motivation were positively related to social support and physical environment (*r*'s ranging from 0.428 to 0.788 and from 0.368 to 708, respectively, all $p < 0.01$). Furthermore, self-efficacy was positively correlated with motivation ($r = 0.684$, $p < 0.01$).

The mean scores of self-efficacy, motivation, social support from friends, parents, and PE teachers, community environment, and school environment exceeded the midpoint of the scales, showing positive perceptions. Furthermore, most of the participants had higher self-efficacy and more social support from friends and PE teachers (**Table 2**).

The result of hierarchical regression is shown in **Table 3**. Individual factors, including self-efficacy ($\beta = 0.450$, $p < 0.01$) and motivation ($\beta = 0.554$, $p < 0.01$), accounted for 85.1% of the variance in the test score ($R^2 = 0.851$, $F = 4{,}332.673$, $p < 0.01$). When social support factors (from friends, parents, and PE teachers) were entered in the second block, the model accounted for an additional 3.8% of the variance ($R^2 = 0.889$, $F = 173.976$, $p < 0.01$). The effects of individual factors declined ($\beta = 0.209$ and $\beta = 0.412$, respectively), and support from friends ($\beta = 0.301$, $p < 0.01$) made a greater contribution to the ATTS test score than self-efficacy ($\beta = 0.209$, $p < 0.01$) did, while this effect was weaker than motivation ($\beta = 0.412$, $p < 0.01$). Supports from PE teachers and parents made a little contribution to the ATTS test score ($\beta = 0.075$, $p < 0.01$). All individual factors and social support factors emerged as significant indicators of participants' ATTS test scores. When physical environmental factors were entered in the third block, the model accounted for an additional 1.4% of the variance. School environment ($\beta = 0.140$, $p < 0.01$) contributed to the reported test score more than community environment ($\beta = 0.045$, $p < 0.01$) did. Friends' support ($\beta = 0.304$, $p < 0.01$) and motivation ($\beta = 0.342$, $p < 0.01$) made greater contributions to the ATTS score than other social ecological factors did. The final full model accounted for 90.3% of the variance in participants' test score ($R^2 = 0.903$, $F = 111.806$, $p < 0.01$). All individual factors, social support factors, and physical environmental factors were significant correlates of participants' ATTS test scores.

The result of independent-samples *T*-test indicated that different sex had significant differences in the ATTS test score ($p < 0.01$), and the male's test score was higher than the female's. Besides, different ages (9–11 years old, 12–16 years old) also had significant differences in the ATTS test score ($p < 0.01$), and the participants' age from 12 to 16 years old had better test scores. The ANOVA results showed that the frequency of participating in table tennis per week and the duration of each table tennis exercise had significant differences in the ATTS test score (all $p < 0.01$), and the more the participation in table tennis, the higher the score the participants get.

Structural equation modeling was used to analyze the relationship between individual factors, social support, physical

TABLE 1 | Internal consistency reliabilities and correlations among variables (N = 1,526).

Variables	1	2	3	4	5	6	7	8
1. ATTS test score	–							
2. PE teachers' support	0.650**	(0.892)						
3. Friends' support	0.852**	0.499**	(0.868)					
4. Parents' support	0.739**	0.423**	0.759**	(0.927)				
5. Community environment	0.490**	0.253**	0.480**	0.464**	(0.797)			
6. School environment	0.590**	0.451**	0.388**	0.319**	0.210**	(0.890)		
7. Self-efficacy	0.829**	0.578**	0.788**	0.769**	0.522**	0.428**	(0.853)	
8. Motivation	0.862**	0.660**	0.708**	0.591**	0.368**	0.569**	0.684**	(0.887)

*Note. Cronbach's alpha coefficients are provided along the diagonal; several internal consistency alphas are not possible due to a single-item scale. **$p < 0.01$.*

environment, and the ATTS test score. The results indicated that the structural model fit the data well (χ^2 = 1415.754, χ^2/df = 4.96, $p < 0.001$; CFI = 0.914; IFI = 0.930; NFI = 0.921; RMSEA = 0.032) (**Figure 1**). It is shown in **Figure 1** that the individual factors, including self-efficacy and motivation, had a positive and significant effect on the test score (β = 0.97, $p < 0.01$). Social support from friends, PE teachers, and parents also had a significant effect on the ATTS test score (β = 0.68, $p < 0.01$). Furthermore, social support had an indirect effect on the ATTS test score through individual factors, and social support had a strong effect on individuals' self-efficacy and motivation (β = 1.04, $p < 0.01$). The physical environment had a certain effect on the ATTS test score (β = 0.30, $p < 0.01$), and physical environment had an effect on adolescents' motivation and self-efficacy (β = 0.27, $p < 0.01$).

DISCUSSION

In this study, it was found that: (1) individual factors played an important role for the improvement of the ATTS test score; (2) social support was positively related to the ATTS test score; and (3) physical environment was also significantly associated with the ATTS test score, which confirmed Hypothesis 1. The results of the multiple linear regression analysis and SEM showed that among the three levels, individual factors were the most important factors for the improvement of ATTS, which confirmed Hypothesis 2. Consistent with previous research evidence (Choo et al., 2015), self-efficacy was identified as an important factor related to the ATTS test score in this study. Similar results were also found by Kololo et al. (2012), whose study found that self-efficacy was a significant predictor of adolescents' PA level. PA was a form of behavior that depended on an individual's preference for activity type, frequency, duration, and intensity (Luke et al., 2004). Furthermore, PA in table tennis was positively related to the ATTS test score. Self-efficacy was significantly correlated with the persistence of individual participation in physical exercise and the frequency of exercise. This research indicated that motivation was highly correlated with ATTS test scores, which was consistent with the results of Wang and Zhang (2016). This study also showed that the ATTS test score was also affected by other individual factors such as age, sex, frequency, and duration of table tennis activities. Adolescents with more previous sports experiences (frequency, duration of table tennis activities) were easier to get a high ATTS test score (Condello et al., 2017).

TABLE 2 | Descriptive statistics for independent and dependent variables (N = 1,526).

Variables	Minimum	Maximum	Mean	SD
ATTS test score (pt)	11.88	99.38	72.74	16.62
PE teachers' support	1.00	5.00	3.50	0.87
Friends' support	1.00	5.00	3.56	1.04
Parents' support	1.00	5.00	3.36	1.02
Community environment	1.00	5.00	3.04	0.88
School environment	1.00	5.00	3.09	0.88
Self-efficacy	1.00	5.00	3.57	0.80
Motivation	1.00	5.00	3.45	1.08

TABLE 3 | Hierarchical regression of social ecological factors on test score (N = 1,526).

Step#	Independent variables	R^2	R^2 change	β	F change
Step 1	Individual factors	0.851	0.851		4,332.673**
	Self-efficacy			0.450**	
	Motivation			0.554**	
Step 2	Social support factors	0.889	0.038		173.976**
	Self-efficacy			0.209**	
	Motivation			0.412**	
	PE teachers' support			0.075**	
	Friends' support			0.301**	
	Parents' support			0.075**	
Step 3	Physical environmental	0.903	0.014		111.806**
	Self-efficacy			0.173**	
	Motivation			0.342**	
	PE teachers' support			0.063**	
	Friends' support			0.304**	
	Parents' support			0.081**	
	Community environment			0.045**	
	School environment			0.140**	

*Note. R^2 values are cumulative, with each incremental step adding to the variance explained; β values are standardized regression coefficients at each step of the regression analysis. **$p < 0.01$. All VIF values of independent variables for each regression model were less than 5.*

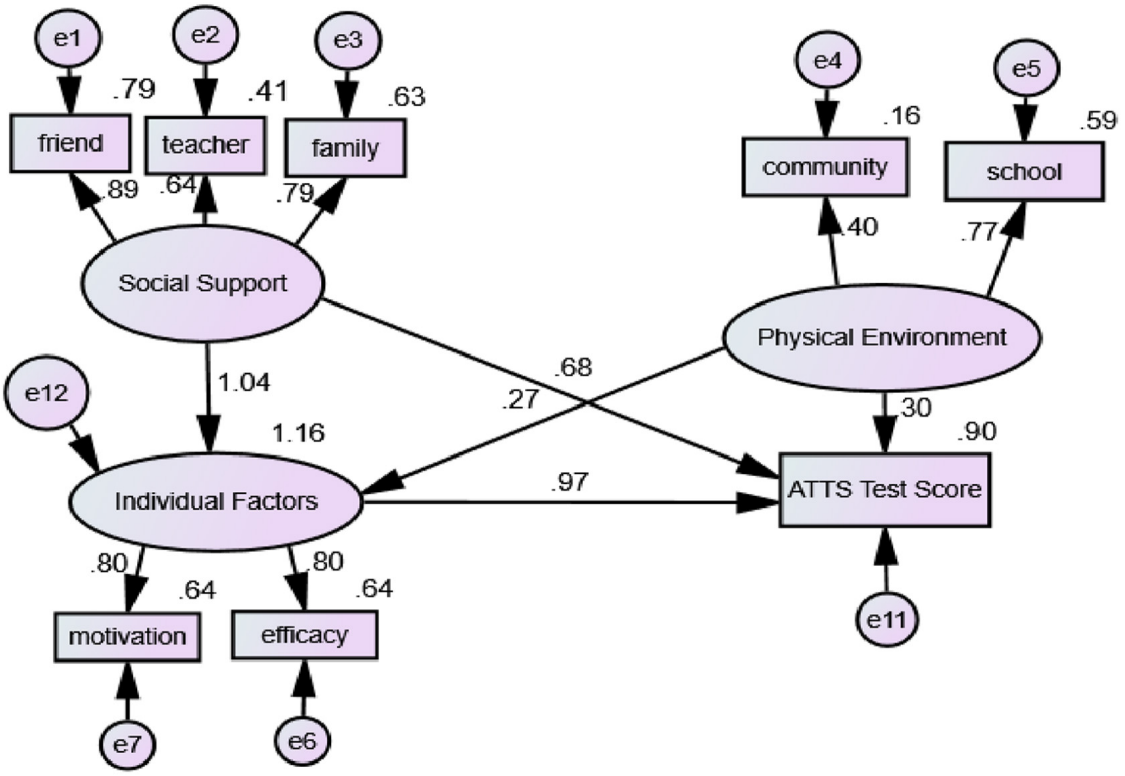

FIGURE 1 | Final model of the variables. *Note*. friend: friends' support; teacher: PE teachers' support; parent: parents' support; community: community environment; school: school environment.

The results of SEM illustrated that individual factors had a mediating effect between social support and the ATTS test score, which confirmed Hypothesis 3, and indicated that self-efficacy had been identified as a mediator between social support and PA. It was consistent with the study of McAuley et al. (2003). SEM also showed that individual factors served as a partial mediator of the effect that the physical environment had on the ATTS test score, which also confirmed Hypothesis 3. Moreover, physical environment had an effect on self-efficacy (Plotnikoff et al., 2010).

Another discovery of this research was that social support had a positive effect on adolescent sports activities, which was consistent with Wang's (2017) finding. In the socio-ecological study of ATTS, social support was an inducement that could make adolescents perform better in table tennis. Support from parents and friends was more conducive to adolescents' table tennis exercise than support from PE teachers. Adolescents' exercise behavior was predicted by their intrinsic motivation (Gillison et al., 2006), and their opinion of PA was directly correlated to their exercise experience in PE lessons (Standage et al., 2012). There was a positive and supportive environment in PE, and their motivation and satisfaction with PA would be higher, which might form a virtuous circle and lead them to participate in exercise more frequently in school and leisure time (Ip et al., 2017).

In addition, it was proved in this study that physical environment had less influence on ATTS than individual factors and social support factors did. In China, the basic exercise locations for primary and secondary school students were schools and communities, and they spent more time to exercise with classmates in the school than in the community (Xie, 2018). However, due to the insufficient table tennis facilities in schools in Shanghai, there were few table tennis courses at schools (Yao, 2007). Similarly, communities also faced the problem of lacking of facilities (Wang et al., 2015; Zhu et al., 2015). Although physical environment had less influence on ATTS than individual factors and social support factors, the impact of the physical environment on ATTS could not be ignored. A favorable physical environment was closely related to students' physical performance. Environments with PA-related resources, such as sidewalks, parks, sports classes, and health clubs, could make students more active in physical activities. The environmental lack of relevant resources or the presence of obstacles, such as bad weather or high crime rate, might reduce the students' tendency to exercise (Loh et al., 2019).

The research of Yan et al. (2014) suggested that communities should provide sports infrastructure to support adolescents' exercise. Schools should improve PE and offer more opportunities for spontaneous games (Langille and Rodgers, 2010). Communities and schools should work together to share resources for sports activities (Yan et al., 2014). Besides, our

study revealed that students' PA behaviors were affected by all factors of the social–ecological framework, which was consistent with Dollman's findings (Dollman, 2018). James (2018) suggested that effective interventions and policies that aimed at improving PA enjoyment, availability of sports facilities, and social support from others should be prioritized to facilitate their PA persistence. Policy-makers should provide a wide "menu" of outdoor physical activities especially for table tennis from which students can choose, which was very important for establishing intrinsic motivation and PA persistence (Brug et al., 2017).

CONCLUSION

The level impacting most significantly on ATTS is individual factors, followed by social support, and that with the least impact is the physical environment. Therefore, cultivating intrinsic interest is an important way to facilitate the continuous activities of adolescents. Second, friends should support each other, and parents should give adolescents appropriate encouragement regarding table tennis exercise. Schools should provide more table tennis facilities. PE teachers should respect adolescents' ideas, listen to students' opinions, and encourage them to participate in table tennis training.

LIMITATIONS

The limitation of our study was that the subjects were from one metropolitan region, and the results might not be generalizable to other cities. Additionally, the policy level of social ecology was not covered in this study. The bivariate correlations between all the variables, including the sociodemographic variables, were not performed, and the sociodemographic variables were also not included in the model analysis. Future research can add policy factors to the study of ATTS and focus on other adolescents' sports participation using the social–ecological model. Furthermore, it cannot be ignored that all the social–ecological measures were based on self-report, which may be interfered by the participants' own perception of individual factors, social support, and physical environment. In addition, longitudinal studies and experimental research designs are necessary to further investigate factors that affect ATTS among Shanghai adolescents as the cross-sectional research design results may lead to difficulty in establishing cause and effect relationships among the study variables.

DATA AVAILABILITY STATEMENT

The datasets generated during the current study are not publicly available as they contain sensitive and potentially identifiable information. Requests to access these datasets should be directed to the corresponding author.

ETHICS STATEMENT

Ethical approval for this study was obtained from the ethics committee at Shanghai University of Sport. All participants signed the written consent forms before they joined the study.

AUTHOR CONTRIBUTIONS

All authors contributed to this manuscript in performing literature search, conceptualizing, drafting, and revising the manuscript.

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Psychological Determinants of Physical Activity and Development in Early Childhood Among Children With Developmental Delays: The Role of Parent Beliefs Regarding the Benefits of Physical Activity

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Among the various psychological determinants of physical activity (PA) in early childhood, relatively little attention has been paid to the role of parent beliefs in the benefits of PA for their child. Believing that PA is beneficial may impact parent behavior, resulting in more opportunities for PA in early childhood, particularly among children with neurodevelopmental disabilities (NDs) who may face more barriers to PA. Greater opportunity for PA may promote the development of motor skills and healthy body composition. This study examined the association between parental beliefs about PA and children's weight status in a sample of 147 children (32 ± 4 months old) with NDs. The proportion of parents with below average (mean − 1SD) perceptions of the benefits of PA whose children were overweight or obese was approximately was 2.5 times (proportion ratio, 2.35; 95% CI, 1.05–5.27) larger than it was for parents with above average (mean + 1SD) perceptions (after adjusting for the confounding effects of ethnicity, marital status, and mothers' self-reported depressive symptoms). Mothers' self-reported depressive symptoms was the only other covariate that was significantly associated with the weight status of these children, though, these data also signal possible ($p = 0.07$) differences in proportions between Hispanic/Latinx and White children in the sample who were classified as overweight and obese. Our study demonstrates the importance of considering parental or caregiver beliefs in the value of PA as another risk factor that may predict risk for overweight and obesity. Future studies should include parental beliefs in the benefits of PA as a potential psychological determinant of PA and associated health outcomes.

Keywords: neurodevelopmental disorders, developmental disabilities, autism, physical activity, parent beliefs, BMI, psychological determinants

INTRODUCTION

The International Classification of Functioning, Disability and Health (ICF: World Health Organization, 2002) describes a biopsychosocial model of human functioning and disability that provides a highly relevant framework for studying the psychological and behavioral determinants of physical activity (PA). From the ICF perspective, functioning or activity is impacted by interactions between health conditions and contextual factors (environmental and personal). This perspective is particularly useful for understanding the relationships between neurodevelopmental disabilities, PA, and psychological and physical health. For children with neurodevelopmental disabilities (NDs), difficulties related to attention, communication, self-regulation, and motor control are common and may become barriers to participation in social and recreational activities, including activities that provide opportunity for PA (e.g., Must et al., 2015; Lakes et al., 2019a), which is essential for psychological, social, and physical development. Barriers may include personal factors, such as children's emotional and behavioral difficulties (e.g., Law et al., 2007) as well as environmental factors, including the need for more supervision and trained providers in recreational programs (e.g., Must et al., 2015). Reductions in opportunities for PA can, in turn, lead to increased sedentary time. For example, children (ages 8–18) with Autism Spectrum Disorder (ASD) have been reported to average 62% more screen time than their typically developing peers (Mazurek and Wenstrup, 2013; American Psychiatric Association, 2013). While this increased screen time is likely due to a number of factors, facing personal and environmental barriers to physically active social and recreational activities may contribute to the amount of time spent in sedentary activities.

These patterns of activity have implications for mental and physical health. Children with NDs or other developmental disabilities have an increased risk of obesity and overweight when compared to typically developing children (e.g., Curtin et al., 2010; Broder-Fingert et al., 2014; Zuckerman et al., 2014; Hill et al., 2015; Zheng et al., 2017), which may compound disability and reduce quality of life (e.g., Khodaverdi et al., 2011; Dhaliwal et al., 2019). Reduced PA and increased sedentary behavior are among the developmental, biological, and environmental risk factors for overweight among children with NDs (Dhaliwal et al., 2019). Therefore, a better understanding of the psychological and behavioral determinants of PA as well as the relationship between patterns of activity and overweight are important research priorities for this population.

Because children with NDs may face more barriers to PA (such as the need for extra supervision on the playground or the need to find PA programs equipped to support their behavioral, motor, and social challenges), strong parental support for PA and strong parental beliefs in the benefits of PA are likely to be especially critical. Supporting PA in the face of many personal and environmental barriers may require substantial commitment to and belief in the importance of PA. Lakes et al. (2017) described how parental beliefs play an important role in the development of positive health behaviors in children and hypothesized that parental beliefs about the benefits of PA are likely to influence parent behavior, particularly the degree to which parents seek and maintain opportunities for their child with ND to engage in PA. The association between such parental support and observed levels of PA in children has been documented by Seibert et al. (2016) who found that parent support and a parent's perceptions of his/her child's physical abilities predicted PA in children with disabilities. Similarly, Brown et al. (2020) found that among parents of school-age children with ASD, parent intentions to support PA were associated with parent PA support behaviors, which in turn predicted PA in children. Their research illustrates the important role parents play in promoting PA among children with NDs.

Our goal in this study was to examine potential psychological determinants, particularly those that might be modifiable via early intervention, that might contribute to PA patterns in young children with NDs as well as the trend toward overweight and obesity in this population. While PA is not the sole predictor of healthy weight in children, it is considered a protective factor against the risk for overweight and is also a modifiable factor that could be addressed in many settings. Given the important role parents play in promoting PA (e.g., Brown et al., 2020), in this study, we explore the association between parental beliefs in the value of PA and weight status in children with NDs. In doing so, we estimate the degree to which differences in parental beliefs about the benefits of PA predict differences in the proportions of children with NDs classified as overweight and obese, whilst also considering as potential confounders other social and environmental factors that have been associated with body composition (and health disparities) in prior research (e.g., child race and ethnicity, household income, cognitive functioning, adaptive behavior, and sleep patterns).

MATERIALS AND METHODS

Participants and Procedures

This study was approved by a University Institutional Review Board. Over a 1 year period, 147 new patients (between the ages of 24 and 39 months at the time of their evaluation) scheduled for or seeking new diagnostic evaluations at a university neurodevelopmental clinic were enrolled in this study. All prospective patients meeting the age criteria who were either scheduled for or requesting a new diagnostic evaluation during the 12 month study time period were invited to participate in the study. Inclusion criteria were: (1) between the ages of 23–39 months at enrollment, and (2) scheduled for or seeking a new diagnostic evaluation at the center for any developmental concern. Participants were allowed to enroll at age 23 months, but all visits took places when the child was between 24 and 39 months of age. Among the 158 eligible children whose parents were contacted, 147 (93%) enrolled in the study. Several declined participating in research, and several others declined because they chose not to follow through with their appointments at the university center either because they had received care elsewhere or had concerns about insurance coverage for university services. The university neurodevelopmental clinic where the study took place was a specialty center for NDs in Southern California, and

at the time served as the primary ND center for a county with a population of more than 3 million people.

A parent or legal guardian provided written informed consent for their child's participation, which included three study visits. During the first two visits, parents completed questionnaires, and clinical researchers administered psychological measures, including Module 1 or 2 of the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012). During the third visit, a physician (a pediatric neurologist or developmental behavioral pediatrician) evaluated the child and met with the parents. Children who (1) met the criteria for the cutoffs "autism" and "autism spectrum" on the ADOS and (2) were diagnosed with Autism Spectrum Disorder (ASD) by a physician were noted as having ASD ($n = 118$), which was the most common diagnostic category among participants. Other diagnoses included global developmental delay ($n = 63$, with some overlap with ASD), speech and language disorders or delays ($n = 69$, with some overlap with ASD and global developmental delay), Attention Deficit Hyperactivity Disorder (ADHD: $n = 1$), hypotonia ($n = 1$), cerebral dysfunction ($n = 2$), and disruptive behavior disorder ($n = 2$).

Measures

Diagnosis of Autism Symptoms

The Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2012) was used to evaluate autism symptoms. A psychology postdoctoral fellow and two board certified developmental behavioral pediatricians who were trained in ADOS administration conducted the ADOS evaluations. Either Module 1 or Module 2 was administered, based on the child's language development. Scores yield a classification of either non-spectrum, Autism spectrum, or Autism.

Primary Dependent Variable

Children's Body Mass Index (BMI) was obtained using the measured height and weight data at the time of their study physician evaluation. BMI percentile and weight status category were calculated using the Centers for Disease Control and Prevention's (CDC) BMI Percentile Calculator (Centers for Disease Control, 2015).

Primary Independent Variable

The Parent Perceptions of Physical Activity Scale (PPPAS) is a 25-item parent-report questionnaire (Lakes et al., 2017) available in two forms—one for infants (Lakes et al., 2019b) and the second for young children (Lakes et al., 2017), which was used in this study. The PPPAS requires about 10 min to complete and assesses parental perceptions of the benefits of (18 items) and barriers to (7 items) PA, using a 4-point Likert scale with responses ranging from Strongly Disagree (1) to Strongly Agree (4). Sample items for the Benefits subscale included: "Increasing activity increases my child's level of physical fitness," "Physical activity in childhood will make my child healthier," "Exercising helps my child sleep better at night," and "Physical activity improves overall functioning for my child." Sample items for the Barriers subscale included: "I worry that my child will not be accepted by others if he/she participates in a group sport or activity program" and "Physical activity will make my child frustrated." Principal components analysis (PCA) for the 25 items yielded two components (Lakes et al., 2017): (1) beliefs in the benefits of physical activity and (2) perceptions of barriers to physical activity. The PPPAS was initially developed for and studied in children under the age of five who were experiencing developmental difficulties as a tool to assess parental perceptions that might impact their PA support behaviors. Validity and reliability of PPPAS scores in this population (children ages 2–3 years with NDs) were reported by Lakes et al. (2017); scores demonstrated good (Cronbach's alpha = 0.83 for Barriers to PA) to excellent (Cronbach's alpha = 0.95 for Benefits of PA) internal consistency as well as sufficient concurrent, discriminant, and predictive validity.

Covariates

The Vineland Adaptive Behavior Scales, Second Edition (Vineland-II; Sparrow et al., 2005) was used to evaluate children's adaptive skills, including communication, daily living skills, socialization, and motor skills. Responses yield standard scores based on United States norms. The manual reports excellent internal consistency coefficients. Among 3 year-old children in the standardization sample, the split-half reliability coefficients were 0.92, 0.90, 0.95, 0.90, and 0.97 for the Communication Domain, Daily Living Skills Domain, Socialization Domain, Motor Skills Domain, and Adaptive Behavior Composite scores, respectively. Test-retest reliability coefficients for ages three to six were 0.92, 0.91, 0.88, 0.90, and 0.94 for the Communication Domain, Daily Living Skills Domain, Socialization Domain, Motor Skills Domain, and Adaptive Behavior Composite scores, respectively. Vineland II scores also showed excellent validity for individuals with ASD (Sparrow et al., 2005), and the measure has been widely used in ASD research.

Parents also completed a brief study-specific demographic questionnaire, a self-report depression screening that measures depressive symptoms over the prior week (Patient Health Questionnaire-9: Kroenke et al., 2001) and a child sleep questionnaire (Children's Sleep Habits Questionnaire: Owens et al., 2000). Children's Sleep Habits Questionnaire scores have shown adequate internal consistency in prior research with clinical populations (internal consistency coefficient = 0.78) as well as adequate test-retest reliability (correlations from 0.62 to 0.79 for the various subscales: Owens et al., 2000).

Parents completed a brief physical activity questionnaire that asks parents to report on the amount of time a child spent engaged in a variety of physical activities over the course of the prior week (Weekly Physical Activity Checklist: Sallis et al., 1993). The instructions indicate that only activities in which the child engaged for more than 15 min at a time should be included. Twenty-eight activities are listed, with space to write in additional activities. Sample activities included: outdoor play (including playground structures), bike riding, swimming, water play, games (including tag), ball sports, walking, running/jogging, martial arts, dancing. For this study, we calculated a total score for weekly bouts of PA of all types. These checklists have been used in numerous studies involving children of different ages, though we are not aware of prior studies validating this measure in 2

and 3 year-old children with NDs. However, many of the listed activities were deemed relevant for this population (e.g., outdoor play, water play, playing with balls, walking, and running), and activities that were not relevant could be simply ignored by the respondent. Any additional activities could be written in. Responses were recorded using checkmarks across the 7 days of the week.

A psychology postdoctoral fellow assessed cognitive functioning using the Mullen Scales of Early Learning (Mullen, 1995). The Mullen contains a battery of tests designed to measure development in infants and preschoolers. Four cognitive scales (receptive language, expressive language, visual reception, fine motor) are used to generate a standardized Early Learning Composite score. The Early Learning Composite score is considered an early measure of overall cognitive function. In the standardization sample (Mullen, 1995), the split-half reliability coefficient for the Early Learning Composite Score in 33–38 month-old children was excellent (0.92). Among children ages 25 to 56 months, test-retest reliability coefficients for the Mullen scales were sufficient, ranging from 0.71 to 0.75. Interscorer reliabilities among 25 to 44 month-old children were excellent (0.98 to 0.99).

Statistical Analyses

The association between parental perceptions of the benefits of PA and the likelihood of overweight and obesity in children was analyzed with a logistic regression model in the Statistical Analysis System (SAS: Version 9.4; SAS Institute, Cary, NC). To explore this association, we first categorized children into four groups based on their level of BMI: underweight (BMI below the 5th percentile); healthy weight (BMI between the 5 and 85th percentile); overweight (BMI between the 85 and 95th percentile); and obese (BMI > 95th percentile). Once categorized, a binomial distribution was used to model the odds of overweight and obesity, and to compare the proportions of children classified as overweight or obese for parents with above (mean+1SD) and below (mean−1SD) average perceptions of the benefits of PA. The research question was answered by estimating the ratio of proportions of children classified as overweight or obese for parents with high and low perceptions of the benefits of PA. Or, put more simply as a question, was the proportion of children classified as overweight or obese substantially lower for parents with above average beliefs in the benefits of PA? The answer to this question was estimated with other covariates held constant at their mean values.

When presenting the results, proportions were chosen over odds due to the time-independent nature of the classification and due to the high incidence of overweight and obesity in children (Greenland, 1987; Nurminen, 1995). Research shows that odds and incidence proportion ratios are only approximately equal to one another when the proportions in comparison groups is uncommon or rare (<10%) (Tamhane et al., 2016). Therefore, presenting the results as proportions avoids the well-documented issues of overestimation that have been associated with the reporting of odds ratios (Greenland, 1987; Nurminen, 1995; Tamhane et al., 2016). Confidence limits for the proportion ratios were derived from the confidence limits for the odds. Magnitude thresholds for a factor increase and decrease in the proportion ratio were as follows: for an increase, 1.1 = small, 1.4 = moderate, 2.0 = large, 3.3 = very large, 10 = extremely large; for a decrease, 0.9 = small, 0.7 = moderate, 0.5 = large, 0.3 = very large, 0.1 = extremely large (Hopkins et al., 2009). Uncertainty in the estimate is expressed as a 95% confidence interval.

TABLE 1 | Socio-economic-, parent-, and child-level sample characteristics.

Characteristic	Value
Socio-economic factors	
Ethnicity, No. (%)	
White	105 (73)
Latinx	39 (27)
Missing	3 (2)
Household income, No. (%)	
<$20,000	19 (13)
$20,000–$30,000	13 (9)
$30,000–$50,000	12 (8)
$50,000–$75,000	25 (17)
$75,00–$100,000	24 (16)
>$100,000	40 (27)
Missing	14 (10)
Parent-level factors	
Married, No. (%)	105 (73)
Missing	(3) (2)
Parent's age, mean (SD) [No. missing]	35.34 (7.54) [16]
Number of children, mean (SD) [No. missing]	2.25 (1.20) [3]
Parental depression, mean (SD) (0–27) [No. missing]	3.92 (4.52) [14]
PPPAS, benefits of PA, mean (SD) (1–4) [No. missing]	3.56 (0.41) [22]
PPPAS, barriers to PA, mean (SD) (1–4) [No. missing]	1.73 (0.55) [15]
Child-level factors	
Age in months, mean (SD) [No. missing]	31.66 (4.37) [3]
Sex, No. (%)	
Boy	106 (72)
Missing	3 (3)
BMI, mean (SD) [No. missing]	16.59 (1.72) [11]
BMI percentile No. (%)	
Underweight: <5th percentile	11 (7.5)
Healthy weight: 5th−85th percentile	94 (64)
Overweight: 85–95th percentile	16 (11)
Obese: >95th percentile	15 (10)
Missing	11 (7.5)
Total weekly PA in bouts of activity, mean (SD) [No. missing]	17.21 (12.00) [5]
Sleep habits[a], mean (SD) [No. missing]	47.10 (8.88) [28]
Daytime sleepiness, mean (SD) (8–24) [No. missing]	11.74 (2.85) [10]
Adaptive behavior[b], mean (SD) [No. missing]	81.44 (13.00) [4]
Cognitive functioning[b], mean (SD) [No. missing]	66.94 (18.14) [7]

[a] *T score (mean: 50 [SD: 10]).*
[b] *Standard score (mean: 100 [SD: 15]).*
No., number; SD, standard deviation; PPPAS, Parent Perceptions of Physical Activity Scale; PA, physical activity; BMI, body mass index; TV, television.

Handling of Missing Data

Table 1 provides descriptive statistics of complete cases for our primary outcome variable and covariates. It also identifies where there were missing values in our data. Research has shown that there is substantial bias in odds ratio estimates (and,

consequently, in proportion ratio estimate which are derived from the odds) when the percentage of missing data is >5% (Knol et al., 2010). Since the percentage of missing data was >5% for both the primary dependent and independent variable, our results represent data analyzed by means of multiple imputation (Berglund and Herringa, 2014). Because the missing values had a monotonic pattern, the logistic and linear regression methods were used for imputing values for categorical and continuous variables, respectively. We used the imputation diagnostics and variance information to estimate the number of imputed datasets required to ensure adequate efficiency (i.e., a relative efficacy score above 0.99, where a score of 1 equals perfect efficiency). We followed an iterative process, making reference to the formula for the Fraction of Missing Information (FMI) (Rubin, 1987), which summarizes the proportion of sampling variance in the model that is due to missing data: $[V_B + (V_B/m)]/V_W$, where V_B and V_W are the estimated variances between and within imputed datasets, respectively, and where m represents the number of imputations specified at this iteration. The imputation procedure is deemed to have had acceptable efficiency when the number of imputations (m) specified results in an FMI of <1%. In the present study, 26 imputed datasets were required to ensure adequate efficiency.

RESULTS

Participant Characteristics

Demographic and subject characteristics for the 147 parents (age, mean ± SD: 35 ± 8 years; 82% mothers) and children (32 ± 4 months) involved in this study are reported in **Table 1**. The majority of parents were married, had multiple children, above- and below-average self-reported health and depressive symptoms (respectively), and were running households with annual income levels (slightly positively skewed) toward the upper end of the distribution. Parents also had well above average perceptions of the benefits of PA, with more moderate perceptions about the absence of barriers. The majority of children were boys (approximately three-quarters) and were White (more than two-thirds). Parental reports of children's daily screen-viewing time, sleep habits, and daytime sleepiness were approximately average. Parental reports also indicated that children were engaging multiple meaningful bouts (15 min or more) of PA across the week (on average, 2–3 bouts per day). Based on standard scores, children were ranked well within the lower tertile of the normal distribution for adaptive behaviors and cognitive functioning.

Preliminary Analyses

Preliminary analysis was conducted according to Bursac et al. (2008) process for the purposeful selection of covariates in a logistic regression model. The initial set of covariates considered for inclusion in the logistic regression model were as follows: parental perceptions of the benefits of PA, parental perceptions of the barriers to PA; child's sex, age, sleep habits, levels of adaptive behavior, cognitive functioning, and frequency of engagement in weekly PA; family race and ethnicity and household income; and mothers' age, marital status, and self-reported depressive symptoms. The first step in the process of purposeful selection involved univariate analyses of the predictive value of each individual covariate against a significance threshold of $p < 0.25$. Only covariates meeting this initial inclusion threshold of $p < 0.25$ were considered for further multivariate analysis. Covariates were thereafter retained in the final logistic regression model if they fulfilled either of the following two criteria: (i) the covariate itself had a substantial effect magnitude and significance threshold of $p < 0.10$, or (ii) removal of the covariate had a substantial confounding effect on the magnitude of other remaining covariates' parameter estimates (reflected by a ≥ 15% change in the predictive value of another covariate). Following this iterative model-building process resulted in the following four variables being retained in the final logistic model predicting proportions of overweight and obesity: parental perceptions of the benefits of PA, ethnicity, marital status, and mothers' self-reported depressive symptoms. Contrary to our expectations, parent reports of a child's weekly PA did not meet criteria for inclusion in the final model.

Primary Analyses

Based on imputed values for BMI percentile, in the final analysis, 11 children were underweight, 94 were healthy weight, and 31 were overweight or obese. As for our primary research question, the association between parental perceptions of the benefits of PA and the proportion of children who are classified as overweight and obese is summarized (alongside other covariates) in **Table 2**. The proportion of parents with below average (mean−1SD) perceptions of the benefits of PA whose children were overweight or obese was approximately was 2.5 times (proportion ratio, 2.35; 95% CI, 1.05 to 5.27) larger than it was for parents with above average (mean+1SD) perceptions (after adjusting for the confounding effects of ethnicity, marital status, and mothers' self-reported depressive symptoms). When viewed against the thresholds for evaluating factor effect magnitudes outlined in the methods section above, this difference in proportions represents a large magnitude (i.e., a factor difference of >2).

TABLE 2 | Associations between covariates and the proportion of children classified as overweight and obese.

Characteristic	Value[a]	95% CI	*p*-value
Socio-economic factors			
Ethnicity[b]	1.74	0.95 to 3.17	0.07
Parent-level factors			
Married[b]	0.69	0.42 to 1.14	0.15
Parental depression[c]	0.41	0.18 to 0.90	0.03
PPPAS, benefits of PA[c]	2.35	1.05 to 5.27	0.04

[a] *Values are proportion ratios, adjusted for the confounding effect of other covariates.*
[b] *Values represent factor differences in the proportion of overweight and obese children associated with a difference of level (e.g., comparing White and Latinx children, or comparing children of married and unmarried mothers).*
[c] *Values represent factor differences in the proportion of overweight and obese children associated with a two standard deviation (SD) difference in the predictor (e.g., comparing the proportion of overweight and obese children in parents with above [mean+1SD] and below [mean−1SD] average perceptions of the benefits of PA).*
CI, confidence interval; PA, physical activity.

Of the other covariates that were included in the final model (see **Table 2**), only mothers' self-reported depressive symptoms was statistically significantly associated with the proportions of children classified as overweight and obese. Perhaps counterintuitively, the proportion was ∼2.5 times smaller (proportion ratio, 0.41; 95% CI, 0.18 to 0.90) for children of parents with above average (mean+1SD) self-reported depression. Marital status was not a statistically significant predictor of overweight and obesity in this sample of children. However, when considered against Bursac et al.'s (2008) criteria for inclusion of a covariate (see section Preliminary Analyses above), its removal from the model resulted in a substantial modification of the parameter estimate for maternal depression (signaling shared variance between marital status and mothers' self-reported depressive symptoms). Finally, whilst ethnicity was not statistically significantly associated with weight status in the final model, with a *p*-value of 0.07, it is noteworthy that the proportion of Hispanic or Latinx children that were classified as overweight and obese was ∼1.75 times larger (proportion ratio, 1.74; 95% CI, 0.95 to 3.17) than the proportion for White children. *Post-hoc* analysis revealed that the association between parental perceptions of the benefits of PA and the proportion of children who are classified as overweight and obese did not differ significantly between Hispanic/Latinx and White children (proportion ratio, 0.84; 95% CI, 0.40 to 1.78).

DISCUSSION

Prior research has suggested that parent beliefs and behaviors may be psychological determinants of PA in children with disabilities. In research with 148 parents of children with disabilities (Seibert et al., 2016), found that parent support for PA and beliefs in their child's perceived competence for PA predicted their promotion of PA. Our overarching hypothesis was that parental beliefs in the benefits of PA would influence the degree to which a parent supports or encourages engagement in PA for young children with NDs, and that this would be reflected in early risk for overweight. Our study provides preliminary support for this hypothesis and extends prior research by documenting an association between parental beliefs in the benefits of PA and child BMI. The proportion of parents with above average (mean+1SD) perceptions of the benefits of PA whose children were overweight or obese was 8%. The proportion was 4 times higher for parents with below average (mean−1SD) perceptions. In other words, approximately one third of the sample of children whose parents had below average perceptions of the benefits of PA were overweight or obese.

A parent's report of perceived barriers to PA was not a substantial predictor of BMI. It is also worth noting that, in this relatively young sample (age, mean ± SD: 32 ± 4 months), the mean score for a parent's perceived barriers to PA was 1.73 on a 4.0 scale, where a score of "2" represents "disagree." Thus, on average, parents in this sample tended not to agree with items measuring barriers (such as perceptions that their child may not have the skills needed to engage in PA or that others might reject their child in a group PA setting). The types of weekly PA reported in this sample primarily included outdoor play, walking, and swimming, with only a few parents reporting that their children were bike riding, playing sports, or engaging in other organized recreational activities. It is likely that personal (e.g., motor competence) and sociocultural barriers to physically active social and recreational activities (including those addressed in the PPPAS) become more salient as children age, and this issue should be addressed in samples of older children with NDs, as a parent's perception of a child's competence (i.e., a potential personal barrier) was found to predict promotion of PA in prior research (Seibert et al., 2016). It is also likely that the PPPAS does not capture all environmental, sociocultural, and personal barriers to PA experienced by children with NDs in this age range. In future research, qualitative methods (i.e., interviews, focus groups) could be used to identify additional personal (e.g., parent stress, parent-child relationships, child behaviors) and environmental barriers (e.g., social attitudes toward children with NDs, availability of accessible programs and facilities) to engagement in PA for young children with NDs.

Parents' self-reported depressive symptoms were the only substantial and statistically significant confounder. For the association between parent depressive symptoms and child overweight, the proportion was 2.5 times smaller (proportion ratio, 0.41; 95% CI, 0.18 to 0.90) for children of parents with above average (mean+1SD) self-reported depression (after adjusting for the confounding effects of ethnicity, marital status, and parental perceptions of the benefits of PA). In other words, parents with above average depressive symptoms were 2.5 times less likely to have children who were overweight or obese. In a recent review of research examining the associations between maternal depression and child overweight, Lampard et al. (2014) found that chronic, but not episodic, depression was positively associated with child overweight. The PHQ-9 used in our research captures current depressive symptoms (over the last 2 weeks) and does not distinguish between episodic depression or chronic depression; however, our results were in the opposite direction of what would be expected for chronic depression and were not consistent with the null finding for episodic depression. Our results also contrasted with those noted in a large study with 4,601 5th grade children, wherein researchers documented a positive association between maternal depression (i.e., symptoms experienced in the prior 7 days), single parenthood, and child BMI, and noted that parenting quality and its relation to sedentary behavior and leisure activity mediated the association (McConley et al., 2011). It is possible that the differences in our findings might differ from other literature as a result of sample characteristics, including the very young age of the children and their developmental difficulties and clinical characteristics. Moreover, our analysis also revealed the possibility of an interaction effect between parent depression and marital status. *Post-hoc* analyses of our data revealed a significant correlation between these two variables, with currently married parents reporting fewer depressive symptoms ($r = -0.252$, $p = 0.005$). Researchers have documented an increased prevalence of depressive symptoms among mothers of children with ASD, particularly around the time of first diagnosis (Taylor and Warren, 2012), so it may be that different patterns of

depressive symptoms in this population explain these divergent findings. It's important to note that our study was conducted at the time of first diagnosis, when depressive symptoms may be more prevalent as well as potentially more transient; mothers, particularly single mothers, facing a new diagnosis of an ND in their 2–3 year old child may exhibit a different pattern of maternal depression than has been studied in prior research examining the relationship between maternal depression, beliefs about PA, and child overweight and obesity.

Finally, it is worth noting that, based on BMI percentile, 11 children were underweight, 94 were healthy weight, and 31 (21% of the sample) were overweight or obese. Prior research (Broder-Fingert et al., 2014) indicated that the risk for obesity was higher in older children (ages 12–15) compared to younger children (ages 6–11) with ASD, but there is limited epidemiological research on patterns of overweight in toddlers and preschoolers with ASD. The Centers for Disease Control in the United States (CDC: Hales et al., 2017) estimates that 13.9% of two- to five-year-old children in the United States are obese; in our sample of children (age, mean ± SD: 32 ± 4 months), 15% were obese and another 16% were overweight. A direct comparison between these statistics is difficult as the CDC estimate includes a much wider age range and focused on obesity; future research should examine the point at which the trajectory of overweight for children with NDs begins to diverge from that of children without NDs, as prior research has suggested that the risk for overweight and obesity grows with age in this vulnerable population (e.g., Broder-Fingert et al., 2014; Hill et al., 2015). Finally, ethnicity approached significance in the model, and Hispanic or Latinx children were 1.7 times more likely than White children to be overweight or obese. These results are consistent with epidemiological studies showing higher rates of unhealthy weight in Hispanic children (Hales et al., 2017) and illustrate the importance of studying health disparities, environmental risks, or differential susceptibility for overweight in early childhood to better understand the factors associated with this increased risk.

Study Limitations and Future Directions

While the results of this study extend prior research and contribute to our knowledge about factors associated with unhealthy weight in early childhood among children with NDs, different patterns could be observed in different age groups. Future research should, therefore, assess the relationship between parental perceptions of the importance of PA and childhood overweight in a sample of children with NDs across a broader age range. Parental influence may be less salient when other risks (e.g., psychiatric medications) are introduced or become more established (e.g., restricted food interests, sedentary behaviors such as screen time). The current study also was somewhat limited in its ability to examine racial and ethnic disparities in childhood overweight and obesity, given the demographics in the region in which the study was conducted. Future research should examine these relationships in populations who experience health disparities. In addition, the majority of participating parents in this study were mothers (82%), and our sample was not large enough to examine differences between mothers, fathers, or alternative guardians (e.g., custodial grandparents). Future research should examine how these associations are similar and different based on the caregiver's relationship to the child and influence on the child's daily patterns of activity.

Parental reports on a child's weekly engagement in PA were not a significant predictor of overweight in this study, but this research should be replicated with the inclusion of objective measures of PA (e.g., accelerometers), as parental report of PA is known to have some recall limitations. In addition, as very young children may engage in more frequent or shorter bouts of PA, it is possible that the measure's focus on bouts of 15 min or more may have limitations in this age group. These limitations could be addressed in future research by using a range of measures, including parent report measures and objective measures of activity.

Finally, our study was limited in that we were not able to collect data on other variables known or hypothesized to impact child overweight, including data on genetics, nutrition, maternal metabolic disorders, endocrine dysregulation, or gut microbiota diversity. Dhaliwal et al. (2019) reviewed developmental, biological, and environmental factors associated with weight gain in children with Autism Spectrum Disorder (ASD), categorizing them as either primary risk factors (those that have been directly implicated to weight gain or obesity), secondary risk factors (factors not specific to children with ASD but which could adversely affect weight), and emerging factors (factors the authors hypothesize may play a role). Primary risk factors included genetics and the use of psychiatric medications for which weight gain is a side effect. Secondary risk factors included parent obesity, nutrition, PA, and sedentary behavior. Emerging risk factors included breastfeeding, maternal metabolic disorders, sleep, endocrine dysregulation, and gut microbiota diversity. Most of the research reviewed by Dhaliwal et al. focused on older children, who have already established patterns of behavior surrounding nutrition, screen time, physical activity, and psychiatric medication use. Our study was designed to contribute to prior research by focusing on a very young group of children, who were not yet taking psychiatric medications and who, due to their young age, had less firmly established behavioral health patterns. Therefore, in spite of limitations due to the exclusion of biological and nutritional factors, our results controlled for a number of socioeconomic, parent, and child factors, and our results suggest that future studies should consider parent beliefs about PA as an important psychological factor to consider when evaluating the diverse risks for overweight in early childhood.

Implications for Parent Education in Interventions, Educational, and Clinical Settings

One of the implications of our findings is that strengthening parental beliefs in the value of PA for young children with NDs may help contribute to healthy development and body composition. Parent education programs could incorporate information about the positive effects of PA on multiple domains of development and functioning. The importance of PA for

physical growth, development, and health is well-established. However, the benefits of PA extend beyond direct physical benefits. Research describing the positive effects of physically active social and recreational programs has grown exponentially in the last 15 years. Physically active interventions that involve cognitive engagement are associated with improvements in executive functions [e.g., see reviews and meta-analyses by Diamond and Lee (2011), Vazou et al. (2016), and Takacs and Kassai (2019)] and self-regulation [e.g., for a review see Pandey et al. (2018)], although substantial variation between different types of interventions has been documented. Children with NDs often exhibit difficulties with executive functioning and self-regulation, suggesting that activities that promote these skills may be especially relevant for their development. Physically active interventions have also shown a positive effect on academic achievement [see review by de Greeff et al. (2018)], another area that is often a concern for children with NDs. Thus, for children with NDs, PA interventions may have the potential to positively impact psychological and academic functioning in addition to physical health.

Research reporting positive effects of physically active interventions for children with NDs, including ASD, is still emerging (Srinivasan et al., 2014), but preliminary studies have shown positive outcomes, such as reductions in stereotypical behaviors (e.g., Ferreira et al., 2019; Lakes et al., 2019a). Of particular salience to early childhood is recent research in a large Irish cohort study (Neville et al., 2020) that demonstrated that for boys with early developmental delay, involvement in sports is associated with a significant decrease in behavioral difficulties between ages 3 and 5 years. This suggests that organized PA in the preschool years could potentially improve behavior even at this early age and is especially promising as it demonstrated this positive effect among boys with developmental delay.

Beginning at first diagnosis of an ND and throughout childhood, clinicians should address parental beliefs about the benefits of PA for their children. Sharing evidence for the positive effects of PA on psychological and physical development may increase a parent's beliefs that PA can be beneficial, which may in turn influence parental behaviors associated with seeking and maintaining opportunities for their children to be active. Future research should examine the degree to which increasing parental perceptions of PA as beneficial are directly associated with increased engagement in PA as well as increased parental behaviors associated with seeking and maintaining opportunities for PA. Developing strong PA habits at an early age could contribute to better long-term health outcomes for children with NDs, and parental beliefs in the benefits of early PA may help support the development of these positive habits.

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 University of California, Irvine. Written informed consent to participate in this study was provided by the participants' legal guardians.

AUTHOR CONTRIBUTIONS

KL, MA, and JD: study concept and design and study supervision. RN and KL: analysis and interpretation of data and drafting of manuscript. KL, RN, MA, and JD: critical revision of manuscript for important intellectual content. KL: obtained funding. All authors: contributed to the article and approved the submitted version.

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Effectiveness of a Physical Education Program on the Motor and Pre-literacy Skills of Preschoolers From the Training-To-Health Project: A Focus on Weight Status

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Many studies reported a positive relationship between motor skills, cognitive functions, and school performance in school-age children; however, little is known in preschool children. The aim of the present study was to demonstrate the effectiveness of a physical education program (PEP) on locomotor, object control skills, and pre-literacy cognitive functions in a wide population of preschoolers and verify whether weight status could influence these abilities. In the context of the Training-to-Health Project, a sample of 1,029 preschoolers was recruited in kindergartens from the urban area of Palermo (Italy). Their gross motor and pre-literacy skills were tested before (PRE) and after (POST) following 16 weeks (2 h/week) of a PEP, which included ludic-motor activities aimed at developing body awareness and fundamental motor and perceptual-sensory skills. Analyses of variance (ANOVA) were performed to assess the skills before and after the intervention and to evaluate the effect of different categories of weight status on the examined variables. Regression analyses were conducted to confirm the hypothesized interrelationship between motor and pre-literacy skills in the considered sample. Both locomotor/object control and pre-literacy skills were significantly higher in children after the PEP ($p < 0.05$). We found 23% of overweight children and no significant difference between weight status classes in both PRE and POST PEP groups. In the POST group, higher locomotor and object control skills were mostly associated with better pre-literacy skills. This study shows that PEP was effective in improving both motor and pre-literacy skills in preschoolers independently from age and gender, while weight status did not affect these skills suggesting that this program can be administrated indifferently in children with different categories of weight status. Therefore, PEP could be a decisive education strategy to enhance motor and cognitive learning in preschool children and to achieve successful academic outcomes.

Keywords: physical education, motor skills, pre-literacy skills, preschooler, weight status

INTRODUCTION

Motor Skills

Fundamental movement skills (FMS), or simply motor skills, are defined as the basic level of movement and include locomotor skills (running, jumping, galloping, hopping, crawling) and object control (bouncing, catching, throwing, kicking) (Bellows et al., 2017; Han et al., 2018). The concept of FMS is strictly related to the quality of motor skill competence (MC), which is the level ability of motor coordination, and it is measured through several test batteries (D'Hondt et al., 2009; Lopes et al., 2012; Figueroa and An, 2017; Maeng et al., 2017; Loras, 2020; Tsuda et al., 2020).

The appropriate development of FMS, which occurs during the preschool period (children aged 3–5 years), allows to build the basis for performing complex movements and task-specific abilities (Figueroa and An, 2017; Aivazidis et al., 2019; Alves and Alves, 2019). Moreover, several studies reported that the practice of physical activity (PA) improves FMS level by inducing a higher MC in childhood (Fisher et al., 2005; Hardy et al., 2010; Battaglia et al., 2018; Aivazidis et al., 2019; Nilsen et al., 2020a). For these reasons, the practice of structured PA in kindergarten during this period results to be crucial (Deli et al., 2006; Barbosa et al., 2016; Figueroa and An, 2017; Kippe and Lagestad, 2018; Alves and Alves, 2019; Jarraya et al., 2019). However, PA in preschool age is limited and, furthermore, the level of PA among children living in Europe varied considerably among countries (Konstabel et al., 2014). The latter topic is also confirmed by the fact that over the years several research groups have focused on the importance of PA in children and adolescents, and the few articles present in the literature about this issue in preschooler demonstrate the recent interest among scientists (Van Capelle et al., 2017; Engel et al., 2018).

It is well-known that PA plays a key role in promoting health and preventing diseases at every stage of life, including children and adolescents (Nielsen et al., 2016; Voss and Harris, 2017; Czenczek-Lewandowska et al., 2018). The lack/low level of PA practice and sedentary behaviors negatively affect body weight in preschooler children (Han et al., 2010; Osinski and Kantanista, 2017; Rodriguez-Ayllon et al., 2019). Furthermore, the assumption of harmful behaviors (e.g., eating unhealthy foods) during the time spent in a sedentary lifestyle has been shown to exacerbate the capacity to maintain an adequate body weight in children by creating a vicious cycle (Pagani et al., 2010; Eichinger et al., 2017). As reported by several researches, both physical inactivity and sedentary/unhealthy behaviors increase the risk of being overweight and obesity in childhood (Tucker, 2008; Han et al., 2010; Hills et al., 2011; Reilly et al., 2019). For this reason, the role of diet and physical activity in children has been investigated in previous studies (Obradovic Salcin et al., 2019; Tabacchi et al., 2020a). In support of the above, Tabacchi et al. (2020a) suggest that raising children in an environment where both motor and cognitive skills are encouraged can improve food literacy and, furthermore, enhance school achievement.

The prevalence rate of overweight and obesity among European children, with different rates between countries, is about 20% and represents a public health problem due to the related risk factors (Ahrens et al., 2014; Eichinger et al., 2017). In order to contrast this phenomenon, a series of political and social initiatives and experimental approaches have been promoted by encouraging the practice of PA among preschoolers (Palmer et al., 2019; Hoza et al., 2020; Popovic et al., 2020).

The beneficial effects of PA for preventing overweight and obesity are well-documented. Furthermore, as reported in the review by Bingham et al. (2016), the interrelationship between PA and several socio-ecological domains, such as anthropometric/demographic features (e.g., age, gender, weight status), and family community level/parental behaviors (e.g., family socioeconomic status/parents' PA level) is widely recognized in early children (Kimbro et al., 2011; Eichinger et al., 2017). In a similar way, FMS have reported to positively affect psychosocial aspects and cognitive functions in preschool-aged children (Rhemtulla and Tucker-Drob, 2011; Oberer et al., 2017). However, only a few studies have investigated the influence of motor skills on PA levels and preschoolers' body weight status, reporting conflicting outcomes (D'Hondt et al., 2009; Logan et al., 2011; Morano et al., 2011; Lopes et al., 2012; Roscoe et al., 2019).

Pre-literacy Skills

Positive influence of PA programs on pre-literacy skills has been found in the kindergarten age (Barnett et al., 2008; Callcott et al., 2015; Mavilidi et al., 2015, 2017).

Pre-literacy refers to kindergarten skills that are predictors of later literacy achievement. These skills include a set of competences, such as (1) knowledge and understanding about printed materials; (2) oral language abilities, e.g., vocabulary, comprehension, and listening; and (3) alphabetic code awareness, e.g., phonological/phonemic abilities to detect and manipulate syllables, phonemes, and word parts (Lonigan and Shanahan, 2010; Puranik and Lonigan, 2011; Pinto et al., 2016).

Given these positive influences of PA on pre-reading/writing and pre-math, researchers and practitioners have developed a variety of preschool-based programs suitable to enhance pre-literacy skills through PA activities. The underlying conceptualization is that active play characterizing preschool-age PA would be a natural and enjoyable context to encourage linguistic development by creating more frequent linguistic and social opportunities, to understand and explain instructions or play rules, to elaborate stimuli from many sources, to experiment direct or indirect performances, and to try new action-based representations of tasks (Boncoddo et al., 2010; Carson et al., 2015).

For example, the Movement with Literacy (MowL) was found to improve phonological awareness, spelling, and motor coordination. It was a program based on a 15-min daily preschool curriculum composed of literacy (Let's Decode) and movement (Moving on with Literacy) curricula (Callcott et al., 2015) and counted in 30 action songs with motor tasks to train fine and gross motor, eye-tracking, balance, rhythm, core strength, and aerobic skills. Another program delivered by classroom teachers over 8 months was made up of 60-min moderate PA units (2 times per day) associating motor (jumping, running,

moving on lines, marching) and early literacy tasks to train oral language, vocabulary, and phonological awareness (Kirk et al., 2014; Kirk and Kirk, 2016). Programs implemented by Mavilidi et al. (2015, 2017) improved phonological and science competences in preschool age. Rhyming, alliteration, and picture naming skills were enhanced through PA activities that associated full-body movements, e.g., physical exercises, or part-body movements, e.g., gestures, and correspondent foreign words. Science competences were improved by an integrated method that trained children to learn planets' names and their correct position from the sun by performing movements from the sun to the closest planet and so on.

Moreover, a Parent-oriented Movement and Pre-literacy Program required 60 min a week over 10 weeks of activities and involved both preschool age children and their parents. It consisted of Fundamental Movement tasks; free-play activities with balls, steps, bricks, or puzzles; and a storybook reading activity shared among children and their parents to enhance motor and literacy skills as print-concept and alphabet knowledge (Bedard et al., 2017).

Purpose

In our previous work we investigated the effect of a 16-weeks physical education program (PEP) in motor and cognitive preschool children's status, finding an improvement on both domains (i.e., motor skills and cognitive functions) (Battaglia et al., 2018). However, as stated in that paper, in the present study we applied the further step for the validation of the study, i.e., to extend the investigation to a larger sample size in order to illustrate the effects of the developed PEP on locomotor, object control skills, and pre-literacy cognitive functions in a larger scale (Battaglia et al., 2018). Moreover, based on this large preschooler sample, the further purpose of the study was to investigate whether weight status could influence these skills.

MATERIALS AND METHODS

Study Design and Participants

The present study is a non-randomized trial carried out within the Training-to-Health Project, financed by the Municipality of Palermo in 2016 with the general aim of enhancing motor and cognitive skills in preschoolers, beyond other scopes, such as monitoring aspects related to these abilities (Tabacchi et al., 2020b). A team of experts from the University conducted the study and recruited physical education specialists (PESs) with previous experience in the field of motor and cognitive science in children, in order to carry out activities within the selected kindergartens. Teachers from the classes were directly involved as support in the program activities. All the personnel taking part in the program was properly trained, and methodologies were standardized to allow the collection of accurate and reliable data.

The study was approved by the Ethical Board of the University of Palermo (N. 2/2018) and followed the criteria for the use of persons in research as defined in the Declaration of Helsinki.

The preschoolers' sampling envisaged a mixed multistage procedure. In the first stage, all the kindergartens of Palermo city boundaries (Municipality of Palermo) ($n = 389$) were identified; in the second stage, the sample was stratified into public ($n = 193$) and private kindergartens ($n = 196$) and the cluster of public kindergartens was selected; in the third stage, $n = 21$ (11%) public kindergartens were randomly chosen in geographical areas stratified by different socioeconomic environments (SEE), every class within the chosen cluster was chosen, and every student within the class was sampled ($n = 1{,}054$). The SEE was denoted according to the "index of socio-economic disadvantage," measured on the basis of four indicators of deprivation in the 55 different city districts (http://cqd.comune.palermo.it/CQDSupera/docs/CQD4982_1221223025117.pdf).

Parents were asked to sign an informed consent to let their children participate the study. Among them, a total of 25 refused to sign (2.4%), and a final sample of 1,029 children was obtained.

Since collecting measures for all the individuals was not possible, as some of them were not present the day of the assessment of a particular item, some results are referred to a slightly lower sample, as indicated in the result tables.

Study Procedure

Participants' weight and height were initially measured, and they were assessed for basic motor skills and pre-literacy abilities by the PESs (we will further indicate this group as the "PRE group").

The motor skill items were measured by the Italian version of the gross motor development test (Ulrich, 2003), which consists in two different aspects of gross motor development, i.e., locomotion (requiring subjects to run as fast as possible for 15 m, jump forward, gallop for 10 m, hop on one leg for 5 m, do a long jump, and take little jumps forward and laterally), and object control (bounce the ball, catch the ball, catch a ball with a tennis racket, and running while kicking a ball and throwing a ball). The combination of these two subtests provides the quotient of gross motor development (QGMD), useful for assessing the overall gross motor skills of children.

Pre-literacy abilities were assessed by choosing four tasks related to visual analysis and spatial orientation abilities, derived from the Italian battery PRCR-2/2009 (Cornoldi et al., 2009), measuring general and specific prerequisites to reading and writing abilities in preschoolers.

Details of these assessment tools are described in our previous paper (Battaglia et al., 2018).

After the initial assessment, preschoolers were subjected to a Physical Education Program (PEP) for 16 weeks, applied with a frequency of twice a week, by the PESs. In agreement with Battaglia's PEP (Battaglia et al., 2018), each lesson (∼60 min) included a warm-up and social interaction phase (∼5 min) which aimed to enhance the fitness level of children and their motivation to participate in activities (e.g., circle time in which children, sitting on the floor, greeted everyone and took turns performing a movement requested by the physical education specialist; activities of running, jumping, catching/throwing/kicking a ball, etc.); a central phase (∼50 min) including specific activities in order to develop perceptual-sensory and fundamental motor and skills in preschool children; and a cool-down phase (∼5 min) in order to relax children and explore their level of satisfaction (e.g., circle time in which children, lying on the ground, performed calming breathing

activities). At the end of the PEP, preschoolers were assessed again for the gross motor and pre-literacy skills, and also anthropometric measures were collected again. This group following the PEP represents the "POST group." Children of the PRE group were included in classroom activities for an equal time as the POST group with teachers. Both groups completed the activities during the school period in a multi-activity area.

BMI and Motor Skill Measures

Age of the preschoolers was retrieved from the birth dates reported in the kindergartens' lists.

Weight and height were measured through Seca electronic scales (maximum weight recordable, 300 kg; resolution, 100 g; Seca Deutschland, Hamburg, Germany) and stadiometers (maximum height recordable, 220 cm; resolution, 1 mm) which were used according to standard procedures (Lohman et al., 1988). Body mass index (BMI) was calculated, and four classes of weight status were obtained according to the BMI percentiles for males and females aged 0–18 years from Cole et al. (2000): underweight below the 5th percentile, normal weight between the 5th and 85th percentiles, overweight between the 85th and 95th percentiles, and obese over the 95th percentile.

The gross motor skills were measured as scores derived from the marks attributed to the single performance. All participants completed three trials of each gross-motor skill and acquired a "1" mark, when a criterion was used incorrectly two out of three times or was not observed, or a "0" grade, when a criterion performance was executed two out of three times. According to the age level of the participant, the sum of the scores detected for each item (maximum total score 48) was converted into standard scores. The QMGD was obtained by summing up the scores of the two subtests for assessing locomotor and object control skills, and it could score from 46 to 154.

The categorization of QGMD in classes of motor abilities was performed according to the manual (Ulrich, 2003): 35–69 (very low motor ability, VL-MA), 70–79 (low motor ability, L-MA), 80–89 (below average motor ability, UA-MA), 90–110 (average motor ability, A-MA), 111–120 (over average motor ability, OA-MA), 121–130 (high motor ability, H-MA), and 131–165 (very high motor ability, VH-MA).

Pre-literacy Skill Measures

Pre-literacy skills were measured through four tasks derived by PRCR-2/2009 (Cornoldi et al., 2009) which is an Italian battery of standardized tasks to test kindergarten children's prerequisites to later reading and writing abilities. The tasks were (1) printed-letter identification aimed at measuring visual analysis and spatial orientation abilities; (2) object naming aimed at measuring linguistic proficiency, the visual attention, and the sequentiality of eye movements; (3) partially hidden-object naming aimed at measuring linguistic proficiency, the visual attention and discrimination, and the sequentiality of eye movements; and (4) pointed-object naming aimed at measuring the visuo-perceptual ability to identify a figure from the background, the linguistic proficiency, the visual attention and discrimination, and the sequentiality of eye movements. More in detail, the printed-letter identification task consisted of a white sheet with 12 target letters printed on the left and four letters for each target (the target and three distracting letters) printed on the right. Each child was asked to identify and cross the letter corresponding to the right target. The object-naming task was composed of 30 objects in five sequences of six objects for each (e.g., animals, flowers, ice cream, sun, star), and each child was asked to name each object. The partially-hidden-object naming task was composed of three sequences of objects, already shown in the object-naming task, but the objects were overlapping and smaller. Each child was asked to recognize and name each object. The pointed-object-naming task was composed of two sequences of overlapping objects that appeared in the partially hidden-object-naming task with four objects for each sequence marked by a dot at 15 mm. Each child was asked to rapidly name the marked objects from left to right and from top to bottom.

The criteria of evaluation were the sum of errors and the time of performance.

Statistical Analysis

Sample descriptive data are shown in number and percentages for categorical outcomes and mean and Standard Deviation (SD) for normally distributed continuous data. Normality of data was evaluated through the skewness/kurtosis test for normality.

The difference between PRE and POST groups skills was calculated through analysis of variance (ANOVA) adjusted for age and gender. This analysis was also used to assess differences in gross motor skills and pre-literacy abilities by classes of weight status.

Linear regression analyses were conducted to assess the degree of correlation between gross motor and pre-literacy abilities. Significance was set at $p < 0.05$. The software STATA.12 was used to perform the statistical analyses.

RESULTS

Sample Characteristics

The characteristics of the sample are shown in **Table 1**.

Differences Between PRE and POST PEP

The analysis of variance showed that the QGMD was significantly higher in the POST group compared to the PRE group (mean 108.8 vs. 123.9, $p < 0.001$); according to the QGMD classes, it passes from "average motor ability" in the PRE group to "high motor ability" in the POST group. This high difference was present also for the components of the QGMD, i.e., locomotor (mean 10.7 vs. 14.0) and object control skills (mean 12.3 vs. 14.1) (**Table 2**). Moreover, all the evaluated locomotor and object control subitems were significantly higher in the test group (**Table 2**), with an average score increase of 0.63 units (range 0.5–0.8) and 0.55 units (range 0.47–0.7), respectively.

With regard to the pre-literacy skills, all of them significantly increased in the POST PEP group, meaning that both errors and time needed to perform the test were significantly lower in this group compared to the PRE group (**Table 3**). For example, the errors in the identification of printed letters were on average 3.4 in the PRE group and they decreased to 2.7 in the POST group; the time needed to naming objects

TABLE 1 | Characteristics of the sample before (PRE) and after (POST) the physical education program.

	No.	%		
Gender				
Males	557	54.1		
Females	472	45.9		
Tot	1,029	100		
	Pre		**Post**	
Age	**No.**	**%**	**No.**	**%**
3 years (≤47 months)	200	19.4	142	13.8
4 years (48–59 months)	393	38.2	380	36.9
5 years (≥60 months)	436	42.4	507	49.3
Tot	1,029	100	1,029	100
Weight status				
Normal	587	69.5	555	66.5
Under	90	10.7	87	10.4
Over	127	15.0	130	15.6
Obese	41	4.9	62	7.4
Tot	845	100	834	100
	Pre		**Post**	
	Mean	**SD**	**Mean**	**SD**
Age (months)	56.11	9.85	58.98	10.03
Height (m)	1.08	0.07	1.09	0.08
Weight (kg)	19.05	3.93	19.36	4.13
BMI (kg/m^2)	15.94	2.02	16.07	2.31

decreased from 72.8 to 62.2 s. On average, the number of errors decreased by 1.05 units (range from 0.7 to 2 units), while the time needed in naming objects decreased of 14.5 s (10.6 and 18.4 s in naming objects and naming partially hidden objects, respectively).

Differences by Weight Classes

When analysis of variance was conducted by categories of weight status, the QMGD, locomotor, and object control skills were not significantly different throughout the classes of underweight, normal overweight, and obesity (**Table 4**). Actually, observing all the skill values in obese preschoolers, reduced performances can be evidenced, even though they were not statistically significant. The same observation can be done for the pre-literacy skills, with a trend of decreasing performances from normal weight to obese individuals (**Table 5**) but no statistical significance in those differences. Similar results were found out also for all the locomotor subitems, with the exception of leaping ($p < 0.05$), and for all the object control subitems (**Supplementary Material 1**).

These results were found out both in POST and PRE PEP groups (PRE group results are not shown in the present paper).

Regressions of Motor and Pre-literacy Skills (POST)—Adjusted for Age and Gender

The regression analysis showed that children with high QGMD make less errors in naming objects and partially hidden objects (coefficients −1.22 and −0.49) and take less time in naming pointed objects (coefficients −0.55) (**Table 6**). The component of object control skills is significantly correlated with all the pre-literacy skills, with higher object control ability associated with better pre-literacy ability (coefficients ranging from −0.04 to −1.13); for the locomotor skills, the time needed in performances was not correlated, but all the other items (errors) were with coefficients ranging from −0.16 to −0.86 (**Table 6**).

These results are confirmed when analyzing the locomotor and object control subitems (**Supplementary Material 2**).

DISCUSSION

The aim of the present study was to investigate the effect of a physical education program (PEP) on motor and cognitive skills in a large preschooler sample focusing on the influence of children's weight status.

As we hypothesized, our findings showed an improvement of the QGMD level and in both of its components, i.e., locomotor and object control skills, after the PEP. These results are in agreement with the outcomes we found in our previous pilot trial in which we examined the effectiveness of this PEP on the aforementioned skills in a sample of 119 preschool children (Battaglia et al., 2018). Since, as we reported in that work, the main issue was to extend the PEP on a larger scale in order to validate its effectiveness, the present study allowed us to confirm previous results.

Our findings are consistent with scientific evidence from the literature demonstrating the positive effect of PA on improving motor and pre-literacy skills in preschool age (Orton et al., 2009; Logan et al., 2012; Zeng et al., 2017; Aivazidis et al., 2019; Popovic et al., 2020). Indeed, although the literature regarding the practice of PA in kindergarten is limited, recent researches have investigated the effects of different PA interventions on several skills and health aspects in preschoolers (Popovic et al., 2020; Toussaint et al., 2020). In 2008, Stodden et al. developed a conceptual model hypothesizing a primary connection between the level of PA and the quality of MC (Stodden et al., 2008). The findings of this seminal work have been confirmed by several subsequent research groups (Lai et al., 2014; Engel et al., 2018; Nilsen et al., 2020b; Xin et al., 2020). Goodway et al. (2003) showed the positive effects of a 9-weeks integrative PA program (18 lessons, 35/min each) on the Test of Gross Motor Development (TGMD) scores in preschoolers compared to children who only carried out the regular kindergarten PA. Based on these results, the authors supported the idea of implementing PA in the kindergarten education program (Goodway et al., 2003). Likewise, DuBose et al. (2018) found a positive relationship between the level of PA in children, measured though an accelerometer, and motor skills. In the same way, pre-literacy skills in preschoolers are positively related to PA

TABLE 2 | Evaluation of the locomotor and object control skills before and after the physical education program.

	PRE		POST		N	*p*-Value*
	Mean	SE	Mean	SE		
QGMD	108.8	0.78	123.9	0.62	805	0.0000
Locomotor skills	10.7	0.17	14.0	0.15	807	0.0000
Locomotor subitems						0.0000
Running	2.6	0.04	3.2	0.04	966	0.0000
Galloping	2.0	0.05	2.7	0.05	967	0.0000
Hopping	1.7	0.05	2.5	0.05	967	0.0000
Leaping	1.2	0.04	1.7	0.04	967	0.0000
Horizontal jumping	2.2	0.04	2.9	0.05	967	0.0000
Skipping	1.3	0.04	1.8	0.04	967	0.0000
Sliding	2.3	0.05	2.9	0.05	967	0.0000
Object control skills	12.3	0.14	14.1	0.15	966	0.0000
Object control subitems						
Two-hand striking	1.4	0.04	2.1	0.05	967	0.0000
Stationary bouncing	1.03	0.03	1.5	0.04	967	0.0000
Catching	2.2	0.04	2.8	0.05	967	0.0000
Kicking	2.0	0.04	2.5	0.05	967	0.0000
Overhand throwing	1.9	0.05	2.4	0.05	966	0.0000

QGMD, Quotient of Gross Motor Development.
**The difference between pre and post was calculated through ANOVA adjusted for age and gender. Significance set at $p < 0.05$.*

TABLE 3 | Evaluation of the pre-literacy skills before and after the physical education program.

	PRE		POST		*N*	*p*-Value*
	Mean	SE	Mean	SE		
Printed-letter identification (error n.)	3.4	0.10	2.7	0.10	751	0.0000
Object naming (s)	72.8	1.09	62.2	0.89	713	0.0000
Object naming (error n.)	2.0	0.09	1.2	0.07	709	0.0000
Partially-hidden-object naming (s)	116.6	1.85	98.2	1.37	688	0.0000
Partially-hidden-object naming (error n.)	5.6	0.20	3.6	0.16	730	0.0000
Pointed-object naming (error n.)	2.3	0.06	1.6	0.06	698	0.0000

**The difference between pre and post was calculated through ANOVA adjusted for age, gender. Significance set at $p < 0.05$.*

TABLE 4 | Differences in QMGD, locomotor, and object control skills by categories of weight status.

	QMGD			Locomotor skills			Object control skills		
	Mean	SD	*p*-Value	Mean	SD	*p*-Value	Mean	SD	*p*-Value
Weight status			0.0843			0.3247			0.0578
Normal	123.0	17.22		13.5	3.73		14.3	2.86	
Under	125.6	16.92		13.8	3.43		14.7	2.71	
Over	124.3	18.46		13.8	3.79		14.4	3.20	
Obese	117.2	19.93		12.6	3.91		13.2	2.41	

programs (Carson et al., 2016; Donnelly et al., 2016; Zeng et al., 2017).

As abovementioned, the results we found regarding the effect of PA on motor and pre-literacy skills are in line with several authors (Callcott et al., 2015; Mavilidi et al., 2015, 2017; Kirk and Kirk, 2016; Bedard et al., 2017). Children with high QGMD performed better on PRCR-2 tasks. These results revealed in these children a higher level on the abilities of visual analysis, visual attention, visual discrimination, spatial orientation, and linguistic proficiency. This could be due to PEP that should

TABLE 5 | Differences in pre-literacy skills by categories of weight status.

	Printed-letter identification (error n.)			Object naming (s)			Object naming (error n.)		
	Mean	**SD**	***p*-Value**	**Mean**	**SD**	***p*-Value**	**Mean**	**SD**	***p*-Value**
(A) Printed letters identification and objects naming									
Weight status			0.1593			0.1078			0.6410
Normal	3.0	2.98		63.0	23.89		1.3	1.06	
Under	2.36	2.32		68.4	28.23		1.1	0.63	
Over	2.55	1.68		62.9	27.73		1.1	0.63	
Obese	1.75	1.58		55.0	25.35		0.9	0.68	
	Partially-hidden-object naming (s)			**Partially-hidden-object naming (error n.)**			**Pointed-object naming (error n.)**		
	Mean	**SD**	***p*-Value**	**Mean**	**SD**	***p*-Value**	**Mean**	**SD**	***p*-Value**
(B) Partially-hidden-object naming and pointed-object naming									
Weight status			0.3365			0.7230			0.9670
Normal	101.4	36.53		3.8	4.67		1.61	1.45	
Under	107.6	45.72		3.4	3.28		1.6	1.47	
Over	100.6	32.93		3.5	4.85		1.63	1.56	
Obese	90.2	39.79		2.9	3.78		1.56	1.55	

TABLE 6 | Results of the regression analysis between motor and pre-literacy skills.

	QGMD				Locomotor skills				Object-control skills			
	Coef	**SE**	***p***	***N***	**Coef**	**SE**	***p***	***N***	**Coef**	**SE**	***p***	***N***
Printed letters	−0.25	0.248	0.324	707	−0.28	0.087	*0.001*	743	−0.18	0.064	*0.005*	744
Object naming time (s)	−0.03	0.031	0.355	673	−0.04	0.011	*0.000*	708	−0.004	0.008	0.576	709
Object-naming errors (n.)	−1.22	0.377	*0.001*	666	−0.59	0.129	*0.000*	702	−0.32	0.093	*0.001*	702
Partially-hidden-object-naming time (s)	−0.03	0.019	0.136	666	−0.02	0.007	*0.008*	701	−0.001	0.005	0.818	701
Partially-hidden-object-naming errors (n.)	−0.49	0.138	*0.000*	698	−0.25	0.048	*0.000*	734	−0.16	0.035	*0.000*	734
Pointed-object naming	−0.55	0.453	*0.000*	679	−1.13	0.157	*0.000*	715	−0.86	0.114	*0.000*	715

The italic was used to underline the significant values ($p < 0.05$).

enable kindergarten children to train visuospatial abilities, which are necessary to master print directionality, to align or put in a column the numbers with consequent accuracy on computation and numerical representations. Visual-motor integration abilities are essential to organizing and spacing letters, words, and numbers on a page. Moreover, motor tasks as jumping, running, moving on lines, and marching revealed to be suitable to train the ability to recognize and produce alliteration and rhyming (Mavilidi et al., 2015, 2017; Kirk and Kirk, 2016). In the context of interaction with peers and movement exercises based on rhythm, fine and gross motor practice, eye-tracking, and balance, children have more opportunities to develop their linguistic and metalinguistic skills, such as alphabet knowledge, letter–sound knowledge, detection and manipulation of phonemes or syllables, and the knowledge to encode and decode words.

While when the effects of PA were analyzed by weight status categories, no significant differences were found on the QMGD and locomotor and object control skills between underweight, normal overweight, and obesity, in both PRE and POST PEP groups. Although few studies have investigated the relationship between motor skills and weight status/BMI domain in preschool age, the findings are conflicting (Lopes et al., 2012; Kim and Lee, 2016; Augustijn et al., 2018; Roscoe et al., 2019). For instance, D'Hondt et al. (2009) showed significantly higher levels of balance, object control, and manual dexterity in children with normal weight and overweight than obese peers. Similarly, Logan et al. (2011) reported significant differences on MC among children ages 4–6 years with a different BMI status indicating lower scores of motor skill proficiency in overweight and obese children compared to normal-weight peers. In contrast, the results reported by a large body of increasing research showed no correlation between FMS and weight status/BMI levels in preschoolers, as we found (Saraiva et al., 2013; Kim and Lee, 2016; Mülazimoglu Balli, 2016).

The key explanation could lie in the fact that cortical areas reach different levels of maturity of each other during the development process, and, moreover, the relationship between executive functioning and weight status in children has only been discovered in some cerebral areas (Liang et al., 2014). Among the

latter, the literature suggests that at an early age the prefrontal cortex results are less developed and this physiological condition does not allow to identify any differences in motor and pre-literacy skills among preschoolers belonging to distinct weight classes (Liang et al., 2014).

Although we found no difference between weight status groups, our results showed lower scores in leaping in children classified as overweight/obese. We suppose that weight status adversely affects this skill performance. Our hypothesis is sustained by several researches in which it has been demonstrated that tasks requiring propulsion are strictly dependent on body mass, reporting an inverse relationship between the amount of body mass and the lower-limb strength scores, which is an association between motor skills and overweight/obese status only for some locomotor skills (Siahkouhian et al., 2011; Castetbon and Andreyeva, 2012).

Therefore, our outcomes seem to suggest that this PEP can be administered in preschoolers with different weight status categories likewise, in order to improve motor and cognitive skills and to provide favorable bases for enabling positive academic achievement.

In the conceptual model of Stodden et al. (2008), an association between higher level of PA and greater scores in both locomotor and object control skills has been suggested. Moreover, the authors support the notion that preschool children with poor level of FMS could be more physically inactive in the future, leading, among other things, to an increased risk of being overweight/obese (Stodden et al., 2008).

As preschoolers currently perform lower than recommended PA levels by increasing the associated health risk and compromising skill development and later school achievement, we suggest that, based on our results, children would spend more time in structured PA in kindergartens (Gu, 2016; Kippe and Lagestad, 2018; Kobel et al., 2019). Therefore, we suggest that this PEP could be adopted as an educational strategy to improve motor and pre-literacy skills in preschool children, known to be a peculiar growth period for the development of these characteristics. Furthermore, we suggest that the activities of this PEP can also be proposed by teachers online, a modality that could be useful in critical and peculiar periods in which the level of physical activity could decrease as during the current COVID-19 pandemic (An, 2020; Giustino et al., 2020). To sum up, the implementation of enjoyable methods of teaching to enhance children's school readiness through motor activities is an important matter to be investigated by educational scientists.

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 Ethical Board of the Azienda Ospedaliera Universitaria Policlinico Paolo Giaccone Palermo (Palermo 1, N. 02/2018). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MB conceptualized the paper. CG and CM collected the data. GT carried out the formal curation and analysis of data and drafted the results. GB, VG, and GT drafted original draft. MB, MA, and GB reviewed and edited the manuscript. AP supervised the final manuscript. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fspor.2020.579421/full#supplementary-material

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Competencies for a Healthy Physically Active Lifestyle: Second-Order Analysis and Multidimensional Scaling

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The physical activity-related health competence (PAHCO) model assumes that individuals require movement competence, control competence, and self-regulation competence to lead a healthy, physically active lifestyle. Although previous research has already established some measurement factors (n = 8) of the three dimensions, no attempts have so far been made to statistically aggregate them on the sub-competence level. Therefore, the goal of the present study was to test two additional factors for PAHCO and subsequently model the second-order structure with two samples from the fields of rehabilitation and prevention. We conducted two questionnaire surveys with persons with multiple sclerosis (n = 475) and teaching students undergoing a basic qualification course in physical education (n = 502). After performing exploratory items analysis, we used second-order confirmatory factor analysis (CFA) and multidimensional scaling to investigate whether the scales could be bundled in accordance with the PAHCO model. The CFAs with 10 factors (42 items) demonstrated a good model fit. In contrast, the second-order analysis with a simple loading structure on the three sub-competencies revealed an unacceptable model fit. Instead, a second-order model variant was preferred [comparative fit index (CFI) = 0.926, root mean square error of approximation (RMSEA) = 0.048, standardized root mean square residual (SRMR) = 0.065] in which body awareness and self-efficacy had theory-conform cross-loadings. The results of multidimensional scaling (two-dimensional solution) were in line with the extracted second-order structure. The present results suggested that the extension of the measurement instrument to 10 first-order factors was psychometrically justified for the two populations. The results from the second-order analyses provided the basis for the creation of sum scores, representing manifest indicators of movement competence, control competence, and self-regulation competence. Future studies are needed that cross-validate the extended measurement model with other populations and that relate the sub-competencies of PAHCO to indicators of health-enhancing physical activity.

Keywords: physical activity, health literacy, PAHCO model, physical literacy, validity, physical activity-related health competence

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INTRODUCTION

There is considerable evidence that physical activity (PA) behavior exerts a beneficial effect on individuals' health (Lee et al., 2012; Warburton and Bredin, 2017). Accordingly, having people and populations adhere to a physically active lifestyle can be considered an important goal of our societies. However, several studies have illustrated that a large percentage of individuals is not sufficiently active (e.g., Guthold et al., 2010; Hallal et al., 2012). A large-scale pooling project comprising a total of 1.9 million adults recently revealed that 27.5% of all individuals globally must be characterized as physically inactive, whereby the study has also registered considerable differences between the countries (Guthold et al., 2018). Specific to Europe, the Eurobarometer Study found that 35% of all participants do not exert forms of PA at least once a week (European Union, 2018). In addition, this survey concluded that the percentage of individuals who never do exercise or sport rose from 42 to 46% between the years 2009 and 2017 (European Union, 2018). To counteract such tendencies, the World Health Organization (2018) has released the "Global Action Plan on Physical Activity 2018–2030" (GAPPA) with the recommendation of focusing on individuals' characteristics and behaviors on the one hand as well as on structures and environments on the other. The consideration of these two major pillars is compatible with socioecological theories, pointing out that PA behavior depends on both individual and environmental factors (Bauman et al., 2012; Sallis et al., 2015). With respect to person-related factors, the GAPPA repeatedly suggests addressing people's literacy and competencies (World Health Organization, 2018). Against the background of the frequent use of these two notions, a crucial question arises: What are those competencies and literacy aspects that have to be targeted when people want to adopt or maintain a healthy, physically active lifestyle? When overviewing the literature on health-enhancing physical activity (HEPA) and approaches underlying the two terms "literacy" and "competence," it becomes apparent that the corresponding descriptions highlight multifaceted and multidimensional requirements for a physically active lifestyle as they integrate physical, motivational, and cognitive aspects (Whitehead, 2007; Sudeck and Pfeifer, 2016; Edwards et al., 2017; Gunnell et al., 2018; Tremblay et al., 2018; Cairney et al., 2019b; Carl et al., 2020b; Martins et al., 2020). In line with this understanding, the literacy and competence approaches assume that an isolated focus on physiological and motor aspects on the one hand (e.g., Lubans et al., 2010) or on motivational and self-regulatory components on the other (e.g., Rhodes et al., 2019) does not account for the complex interplay of personal factors involved when people perform activities on a regular basis. In summary, the approaches using the terms "literacy" and "competence" share a considerable number of commonalities. Nevertheless, there are some conceptual differences (Carl et al., 2020c) that are in line with their separate mentions within the GAPPA (World Health Organization, 2018). The *physical literacy* approach has gained increasing attention during the last two decades (Edwards et al., 2017; Martins et al., 2020) and has put the literacy aspect within the GAPPA on a very solid and elaborate level. However, the approach has not fully exhausted its health potential, since the links to health as an important outcome have not been sufficiently discussed so far (Cairney et al., 2019b). The inclusive character of the framework also comprises competitive and more risky forms of movement (Durden-Myers et al., 2018; Robinson et al., 2018)—forms that may even counteract the promotion of an individual's health. The *competence* concept has the potential to offer a different perspective on physically active lifestyles within the GAPPA by highlighting the domain specificity, context boundedness, goal directedness, and action relatedness of personal factors (Robinson et al., 2015; Carl et al., 2020c). While movement competence as a specific sub-aspect has frequently been the subject of scholarly endeavors (Robinson et al., 2015), there have not yet been academic debates centering on multidimensional competencies for a healthy, physically active lifestyle. To stimulate scientific discussions in this area, the physical activity-related health competence (PAHCO) model has recently been introduced in international literature (**Figure 1**).

THEORETICAL BACKGROUND AND PURPOSE

The PAHCO model (Sudeck and Pfeifer, 2016) constitutes an integrative framework at the intersection of health literacy and physical literacy (Carl et al., 2020c) that assumes three interrelated and equivalent sub-competencies as essential for a healthy, physically active lifestyle: first, people require *movement competence*, allowing them to participate in planned exercise sessions and be physically active in leisure time (e.g., swimming) or to master important challenges of daily life (e.g., climbing stairs or carrying bags); second, *self-regulation competence* serves as the psychological component, designed to ensure the regular execution of these activities; and third, *control competence* is needed, guaranteeing that individuals not simply apply any stimulus as frequently and intensively as possible. As a rather "qualitative" (Pesce, 2012) domain, this competence component ensures that people do not merely follow the slogan "the more, the better." Instead, meeting the complex demands of health (Sørensen et al., 2012), this component is geared toward assigning an adequate load to the body for the promotion of physical health and mental well-being. According to the PAHCO model, these three competence areas are, in turn, the result of the integration and coupling of basic elements (see the left side of **Figure 1**). This assumption harmonizes with theoretical descriptions of competencies in general (e.g., Lichtenberg et al., 2007; Baartman and DeBruijn, 2011). For example, movement competence is formed by the interplay of basic motor abilities, basic motor skills, and a sound body awareness. The basis of control competence is a solid knowledge base in terms of the health-related benefits of PA (effect knowledge) and the appropriateness of certain methods and exercises to achieve these benefits (action knowledge). Finally, the model names positive attitudes toward PA as well as high PA-specific self-efficacy as the basis of self-regulation competence. In addition to these pathways characterizing a transformation of basic elements from the same vertical height, the model also explicitly considers

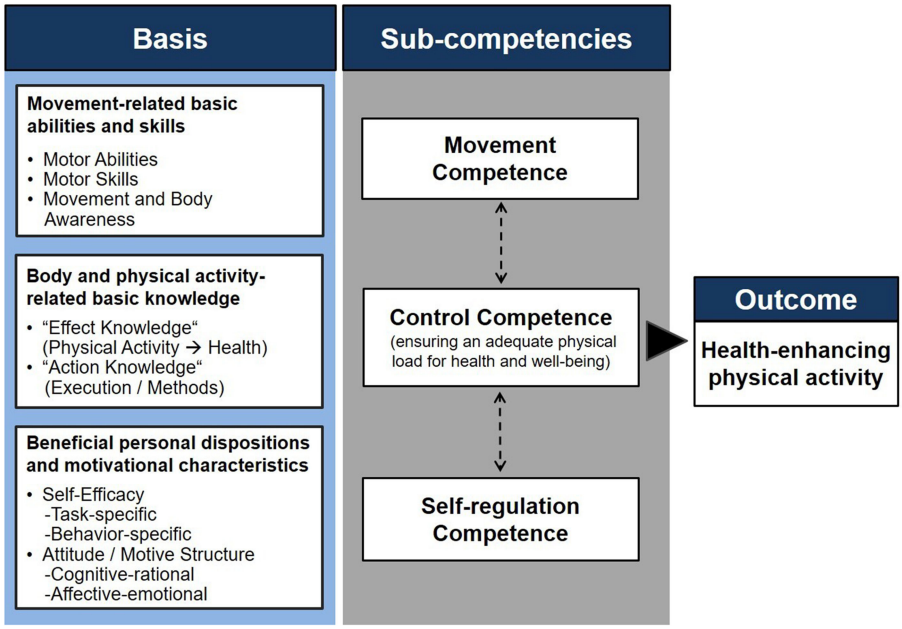

FIGURE 1 | The physical activity-related health competence (PAHCO) model (Sudeck and Pfeifer, 2016).

the integration of basic elements from another vertical height into the three competence areas (Sudeck and Pfeifer, 2016; Carl et al., 2020c). For instance, a good body awareness not only contributes to movement competence but can also be used as a feedback source for the identification of an adequate training load (Edwards and Polman, 2013; Smits et al., 2014; Thiel et al., 2018). Another example is the assertion that at least a minimum amount of task-specific self-efficacy is necessary to master given locomotor tasks (movement competence). The PAHCO model has been the subject of some publications in the German-speaking area (Wolters et al., 2016; Gawlik et al., 2018; Hecht, 2020; Schmid et al., 2020) and on the international level (e.g., Sudeck et al., 2018; Carl et al., 2020a; Haible et al., 2020). Also, this framework has already served as the theoretical foundation for interventions and programs (Ley et al., 2014; Streber and Pfeifer, 2018; Bruland et al., 2019; Haible et al., 2019). However, there is currently no diagnostic tool that meets the multidimensional and integrative character of the PAHCO model and, hence, provides consultants, coaches, or therapists with the opportunity to comprehensively assess the competence status of their patients or clients. Nevertheless, two studies including four samples were highly important in the past, as they paved the way for a potential assessment tool (**Table 1**).

The goal of these studies was to develop competence-oriented items and multidimensional scales on the sub-competence level. In a first article, Sudeck and Pfeifer (2016) successfully tested three single aspects of PAHCO with two different samples from both the fields of rehabilitation and prevention (**Table 1**). Inspired by this work, Carl et al. (2020b) recently extended this questionnaire in two consecutive steps, resulting in a five-factor and lastly in an eight-factor measurement model. These measurement models, however, have been developed with two specific samples, which limit the generalizability of the assessment. Therefore, it would be a value *per se* to cross-validate (Blackford, 2017) the measurement models previously extracted. Comparing the current status of the assessment with conceptualizations in publications (Pfeifer et al., 2013; Sudeck and Pfeifer, 2016), two model aspects could still be theoretically considered when striving for a multidimensional operationalization of the sub-competence level. First, no attempts have been undertaken in the context of PAHCO to empirically capture the cognitive-rational attitude component. Second, there is currently no assessment of body awareness. In this context, it is worth mentioning that the exploratory analyses in the second sub-study of Carl et al. (2020b) rejected a first operationalization of the body awareness aspect for both content-related and statistical reasons. Thus, it would be important to reconsider this factor without detaching from a competence-oriented operationalization. Adding the two elements of body awareness and cognitive attitude toward PA to the existing assessment would lead to a 10-factor measurement model. In case of successful testing, it would further be relevant to explore whether the 10 factors can be mathematically pooled into three overarching factors called movement competence, control competence, and self-regulation competence, as theoretically postulated by the PAHCO model. The results of the analysis would be decisive for the creation of sum scores for the three sub-competence areas of the PAHCO model. Such an empirical bundling (Cairney et al., 2019a), in turn, would provide future studies with the opportunity to inspect the associative power of the three sub-competencies (not only of the 10 single scales) with indices of HEPA. Therefore, the goal of the present study was to

TABLE 1 | An overview of the stepwise approach for the assessment development and validation of PAHCO.

Samples (*n*)	Sector	Publication	Number of included PAHCO aspects	Included aspects
Medical rehabilitation ($n = 1,028$)	Rehabilitation	Sudeck and Pfeifer (2016)	3	Affect regulation, control of physical load, self-control
University sports ($n = 1,331$)	Prevention	Sudeck and Pfeifer (2016)	3	Affect regulation, control of physical load, self-control
COPD rehabilitants ($n = 351$)	Rehabilitation	Carl et al. (2020b)	5	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy
Apprentices in nursing care and car mechatronics ($n = 745$)	Prevention	Carl et al. (2020b)	8*	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy, MED, MSD, MBD
Persons with multiple sclerosis ($n = 475$)	Rehabilitation	Present study	10	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy, MED, MSD, MBD, body awareness, cognitive attitude
Teacher students undergoing a basic qualification program in PE ($n = 502$)	Prevention	Present study	10	Affect regulation, control of physical load, self-control, emotional attitude, self-efficacy, MED, MSD, MBD, body awareness, cognitive attitude

*MED, manageability of endurance demands; MSD, manageability of strength demands; MBD, manageability of balance demands; PE, physical education; PAHCO, physical activity-related health competence; COPD, chronic obstructive pulmonary disease. *In exploratory analyses, the ninth factor body awareness has shown bad reliability coefficients. Therefore, it was excluded in this step.*

(1) cross-validate the three-, five-, and eight-factor measurement models on PAHCO with further populations, (2) subsequently investigate the reliability and validity of two further aspects of PAHCO (i.e., body awareness and the cognitive-rational attitude component) including the testing of a 10-factor measurement model, and (3) finally bundle these 10 first-order PAHCO factors to model-conform second-order factors. To achieve these goals, we again used two diverse samples (**Table 1**) from the two major strands of HEPA, namely, the fields of rehabilitation (Study 1) and prevention (Study 2). The selection of these populations was based on the approval of two research projects in which PAHCO had an important role. Study 1 comprised persons with multiple sclerosis (pwMS). MS is one of the most frequent neurological diseases, for which PA and exercise represent a highly important therapy (Pedersen and Saltin, 2015; Motl and Pilutti, 2016). Study 2 involved teaching students acquiring a basic qualification certificate in physical education. Teachers often report physical complaints and experience considerable mental stress during the workday (Erick and Smith, 2011; von der Embse et al., 2019), which calls for health promotion and, specifically, PA promotion initiatives for future teachers.

MATERIALS AND METHODS

Participants

Persons With Multiple Sclerosis (Study 1)

The previous step within the successive validation and assessment development strategy (**Table 1**) was conducted with a comparably healthy (apprentices) population (Carl et al., 2020b). Since the manageability of balance demands (MBD) factor has not been associated with indicators of PA in the last study (Carl et al., 2020b), we subsequently decided to examine pwMS who typically have problems with motor control (Kister et al., 2013; Rommer et al., 2019). Data were taken from a baseline online survey of the project "MS bewegt" [Engl. *ms moves*], which was specifically installed to launch an Internet-based and competence-oriented program for the promotion of PA in pwMS. Between February and April 2019, voluntary participants were recruited via website newsletters, social network groups, and a mailing list. A total of 484 people followed the link in the message and fully completed the questionnaire survey. We had to exclude the self-report of nine participants due to incomplete consent to data protection ($n = 6$) or not confirming the existence of an official medical diagnosis of MS ($n = 3$). The remaining 475 participants were predominantly female (73.5%), on average 47.8 $\pm$ 10.0 years old, and had a body mass index (BMI) of 25.2 $\pm$ 5.6 kg/m^2. The included pwMS had a mean patient-determined disease steps (PDDS) value of 2.74 $\pm$ 1.96, with their first official diagnosis being made 15.22 $\pm$ 9.27 years ago. Among the participants, 61.9% were undergoing immunotherapy and 62.7% were still employed.

Teaching Students (Study 2)

To cross-validate the potential 10-factor measurement model with a different population from the prevention sector, we additionally recruited a sample of teaching students undergoing a basic qualification program in physical education. In Bavaria, Germany, all elementary, middle, and special education teacher candidates must acquire theoretical and practical knowledge in physical education. Depending on individual's educational focus and preferences, physical education can thereby be taken

at three different levels, i.e., physical education as a primary, main subject (German: *Hauptfach*), as a secondary, minor subject (German: *Didaktikfach*), or as a third, subsidiary subject (German: *Basisqualifikation*). The basic qualification program is the compulsory course for all elementary, middle, and special education teacher candidates who chose physical education as their third, subsidiary subject (i.e., neither as a primary nor as a secondary subject). Given this preference, it can be assumed that this sample tends to target those individuals who are less interested in or familiar with the topics of PA and health. Within the scope of the PArC-AVE Study (Popp et al., 2020), as a part of the research consortium Capital4Health (here project phase 2), we asked all representatives of the *Working Group Sport Science and Sport of the Universities in Bavaria* (AKS), who coordinate the basic qualification programs in physical education at their universities ($n = 8$), to support the statewide survey in the winter term 2018/2019. All those coordinators were willing to organize the distribution and collection of paper-pencil questionnaires or, if desired, to provide the students with access to an equivalent online survey. This combined assessment strategy led to a final sample of $n = 502$: ongoing elementary school teachers, 61.8%; middle school teachers, 27.0%; and special education teachers, 11.2%. Two coordinators endorsed the organization via online surveys (6.0%, $n = 30$), while six coordinators preferred paper-pencil variants (94.0%, $n = 472$) to increase the response rate. The participants were predominantly female (87.6%), had a mean age of 23.1 ± 3.7 years, and showed an average BMI of 22.6 ± 3.7 kg/m².

Measures

We used the latest version of the PAHCO questionnaire with eight subscales (Carl et al., 2020b). The *cognitive attitude component toward PA* was measured using a German subscale for the assessment of attitude components in physical exercise (Brand, 2006). This tool comprised four items, rated on a seven-point Likert scale. Within the questions, we replaced the term "sport" with "physical activity" to relate the items to the more inclusive and, for this study, more convenient concept. Since the empirical results from the validation study (Brand, 2006) and our first experiences from a project in the context of pulmonary rehabilitation (Geidl et al., 2017) had shown that participants had some problems with the negatively formulated item "useless," we decided to modify it by adopting the positively connotated adjective "useful" instead (ATCOG3, see **Appendix Table 1**). *Body awareness* was assessed with five items on a five-point Likert scale. For the competence-oriented construction of the scale, we followed the basic differentiation between basic sensory and interpretative aspects (Ginzburg et al., 2014) on the one hand (e.g., item BAW2, having a good feeling for one's posture) and more complex aspects of use (e.g., item BAW7, the adequate use of body signals) on the other (**Appendix Table 1**). We profited from the experiences of a previous study with apprentices in which the initial operationalization of body awareness was not successful (Carl et al., 2020b). Two items were adopted as-is, one item underwent terminological change, and two items were newly developed. All sociodemographic (e.g., age, gender, height, weight), relevant medical (Study 1: e.g., subtype of MS, time since the last relapse), and education data (Study 2: e.g., study program, locality) were captured with self-report questions. However, since there was no validated German self-report tool for the assessment of the severity of the MS disease, we relied on the English version of the PDDS Questionnaire with its nine severity graduations (Learmonth et al., 2013). The first author of this study and a certified German–English translator independently performed a literal translation of this tool, seeking an agreement by consensus afterward.

Statistics

All items were exploratively screened on the basis of common statistical parameters on the one hand (item difficulty, variance within the sample, Cronbach's α, part–whole correlation) and of content-related arguments on the other. As the Mardia test revealed significant violations of multivariate normality (skewness and kurtosis, $p < 0.001$), we relied on robust maximum likelihood estimators (MLR) with Satorra–Bentler scaled statistics to interpret the fit of the models. In addition to the chi-square (SB–χ^2) statistics, which tend to systematically reject models of high complexity and models that are tested with huge sample sizes (Cheung and Rensvold, 2002), we paid attention to a variant that takes into account the underlying degrees of freedom (SB–χ^2/df). We also followed suggestions by Hu and Bentler (1998), who recommended indicating standardized root mean square residual (SRMR), root mean square error of approximation (RMSEA), and comparative fit index (CFI). To evaluate the magnitude of these coefficients, we adhered to guidelines indicating good ($\chi^2/df \leq 2.0$, RMSEA ≤ 0.05, SRMR ≤ 0.05, CFI ≥ 0.95) or satisfactory/acceptable ($\chi^2/df \leq 3.0$, RMSEA ≤ 0.08, SRMR ≤ 0.10, CFI ≥ 0.90) model fits (Schermelleh-Engel et al., 2003; Weiber and Mühlhaus, 2015). Missing values were treated by applying full information maximum likelihood (FIML) procedures. After the interpretation of the models, we extracted information on indicator and factor reliability. Discriminant validity was determined by following the criterion of Fornell and Larcker (1981), which postulates that discriminant validity is given when the average variance extracted (AVE) of each construct is higher than the squared correlation with any other construct. To inspect whether the 10 factors could be bundled into three overarching factors, we combined both samples (PwMS and teaching students) into one dataset ($n = 977$) and extended the measurement model to a second-level CFA (Chen et al., 2005). More specifically, we computed a 10-factor measurement model with three correlated yet non-overlapping second-order factors (**Figure 2A**). In accordance with the outlined model assumptions, we statistically pooled manageability of strength demands (MSD), manageability of endurance demands (MED), manageability of balance demands (MBD), and body awareness into a second-order factor called *movement competence*, the factors affect regulation and control of physical load to a second-order factor *control competence* and, ultimately, emotional

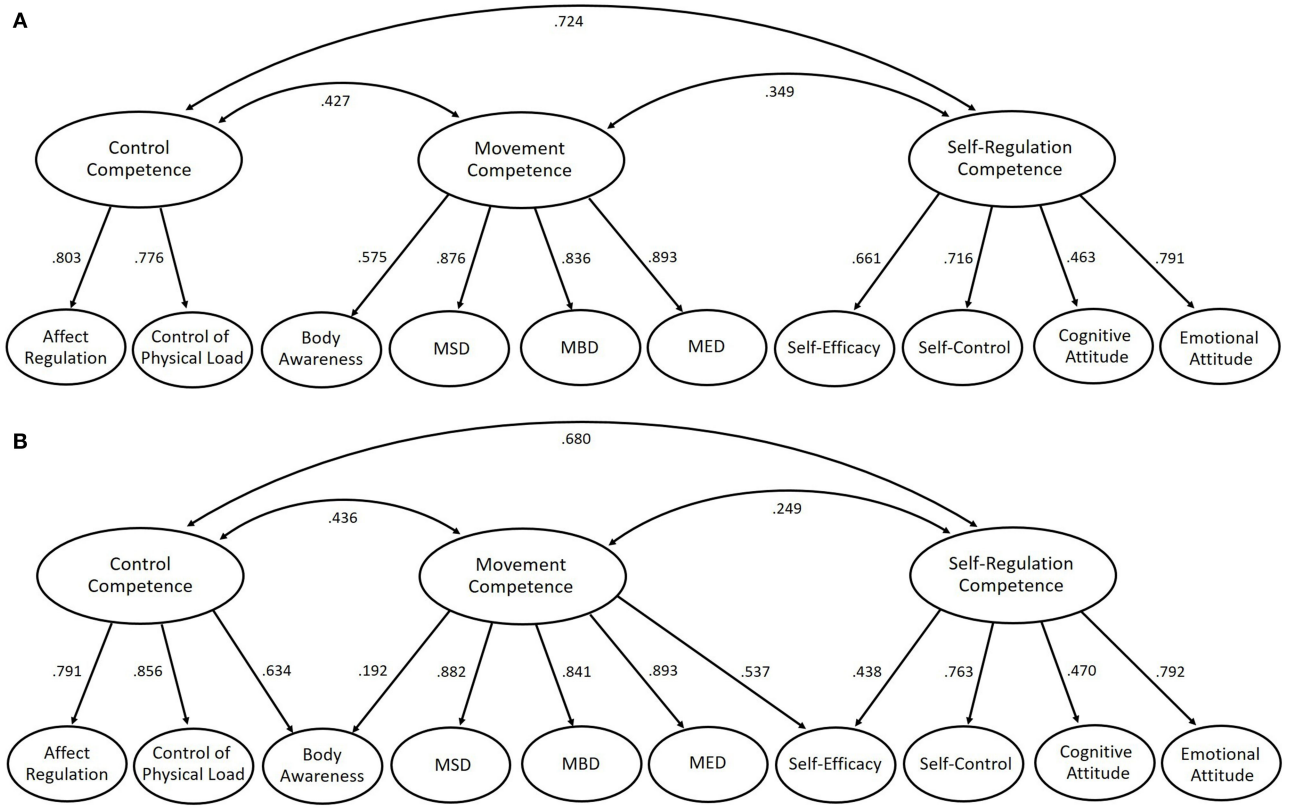

FIGURE 2 | Second-order confirmatory factor analysis (CFA) modeling with the 10 first-order factors **(A)** and a one-on-one allocation (simple structure) **(B)** and two theory-conform cross-loadings. The item level and the correlations between the first-order factors have been omitted in this figure for presentation reasons. The loadings can be retrieved from **Tables 2**, **3**, respectively, whereas the manifest correlations can be taken from **Appendix Table 4**.

attitude, cognitive attitude, self-efficacy, and self-control to a second-order factor *self-regulation competence*. Since the model posits that body awareness can be viewed as an important aspect of control competence and self-efficacy an important aspect of movement competence (see *Introduction*), we successively compared this simple loading model (**Figure 2A**) to a variant that freely estimated these two cross-loadings (**Figure 2B**). We interpreted the model comparisons by using the Satorra–Bentler scaled chi-square difference test (ΔSB–χ^2) as well as the information criteria by Akaike (AIC) and Bayes (BIC). Furthermore, we transformed the standardized covariance (correlation) matrix with the first-order factors into a distance matrix (with the formula $1–r$). Afterward, metric multidimensional scaling (MDS) was performed to more deeply analyze the suitability of a second-order solution and to visually examine the conceptual proximity between the first-order factors. Due to the number of first-order factors ($n = 10$), we limited the analysis to a two-dimensional ($k = 2$) MDS solution ($Q = 2.25$). This decision was supported by the Q coefficient (Backhaus et al., 2015), which would not have surpassed the critical value of 2.00 for three dimensions ($Q = 1.50$). Accordingly, applying more dimensions would have inhibited the interpretability of the solution. All analyses were run with the software R (Version 3.4.3), including the package Lavaan (Rosseel, 2017).

RESULTS

Persons With Multiple Sclerosis (Study 1)

There was a good fit for the three-factor [SB–χ^2/df = 2.14, CFI = 0.978, RMSEA = 0.049 (CI_{90} = 0.039–0.058), SRMR = 0.032] and five-factor [SB-χ^2/df = 2.18, CFI = 0.973, RMSEA = 0.050 (CI_{90} = 0.044–0.056), SRMR = 0.047] measurement models on PAHCO. The eight-factor variant, which had recently been worked out with apprentices, showed a satisfactory fit [SB–χ^2/df = 2.82, CFI = 0.938, RMSEA = 0.062 (CI_{90} = 0.058–0.065), SRMR = 0.040], which also demonstrates the validity of the measurement models for this population. Subsequently, we submitted the five new items of the body awareness factor and the four items of the factor cognitive attitude toward PA to exploratory item analysis. Both factors had good internal consistency with Cronbach's $\alpha = 0.93$. All five items of the body awareness factor ranged in the middle of the scale (item difficulty: 0.58–0.61), thereby displaying no further statistical anomalies. In contrast, there was high agreement to the items of the cognitive attitude toward PA scale (item difficulty: 0.92–0.93), which was

associated with high values for skewness and kurtosis (**Appendix Table 2**). In summary, however, the items did not lie beyond the critical cutoff of 0.95, and, more importantly, there is a content-related argument for this finding. PwMS are typically well aware of the array of beneficial effects resulting from PA, especially when it is executed in a disease-adapted fashion (Frau et al., 2015). Therefore, we continued the development process with the inclusion of these two factors. The CFA with the 10 factors and the 43 items showed a satisfactory model fit [SB–χ^2/df = 2.48, CFI = 0.931, RMSEA = 0.056 (CI_{90} = 0.053–0.059), SRMR = 0.042]. All items loaded significantly ($p < 0.001$) on their corresponding factor ($0.710 \leq \lambda \leq 0.992$), and the AVE (0.617–0.906) was good overall (**Table 2**). Even though the MBD, MSD, and MED factors were highly correlated ($0.758 < r < 0.834$), the Fornell–Larcker criterion was not violated in this sample. The factor reliabilities were consistently located in a good area ($0.906 \leq \alpha \leq 0.975$).

Teaching Students (Study 2)

The sample with the teaching students undergoing basic qualification in physical education also revealed good model fits for the three-factor [SB–χ^2/df = 2.32, CFI = 0.975, RMSEA = 0.052 (CI_{90} = 0.042–0.062), SRMR = 0.034] and five-factor [SB–χ^2/df = 2.18, CFI = 0.966, RMSEA = 0.049 (CI_{90} = 0.042–0.055), SRMR = 0.042] measurement models. The eight-factor measurement model displayed a satisfactory model fit as well [SB–χ^2/df = 2.14, CFI = 0.941, RMSEA = 0.048 (CI_{90} = 0.044–0.052), SRMR = 0.047]. The item analysis with the second sample indicated that the fourth item of the MBD factor was too easy for this population, showing an item difficulty of 0.96 and a kurtosis of 19.98 (**Appendix Table 3**). Following the claim that the assessment must fulfill the basic psychometric requirements in healthy populations as well, we decided to remove this item for all further steps. This decision was supported by the argument that the item covered a comparably easy dynamic locomotor task (maintaining balance while going downstairs). Items 5 and 6 of this factor also referred to stair climbing but included at least a second task (carrying a full shopping bag, carrying a glass full of water), which means that the dynamic locomotor aspect of balance was still sufficiently represented within the remaining item set of MBD when eliminating this particular question. The other items, including those of the two additional body awareness and cognitive attitude toward PA factors, revealed no statistical anomalies. The CFA with the 10 factors and 42 items demonstrated a good model fit [SB–χ^2/df = 1.98, CFI = 0.933, RMSEA = 0.044 (CI_{90} = 0.041–0.047), SRMR = 0.046]. All items loaded highly significantly on their corresponding factors ($p < 0.001$). Nevertheless, two items showed low regression weights ($\lambda_{STR5m} = 0.61$, $\lambda_{BAW4} = 0.62$). This finding was tolerated due to the fact that these items had not disclosed any problems in previous studies and that the corresponding indicator reliabilities (0.37 and 0.38) did not fall in an unacceptable area (Weiber and Mühlhaus, 2015). In the sample of teaching students, the AVE was consistently located within an acceptable area ($0.504 \leq$ AVE ≤ 0.764). However, the AVE of the factors body awareness (AVE = 0.518) and control of physical load (AVE = 0.504) were lower than their squared correlation with each other ($r^2 = 0.634$). The violation of the Fornell–Larcker criterion indicates that the present assessment could not sufficiently discriminate between these two PAHCO constructs in this sample.

Investigation of the Second-Order Structure on Physical Activity-Related Health Competence

The stepwise assessment development on PAHCO comprised a total of six different samples (**Table 1**). Starting with a three-factor variant, the continuous cross-validation and extension strategy led to a 10-factor measurement model. We next examined whether the 10 specified factors could be pooled into three overarching constructs. The simple loading model (**Figure 2A**) with the merged dataset, however, displayed an insufficient fit [SB–χ^2/df = 3.63, CFI = 0.913, RMSEA = 0.052 (CI_{90} = 0.050–0.052), SRMR = 0.109], with two statistical indicators lying outside the cutoff values (SB–χ^2/df > 3.0 and SRMR > 0.10) for acceptable model fits (Schermelleh-Engel et al., 2003; Weiber and Mühlhaus, 2015). Congruent with the assumption of the PAHCO model that body awareness can also be interpreted as an aspect of control competence and self-efficacy as an aspect of movement competence (Pfeifer et al., 2013; Sudeck and Pfeifer, 2016), we further tested a second-order variant in which these two cross-loadings were additionally allowed to be freely estimated (**Figure 2B**). Even though the SB–χ^2/df statistics still showed a slightly too high value, the remaining fit indices of this theory-conform second-order CFA were satisfactory [SB–χ^2/df = 3.24, CFI = 0.926, RMSEA = 0.048 (CI_{90} = 0.046–0.050), SRMR = 0.065], and the SRMR especially turned into an acceptable area. The two cross-loadings, both significant ($p < 0.001$) and substantial in magnitude for a second-order model ($\lambda_{BAW-CC} = 0.634$, $\lambda_{SE-MC} = 0.537$), contributed to this finding. The pattern revealed that the two loadings even had a stronger conceptual proximity to the second-order cross-factors than to the primary second-order factors ($\lambda_{BAW-MC} = 0.192$; $\lambda_{SE-SRC} = 0.438$), occupying a larger loading in comparison. In the case of the movement competence to body awareness loading, the reduction was considerable, falling below a value of 0.20. Even though such a decrease is considered significant in some recommendations (Tabachnick and Fidell, 2001), the loading was still highly significant ($p = 0.004$), with the pattern being in accordance with the discriminant validity phenomenon described in the PwMS sample. Nevertheless, the direct comparison between both second-order models (ΔSB–$\chi^2 = 317.3$, Δdf = 2, $p < 0.001$, ΔAIC = 363, ΔBIC = 358) statistically favored the latter variant of the two solutions. The model results are similar when second-order CFAs are computed for the pwMS and teaching student samples separately (for an overview, **see Appendix Figure 1**).

MDS based on the distance matrix (**Appendix Table 4**) showed that those factors that could be grouped according to PAHCO could be pooled together spatially. The two cross-factors self-efficacy and body awareness were located at the interface of their corresponding superordinate factors (**Figure 3**). Movement competence (blue surface) and control competence (yellow surface) occupied a field of limited expansion with a

TABLE 2 | Analyses of reliability and discriminant validity of the final 10-factor measurement model on physical activity-related health competence (PAHCO) with the sample of persons with multiple sclerosis.

	Loading	Indicator reliability	Factor reliability	Average variance extracted	Highest squared correlation
Manageability of Endurance Demands (MED)			0.941	0.800	0.646
END30	0.891	0.794			
END60	0.930	0.865			
END10s	0.855	0.731			
END30s	0.901	0.812			
Manageability of Strength Demands (MSD)			0.929	0.756	0.696
STR15	0.822	0.676			
STR25	0.845	0.714			
STR5m	0.893	0.797			
STR15m	0.914	0.835			
Manageability of Balance Demands (MBD)			0.957	0.785	0.696
BAL1	0.873	0.762			
BAL2	0.836	0.699			
BAL3	0.847	0.717			
BAL4	0.940	0.884			
BAL5	0.932	0.869			
BAL6	0.883	0.780			
Body Awareness			0.933	0.715	0.572
BAW2	0.783	0.613			
BAW4	0.804	0.646			
BAW3b	0.815	0.664			
BAW7	0.920	0.846			
BAW8	0.897	0.805			
Control of Physical Load			0.906	0.617	0.572
CCPL1	0.767	0.588			
CCPL2	0.820	0.672			
CCPL3	0.787	0.619			
CCPL4	0.785	0.616			
CCPL5	0.838	0.702			
CCPL6	0.710	0.504			
Affect Regulation			0.947	0.820	0.493
AR1	0.867	0.752			
AR2	0.913	0.834			
AR3	0.945	0.893			
AR4	0.895	0.801			
Self-Efficacy			0.918	0.816	0.486
SE1	0.838	0.702			
SE2	0.992	0.984			
SE3	0.873	0.762			
Self-Control			0.923	0.801	0.482
SC1	0.869	0.755			
SC2	0.916	0.839			
SC3	0.900	0.810			
Emotional Attitude			0.975	0.906	0.493
ATEM1	0.914	0.835			
ATEM2	0.957	0.916			
ATEM3	0.974	0.949			
ATEM4	0.962	0.925			

(Continued)

TABLE 2 | Continued

	Loading	Indicator reliability	Factor reliability	Average variance extracted	Highest squared correlation
Cognitive Attitude			0.933	0.781	0.260
ATCOG1	0.892	0.796			
ATCOG2	0.856	0.733			
ATCOG3	0.916	0.839			
ATCOG4	0.869	0.755			

well-interpretable structure. The subdimension of self-regulation competence (red surface) was comparably broad in its conception and operationalization. MDS unfolded that the cognitive attitude component was somewhat outstanding with respect to the other factors, contributing to a graphical expansion of the self-regulation competence surface. Even though the emotional attitude toward PA and the affect regulation factors displayed an empirical proximity, the graphical solution endorsed a theoretical separation between these two PAHCO aspects. After flipping and rotating the 10 points by 95° around the zero of the coordinate system (transformation formula: $x' = x \cdot \cos \alpha + y \cdot \sin \alpha$; $y' = -x \cdot \sin \alpha + y \cdot \cos \alpha$), the resulting configuration could be interpreted along two dimensions. The x-axis spanned a continuum from a rather isolated level (including the factors of both attitude components) on the left to a complex and more competence-/action-oriented level (such as control of physical load or body awareness) on the right. The points on the y-axis, in contrast, could be ordered from body functions on the top (such as the facets of movement competence MBD, MSD, or MED) to more cognition and emotion-oriented factors (including self-control or the attitude components) at the bottom (**Figure 3**). In summary, we determined a fit between the configural constellation of the theoretical model (**Figure 1**) and the empirical data gained through MDS (**Figure 3**).

Given the model fit of the second-order structure of PAHCO using the basic 10-factor assessment, we were entitled to create sum scores for the 10 first-order factors and the 3 second-order factors in these two specific populations. The two first-order factors body awareness and self-efficacy, which displayed theory-conform cross-loadings (**Figure 2B**), were included in the score of two competence domains, each with a relative weight of 0.70[1]. Documents on the validated instrument (i.e., the questionnaire instrument, an input mask, an evaluation syntax, and an interpretation guide) can be freely downloaded from a website of the local university[2]

When applying this aggregation procedure, the sum scores of self-regulation and control competence were correlated most strongly across both samples ($r = 0.709$). Albeit slightly lower in magnitude, movement competence was also strongly associated with self-regulation ($r = 0.496$) and control competence ($r = 0.625$).

DISCUSSION

The present article endorsed the factorial structure of measurement models tested in earlier studies (Sudeck and Pfeifer, 2016; Carl et al., 2020b) using two different samples from the rehabilitation (pwMS) and prevention (teaching students) context. In addition to the eight-factor measurement model, we also included measures of body awareness and cognitive attitude toward PA, thus allowing the investigation of a 10-factor measurement. In summary, the application of the cognitive attitude toward PA scale, transferred and adapted from Brand (2006), was psychometrically warranted. In terms of body awareness, we revised and extended operationalizations that had to be rejected in previous studies (Carl et al., 2020b). The reliability, factor loadings, and overall model fit with the new item set indicated that the operationalization in this study was more adequate. However, although not found in the pwMS sample, the second study with the basic qualification students raised some concerns regarding the discriminant validity of the body awareness factor showing a significant overlap with the control of physical load factor. Indeed, two items (BAW7, BAW8) could also be interpreted as side aspects of the control of physical load factor. Providing a first explanation of the different findings across both samples, sensory inputs could be an integral part of the identification of an adequate physical load among most individuals and pwMS might present a special population who, due to the impaired motor control system, might also have learned to rely on other information sources than their afferent input to regulate their physical load (e.g., feedback from others, intuition, personal experience, guidelines from disease-specific PA recommendations). Second, the ongoing teachers, who have all refrained from choosing physical education as a special subject, could draw on less experience with physical exercise and may therefore prioritize sensory control strategies and more internal foci of attention to arrange strenuous activities (Perkins-Ceccato et al., 2003; Castaneda and Gray, 2007). Third, the possibility cannot be fully excluded that the theoretical

[1]Due to the importance of these two PAHCO aspects resulting from their integrative function, we refrained from using a shared relative weight of 0.50 for each corresponding second-order factor. A relative weight of 1.00, in contrast, would give these two factors too strong an influence among the PAHCO indicators. Therefore, we chose a relative weight of 0.70 for both indictors to feed into the sum score of both corresponding second-order factors.

[2]English Version: https://www.sport.fau.eu/das-institut/forschung/bewegung-und-gesundheit/forschungsprojekte/bgk/ German Version: https://www.sport.fau.de/das-institut/forschung/bewegung-und-gesundheit/forschungsprojekte/bgk/bgk-erstellung-eines-assessmentinstruments/.

TABLE 3 | Analyses of reliability and discriminant validity of the final 10-factor measurement model on physical activity-related health competence (PAHCO) with the sample of teaching students.

	Loading	Indicator reliability	Factor reliability	Average variance extracted	Highest squared correlation
Manageability of Endurance Demands (MED)			0.836	0.585	0.246
END30	0.680	0.462			
END60	0.772	0.596			
END10s	0.783	0.613			
END30s	0.818	0.669			
Manageability of Strength Demands (MSD)			0.800	0.543	0.171
STR15	0.787	0.619			
STR25	0.803	0.645			
STR5m	0.610	0.372			
STR15m	0.732	0.536			
Manageability of Balance Demands (MBD)			0.899	0.594	0.224
BAL1	0.783	0.613			
BAL2	0.756	0.572			
BAL3	0.857	0.734			
BAL5	0.774	0.599			
BAL6	0.672	0.452			
Body Awareness			0.841	0.518	0.634
BAW2	0.633	0.401			
BAW4	0.617	0.381			
BAW3b	0.632	0.399			
BAW7	0.863	0.745			
BAW8	0.815	0.664			
Control of Physical Load			0.855	0.504	0.634
CCPL1	0.766	0.587			
CCPL2	0.728	0.530			
CCPL3	0.662	0.438			
CCPL4	0.640	0.410			
CCPL5	0.722	0.521			
CCPL6	0.733	0.537			
Affect Regulation			0.926	0.763	0.419
AR1	0.821	0.674			
AR2	0.899	0.808			
AR3	0.928	0.861			
AR4	0.841	0.707			
Self-Efficacy			0.876	0.738	0.362
SE1	0.759	0.576			
SE2	0.989	0.978			
SE3	0.812	0.659			
Self-Control			0.906	0.767	0.372
SC1	0.811	0.658			
SC2	0.920	0.846			
SC3	0.892	0.796			
Emotional Attitude			0.920	0.746	0.419
ATEM1	0.823	0.677			
ATEM2	0.876	0.767			
ATEM3	0.894	0.799			
ATEM4	0.860	0.740			

(Continued)

TABLE 3 | Continued

	Loading	Indicator reliability	Factor reliability	Average variance extracted	Highest squared correlation
Cognitive Attitude			0.871	0.637	0.136
ATCOG1	0.805	0.648			
ATCOG2	0.783	0.613			
ATCOG3	0.792	0.627			
ATCOG4	0.812	0.659			

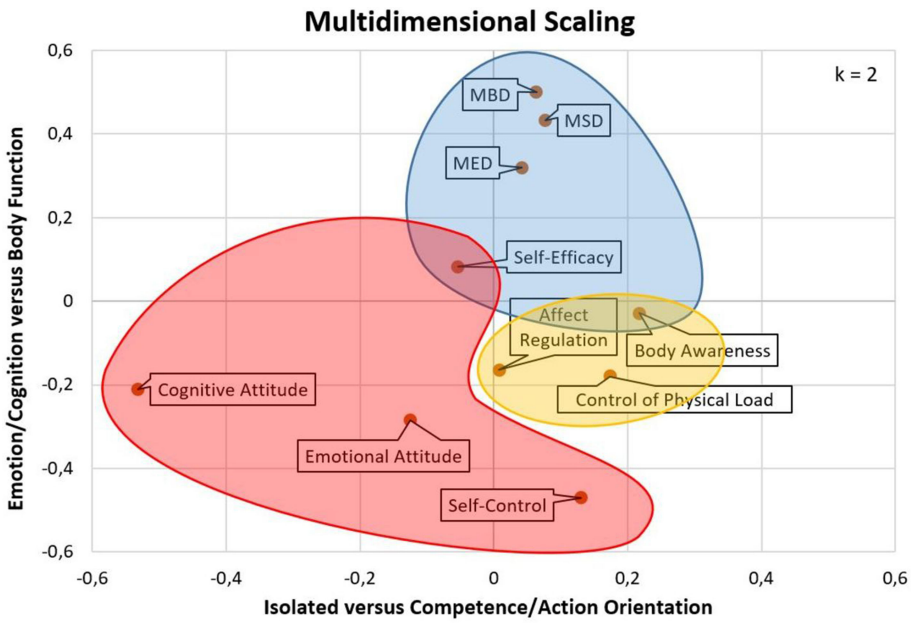

FIGURE 3 | Multidimensional scaling (two-dimension solution).

construction strategy was not adequately implemented because the items may not capture body awareness as conceptually intended. To accumulate evidence on one of these potential explanations, it is necessary to conduct further studies with other populations. Despite this open point, the present study could extract a theory-conform measurement model that meets the multidimensional and integrative character of the PAHCO model. An initial second-order CFA rejected a first measurement model with a simple loading structure. The free estimation of two cross-loadings significantly improved the model fit. From a theoretical perspective, these two loadings can be directly deduced from two articles introducing the PAHCO model (Pfeifer et al., 2013; Sudeck and Pfeifer, 2016). In line with the statistical fit of the alternative measurement model, it would have been inappropriate to neglect that (a) sound body awareness can contribute to the identification of an adequate physical load in the context of health-oriented exercise (Williams, 2008) and that (b) the execution of motor actions depends on a minimum level of (task-specific) self-efficacy. The subsequent MDS could reproduce the identified second-order structure by mapping the first-order factors along two axes. The graphical representation revealed that the cognitive attitude toward PA factor was slightly outstanding, thus widening the PAHCO and, importantly, the self-regulation surface. Following our interpretation along the x-axis (isolated vs. action-/competence-related orientation), this component may have more characteristics of a basic element, similar to the self-efficacy or the emotional attitude factors, which (as self-regulation elements) also have negative values on the abscissa. In this regard, it would be worth identifying self-regulation elements that are even more competence-oriented. For instance, Sudeck and Pfeifer (2016) suggested taking up the idea of motivational competence that describes an individual's capacity to make motive-congruent decisions (Rheinberg and Engeser, 2010). In this context, it would be crucial to transfer this sub-competence to PAHCO by undertaking a theoretical-conceptual discussion first. From the perspective of behavioral relatedness, technically named criterion validity, it would be necessary to relate the latent second-order factors or sub-competence scores to pivotal outcomes of HEPA (**Figure 1**). As outcomes,

this would, for example, include the volume of PA performed (Sudeck and Pfeifer, 2016; Carl et al., 2020b) or, covering qualitative and health-related aspects of HEPA, parameters such as positive affect (Sudeck et al., 2018), perceived vitality (Schmid et al., 2020), or subjective health (Carl et al., 2020b). Nevertheless, focusing the internal structure of the framework, the present second-order approach could substantiate the integrative and interrelated nature of the PAHCO model. In concert with metatheoretical assumptions, *integrative* means that competencies do not refer to comparably isolated and context-independent (Klieme et al., 2010) movement characteristics such as motor skills. Instead, they require a combination of different abilities and skills, resulting in a multidimensional conceptualization of competencies. Accordingly, to describe a person as competent, the individual should be able to master a number of tasks and demands in different yet concrete situations (Klieme et al., 2010). The present assessment takes this assumption into account using a competence-oriented formulation of items, especially in the area of movement and control competence. The *interrelated* character of PAHCO could be demonstrated by two concrete study results. First, we registered considerable associations *within* the three sub-competencies, i.e., across the different first-order factors. Second, the sum scores *between* the three sub-competencies were correlated, which puts the postulated arrows on the sub-competence level of the PAHCO model (**Figure 1**) on a stronger empirical basis.

LIMITATIONS

Despite the considerable diversity regarding the examined target groups spanning healthy, young, and well-educated people on the one hand and comparably older individuals with a specific chronic condition on the other, restraint is warranted regarding the external validity of the findings. Currently, it is not possible to generalize the model findings to the population level. More specifically, the selection of the samples was linked to the approval of two research projects, meaning that the previous strategy was so far not able to overcome convenience sampling. In addition, we cannot exclude a selection bias on the project level. In Study 2, the recruitment was realized by contacting the official coordinators of the regional universities. Through their involvement, every Bavarian student of the winter term cohort was personally invited, finally leading to a high participation rate. In Study 1, in contrast, we used different disease-specific social communication channels. This recruitment strategy may have primarily attracted individuals with a special interest in topics of PA and exercise. Furthermore, the present validation was based on different survey formats. While the findings of Study 1 relied on an online format, the insights of Study 2 result primarily from the application of paper-pencil questionnaires (most coordinators preferred this mode to enhance the response rate). Lastly, the PDDS Questionnaire, which provided valuable information for the description of the pwMS sample, has been specifically translated for this study by two independent experts. Future studies should strive for a thorough validation of this instrument.

CONCLUSION

The present study built on previous measurement models on PAHCO (Sudeck and Pfeifer, 2016; Carl et al., 2020), cross-validated them, and extended them through the specification of additional operationalizations for body awareness and cognitive attitude toward PA. The 10-factor measurement model showed satisfactory global model fits in pwMS and teaching students. Assuming that the 10 factors have the potential to represent the three sub-competencies of PAHCO in a sufficient (yet not exhaustive) manner, we performed second-order analyses with this set of measurement factors. The second-order confirmatory factor analyses and MDS techniques demonstrated an acceptable model fit for the postulated hierarchical structure when theory-conform cross-loadings for the body awareness and self-efficacy factors are considered. This finding can be interpreted as an empirical rationale for the development of sum scores (movement competence, control competence, self-regulation competence) in these two populations. To the knowledge of the authors, this is the first study that has modeled the sub-competence level of PAHCO in an empirical, multidimensional way. However, further validations are necessary that examine the second-order measurement model in other ideally more representative samples, especially when researchers intend to implement the instrument on a larger scale. Based on the positive findings from the present samples and the previous validation studies, we can specifically recommend the use of the PAHCO instrument (which can be freely accessed on a website) in the fields of rehabilitation and prevention. If researchers plan to implement the instrument with very specific target groups (e.g., if the goal is to promote healthy, physically active lifestyles), it would be valuable to also check aspects of validity.

DATA AVAILABILITY STATEMENT

Both studies are part of a research project and data will be published as soon as the projects are completed. The data is made available upon request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Landesärztekammer Baden-Württemberg (F-2018-059) and Friedrich-Alexander Universität Erlangen-Nürnberg, Medizinische Fakultät (467_18B). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JC defined the validation strategy, developed the new items, initiated and organized the surveys in both studies, performed

the analyses, and drafted the manuscript. GS contributed to the item development and refined the manuscript. KP had the major responsibility for both studies and also refined the manuscript. All authors have approved the final version of the manuscript and agree with the order of presentation of the authors.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2020.558850/full#supplementary-material

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Understanding of Physical Activity in Social Ecological Perspective: Application of Multilevel Model

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In the social ecological model, personal characteristics are important determinants of health behaviors, however, multi-dimensional approaches that consider social and physical environments must be utilized to gain a broader picture. Accordingly, this study examines the effects of personal, social, and physical environment variables as factors affecting levels of physical activity (METs). Our findings are based on 72,916 responses from the 2015 Community Health Survey in South Korea. Individual characteristics considered included sex, education level, marital status, age, and income. The social environment variables considered were trust between neighbors and the social network with neighbors. The physical environment variables were satisfaction with living environment and satisfaction with public transportation. The analysis was conducted using a multilevel model in order to accurately consider the characteristic differences of the variables. Regarding personal characteristics, sex, education level, and age have a significant effect on physical activity. Of the social and physical environment variables, social network with neighbors and satisfaction with public transportation have a significant effect on physical activity. This study confirms that a macroscopic understanding is needed to explain individual levels of physical activity; the results of this study will be helpful for public health interventions concerning physical activity.

Keywords: CHS, social ecological model, physical activity, individual characteristic, social environment, physical environment

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INTRODUCTION

Engagement in physical activity is widely known to be beneficial to human health in many ways. However, in spite of the range of positive benefits to physical activity, the proportion of adults in Korea who do not achieve sufficient levels of physical activity increased from 24.6% in 2008 to 42.9% in 2014 (Yang, 2016). The effects on society of neglecting physical activity, including the resulting deaths, are greater than those of obesity and similar to those of smoking (Lee et al., 2012).

Increasing levels of physical activity has been a goal in many public health contexts and theoretical studies have been performed to predict engagement in physical activity. The social ecological model constructed by Bronfenbrenner (1977) proposed that behavior is affected by a range of variables on the individual level and the broader social, physical, and policy environments. Variables on the individual level can include demographic characteristics, as well as beliefs and attitudes in relation to behavior. Factors of social environment consider how supportive of

engagement in physical activity the people around an individual are. Physical environment factors include the facility accessibility of engagement in physical activity. Finally, the policy environment describes the laws and policies of the central and local governments for engagement in physical activity. Theories such as Social Cognitive Theory (SCT), Theory of Planned Behavior (TPB), Self-Determination Theory (SDT), and Transtheoretical Model (TTM) for explaining physical activity greatly enhance understanding of psychological motivators (Nigg et al., 2008; Buchan et al., 2012). However, the social ecological model puts forward a multidimensional approach, incorporating the social and physical environment as well as admitting that personal aspects are important factors in health behavior (McLeroy et al., 1988). Furthermore, although personal, social, and physical environments are all quite important for promoting physical activity, such factors may have synergic effects (Susser and Susser, 1996). This is supported by the observation that it is more efficient to improve the environment around individuals than to directly change the individuals themselves (Spence and Lee, 2003).

A study by Wilson et al. (2004), which described the socio-economic level of individuals in the social ecological model, found that people who have a lower socio-economic status are less likely to engage in physical activity than those of higher socioeconomic status. Other studies have found similar results, presenting further complex links. Görner et al.'s (2020) study reports that socioeconomic factors affect the swimming ability of middle school students: middle and upper economic classes were found to better swimmers due to more learning opportunities and to access to better educational environments. Additionally, people with lower socio-economic statuses are less aware of their own health problems than those with higher statuses, resulting in reduced participation in physical activity (Prentice, 2006). It is widely acknowledged that sex, age, income, and psychological variables can predict physical activity (Hwang and Kim, 2017; Siahpush et al., 2019).

Recent studies (Bjornsdottir et al., 2019; Yen and Li, 2019) have investigated social and physical environment variables, which, unlike variables on the individual level, can be integrated into studies despite the lack of empirical research. Thornton et al. (2017) used the social ecological model to establish the effects of individual demographic and psychological variables, as well as social and physical environmental variables, on physical activity, indicating that all social ecological variables have significant effects. Neighborhood social cohesion, considered an important facet of social environment, is one of the most important factors in promoting health awareness. Conceptually, it considers the degree of trust, familiarity, and strength of network relations with neighbors (Mendes de Leon et al., 2009). Furthermore, Neighborhood Social Cohesion has been verified as an important variable affecting the physical activity of the elderly (Kim et al., 2020). In addition, studies into physical environment prove that the architectural and urban environment of the local community influences physical activity (Sun et al., 2020). To create a physical environment conducive to promoting physical activity various factors should be considered, such as pedestrian infrastructure, public transport access and infrastructure, and access to community and park facilities (Omura et al., 2020). These studies show how important it is for an individual to have people around who are also engaged in exercise and to provide support for the individual's physical activity, underlining that infrastructure and accessibility play a significant role in facilitating engagement in physical activity. Moreover, other studies, such as those of de Bruijn et al. (2006) and Lee and Shepley (2012), have integrated physical environmental variables with the planned behavior model theory to investigate physical activity levels. This work has proved that the physical environment must be accounted for in promoting physical activity. As previously noted, studies have worked to research physical activity by integrating the social ecological model with other theoretical models.

Nevertheless, it should be acknowledged that the studies that have applied this social ecological model show certain limitations in their analytical methods. The individual, social, and physical environments, considered as variables of a social ecological model, exist within a multilevel structure. To expand upon this: if variables related to individual characteristics should be assigned level 1 variables and social and physical environment variables, which can be considered group characteristics, should be assigned level 2. Nevertheless, in the studies of de Bruijn et al. (2006) and Rhodes et al. (2006) the relationship between physical environment variables and physical activity was verified using a structural equation model and path analysis. Nategh et al.'s (2017) study verified social ecological variables through the Pearson correlation test. The multilevel model can be used to analyze the data divided into individual and group information but the methods used in previous studies could result in interpretation errors because the analysis neglects such levels of variables. For this reason, this study adopts the multilevel structure outlined above. The Community Health Survey calculates the basic data and statistics necessary for establishing a national health promotion plan and a local health care plan at the national level. Using this data has many advantages: not only is it collected through a systematic process but it produces more reliable results because of its large sample. A study by Koo and Kim (2018) used the Community Health Survey data to derive social ecological factors affecting physical activity levels of the elderly. In this study, the interaction effect was analyzed through decision tree analysis. Kim and Suh (2017) analyzed the social ecological factors affecting the walking habits of office workers using a multilevel model. Accordingly, this study aimed to investigate the social ecological factors affecting both moderate and vigorous physical activity as well as walking. In addition to conventional identification of the determinants of physical activity on the individual level, a macroscopic investigation through the social ecological model could help provide a more persuasive view of human behavior. Thus, this study drew on panel data from the Community Health Survey in South Korea, assessing them through the social ecological model. Specifically, this study investigated the effects that individual characteristics and social and physical environments exert on individual physical activity. Thus, this study utilized data from the 2015 Community Health Survey in South Korea and set the research questions below to achieve its objectives.

1. How do individual characteristics (sex, education level, marital status, age, and income) affect physical activity?
2. What effects do social (neighborhood trust and social network with neighbors) and physical (life environment satisfaction, and public transportation satisfaction) variables have on physical activity?

MATERIALS AND METHODS

This study investigated the effects that individual characteristics and social and physical environments have on individual physical activity. Specifically, this study used a multilevel model to analyze level 1 individual characteristic variables that affect physical activity, including sex, education level, marital status, age, and monthly income, and level 2 social environment variables (trust between neighbors and social network with neighbors) and physical environment variables (life environment satisfaction and mass transportation satisfaction) to statistically verify the effects of variables on individual physical activity levels.

Characteristics of the Analysis Data

The data used in this study was obtained from the 2015 Community Health Survey of Korea Centers for Disease Control and Prevention, which is a 2015 panel data survey of indicators related to residence and health for adults aged over 19 covering 17 cities and provinces in South Korea. Data collection was coordinated by the Korea Centers for Disease Control and Prevention. The acquisition of the raw data for research purposes was approved by the commission board after undergoing a privacy and research ethics process. The raw data is representative because it was extracted using the weight of population structure in South Korea. Although the raw data included responses from 228,558 people, 72,916 people were selected for the final analysis through a data-refining process. To calculate metabolic equivalents (METs) we had to use variables regarding individual activity time. However, these variables had a lot of missing values. For instance, a variable with regard to average daily activity time for walking physical activity (minutes) had 51,892 missing values and a variable regarding average daily activity time for moderate physical activity (minutes) had 78,111 missing values. Therefore, we used list wise deletion as we still had adequate data to represent the population after removing 155,642 observations with missing values (see **Figure 1**). **Table 1** presents the general characteristics of the subjects.

Dependent Variables

Physical activity, which appears in this study as a dependent variable, was calculated using the International Physical Activity Questionnaire (IPAQ), following previous studies (Oh et al., 2007). The amount of physical activity engaged in is presented in terms of METs, calculated from the answers to the IPAQ. The Community Health Survey provided open-ended questions designed to find the number of days and hours consumed by walking (low-impact), moderate, and vigorous physical activity during the previous week. Individual METs were assigned to subjects based on the following formulas.

METs = Vigorous MET + Moderate MET + Walking MET

- Vigorous MET = 8 × average daily activity time for vigorous physical activity (minutes) × number of days performed
- Moderate MET = 4 × average daily activity time for moderate physical activity (minutes) × number of days performed
- Walking MET = 3.3 × average daily activity time for walking physical activity (minutes) × number of days performed

Independent Variables

The level 1 independent variables (individual characteristic variables) used in this study included sex, education level, marital status, age, and monthly income. To provide practical meanings to these variables for analysis, all individual characteristics excluding age were converted into dummy variables (reference group: male, below high school, married, and below 1,000 thousand won). These reference groups were only used for statistical comparison.

Level 2 variables (environmental characteristics) included social environment (trust between neighbors and social network with neighbors) and physical environment (life environment satisfaction and mass transportation satisfaction) as independent variables. Statements were given to measure the satisfaction levels of each independent variable. Level of trust between neighbors was measured through the item "I can trust the people in my neighborhood," and the social network with neighbors item asked, "How often do you see or contact your neighbors who are most frequently in contact." The life environment satisfaction item was "I am satisfied with life environment in my neighborhood (including electricity, water and wastewater system, garbage collection, and sports facilities)," and the mass transportation satisfaction item was "I am satisfied with mass transportation status in my neighborhood (including bus, taxi, subway, and train)."

Except for social network with neighbors which was measured by 7-point Likert scale, the items for trust between neighbors, life environment satisfaction, and mass transportation satisfaction were set as categorical variables (Yes/No). These items were assessed with the percentage of respondents who selected "Yes" in each region. For example, of the 6,652 respondents in the Seoul region, 4,195 respondents answered Yes to the item "I can trust the people in my neighborhood." Therefore, 63.0% was recorded as the value for the variable. These variables were assessed by two experts to ensure the content validity. **Table 2** summarizes specific information about the variables.

Data Processing

The data obtained from the Community Health Survey were cleaned using SPSS 24.0 and frequency analysis was conducted to find basic information on the 72,916 respondents for the final analysis. A multilevel model analysis was then conducted utilizing HLM version 8 (Raudenbush and Bryk, 2002). Model 1 is an unconditional model with no independent variables and is the base model for calculating ICC only. Model 2 considers variables

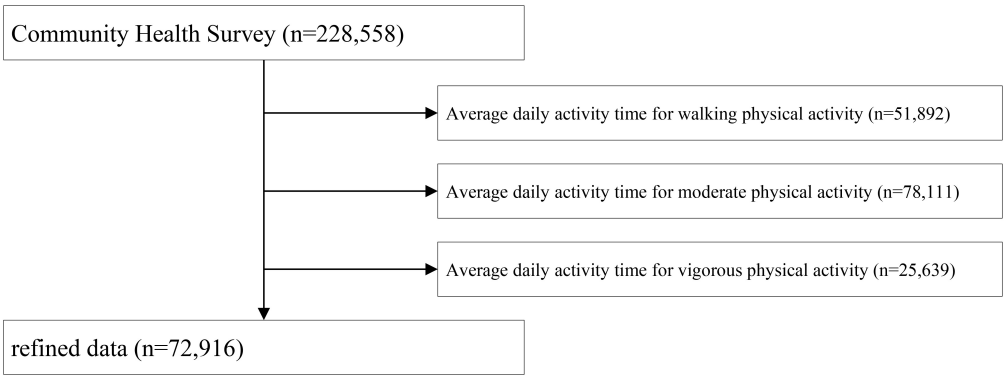

FIGURE 1 | Flow chart.

at the individual level, which attempts to explain physical activity only using individual characteristics. Model 3 considers group-level variables (social and physical environment) alongside Model 2 and is the model that is ultimately tested in this study. In other words, Model 3 applies a social ecological model that considers individual and environmental variables. The reason for the three models is to calculate the ICC (intra-class correlation coefficient) for each model. ICC can be theoretically meaningful in understanding how much of the overall variation in the response is explained simply by clustering (Woltman et al., 2012). We used intra-class correlation analysis (ICC) to compare the variance between between-group and within-group. ICC was calculated using the following equation τ_{00} is the averaged variance between groups.

$$ICC = \frac{\tau_{00}}{\tau_{00} + \sigma^2}$$

TABLE 1 | Demographic characteristics of analytical data.

	Type	*n*	%
Sex	Male	35,957	49.3
	Female	36,959	50.7
Education level	Uneducated	3,483	4.8
	Village school	118	0.2
	Elementary school	11,712	16.1
	Middle school	7,864	10.8
	High school	21,130	29.0
	College	8,510	11.7
	University	17,129	23.5
	Graduate school	2,970	4.1
Marital status	Married	52,055	71.4
	Divorce	2,285	3.1
	Bereavement	6,226	8.5
	Separation	859	1.2
	Single	11,491	15.8
Age	19	810	1.1
	20–29	7,447	10.2
	30–39	10,891	14.9
	40–49	14,840	20.4
	50–59	15,431	21.2
	60–69	12,475	17.1
	70–79	9,031	12.4
	80–89	1,933	2.7
	90-	58	0.1
Monthly income (unit: ₩1,000)	-500	4,183	5.7
	500–1000	8,394	11.5
	1000–2000	12,287	16.9
	2000–3000	13,944	19.1
	3000–4000	12,326	16.9
	4000–5000	8,726	12.0
	5000–6000	5,251	7.2
	6000-	7,805	10.7

RESULTS

Table 3 shows the results of the multilevel analysis on level 1 and level 2 variables. Based on a comprehensive review of the level 1 variables, males were more likely to participate in physical activity than females (t = 12.2***). Regarding education level, the lower the educational level, the more physical activity was recorded (t = 16.4***). Finally, it showed that physical activity decreases with increasing age (t = −4.2***). However, the differences in

TABLE 2 | Variables.

DV	METs	Calculated by the METs formula
IV	Sex	Dummy variable
	Education level	Dummy variable
	Marital status	Dummy variable
	Age	Original scale
	Monthly income	Dummy variables
	Trust between neighbors	Percentage of participants who response "Yes"
	Social network with neighbors	Average value (7-point Likert Scale)
	Life environment satisfaction	Percentage of participants who response "Yes"
	Mass transportation satisfaction	Percentage of participants who response "Yes"

TABLE 3 | Results of multilevel analysis.

Parameter		Model 1 null model			Model 2 random intercept model			Model 3 intercept as outcome model		
		Estimate	*SE*	*t*	Estimate	*SE*	*t*	Estimate	*SE*	*t*
Level 1	Sex (male)				1136.1	42.6	26.6***	1135.8	92.7	12.2***
	Education level (below high school)				1952.8	53.5	36.4***	1951.0	118.3	16.4***
	Marital status (married)				148.8	50.3	2.9**	149.1	117.3	1.27
	Age				−12.6	1.73	−7.2***	−12.6	2.9	−4.2***
	Monthly income (1000–5000)				78.4	65.4	1.1	78.9	176.7	0.4
	Monthly income (5000-)				−317.0	82.8	−3.8***	−314.0	200.7	−1.5
Level 2	Trust between neighbors							−49.6	60.2	−0.8
	Social network with neighbors							1302.0	563.2	2.3*
	Life environment satisfaction							43.4	41.7	1.0
	Mass transportation satisfaction							66.7	12.2	5.4***
ICC		0.03			0.03			0.02		
Deviance		1469838.6			1467631.7			1467571.7		

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

levels of physical activity according to marital status and monthly income were not statistically significant.

Amongst the level 2 variables, better social networks with neighbors resulted in more physical activity (t = 2.3*). Additionally, the higher the level of mass transportation satisfaction, the more physical activity was found (t = 5.4***). On the other hand, trust between neighbors and life environment satisfaction had no statistically significant effects on physical activity. The results suggest that the stronger the social network with neighbors and the greater the satisfaction mass transportation, the more physical activity there is. The value of intra-class correlation was determined as 0.03 or less, which suggests that the differences in physical activity are more important in relation to the individual level than the environmental level (Koo and Kim, 2018).

Comprehensively looking at the results, it was found that education level was the factor that had the greatest influence on physical activity in level 1 variables representing individual characteristics. In the level 2 variable, which is an environmental characteristic, mass transportation satisfaction has the greatest effect on physical activity, suggesting that access to physical activity facilities is the most important. In addition, as variables explaining physical activity, social and physical environments are also important, but personal characteristics factors are more important than anything else.

DISCUSSION

The social ecological model contributes significantly to the theoretical understandings of engagement in physical activity. This study utilized a multilevel model to describe the individual characteristic variables and the social and physical environment variables that affect individual physical activity levels. Thus, the results of this study form a contribution to the understanding of the determinants of an individual's engagement in physical activity from a macroscopic viewpoint.

Sex, education level, and age all had a significant effect on physical activity. Males reported statistically higher physical activity than females. A study by Li et al. (2017) on the elderly reports that males walk more steps per day than females do and that males engage in more intense physical activities than females. A study focusing on college students by Lauderdale et al. (2015) indicates sex differences in physical activity using self-determination theory. That study reported that male students engaged in more physical activity than female students due to their higher intrinsic motivation. Higher motivation implies more frequent execution of an action due to its inherent interest and enjoyability, so this result could be explained by the observation that male students are more interested in physical activity than female ones. Nevertheless, because that study was focused on college students, its results should be interpreted with care. Eime et al. (2018) have found that females are less likely to participate in physical activity than males. They suggested increasing participation by modifying and improving motivations to be physically active. Females are afraid of injuries and are less likely to participate as they perceive the benefits to health as low (Nxumalo and Edwards, 2017). In order to improve the perception of physical activity amongst females, physical activity needs to be better promoted to women and there needs to be more programs designed for them.

The lower the educational level, the higher the level of physical activity. Our results are in line with those of Bauman et al. (2011) and Wallmann-Sperlich et al. (2013), whose studies indicate that people with higher levels of education tend to engage in more sedentary behavior. That is, people with relatively higher levels of education are more likely to have office jobs that require more sedentary activity and they tend to move from place to place by car, overall seeking to reduce the level of their physical labor. This could explain the results of this study. However, participation in vigorous activities such as swimming and jogging

is subject to financial, social, and environmental constraints and a low education level may still hinder participation. In addition, a longitudinal study spanning 13 years showed that the inequality gap concerning vigorous activity increased over time (Gugusheff et al., 2020). In order to remove socioeconomic barriers to access for different types of physical activity, environments and policies that make it possible to participate in sports at a low cost should be supported. On the other hand, it was found that income was not a factor affecting physical activity. There may be differences in the type of physical activity depending on income, but a low income does not cause a lack of physical activity. According to Shuval et al. (2017), low income is positively related to light activity and high income is related to less frequent and stronger activity. In other words, there may be differences in physical activity patterns depending on income but there is no difference in physical activity levels (METs). In addition, parks and facilities in South Korea are continuously being developed and allow anyone to participate in physical activities regardless of cost. Physical activity decreased as age increased. This result is consistent with numerous previous studies and a multi-faceted approach is required if physical activity levels of the elderly are to be increased (Laitakari et al., 1996; Cheung et al., 2007). Netz and Raviv (2004) attributed the reduced physical activity of the elderly to their lower self-efficacy related to physical activity. This creates a barrier to entry, limiting access to physical activity. Intervention is necessary and a macroscopic approach is required. Telama et al. (2005) reported that continuous exercise in adolescence can increase the likelihood of exercise in old age. In that study, incentive systems to enhance physical activity in adolescence and promote continuous exercise schedules were explored. More detailed policies and research related to strategies for enhancing physical activity should be developed on a life-cycle basis.

The level 2 variables that relate to social and physical environments show that the social network with neighbors and mass transportation satisfaction had a significant effect on physical activity. Greater social networks between neighbors imply higher frequency of direct contact. Social isolation can significantly reduce physical activity in adults, meaning that close networks of people nearby constitute a key factor in enhancing physical activity (Caspi et al., 2006). A study of Australian 1,289 adults from 18 to 89 years old (Lauder et al., 2006) showed that isolated people tend to be more overweight than socially connected people. The benefits of social networks include the promotion of social comparison and enhanced self-efficacy through encouragement by others (Duncan and McAuley, 1993; Rovniak et al., 2002). Social networks are beneficial in increasing people's level of physical activity as they have a positive relationship with physical activity (Aliyas, 2020). In addition, social networks minimize the disturbance and stress factors of health behaviors (Gao et al., 2015). Help from neighbors can aid in finding solutions to disturbance factors through discussion of countermeasures.

Mass transportation satisfaction as a physical environment variable has a positive effect on physical activity. The physical environment includes sports facilities, mass transportation facilities, and access to facilities in the regional community. Among these factors, mass transportation has been found to contribute positively to individual health, in addition to its other benefits. People using mass transportation walk 5–33 min more than those using a car, and the level of physical activity among those people using mass transportation is higher, for that and other reasons (Besser and Dannenberg, 2005; Wasfi et al., 2013; Lachapelle and Pinto, 2016). Well-equipped sports facilities in the regional community are an important variable that can affect physical activity. This study found that mass transportation satisfaction has a positive effect on physical activity, suggesting that it can, among other things, improve accessibility to sports facilities.

In spite of the valuable contributions it offers, this study has some limitations. The age of the participants in the analysis of this study ranged from 19 to 70 years, meaning that the results should be carefully examined to enable the development of intervention programs for specific age groups. Furthermore, studies on specific age groups should be performed to develop specific intervention measures. In addition, because the data in this study was drawn from limited measurement variables through the Community Health Survey data, follow-up work could build upon these findings and obtain more detailed information by examining additional variables through additional surveys. Finally, Community Health Survey participants that did not respond to physical activity intensity items were excluded from the analysis as METs could not be calculated for this group. While the sample completing the physical activity items is not notably biased toward any particular group, demographic distributions do differ from the full survey sample, which may limit generalizability to some extent.

CONCLUSION

On an individual level, males are more likely to engage in physical activity, which suggests a gendered difference in motivation to exercise. As such, the issue of how to enhance physical activity levels among females requires closer consideration. In relation to education level, those with more education tend to engage in physical activities less, which may be related to the fact that those with higher levels of education more commonly work in office-based jobs. To combat the reduced physical activity that comes with aging it is necessary to promote continuous participation in exercise from adolescence, lowering the barrier to engagement in physical activity at older ages. Social and physical environments should be enhanced to enable more physical activity within communities by organizing leadership-level meetings and clubs that facilitate local social networks and promoting the development of mass transportation on the regional community level.

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

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 for participation was not required for this study in accordance with the National Legislation and the Institutional Requirements.

AUTHOR CONTRIBUTIONS

Both authors contributed to literature review, study design, data analysis, drafting, and revising.

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Inspiratory Muscle Strength and Cardiorespiratory Fitness Association With Health-Related Quality of Life in Healthy Older Adults

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The main purpose of this study was to explore similarities and differences in the association between two capabilities affecting the cardiorespiratory system (overall and multifactorial cardiorespiratory fitness and inspiratory muscle strength) and the health-related quality of life (HRQoL), in a group of active healthy seniors. Sixty-five individuals (age, 73.01 ± 5.27 years; 53 women) who participated regularly in a multicomponent training program completed the EuroQol 5D-5L questionnaire, the 6-min walking test (6MWT), and the maximum inspiratory pressure test (MIP). Non-parametric correlations (Spearman's rho) were conducted to analyze the association between HRQoL indices (EQindex and EQvas), MIP, and 6MWT, considering both, the whole sample and men and women separately. Furthermore, partial correlation was made by controlling age and sex. We found a moderate association between HRQoL and cardiorespiratory fitness (EQvas: $r = 0.324$, $p = 0.009$; EQindex: $r = 0.312$, $p = 0.011$). Considering sex, relationship EQvas-6MWT decrease to small ($r = 0.275$; $p = 0.028$) whereas EQindex-6MWT remained moderated ($r = 0.425$; $p = 0.000$). When we considered women and men separately, the association between HRQoL and 6MWT appeared only in women, while the observed strong trend ($p = 0.051$) toward a large and positive association between EQindex and MIP, mediated by the covariate age, appeared only in men. Conversely to the cardiorespiratory fitness, MIP is not a limiting factor of HRQoL in healthy active elderly. Moreover, MIP and HRQoL should be included in the assessment of exercise interventions because they provide different information about the cardiorespiratory system deterioration. Similarly, EQvas and EQindex confirm to be complementary in the assessment of HRQoL. Furthermore, like aging process is different for men and women, the association between MIP and cardiorespiratory fitness with HRQoL may behave differently, so keeping on research these associations could help to improve training programs for this population.

Keywords: aging, multicomponent exercise program, physical function, respiratory system, well-being aging

INTRODUCTION

Cardiorespiratory fitness (CRF) is a predictor of mortality and comorbidity, regardless of race and sex (DeFina et al., 2015; Strasser and Burtscher, 2018). It is positively associated to better functional capacity (Mandsager et al., 2018; Tomás et al., 2018) and thus to higher health-related quality of life (HRQoL) (Ciprandi et al., 2018; Ihász et al., 2020). Moreover, it has shown to be inversely related to cardiovascular disease as well as chronic pathologies that can affect healthy senior adults (DeFina et al., 2015; Bouaziz et al., 2018, 2019).

This multifactorial predictor is severely affected by the aging process, which involves alterations and adaptations in all body systems (Vilaça et al., 2019), with special attention to the decline in muscle mass (Cruz-Jentoft et al., 2019) and muscle strength (Blasco-Lafarga et al., 2020). These two factors, muscle mass and muscle strength, follow similar, but not equal impairment processes (Blasco-Lafarga et al., 2021). Shaw et al. (2017) reviewed the epidemiology of sarcopenia attending to the similarities and differences between the patterns of variation with age, gender, geography, time, and individual risk factors. They conclude that the rate of decline in muscle mass is much less rapid than the rate in muscle strength. These losses imply a reduction in functional capacity and activities of daily living (Manini and Clark, 2012; Tsekoura et al., 2017; Wang et al., 2020), both considered determinant factors in the HRQoL in older people. Higher functional capacity levels are related to higher HRQoL (Ran et al., 2017; de Oliveira et al., 2019), and this is of paramount importance, especially in women, who display worse results on HRQoL and functional capacity than men of the same age due to a higher prevalence of disability and chronic conditions (Orfila et al., 2006). Furthermore, aging process is different for men and women. Overall, men, who have higher values in both bioenergetics and neuromuscular capacities, refer greater losses with age (Botoseneanu et al., 2016; Riddle et al., 2018), as well as less life expectancy (Ventura-Clapier et al., 2017; Crimmins et al., 2019). Particularly in the CRF, Eriksen et al. (2016) analyzed 16,025 adults ranging from 18 to 91 years and found that men lost 0.26 ml/min/kg/year while women lost 0.23 ml/min/kg/year. Already in 1994, Enright pointed out that inspiratory muscle strength was 30% higher in men than in women, and men losses were also larger (Enright et al., 1994).

On the one hand, the association between lung function and health-related quality of life has previously been studied in older adults with pathology, but the effects of lung function on HRQoL among general population is not clear (Wen et al., 2019). The progressive reduction in thoracic wall compliance, lung elastic recoil, and loss of strength in respiratory muscles (Janssens, 2005), related to age, lead to an increment in dyspnea during daily living activities, limiting physical activity or exercise performance (Mills et al., 2015), and also influencing quality of life (Wen et al., 2019). These authors suggested that lower values in FVC and FEV1 were associated with decreased scores in total HRQoL and physical domain in participants without comorbidities. According to recent studies, respiratory muscle weakness alone becomes a major limiting factor for physical fitness improvement, since it triggers a reduction in general muscle strength, dyspnea, and changes in lung function (Vilaça et al., 2019). This fact indicates that changes in inspiratory muscle strength (a variable little used in the field of healthy older adults), could detect respiratory diseases earlier than spirometric values (Schoser et al., 2017), being important to know the optimal maximum inspiratory force values for each age group, even in the absence of pathology. Recently, our research group (Roldán et al., 2019) has confirmed a moderate and positive association between the maximum inspiratory pressure (MIP) and the CRF in a recent study with healthy older adults, and this association has shown to be modified by the covariates age and sex.

On the other hand, in the last decades, the prevention policies and health promotion in the field of seniors have become a main concern for administrations and healthcare professionals (Monteagudo et al., 2020); a link to avoid disease and disability, maintaining high physical and cognitive function, and sustaining engagement in social and productive activities (Ciprandi et al., 2018). Active aging and quality of life are thus main targets in these health policies, and HRQoL arises as a key factor in the analysis of their impact, even in pathologic situation or to assess any treatment benefit (Huang et al., 2011). Its multidimensional approach and the inclusion of physical, mental, and social aspects (Ciprandi et al., 2018), explain its relevance.

In this context, the present study aims to explore similarities and differences in the association between the HRQoL and two capabilities affecting the cardiorespiratory system (the overall CRF and the more local MIP), in a group of active healthy seniors. The influence of age and sex will also be considered. According to our previous studies, we hypothesize that people who present higher values in CRF will have greater HRQoL. In addition, we expect that higher inspiratory muscle strength will also be related to higher HRQoL, although the level of this association may be different, because the inspiratory strength requires a small neuromuscular and physiological response compared with the multifactorial assessment of the CRF.

MATERIALS AND METHODS

Participants

Sixty-five active Spanish healthy elderly (53 women) volunteered to participate in this cross-sectional study approved by the local research ethics committee (H1506353751695). Previously, all of them were fully informed about the experimental procedure and signed the written consent. Inclusion criteria were as follows: (1) to be over 60 years old and (2) to participate regularly in the multicomponent training program EFAM-UV© (thus physically and cognitively able to follow the training program, with no medical contraindications). Exclusion criteria were as follows: (1) to be smoker; (2) to have heart or respiratory disease; (3) to have hypertension; and (4) to suffer from retinopathies, adverse pharmacological treatments, ribcage disease, fatigue, pain, or illness.

Measurements

Health-Related Quality of Life

HRQoL was assessed using the Spanish version of the EuroQuol 5D-5L questionnaire (EQ-5D-5L) (Herdman et al., 2011). This

questionnaire comprises five dimensions (mobility, self-care, daily activities, pain/discomfort, and anxiety/depression). Each dimension is assessed on a single question with five response levels (EQindex; utility index) using five possible levels of problem (1 = no problems; 2 = slight problems; 3 = moderate problems; 4 = severe problems; 5 = unable/extreme problems). The five-dimension scores can be combined, and 3,125 possible health states are thus obtained. These health scores can be converted into a utility index ranging from −1 to +1, by applying the appropriate formula. An index score of 1 means perfect health state, and it coincides with the value 11,111. On the other hand, in Spanish population, the worst health corresponds to −0.654, and with the 5-digit number 55,555 (Herdman et al., 2011; Kim et al., 2013; Mateo et al., 2015).

Furthermore, EuroQol includes a standard visual analog scale (VAS; EQvas) in which respondents rate their overall health using a scale from 0 to 100. Participants answered the questionnaire themselves. Assistance was limited to rereading questions slowly when required.

Inspiratory Muscle Strength

Inspiratory muscle strength was measured by MIP test using an electronic device Powerbreathe® K5 (Powerbreathe K5, HaB International Ltd. UK). Following the protocol of Neder et al. (1999), participants were seated in a chair with their feet on the floor and their backs straight, and repeated three forced inspiration with a nose clamp. If the difference between these three inspirations was > 10%, up to five measurements could be taken. The best value was retained for further analysis.

Cardiorespiratory Fitness

CRF was measured by means of the 6MWT. Recently, Sperandio et al. (2019) compared the main physiological variables in 6MWT with the same variables in cardiopulmonary exercise testing (CPET) in healthy middle-age and older adults. They conclude that 6MWT is valid for assessing CRF in this population since there is a strong correlation between peaks VO_2 in the 6MWT and in the CPET.

Attending to the protocol from Rikli and Jones (1999), the senior participants walked as fast as possible without running around a rectangle of 20 × 5 m, with signaling cones each 5 m. They were encouraged during the test and were informed every minute for the time. At the end, technician noted the total distance covered.

Experimental Procedure

The assessments were carried out during three testing days, separated from 2 to 5 days. On their 1st day, the participants came to the lab and fulfill the HRQoL questionnaire. Then they were evaluated of body composition, blood pressure, arterial oxygen saturation, and maximum inspiratory pressure. On the 2nd day, they performed some strength tests like the hand grip test and the seat to stand test, not included in this study. On their 3rd day, they performed the 6MWT to assess the CRF.

Statistical Analysis

Data were analyzed with Statistical Package for the Social Sciences, SPSS v26 for Mac (IBM Inc. Chicago, USA). After testing for normality (Kolmogorov-Smirnov for the total sample and women; Saphiro-Wilk for men), the Mann–Whitney *U*-test for non-parametric mean comparisons, and the nonparametric correlation analysis (Spearman's rho) were conducted to analyze the association between HRQoL indices (EQindex and EQvas) and the cardiorespiratory outcomes (maximum inspiratory pressure and 6MWT). The analyses were first performed considering the whole sample, followed by partial correlation controlling by age (r^a), sex (r^s), and sex+age (r^{s+a}). Later on, the correlation analyses were repeated considering women (r^w) and men (r^m) separately, now only controlling for the age. Significance was considered $p < 0.05$. To assess the degree of these associations, we considered: $r < 0.1$, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; >0.9, almost perfect; and 1 perfect (Hopkins, 2002). To add information about associations, scatter plot of *z*-scores and R^2 were included as a measure of the effect size following Sullivan and Feinn (2012).

RESULTS

Sample Characteristics and Differences by Sex

Sample characteristics are described in **Table 1**. There were sex differences in all the variables except in age, BMI, oxygen arterial saturation, and quality of life (EQvas and EQindex). Men and women show CRF scores above the mean, for their age group, according to Rikli and Jones (2013), specifically, 14.10% for men and 9.87% for women. However, despite this values, the MIP outcomes were discrete, similar to previous studies in the older adults following the EFAM-UV© program (Roldán et al., 2019; Blasco-Lafarga et al., 2021) or similar interventions with Pilates (Alvarenga et al., 2018).

Correlations

Age was negative and moderately associated to HRQoL (although only to EQindex: $r = -0.278$; $p = 0.024$), MIP ($r = -0.373$; $p = 0.002$), and 6MWT ($r = -0.438$; $p = 0.000$). On the one hand, considering the whole sample (**Table 2**), while the MIP showed no other association, we found the expected moderate association between HRQoL and CRF (EQvas: $r = 0.324$, $p = 0.009$; EQindex: $r = 0.312$, $p = 0.011$). Introducing the covariate sex, this relationship was slightly modified: EQvas-6MWT decreased to small ($r = 0.275$; $p = 0.028$) and EQindex-6MWT increased a bit but remained moderated ($r = 0.425$; $p = 0.000$). Adding sex and age as covariates, EQvas-6MWT association remained small ($r = 0.319$; $p = 0.011$) whereas EQindex-6MWT decreased to small ($r = 0.264$; $p = 0.037$).

On the other hand, when we considered women and men separately, the association between 6MWT and both components of the HRQoL became moderated in women. However, these associations became non-significant in men. Furthermore, and noteworthy, in the men group, we observed a strong trend ($r = 0.573$; $p = 0.051$) toward a large and positive association between EQindex and MIP. Finally, considering age as covariate

TABLE 1 | Sample characteristics.

	Total ($n = 65$)	Women ($n = 53$; 81.54%)	Men ($n = 12$; 18.46%)	p-value
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Anthropometric variables				
Age (years)	73.01 ± 5.27	73.48 ± 5.39	70.94 ± 4.33	0.133
Height (m)	1.56 ± 0.08	1.53 ± 0.05	1.68 ± 0.07	**0.000**
Weight (kg)	68.55 ± 12.01	65.19 ± 9.63	83.43 ± 10.21	**0.000**
FM (%)	38.52 ± 6.43	39.79 ± 5.58	32.89 ± 7.11	**0.000**
BMI (kg/m^2)	28.21 ± 3.84	27.93 ± 3.88	29.45 ± 3.55	0.219
MM (kg)	39.95 ± 8.20	37.16 ± 4.40	52.28 ± 9.80	**0.003**
Physiological variables				
SaO_2 (%)	95.55 ± 1.53	95.40 ± 1.58[a]	96.17 ± 1.19	0.423
SBP (mmHg)	141.24 ± 17.02	139.16 ± 17.11[a]	150.25 ± 13.88	**0.041**
DBP (mmHg)	79.60 ± 8.81	78.56 ± 7.99[a]	84.13 ± 10.99	**0.048**
Inspiratory strength and functional capacity				
MIP (cmH_2O)	52.89 ± 23.51	45.19 ± 16.38	86.92 ± 19.97	**0.000**
Distance walked at 6MWT (m)	557.26 ± 74.49	541.53 ± 66.97	626.71 ± 68.00	**0.000**
Health-related quality of life				
EQvas (%)	82.49 ± 17.58	82.26 ± 18.36	83.50 ± 14.30	0.894
EQindex (UA)	0.86 ± 0.13	0.86 ± 0.14	0.87 ± 0.09	0.704

[a]*Fifty-two women for these variables.*

FM, fat mass; BMI, body mass index; MM, muscle mass; SaO_2, arterial oxygen saturation; SBP, systolic blood pressure; DBP, diastolic blood pressure; MIP, maximum inspiratory pressure; 6MWT, 6-min walking test; EQvas, EuroQol-visual analog scales; EQindex, EuroQol index.

TABLE 2 | Association between the two components of the HRQoL questionnaire and the cardiorespiratory parameters MIP and 6MWT.

	MIP	MIP^{s}	MIP^{s+a}	MIP^{w}	MIP$^{w(a)}$	MIP^{m}	MIP$^{m(a)}$
EQvas	0.057	0.112	0.039	0.077	0.046	0.485	0.346
EQindex	−0.028	0.017	−0.107	−0.032	−0.118	**0.573**†	0.449
	6MWT	**6MWT^{s}**	**6MWT^{s+a}**	**6MWT^{w}**	**6MWT$^{w(a)}$**	**6MWT^{m}**	**6MWT$^{m(a)}$**
EQvas	**0.324****	**0.275***	**0.319***	**0.446****	**0.443*****	−0.241	−0.216
EQindex	**0.312***	**0.425*****	**0.264***	**0.426****	**0.333***	−0.133	−0.093

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.005$; $^{\dagger}p = 0.051$.

EQvas, EuroQol-visual analog scale; EQindex, EuroQol index; MIP, maximum inspiratory pressure; 6MWT, 6-min walking test; s, controlling by sex; s+a, controlling by sex + age; w, women group; w(a), women group controlling by age; m, men group; m(a), men group controlling by age.

in each group, the relationship between HRQoL and 6MWT changed. Although the association remains moderate for both components of HRQoL, in this case, it is slightly higher for EQvas ($r = 0.443$; $p = 0.001$; EQindex: $r = 0.333$; $p = 0.016$).

z-Score scatterplot and R^2 confirm these results. **Figure 1A** shows a small effect size for relationship between EQvas and 6MWT ($R^2 = 0.0665$). **Figure 1B** shows a medium effect size for association EQvas-MIP in the men group ($R^2 = 0.2947$). In the women group, there is a small effect size in EQvas-6MWT association ($R^2 = 0.1128$).

Figure 2A shows a small effect size for relationship between EQindex and 6MWT ($R^2 = 0.1505$). **Figure 2B** shows a medium effect size for association EQindex-MIP in men group ($R^2 = 0.3982$). In the women group, there is a medium effect size in EQvas-6MWT association.

DISCUSSION

The purpose of this study was to analyze the association between HRQoL and CRF and inspiratory muscle strength in healthy active older adults, looking for similarities and differences. Although the relationship between HRQoL and CRF has been studied previously, up to our knowledge, no study has investigated the association between inspiratory muscle strength and HRQoL assessed by EQ-5D-5L questionnaire in this healthy population. Noteworthy, women presented inspiratory muscle strength values a 30.48% below the mean for their age, while men are 15.61% below the mean according to Black and Hyatt (1969). However, previous studies of the group pointed out that these lower MIP values were due to differences in the device of assessment (manual vs. electronic), leading to a false sense of low

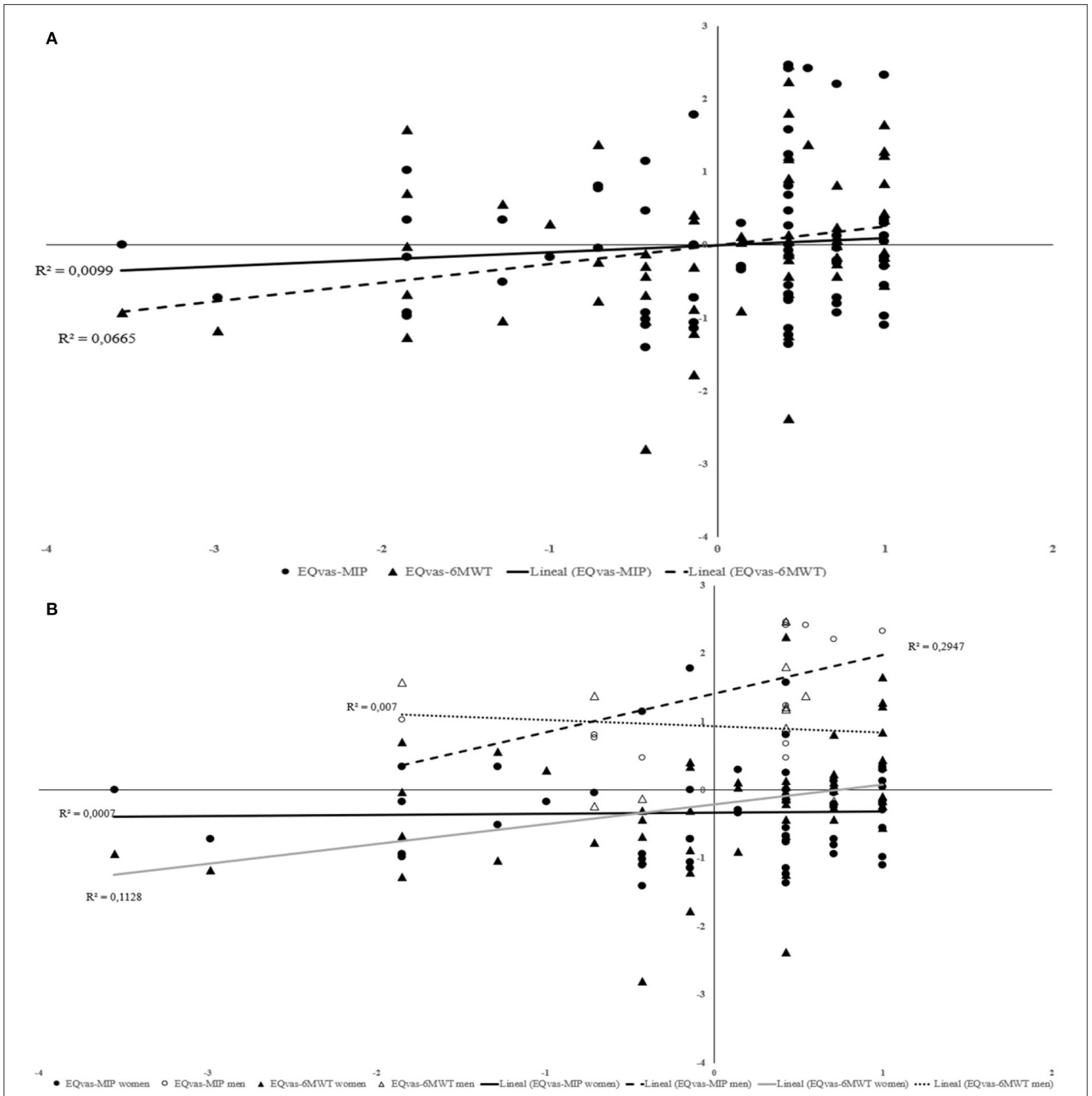

FIGURE 1 | Relationship between EQvas and functional capacity; EQvas and inspiratory muscle strength for total sample **(A)** and considering women and men separately **(B)**.

values (Roldán et al., 2019; Blasco-Lafarga et al., 2020). An idea supported by the results in Alvarenga et al. (2018).

Different limiting factors of the HRQoL have been previously studied in the older adults, although mainly in the context of pathological populations (Blanco-Reina et al., 2019; Ko et al., 2019). For example, with regard to cardiorespiratory responses, Wanderley et al. (2011) found a positive association between some-perceived health components of the Short Form-36 Health Survey (SF-36) and CRF in elderly with chronic pathologies, being this relationship independent of BMI, chronic condition, and education. More recently, Chung et al. (2017) found a positive and moderate association between HRQoL (measured through SF-36, another questionnaire to evaluate generic health-related quality of life) and physical function, but now in a sample

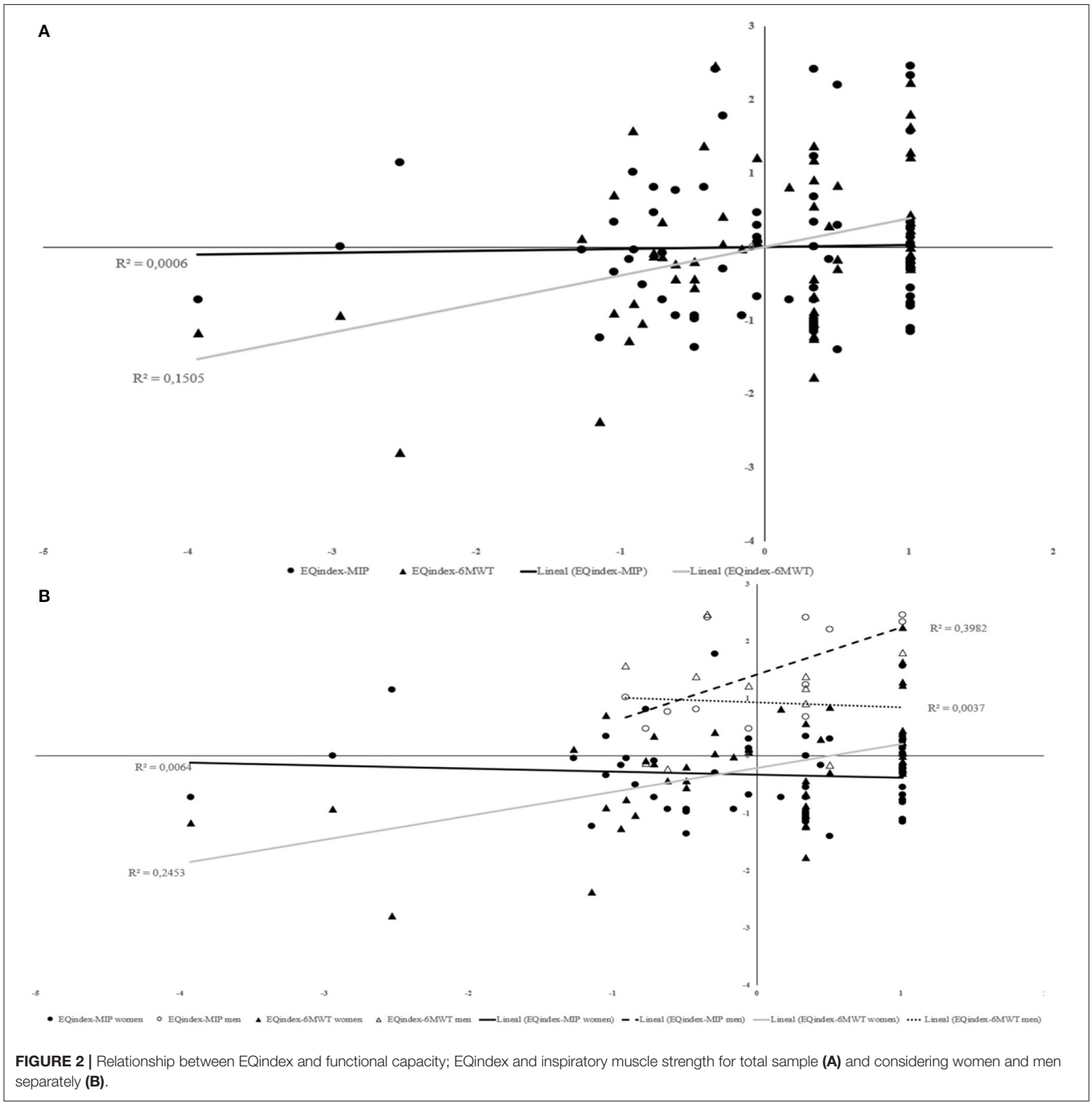

FIGURE 2 | Relationship between EQindex and functional capacity; EQindex and inspiratory muscle strength for total sample **(A)** and considering women and men separately **(B)**.

of healthy seniors ranging from 65 to 84 years, giving some light to this relationship in the scope of healthy elderly.

Similarly, in a previous study of our research group, we found a positive and moderate association between EQindex and physical fitness in 58 healthy but sedentary older adults (Monteagudo et al., 2020). However, we did not find association between EQvas and physical fitness. In the current study, we found not only the expected moderate association between EQindex and CRF but also regarding EQvas. Besides, when considering age or sex + age, we obtained a reduction in the association between EQindex and CRF confirming that EQvas and EQindex behave differently in attending these covariates. On the one hand, this difference between studies might be attributed to the different assessments of physical fitness. In Monteagudo et al. (2020), physical fitness was obtained from the average of the standardized values of three well-known test: the Five-Times-Sit-to-Stand-Test, the 6-min walk, and the habitual gait speed in 6 m. In the current study, we only considered the 6-min walking test, increasing the importance of this outcome as a measure of the overall physical fitness. On the other hand,

the persistent association between EQindex-CRF indicates that EQindex is a score influenced not only by CRF but also by strength and/or functional outcome. The fact that EQvas shows now an association not previously displayed, might be related to this increased importance of the CRF, pointing out that the worsening in this capacity affects the self-perception of mental or social health linked to EQvas. Moreover, EQindex might be more dependent on the physical deterioration and impairment process due to aging, compared with EQvas. Therefore, sex and also age are important in this population due to their heterogeneity, so the fact of not considering these variables in the analyses may hide some results and even lead to confusion in their practical applications.

On the other hand, it is known that active older adults have higher HRQoL values compared with inactive ones. Our data showed HRQoL values higher than expected in a healthy active population (Acree et al., 2006). In this sense, the Rejeski and Mihalko (2001) review concludes that physical activity can improve the perception of physical function and mental health, something that supports our results, because despite being a healthy sample, the fact of practicing physical activity on a regular basis makes them feel better. In this way, it could have been expected that elderly with greater inspiratory muscle strength would have better results in their HRQoL. However, this association is not fulfilled. Only the HRQoL component EQindex displays a strong trend to be associated with MIP in men, but the influence of age is even stronger and mediates it.

Renwick and Connolly (1996) investigated the association between respiratory function and quality of life, concluding that airway obstruction is a limiting factor; hence, people with preserved respiratory function have higher HRQoL values. In addition, it is very likely that the reduction in inspiratory muscle strength due to age may affect this association negatively. Notwithstanding, this deterioration it is not such in our healthy sample, and the reduction is not enough to cause dyspnea or fatigue, so the elderly does not perceive this loss of strength as a limitation. As a main finding, in absence of respiratory disease, the strength of the inspiratory muscles might be too local to be perceived as a limiting factor and affect the self-perceived health.

With regard to the CRF assessed through a walking test, walking has previously shown to integrate the valuation of physical, physiological, and cognitive function, with the participation of a large muscle mass, so our results are aligned with previous literature and confirm our hypothesis. Our results also confirm that sex differences and age are important mediators on the association of HRQoL and physical fitness, which was a second aim of the present study. The aging of both muscular systems is different, and although sarcopenia appears also in the respiratory muscles, it is a slower process compared with peripheral muscles (Shin et al., 2017) which are responsible for any physical activity and/or social relationships. Despite this, it is interesting to know that 6 weeks of inspiratory muscle training are able to improve HRQoL in relation to functionality domains (functional capacity and physical limitations) (Vilaça et al., 2019). Perhaps, this association depends not only on structural factors (a greater lower limb tone allows walking more, and therefore greater HRQoL) but also on nervous factors as a consequence of the metaboreflex (a greater inspiratory muscle tone results in walking more and a higher HRQoL).

This is the first study that has investigated the association between inspiratory muscle strength and HRQoL assessed by the EQ-5D-5L questionnaire in healthy older adults. Nonetheless, there are also some limitations that need to be outlined. First, the sample size should be bigger, at least in the men group, in order to generalize the results. Moreover, we performed this study in a sample of healthy older adults who performed the same multicomponent training program, so results are only representative of one type and dose of exercise. Whether the type of exercise and type of program can affect our findings and associations should be tested and deserves to be included in future studies. Finally, the design of the study should be highlighted like other limitations due to cross-sectional studies not showing evidence of a temporal relationship between outcomes.

To summarize, the fact that functional capacity is conditioned by sex (Botoseneanu et al., 2016) justifies that in our results, the association with HRQoL behaves differently in men and women. Although in most of the elderly physical exercise programs, women participation is higher than men, it would be a mistake to analyze the data without considering them separately since it can be misleading (Martínez del Castillo et al., 2009). Inspiratory muscle strength and CRF losses are greater in men compared with women and therefore the association of these variables with HRQoL behaves differently. Women confirm the hypothesized association between HRQoL, with slight differences either in the use of EQvas or EQindex, but not with the inspiratory strength. Conversely, men fail in this expected association, whatever the HRQoL index, but display a trend toward significance in the relationship between MIP and EQindex mediated by age. Noteworthy, the small sample size of the male group influencing these results needs further confirmation.

CONCLUSION

In active healthy elderly, MIP do not seem to be a limiting factor for HRQoL when values of CRF are within the standard. MIP and HRQoL should be included in the assessment of exercise interventions because they provide information before significant losses in functional capacity occur. Besides, it is important to consider age and sex when analyzing these associations since older adults' population are characterized by being very heterogeneous. Keeping on research, these associations could help to improve training programs and their impact in this population.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The data is part of a thesis not yet published. Requests to access these datasets should be directed to Ainoa Roldán Aliaga ainoa.roldan@uv.es.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Research ethics committee of University of Valencia (H1506353751695). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

CB-L and AR contributed to conceiving, designing, performing the experiment, analyzing the data, drafting, and reviewing the article. PM contributed to performing the experiment, conceiving and interpreting the data, drafting, and revising the article. GS-S and AC performed most of the data analysis and drafting of the article. All authors contributed to the article and approved the submitted version.

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Objectively Measured Physical Activity Increases Only in Males During a Summer Camp for Obese Children

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Childhood obesity is a major public health challenge. Summer camps for children with obesity represent an alternative setting to improve eating and physical activity habits. Here we evaluated if the participation in the camp improves objectively measured physical activity and sedentary behavior and whether there are differences between male and female participants. Twenty-eight children, 13 males and 15 females (body mass index >97° centile, weight excess >30%, Tanner stage I), agreed to participate in an 8-day camp. During the summer camp, children participated in sports-like games and outdoor activities for at least 3 h a day, and the school-camp staff also provided a theoretical nutritional learning plan. Accelerometry-derived physical activity was measured through the SenseWear Mini Armband during a week at home and during the camp experience. Before camping, the participants were far above the minimum daily values of moderate- to vigorous-intensity physical activity (MVPA) to be considered sufficiently active (≥60 min/day), but male participants were more active than females (MVPA: 186.2 ± 94.2, 111.0 ± 64.7; $P = 0.020$). Male participants increased their MVPA (234.3 ± 114.8, $P = 0.020$), whereas females not (111.9 ± 52.9, $P = 0.020$). No difference emerged for the sedentary behavior either before or during the camp. This study suggests that participation in a summer camp for obese children can determine different responses in physical activity levels, depending on the sex of young participants. Thus, summer camps for obese children should put particular attention on female participants, besides reducing sedentary behavior in both males and females.

Keywords: childhood obesity, physical activity, summer camp, accelerometry, sedentary behavior, activitystat, children

INTRODUCTION

Childhood obesity is a major public health challenge, and several studies suggest that obesity is continuously increasing among the young population in many, but not all countries worldwide. These international data indicate that in the vast majority of high-income and upper middle-income countries, a stark difference in the prevalence of obesity by sex exists, with

boys showing a greater obesity prevalence than girls (Shah et al., 2020). The number of school-aged children and adolescents facing obesity is predicted to rise from 150 million worldwide to more than 250 million by 2030 (Shah et al., 2020), putting a massive burden on healthcare systems with the aging population (Hruby and Hu, 2015). Indeed, obesity implications relate not only to the present health status of younger people. Obese children are at higher risk of developing adult obesity and related complications later in life, such as atherosclerosis, type 2 diabetes mellitus, and cardiovascular diseases (Freedman et al., 2007; Haines et al., 2007; Gordon-Larsen et al., 2010). Therefore, the treatment of obesity plays a central role in public health. However, traditional interventions of obese children and adolescents with dietary restrictions associated or not with physical activity programs often fail (Mauro et al., 2008). The adoption of multidisciplinary and intensive protocols could overcome the limitations of traditional ones. In this context, camps for obese children represent a useful instrument for nutritional and lifestyle re-education, improving short- and long-term eating, and physical activity habits (Di Pietro et al., 2004; McCarty et al., 2012; Barnett et al., 2018). Previous physical activity is a key determinant of actual physical activity in children (Condello et al., 2017), and there is evidence that an 8-day summer camp is enough to determine positive behavioral changes toward physical activity in the long term (Di Pietro et al., 2004). A previous study on asthmatic children indicated that camp experience improves intentional health behavior adoption (Lin et al., 2008) according to the Stages of Change Model (SCM). The SCM describes this process of health behavior change as a gradual process encompassing different stages, also influenced by self-efficacy and social support (Marcus et al., 1992; Wallace et al., 2000). Moreover, important determinants of children's physical activity, such as time spent outdoors (Puggina et al., 2018) or having a companion for physical activity (Jaeschke et al., 2017), might be prompted by camping experience.

The relationship between accelerometer-determined physical activity and accurate body composition measures in children is well-known (Jiménez-Pavón et al., 2010). Moreover, while obese children spend more time engaged in sedentary behavior (Maffeis et al., 1996), compared with non-obese children, no differences emerge in total lean body mass–adjusted physical activity energy expenditure assessed through the doubly labeled water technique, despite lower accelerometer-derived physical activity levels (Ekelund et al., 2002). Thus, it is important to add insights into the field of childhood obesity and physical activity to adopt the best countermeasures. While most studies focused on diet or investigated self-reported physical activity, there is a lack of objective data regarding the physical activity performed on camps for obese children. Furthermore, the recent evidence of sex/gender-related difference in childhood obesity prevalence, together with findings suggesting a difference between boys and girls in physical activity levels (Trost et al., 2002; Sherar et al., 2007; Munakata et al., 2010; Hallal et al., 2012; Pearce et al., 2012; Telford et al., 2016; Aleksovska et al., 2019), highlights the importance of considering the role of sex in treating obesity in children and adolescents. Therefore, here we present an experience on the effect of a short-term summer camp in obese children in Italy, aiming to evaluate if the participation in the camp improves daily physical activity and sedentary behavior and whether there are differences between male and female participants.

MATERIALS AND METHODS

Participants

Twenty-eight prepubertal children from a rural area in central Italy, 13 males [9.8 ± 1.7 years, body mass index (BMI) 27.0 ± 3.7 kg/m^2] and 15 females (8.5 ± 1.8 years, BMI 26.9 ± 4.0 kg/m^2), attending the outpatient clinic, agreed to participate. To be selected for participation in the study, young patients had to fulfill the following inclusion criteria: not participate in sports activities from at least 1 year, BMI >97° centile, weight excess >30%, and Tanner stage I. For each participant, parents gave informed consent and accompanied their children during the 1st day, on a weekday, and on the last day of the camping. The Ethics Committee of the "G. D'Annunzio" University of Chieti–Pescara approved this study.

Procedure

Weight, height, and objective physical activity were assessed about a week before and during the participation in the camp. In particular, participants wore a triaxial multisensory device (SenseWear Mini Armband; BodyMedia, Inc., Pittsburgh, PA) during the week before and during the camping week. Weight was assessed three times when the device was delivered at the beginning and the end of camp for obese children. School camp for obese children took place during the summer holidays in a seaside resort and lasted 8 days. The camp team comprised two pediatricians, a dietitian, a psychologist, two sport scientists, a schoolteacher, and a nurse. During camping, participants had five slightly hypocaloric meals a day (basal metabolism × 1.2) and participated in sports-like games and outdoor activities for at least 3 h a day. In particular, games were chosen and designed to allow participants to be gratified by participation despite their weight excess and comprised games inspired to judo, wrestling, and other combat sports; Latin sport dances; throwing sports; and orienteering. In particular, combat sports and sport dances were chosen to satisfy both male and female preferences. The summer camp staff also provided a theoretical nutritional learning plan, whereas outdoor activities included educational visits to the farm and the surrounding natural environment.

Anthropometry

A first-level anthropometrist of the International Society for the Advancement of Kinanthropometry carried out the body measurements of the participants in their fasting condition. Body mass and stretched stature were measured to the nearest 0.1 kg and 0.1 cm, respectively, with the participants dressed in light clothing and without shoes, using a stadiometer with a balanced-beam scale (Seca 220; Seca, Hamburg, Germany). The participant BMIs were calculated as body mass/stature^2 (kg/m^2). The evaluation of the weight status was obtained from BMI, according to Cacciari et al. (2006).

Physical Activity and Sedentary Behavior Measurement

Daily physical activity and sedentary behavior were measured under free-living conditions for 5 consecutive days, including 3 weekdays and at least 1 weekend day, using SenseWear Mini Armbands (Welk et al., 2007; Scheers et al., 2013; Wetten et al., 2014). The participants wore their monitors all through the 5 measurement days, except while bathing. No raining days were present among the recorded periods. The wear time criteria were at least 600 min/day with at least 3 valid weekdays and a valid weekend day. It has been shown that 3 weekdays of recording using the SenseWear Pro3 Armband were enough to achieve a reliability of 0.80 for sedentary behavior, light-intensity physical activity (LIPA), moderate-intensity physical activity (MPA), physical activity level, and energy expenditure (Scheers et al., 2012). The SenseWear Mini Armband relies on the same technology but mounts a 3-axis accelerometer instead of the 2-axis version in the SenseWear Pro3 (Johannsen et al., 2010). The internal algorithms are slightly different between the monitors. However, the SenseWear Mini Armband showed slightly better performance over the SenseWear Pro3 (Johannsen et al., 2010). The SenseWear Mini Armband integrated the information gathered by the 3-axis accelerometers and sensors (i.e., skin and near-body temperature, heat flux, galvanic skin response) with the sex, age, stature, weight, smoking status, and handedness of the user, using the SenseWear Professional 8.0 software (BodyMedia, Pittsburgh, USA). It has been shown that combining accelerometry with physiological parameters can improve measurement accuracy (Welk et al., 2007; Johannsen et al., 2010; Wetten et al., 2014). The SenseWear Mini Armband provided extensive information about wear time, daily physical activity (e.g., intensity, number of daily steps, energy expenditure), and other behaviors such as sleep and sedentary behavior. The SenseWear Mini Armband was worn on the left arm, over the triceps, as it has been shown able to furnish reliable recording compared with other placements (i.e., wrist, hip, ankle), and in respect to both other devices and placements (Wetten et al., 2014), in both healthy and pathological conditions (Welk et al., 2007; Scheers et al., 2013), according to the manufacturer's validation.

From the recorded data, the focus in the present study was on time spent on physical activity according to three intensity levels: an intensity >3 METs and ≤6 METs (i.e., MPA); an intensity >6 METs and ≤9 METs (i.e., vigorous-intensity physical activity; VIPA); and an intensity >9 METs (i.e., very vigorous-intensity physical activity). The total time spent above 3 METs was considered as moderate- to vigorous-intensity physical activity (MVPA). Besides, sedentary behavior and the time spent in LIPAs were considered. As SenseWear Mini Armband cannot distinguish between sitting and standing, sedentary behavior was considered as the whole time spent in physical activities with an intensity ≤1.5 METs, excluding nocturnal sleeping. The LIPA was the time spent in physical activities >1.5 METs and ≤3 METs. The numbers of daily bouts of sedentary behavior that lasted <6 consecutive min ($SB_{sporadic}$), between 6 and 10 min (SB_{medium}), 11 and 30 min (SB_{long}), and longer than 30 min ($SB_{verylong}$) were calculated using a specifically written application (Izzicupo et al., 2020).

TABLE 1 | Physical activity and sedentary behavior before camping.

	Females (n = 15)	Males (n = 13)	P
Steps (n.)	11,880 ± 3,199	14,516 ± 5,275	0.205
METs	1.77 ± 0.38	2.00 ± 0.35	0.147
SB (min)	280.6 ± 289.4	309.3 ± 259.4	0.982
LIPA (min)	642.2 ± 333.4	543.0 ± 272.3	0.420
MPA (min)	105.3 ± 60.0	165.3 ± 82.8*	0.045
VPA (min)	5.7 ± 6.3	20.9 ± 23.6*	0.025
MVPA (min)	111.0 ± 64.7	186.2 ± 94.2*	0.020
$SB_{sporadic}$ (n.)	38.9 ± 16.9	44.9 ± 25.1	0.629
SB_{medium} (n.)	6.2 ± 4.7	7.7 ± 5.2	0.394
SB_{long} (n.)	4.8 ± 5.8	5.8 ± 5.8	0.854
$SB_{verylong}$ (n.)	2.4 ± 4.1	1.9 ± 2.5	0.522

*METs, metabolic equivalent of the task; SB, sedentary behavior; LIPA, light-intensity physical activity; MPA, moderate-intensity physical activity; VPA, vigorous-intensity physical activity; MVPA, moderate- to vigorous-intensity physical activity; $SB_{sporadic}$, sedentary behavior shorter than 6 min; SB_{medium}, sedentary behavior between 6 and 10 min; SB_{long}, sedentary behavior between 11 and 30 min; $SB_{verylong}$, sedentary behavior episodes longer than 30 min. *Significant difference between male and female participants.*

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Science, version 24.0 (SPSS Inc., Chicago, IL) and initially tested for normality with the Shapiro–Wilk statistic and presented as mean ± SD. An *a priori* level of significance was set at $p < 0.05$. As data were not normally distributed, the Mann–Whitney U-test was applied to investigate the effect of the independent variable sex on the dependent variables weight, BMI, and objectively measured physical activity and sedentary behavior. Wilcoxon signed-rank test was applied to investigate differences in weight, BMI, and objectively measured physical activity and sedentary behavior before and after the participation at the campus in both male and female participants.

RESULTS

Physical Activity and Sedentary Behavior Before Camping

Before camping, the participants were far above the minimum daily values of MVPA (≥60 min/day) to be considered sufficiently active but spent a considerable amount of time in sedentary pursuits (≥240 min/day). Most of the day was spent in LIPAs, and more than two episodes per day of sedentary behavior exceeding 30 min took place. Despite the high levels of physical activity, male participants were more active than females in MPA, VPA, and MVPA (**Table 1**).

Physical Activity and Sedentary Behavior During Camping

During the participation in the camp, male participants increased their MPA and MVPA, whereas females maintained unchanged their physical activity levels. As a consequence, MPA, VPA, and MVPA were higher in male participants than in females during the camp. No difference emerged for sedentary behavior, LIPA, and for the sedentary behavior episodes of any investigated lengths (**Figure 1**). Furthermore, steps per day and average METs per day were also higher in males than in females (16,472 ± 3,774, 12,058 ± 2,170; and 2.10 ± 0.41, 1.76 ± 0.35, respectively). No significant reduction in weight and BMI was observed at the end of the camp.

DISCUSSION

In this study, we found that the camp experience in children with obesity determines different changes in physical activity levels between males and females. In particular, whereas male children increased MPA and MVPA during the camp compared with their levels before camping, females unchanged their habits in terms of physical behaviors. Furthermore, male participants showed higher MPA, VPA, and MVPA, even before participating in the camp. Additionally, there was no difference in sedentary behavior between males and females, and the camp participation did not determine changes. These results are consistent with persistent findings in the literature indicating that female children are less active than males (Trost et al., 2002; Sherar et al., 2007; Munakata et al., 2010; Hallal et al., 2012; Pearce et al., 2012; Telford et al., 2016; Aleksovska et al., 2019). Previous studies indicate several potential gender factors affecting female children and adolescents' physical activity levels, including lower perceived enjoyment when taking part in physical education (Cairney et al., 2012) and less social support to engage in physical activity (Edwardson et al., 2013), which could, in turn, lead them to participate less in organized sports (Vella et al., 2014). Furthermore, lower physical activity levels in girls may be related to maturing at an earlier chronological age, suggesting that biological reasons may also contribute to the sex difference in physical activity (Sherar et al., 2007; Wickel et al., 2009). Independently from sex- and gender-related factors, the measured levels of physical activity are far above the levels reported for the general pediatric population and obese children. Although surprising, several factors may have determined such a high level of activity, particularly the summer season and the rural location. Seasonal variations in children's physical activity have been previously reported, with a peak during June and higher levels for those living in a rural area, particularly during the weekend days (Atkin et al., 2016). Other factors, such as family income and cultural influences, might have further affected our sample's physical activity levels. However, their collection was beyond the scope of the present investigation. Finally, the device used in the present study for physical activity assessment might return higher values than others, although validated in children for energy expenditure in semistructured activities settings (Lee et al., 2016). Indeed, physical activity levels very close to the ones of the present study (boys: 179 ± 90 min/day; girls: 136 ± 59 min/day) were already reported in a previous investigation using the SenseWear Armband (Soric and Misigoj-Durakovic, 2010).

Previous studies showed that male children dedicate more time to sedentary pursuits such as television watching (Munakata et al., 2010), but no difference emerged between the two gender groups in sedentary behaviors, in the present study. There is evidence that screen time (time spent in visual media activities on screen devices, including watching television or videos, playing games, video chatting, searching the Internet, and reading or writing on a computer, tablet, or smartphone for entertainment purposes) can be more deleterious than other types of sedentary behavior, such as passive transportation, school time, and studying, from both a health and behavioral perspective. Screen time may affect sleep time and quality, as well as eating disorders, aggression, sexual behavior, substance abuse, and academic difficulties (Strasburger et al., 2010; Jones et al., 2019). However, as we used objective measurements, we cannot distinguish for diverse sedentary activities.

Physical activity is a potent protective factor against the development of childhood obesity (Chung et al., 2012; Di Blasio et al., 2016). On the other hand, the decline in physical activity during adolescence increases the risk of becoming obese in adulthood (Pietiläinen et al., 2008). These findings seem partially in contrast with the higher obesity prevalence in males comparing to females. While it is true that the latter are less active and that physical activity safeguards against childhood obesity, it should be expected that the prevalence of obesity will be higher in girls than in boys. Furthermore, in the present study, both males and females were far above the minimum daily values of MVPA to be considered sufficiently active, even though they were obese. However, younger obese children generally meet the daily recommendations for physical activity (Chung et al., 2012), and the results of the present study are consistent with this evidence (**Table 1**). Older children, regardless of weight status, did not meet physical activity recommendations, especially girls (Trost et al., 2002; Sherar et al., 2007; Chung et al., 2012; Aleksovska et al., 2019). In particular, the decline in physical activity in females may occur earlier because of anticipated sexual maturity (Sherar et al., 2007; Wickel et al., 2009) with respect to males. Considering both the decline in physical activity occurring with aging and the central role of an active lifestyle in preventing body weight gains, multidisciplinary treatments of obesity, including physical activity, have been extensively designed and investigated.

Camps for obese children can improve short- and long-term eating and physical activity habits (Di Pietro et al., 2004; McCarty et al., 2012). However, in the present study, the camp experience did not improve physical activity levels in female children, while it was effective in males. Participants took part equally in the organized outdoor activities and sport-like games. Furthermore, camp activities were designed to satisfy both males' and females' preferences. Notwithstanding, lower perceived enjoyment when taking part in physical education in girls (Cairney et al., 2012) and other psychosocial factors might have affected the female involvement levels during the organized activities, resulting in lower measured physical activity. Alternatively, the source of the

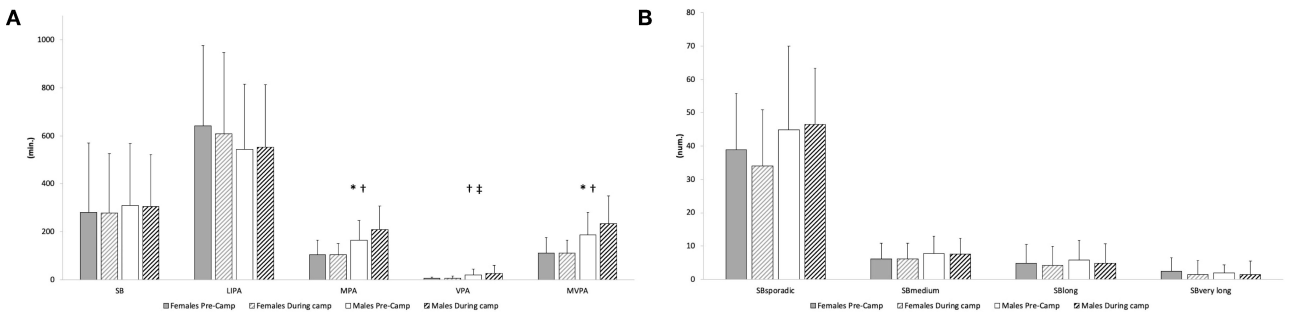

FIGURE 1 | (A) Physical activity and sedentary behavior before and during camping. **(B)** sedentary episodes of different length before and during camping. SB, sedentary behavior; LIPA, light-intensity physical activity; MPA, moderate-intensity physical activity; VPA, vigorous-intensity physical activity; MVPA, moderate- to vigorous-intensity intensity physical activity; $SB_{sporadic}$, sedentary behavior shorter than 6 min; SB_{medium}, sedentary behavior between 6 and 10 min; SB_{long}, sedentary behavior between 11 and 30 min; $SB_{verylong}$, sedentary behavior episodes longer than 30 min. *Significant difference between male and female participants before camping. †Significant increase in male participants during the camp. ‡Significant difference between male and female participants during the camp.

difference found between male and female children might be due to the spontaneous physical activity during the remaining part of the day. It is possible that female campers compensated for physical activity performed outdoor and during games, reducing the activity in the remaining part of the day. There is still debate in the scientific community about compensation mechanisms in physical activity after its increase in a part or during the whole day. The "activitystat" and "energystat" hypotheses sustain the existence of innate set points that control physical activity or energy expenditure over time (Rowland, 1998; Gomersall et al., 2013). They are hypothesized to regulate physical activity and energy expenditure via homeostatic feedback processes (Wilkin, 2011). As such, increases in physical activity, sedentary time, or energy expenditure in one part of the day are supposed to result in decreases in physical activity, sedentary time, or energy expenditure, respectively, in another part of the day (Rowland, 1998; Rowlands, 2009), as well as in the subsequent days (Ridgers et al., 2018).

Several studies reported findings confirming or confuting such hypotheses. It was also demonstrated that, in some people, an additive effect could follow the introduction of an exercise program, making them even more active at other times (activity synergy) (Goodman et al., 2011; Di Blasio et al., 2012, 2014, 2018; Izzicupo et al., 2013a). On the other hand, despite the evidence that the genotype could partly influence training adaptation and spontaneous activity (Izzicupo et al., 2010, 2013b; Lightfoot et al., 2018), physical inactivity leads to obesity independent of genetic factors, as demonstrated in a rare group of monozygotic twin pairs discordant for obesity in young adulthood (Pietiläinen et al., 2008). Our study indicates that females perform less physical activity than males during a summer camp for obese children. This result may be due to a lower involvement in structured activities, the reduction of spontaneous physical activity during the remaining part of the day, or both. Considering the difference in physical activity during the camp between male and female children observed in this study, it is also possible that both physical activity compensation and synergy can occur in obesity treatment, depending on the sex of the participants. However, determining if this effect is due to an innate, biological set point or by gender stereotypes was beyond the aims of the present study.

Participants' sedentary time did not change during the camp experience, despite increased MPA, VPA, and MVPA in males. This result suggests that the participant replaced LIPA and sleep time instead of sedentary behavior to perform MVPA. Ideally, an intervention should increase physical activity and reduce sedentary time, especially addressing screen time (Ricci et al., 2020), leaving sleep unaltered, or improving it if inadequate. Thus, understanding how to avoid compensation and favoring activity synergy is a priority for future research that can help to design obesity treatment in children in consideration of sex/gender factors.

This study has a series of limitations. First, the sample size was small, and data not normally distributed, making us lean toward non-parametric analysis. However, the sample was slightly larger than the minimum required for medium effect size ($n = 24$). Second, detailed data collection was performed only for objectively measured physical activity and sedentary behavior, without any other biomarker or social and environmental factors explaining current findings. Furthermore, relying only on the objective measurement of physical activity, we did not detect important aspects through the use of questionnaires or diaries that would have allowed us to evaluate the physical activity and sedentary behaviors domains, as well as to take a deeper look at the physical activity levels actually carried out during the structured activities. Third, sex/gender factors were not systematically reported, although camp activities' design considered them. However, the present study also has strengths. To our knowledge, this is the first study describing objectively measured physical activity and sedentary behavior in obese children during a camp experience. Furthermore, the intensive nature of a camp for obese children allows introducing significant changes in participants' lifestyles, which are challenging to obtain with home-based programs or sports participation, especially in terms of quantity of physical activity. This aspect is particularly relevant for investigating the compensation events of physical

activity, and the homogeneity of the sample, composed only of obese children who did not take part in sports activities, reinforces our results.

CONCLUSIONS

The present study indicates that participation in a summer camp for obese children can determine different responses in spontaneous physical activity, depending on the sex of young participants. Camps for obese children represent a useful instrument for long-term nutritional and lifestyle re-education. However, our study demonstrates that sedentary behavior remains unchanged in the short term, regardless of sex, and female obese children do not improve physical activity. Thus, future studies should (i) address explanatory variables for compensation effect in females during camps participation and (ii) manipulate daily activities trying to reduce sedentary time to provide insights useful for a better designing intensive period of treatment of obesity through training camps.

PRACTICAL APPLICATION

Childhood obesity is a major public health challenge, but the traditional treatment of obese children and adolescents with dietary restrictions associated or not with physical activity programs often fails. Thus, camps for obese children have been proposed for nutritional and lifestyle intensive re-education. Sports-like games and outdoor activities are often part of the summer camp programs and are supposed to increase children's physical activity levels. However, several studies indicate that increases in physical activity in one part of the day may result in subsequent, compensative decreases in physical activity in other parts of the day. From a practical point of view, this study suggests that during summer camps for obese children, physical activity and sedentary behavior should be monitored through objective measurement to quantify compensation in physical activity and sedentary behavior. Questionnaires can also be useful to determine which kind of specific sedentary behavior is performed by children. Strategies for addressing sedentary behavior should be designed, as proposed sport-like games and outdoor activities do not decrease sedentary time in the remaining part of the day. Finally, girls need special attention during leisure time, as they compensate for structured physical activities in the remaining part of the day.

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 ethics committee of the University of Studies G. D'Annunzio of Chieti - Pescara. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

PI, ADBl, and MD: conceptualization and design of the study. PI, AD, and BG: methodology. PI and AD: formal analysis. PI, ADBl, EM, AD, and BG: data collection. AD, BG, and LC: data curation. PI, AD, and ADBl: writing—original draft preparation. BG, GN, LC, and EM: visualization. PI, LC, MD, GN, and ADBa: supervision and editing. ADBa: funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Importance of Providing Additional Choices in Relation to Pupils' Happiness, Mastery, Well-Being, Contentment, and Level of Physical Activity in Physical Education

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Previous research points to the importance of providing support to autonomy in PE, because it has a particularly positive effect on motivation in PE. However, previous research has not examined the association between autonomy and the variables; happiness, mastery, well-being, contentment and activity level in PE. This study examined how increased self-determination affects happiness, mastery, well-being, contentment and activity level in PE. The study is an intervention (cross-over study) with one control group (one class) and two intervention groups (two classes), using questionnaires and accelerometers among 88 tenth graders (41 boys and 47 girls). The three classes included approximately the same number of boys and girls. The intervention groups included, respectively, 30 and 29 pupils in each class, and 29 pupils' in the control group. The pupils' experiences of happiness, mastery, well-being, contentment was measured three times–after a month with, respectively, ordinary PE, teacher-directed PE, and self-organized PE (autonomy), and the activity levels (accelerometer) was measured during the 24 lessons that took part in the period of teacher-directed PE and self-organized PE. Factor analysis, repeated measures ANOVA (mixed method ANOVA design) and paired sample *t*-tests with Bonferroni correction were performed, in order to look at differences in happiness, mastery, well-being, contentment and activity level during periods of; self-determination, teacher-directed PE and ordinary PE. The results show that self-determination in PE gives the pupil a significant increased experience of happiness, well-being and contentment, and also a higher activity level in PE. The results indicate that increased self-determination in PE can positively affect lower secondary school pupils' happiness, well-being, contentment and activity level in PE, and that teachers should strive to encourage self-determination among pupils in PE. Further research should be based on intervention studies studying self-determination over longer continuous period, in classes with both older and younger pupils.

Keywords: autonomy, physical education, activity level, happiness, mastery, well-being, contentment

INTRODUCTION

Physical education (PE) at school provides structured and regular physical activity (PA) for almost every child around the world (Fairclough and Stratton, 2005a; Long et al., 2013; Chen et al., 2014; Calahorro-Cañada et al., 2017), and is an important arena–taking the decline in PA during adolescence into account (Bélanger et al., 2009; Kolle et al., 2012; Lagestad et al., 2018). PE can help to make children and young people more physically active, helping to bring them the health benefits of this (Loprinzi et al., 2012; Meyer et al., 2013). Children and adolescents who engage in moderate-to-vigorous PA (MVPA) are at lower risk of developing chronic health issues (Janssen and Leblanc, 2010). An active lifestyle and lifelong pleasure in movement are major aims of PE in Norwegian schools (Norwegian Directorate of Education Training, 2019), and happiness, mastery, well-being, contentment and PA may be important indicators of the achievement of these aims. Hassandra et al. (2003), showed that PE can be important in helping to promote PA into adulthood. A study by Kalajas-Tilga et al. (2020) concluded that to enhance adolescents' daily MVPA, special focus should be put on increasing their intrinsic motivation toward physical education. Delextrat et al. (2020) concluded that activity type could be associated with the intensity of PA in PE.

Self-determination in relation to choosing activities in PE is one of the core values in the new curriculum in Norway (Norwegian Directorate of Education Training, 2019). Earlier research has shown that self-determination has a particularly positive effect on motivation in PE (Deci and Ryan, 1985, 2000; Ryan and Deci, 2007), in which the psychological need for autonomy, competence and belonging are seen as necessary in order to increase inner motivation (Ryan and Deci, 2007). Self-determination theory suggests that the level of activity, happiness, feelings of competence and mastery, well-being and contentment in PE, can all be increased by self-determination (Deci and Ryan, 1985, 2000). Inner motivation comes from within, leading to the kind of behaviors we want to pursue. Outer motivation on the other hand, comes from an external source. Inner motivation is especially important for children and young people in terms of a lifelong delight in movement and is closely connected to learning (Deci and Ryan, 1985).

Pupils will benefit from teachers' adoption of an autonomy supportive teaching style, as pointed out by Cheon and Reeve (2013). A study showed that pupils with more autonomous motivational profiles, reported being more active at secondary school and in early adulthood (Haerens et al., 2010). In their study, including secondary school pupils (13 years of age) reporting on their PE teachers, Haerens et al. (2018) found that in relation to four clustered motivating profiles, the high-autonomy support group showed the most optimal pattern of outcomes (e.g., need satisfaction, autonomous motivation). Another study showed that all pupils–independent of their motivational regulations, were more engaged and showed less oppositional defiance when they interacted with an autonomy-supportive teacher, instead of a controlling teacher during PE (De Meyer et al., 2016). Also a study by Van den Berghe et al. (2015) found that pupils behavioral and emotional engagement was positively related to need support in PE. Interventions have also been successful in increasing autonomy support among teachers (Tessier et al., 2010; Cheon et al., 2012; Aelterman et al., 2014; Cheon and Reeve, 2015; Ulstad et al., 2018).

Several intervention studies have looked at autonomy in PE from a pupil perspective–indicating that autonomy can positively affect pupils' happiness, mastery, well-being and contentment. Two studies found a positive association between self-determination in PE and PA and motivation in PE (Lonsdale et al., 2009, 2013). found that the sense of autonomy was raised if the pupils were able to make choices. Several other studies also indicate that self-determined instruction is positively reflected in the pupils' motivation (Prusak et al., 2004; Ntoumanis, 2005; Ward et al., 2008; How et al., 2013). Ward et al. (2008), Prusak et al. (2004), Lonsdale et al. (2009, 2013), and How et al. (2013), all measured pupils' motivation. However, these studies look primarily at pupils' inner motivation. No experimental study examine how self-determination affects pupils experiences of happiness, mastery, well-being or contentment in a study. However, studies have examined some of these variables. The findings of Ntoumanis (2005) suggest that if teachers manage to support pupils' basic psychological needs, they positively impact pupils' well-being. Furthermore, the study of (Lagestad, 2017), indicate that autonomy can positively affect pupils' happiness, mastery, well-being and contentment, but they did not measure the relationship between these variables, and providing additional choices.

Although a number of studies indicate that increased self-determination in PE can positively affect happiness, mastery, well-being, contentment and activity level, earlier research has not studied these connections by means of interventions taking in these variables, using pre-post designs. Some of these studies do not have a pupil perspective, and the activity level is not measured with an accelerometer–which is the preferred method (Kolle et al., 2012). Fairclough and Stratton (2005b) point out that few studies have investigated psychological factors and activity level, whilst referring to the relationship between inner motivation, effort, and happiness. They suggest that it can be expected that pupils' enjoyment, activity level and motivation will increase in unison, and that one can also propose that mastery, well-being and contentment will be positively affected. Intervention and experimental studies has been highlighted as important in the future research on self-determination in PE (Van den Berghe et al., 2014). Taking other research into account (Chen et al., 2014; Gao et al., 2015), we will argue that happiness, mastery and well-being during PA in PE, will help adolescents to apply more PA into their daily regime, and thereby positively affect PA in a lifelong perspective–a main aim of PE in Norwegian schools (Norwegian Directorate of Education Training, 2019).

From a pupils' perspective the present study will explore the extent to which increased autonomy affects pupils' feelings and behavior PE. The question that this study addresses is the following: To what extent will self-selected activities in PE affect high school pupils' happiness, mastery, well-being, contentment and level of activity in the subject of PE, compared to ordinary and teacher-directed instruction? Our hypothesis is that increased autonomy will positively affect these variables, and

that a teacher-directed instruction style (with no self-selected activities in PE at all) will negatively affect these variables.

METHOD

Participants and Design

In order to address this research question, an intervention crossover study (a longitudinal study in which the participants receive three different treatments) were carried out, comprising questionnaires, accelerometer measurements and observations. Based on power calculations (Cohen, 1988) related to a previous study (Cheon et al., 2012), with standards deviation (SD = 0.23) and expected differences between groups ($\Delta = 0.39$, $\alpha = 0.05$, $\beta = 0.8$), at least 53 participants had to be included in the study. On the basis of a stratified selection, a local authority high school in a mid-Norwegian town was chosen, and three 10th grade classes with, together, 88 pupils (age 15–16) were selected. The intervention groups included, respectively, 30 and 29 pupils in each class, and 29 pupils in the control group. These three classes shared the same PE teacher, which was a requirement for participation in the study. Furthermore, the PE teacher was both qualified and willing to do the experiment. A random selection was undertaken to establish which classes would be a control group and which intervention groups 1 and 2. The research project and the ethics of the study was approved by the Norwegian Centre for Research Data (NSD), and the headteacher, the teacher and all the participating pupils and their parents signed an informed consent.

Data Collection

Data collection took place between November 2018 and February 2019. The first period (1 month) all three groups had ordinary instructions, and the pupils completed a questionnaire concerning their understanding of happiness, mastery, well-being and contentment in relation to PE at the end of October/beginning of November 2018 (**Figure 1**). In period 2 (November/December 2019) the three classes had different PE instruction in 4 PE lessons (each of 90 min duration) per class during a 30-day period (one lesson per week in line with the Norwegian curriculum). Intervention group 1 carried out self-determined PE, while intervention group 2 had teacher-directed PE. This regime took place in a 1-month continuous period (4 lessons of 90 min each). During these 4 lessons all three groups wore an accelerometer to measure their PA. The pupils wore accelerometer only during the PE lessons. In period 3 (January/February 2020) the intervention groups "crossed over" (intervention group 1 carried out teacher-directed PE, while intervention group 2 had self-determined PE) with the same test protocol, answering questionnaires at the end of the month. The control group conducted the same test regime but had ordinary instruction all 3 months. The teacher self-determined PE was organized by letting the pupils chose their own activity in a 1-month continuous period (4 lessons of 90 min each). The teacher-directed PE was designed in the way that the teacher was told to organize all lessons and to have a clear "teacher leading style," as described in Brattenborg and Engebretsen (2007), during a 1-month continuous period (4 lessons of 90 min each). Based on our hypothesis, the PE teacher was instructed to have a teacher-directed PE style. It was essential that he should offer the pupils no additional choices at all, where the pupils were told to just follow the instructions from the teacher. The teacher were told to use a "follow me" instruction, telling the pupils exactly what to do in each activity. The teacher-directed style were in this project defined as a strategy were the teacher had control over which activities that should be conducted, and how the activities he had planned for the PE lessons should be organized. Because we also wanted to study the effect of ordinary teaching, the PE teacher were told to organize the ordinary instruction during a 1 month continuous period (4 lessons of 90 min each), using the teaching style that the teacher used in his ordinary PE lessons. Teacher and pupils were also observed during these 12 lessons, and after the 30 days the same questionnaire was answered again. During January and February, there was a further 30-day period of differing instruction in which the control group again had ordinary PE, but where intervention group 1 had teacher-led activities and intervention group 2 had self-determined PA (crossover study). Also during these 30 days, the pupils wore an accelerometer to measure their activity level, and answered the same questionnaire at the end of the period.

Measures

The questions used to assess happiness, mastery, well-being and contentment had been specifically developed for PE and PA research, and had been used earlier in the REPAC project (Säfvenbom et al., 2018). Whilst these questions are closely connected to these variables, they also connect to self-determination as a theoretical framework based on; basic psychological needs (Vlachopoulos and Michailidou, 2006), motivation (Guay et al., 2000), belonging (Anderson-Butcher and Conroy, 2002) and enthusiasm (Lagestad et al., 2019). Each question/statement offered alternative answers on a 1-7 Likert scale. Several questions (mostly statements)–most of the questions with a high face validity according to the dependent variables; happiness, mastery, well-being and contentment, was included in each variable. This strategy to create the dependent variables was based upon theoretical constructions, using factor analysis to measure the reliability. Happiness included the five questions: "Because PE is fun and exciting," "Because it feels good to have PE," "I always looking forward to PE," "I want to have PE," and "I am always happy in PE." Mastery included the four questions: "I feel I have a great progress according to the main aim of PE," "I feel I am doing the exercises in PE the right way," "I feel I am doing the activities in PE very well," "I feel I can master the PE tasks." Well-being included the six questions: "I feel very convenient together with the other pupils in PE," "Because I feel PE is nice," "I feel I am an important person in PE," "I wish I was not a part of the group in PE [the values in this question were changed]," "I feel like being accepted in PE," and "I enjoy having PE." Contentment included the four questions: "What do you feel about the PE lessons?," "What do you feel about the organization of the PE lessons?," "I feel strongly that PE fits me," and "The PE lessons definitely reflects how I wish PE to be."

Observations were made in order to ensure that the different groups carried out the PE in accord with the intention for

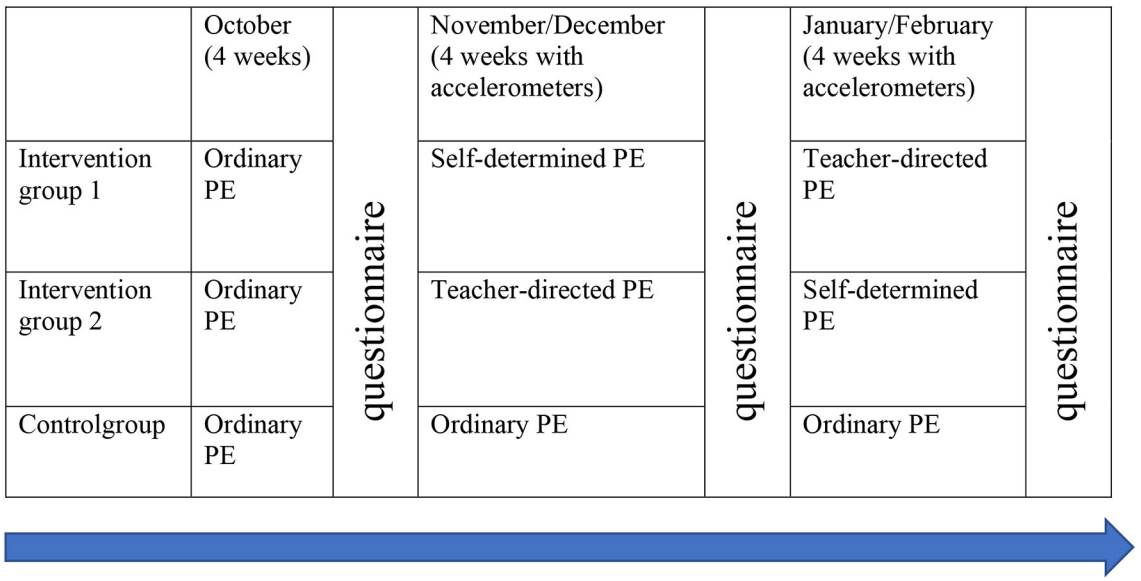

FIGURE 1 | The organization of the data collection.

each group in each period, the quality of the accelerometer measurements, as well as gathering observational data which could help the quantitative analysis around happiness, mastery, well-being, contentment and PA. The same observer were present in all 24 lessons during the data collection period. This observation ensured that the procedures was followed in each class at every time. The accelerometers where given out and back at the exact same place each time, the absence where documented in the same way, and during the observation, all activities that was conducted at each lesson was documented. As pointed out by Haerens et al. (2013), in studies related to changes in need-supportive teaching practices after exposure to an intervention, observations may benefit the study greatly. ActiGraph GTM1 (ActiGraph, Fort Walton Beach, Florida) accelerometers were used to measure the young peoples' moderate and vigorous PA (MVPA) during PE. These were tested in advance of the project, being used continuously for a week. Each of the 88 pupils used the same accelerometer in all the lessons during the time measurements were being taken, and the data gathered was uploaded to Actilife software and processed every 14 days. The raw data files were measured at 5 second intervals (epochs). Periods of time where data were missing were defined, in conformity with Kolle et al. (2012), as a continuous period of 20 min or more where the accelerometer had measured no counts. The limit for moderate intensity was set at 2,000 counts, according to the limits set in other studies (Kolle et al., 2012; Meyer et al., 2013; Andersen, 2017). All the pupils included in the study returned valid questionnaires and accelerometer data.

Statistical Analysis

Factor analysis was used to look at whether the four to six questions included in the different indexes belonged together in meaningful clusters, in order to confirm a pre-proposed connection between different variables (confirmatory approach). The factor analysis showed that all the different indexes had an eigenvalue well over 1 (from 2.9 to 4.0), that all the questions in all the different indexes had a high common covariance (between 0.7 and 0.9) and that the total variance shown by the questions included in the different indexes was high (between 0.70 and 0.80). Furthermore, there were no multicollinearity between the questions included in the indexes.

A mixed method ANOVA design was used to study changes through time (Gray and Kinnear, 2012) in happiness, mastery, well-being, contentment and possibility to choose, as well as revealing the differences between the three groups, using *post-hoc* tests with Bonferroni corrections. Effect size was reported with the help of η_p^2 (partial eta-squared), where $0.01 < \eta^2 < 0.06$ indicates a small effect, $0.06 < \eta^2 < 0.14$ a medium effect, and $\eta^2 > 0.14$ a large effect (Cohen, 1988). *T*-tests with Bonferroni corrections were used to show differences between the groups according to periods of different teacher style (self-determined PE, ordinary PE and teacher-directed PE), where mastery, happiness, possibility of making choices, well-being, contentment and activity level were concerned. SPSS data analytic software (version 25.0: IBM, Armonk, NY, USA) was used to analyse the data. The observation notes were used to expand and complement the quantitative data, as well as possibly supporting the analytic findings.

RESULTS

The analysis showed a significant change in the groups, over time (**Figure 2**), in the perception of having choice ($F_{2,166} = 5.65$,

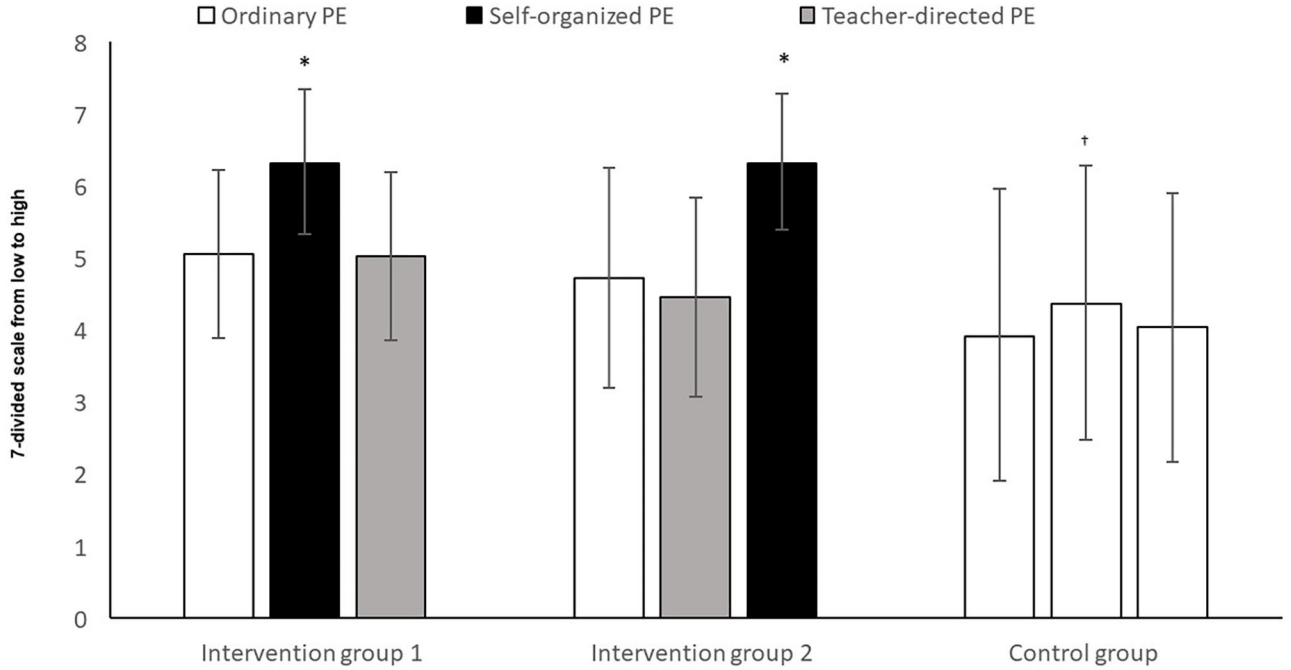

FIGURE 2 | Perception of having choice among the pupils after three periods of ordinary PE, teacher-led PE and self-determined. *Significantly greater perception of choice in self-determined PE, compared to ordinary and teacher-led PE ($p < 0.05$). †Significantly lower perception of choice in the control group, compared to intervention groups 1 and 2 ($p < 0.05$).

$p = 0.008$, $\eta^2 = 0.06$). There was also a significant difference in perception of choice between the groups ($F_{2,83} = 11.86$, $p = 0.000$, $\eta^2 = 0.22$), together with an interaction between time and group ($F_{4,166} = 11.87$, $p = 0.000$, $\eta^2 = 0.22$). *Post-hoc* tests with Bonferroni corrections showed that both intervention group 1 and intervention group 2 reported a significantly higher perception of having choice, than the control group (mean difference = 1.35, 95% CI = 0.6, 2.1, $p = 0.000$ and mean difference = 1.06, 95% CI = 0.4, 1.8, $p = 0.001$), but there was no significant difference between the two intervention groups ($p = 0.968$).

Intervention group 1 experienced a significantly greater degree of choice in self-determined PE, compared to both ordinary PE ($t = -4.45$, $p < 0.05$) and teacher-directed PE ($t = -6.18$, $p < 0.05$). There was, however, no significant difference between ordinary PE and teacher-directed PE in intervention group 1 ($t = 0.14$, $p > 0.05$).

Intervention group 2 experienced a significantly greater degree of choice in self-determined PE compared to both ordinary PE ($t = -5.11$, $p < 0.05$) and teacher-directed PE ($t = -6.18$, $p < 0.05$). There was, however, no significant difference between ordinary PE and teacher-directed PE in intervention group 2 ($t = 1.00$, $p > 0.05$).

There were no significant differences in the control group in respect of perception of opportunities for choice between T1 and T2 ($t = -1.14$, $p > 0.05$), T2 and T3 ($t = 0.94$, $p > 0.05$), nor between T1 and T3 ($t = -0.22$, $p > 0.05$).

The analysis showed no significant change (**Figure 3**), over time, between the groups in their perception of happiness ($F_{2,148} = 2.35$, $p = 0.099$, $\eta^2 = 0.03$). There was, however, a significant difference between the groups in their perception of happiness ($F_{2,74} = 8.31$, $p = 0.001$, $\eta^2 = 0.18$), but no interaction between time and group ($F_{4,148} = 2.16$, $p = 0.076$, $\eta^2 = 0.06$). *Post-hoc* tests with Bonferroni corrections showed that both intervention group 1 and intervention group 2 reported significantly more perception of happiness than the control group (mean difference = −7.56, 95% CI = −12.4, −2.7, $p = 0.001$ and mean difference = −5.86, 95% CI = −10.4, −1.3, $p = 0.007$), but there was no significant difference between intervention group 1 and intervention group 2 ($p = 1.000$).

Intervention group 1 experienced no significantly higher degree of happiness in self-determined PE than in either ordinary PE ($p > 0.05$) or teacher-directed PE ($t = -0.09$, $p > 0.05$). Nor was there any significant difference in intervention group 1 between ordinary PE and teacher-directed PE ($t = -1.73$, $p > 0.05$).

Intervention group 2 experienced a significantly higher degree of happiness in self-determined PE than in teacher-directed PE ($t = -2.69$, $p < 0.05$). They experienced no significantly higher degree of happiness in self-determined PE than in ordinary PE ($t = -1.86$, $p > 0.05$). Nor was there any significant difference between ordinary PE and teacher-directed PE in intervention group 2 ($t = 0.04$, $p > 0.05$).

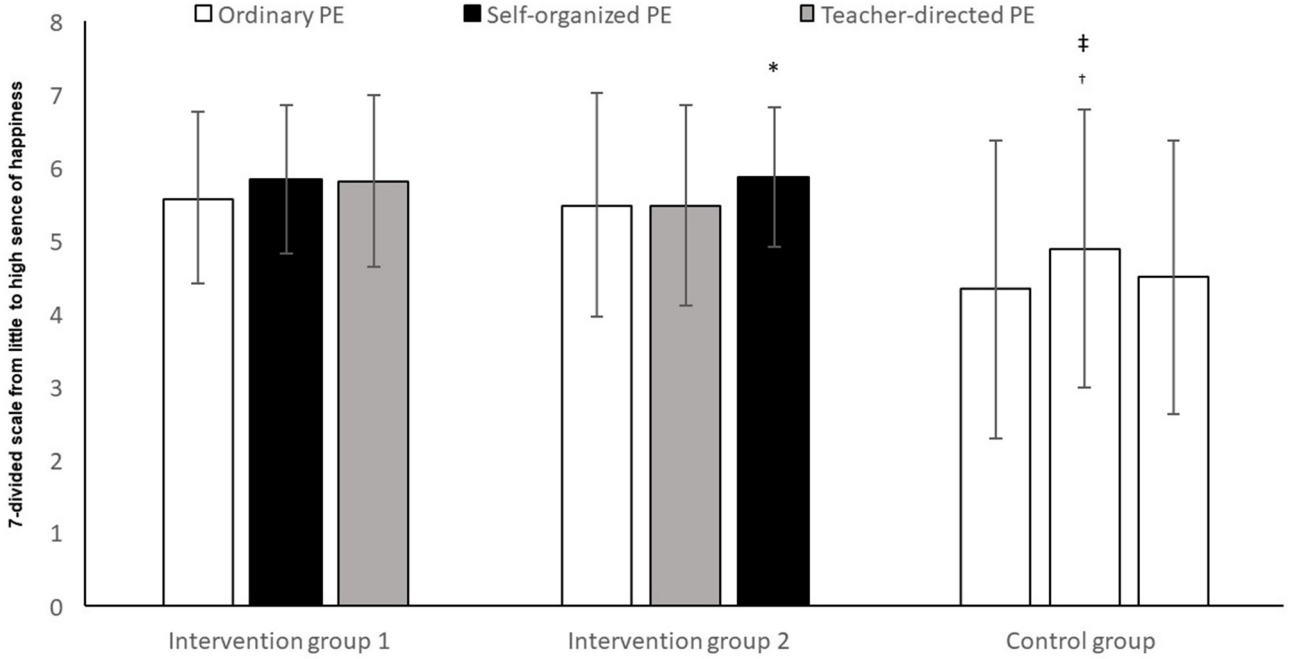

FIGURE 3 | Perception of happiness among pupils in ordinary PE, teacher-directed PE and self-determined PE after 3 time periods. *Significantly higher perception of happiness in self-determined PE compared to teacher-directed PE ($p < 0.05$). †Significantly lower perception of happiness in the control group, compared to intervention groups 1 and 2 ($p < 0.05$). ‡ Significantly higher perception of happiness in the control group in T2 compared to T1 ($p < 0.05$).

In the control group, there was a significant difference in their experience of happiness between T1 and T2 ($t = -2.17, p < 0.05$). There was, however, no significant difference in their experience of happiness between T2 and T3 ($t = 1.71, p > 0.05$), nor between T2 and T3 ($t = -0.44, p > 0.05$).

The analysis showed no significant change (**Figure 4**), over time, in the perception of mastery of the groups ($F_{2,156} = 2.63$, $p = 0.075$, $\eta^2 = 0.03$). Nor was there a significant difference between the groups ($F_{2,78} = 2.76$, $p = 0.066$, $\eta^2 = 0.07$), nor any interaction between time and group ($F_{4,156} = 1.85$, $p = 0.123$, $\eta^2 = 0.05$).

The analysis showed a significant change in well-being between the groups (**Figure 5**), over time ($F_{4,156} = 5.64$, $p = 0.004$, $\eta^2 = 0.05$). There was also a significant difference in well-being between the groups ($F_{2,74} = 3.66$, $p = 0.030$, $\eta^2 = 0.09$). There was, however, no interaction between time and group ($F_{4,148} = 1.55$, $p = 0.190$, $\eta^2 = 0.04$). *Post-hoc* tests with Bonferroni corrections showed that intervention group 1 reported significantly more well-being than the control group (mean difference = 4.76, 95% CI = 0.4, 9.1, $p = 0.009$), but the analysis found no significant differences between intervention group 2 and the control group ($p = 0.241$) or between intervention group 1 and 2 ($p = 0.878$).

Intervention group 1 experienced no significantly higher level of well-being in self-determined PE than in ordinary PE ($t = -1.51$, $p > 0.05$), or in teacher-directed PE ($t = 0.75$, $p > 0.05$). Neither, in intervention group 1, was there any significant difference between ordinary PE and teacher-directed PE ($t = -1.41, p > 0.05$).

There were no significant differences in the control group where perception of well-being was concerned between T1 and T2 ($t = -0.79, p > 0.05$), T2 and T3 ($t = -0.84, p > 0.05$), nor between T1 and T3 ($t = -1.46, p > 0.05$).

The analysis showed a significant change (**Figure 6**), over time, in the experience of contentment between the groups ($F_{2,158} = 9.74$, $p = 0.003$, $\eta^2 = 0.11$). There was also a significant difference in the experience of contentment between the groups ($F_{2,79} = 7.46$, $p = 0.001$, $\eta^2 = 0.16$), and an interaction between time and group ($F_{4,158} = 9.62$, $p = 0.000$, $\eta^2 = 0.20$). *Post-hoc* tests with Bonferroni corrections showed that both intervention group 1 and intervention group 2 reported a significantly higher level of contentment than the control group (mean difference = 3.83, 95% CI = 1.3, 6.4, $p = 0.001$ and mean difference = 2.78, 95% CI = 0.3, 5.2, $p = 0.020$), but there was no significant difference between intervention group 1 and intervention group 2 ($p = 0.920$).

Intervention group 1 experienced a significantly higher level of contentment in self-determined PE than those in ordinary PE ($t = -3.50$, $p < 0.05$). They did not experience a significantly higher level of contentment than those in teacher-directed PE ($t = 1.98$, $p > 0.05$). Nor were there any significant differences between ordinary PE and teacher-directed PE in intervention group 1 ($t = -1.36$, $p > 0.05$).

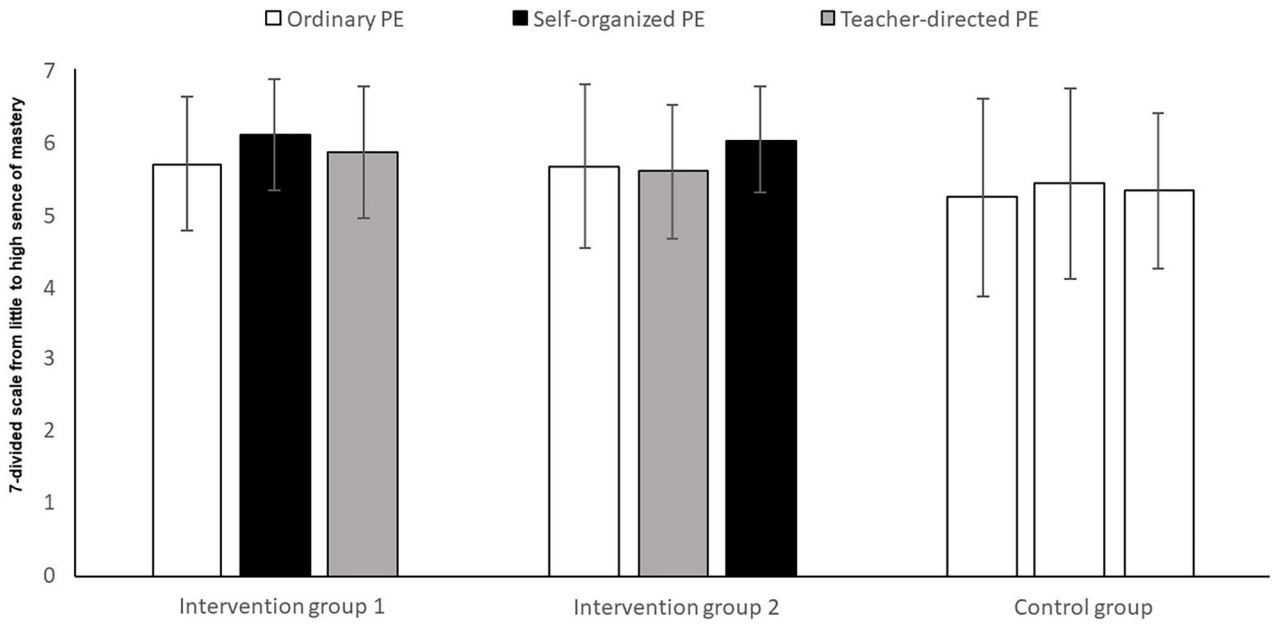

FIGURE 4 | Perception of mastery among pupils after three time periods of ordinary PE, teacher-directed PE, or self-determined PE.

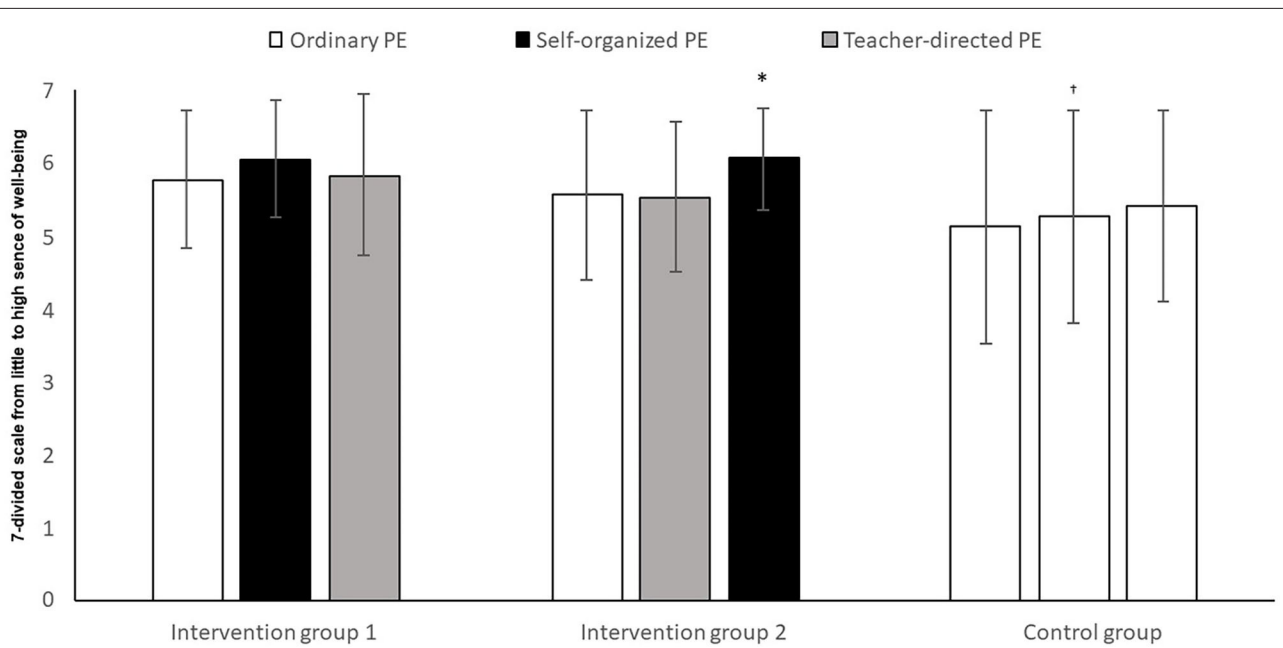

FIGURE 5 | Experience of well-being among pupils after three time periods of ordinary PE, teacher-directed PE, or self-determined PE. *Significantly higher perception of well-being in self-determined PE, compared to ordinary instruction or teacher-directed ($p < 0.05$). †Significantly lower perception of well-being in the control group, compared to intervention groups 1 and 2 ($p < 0.05$).

Intervention group 2 experienced a significantly higher level of contentment in self-determined PE than those in teacher-directed PE ($t = -5.19$, $p < 0.05$) and ordinary PE ($t = -3.20$, $p < 0.05$). There were, however, no significant differences between ordinary PE and teacher-directed PE in intervention group 2 ($t = 1.60$, $p > 0.05$).

In the control group, there was a significant increase in the perception of contentment between T1 and T2 ($t = -3.81$, $p < 0.05$), and T1-T3 ($t = -2.47$, $p < 0.05$).

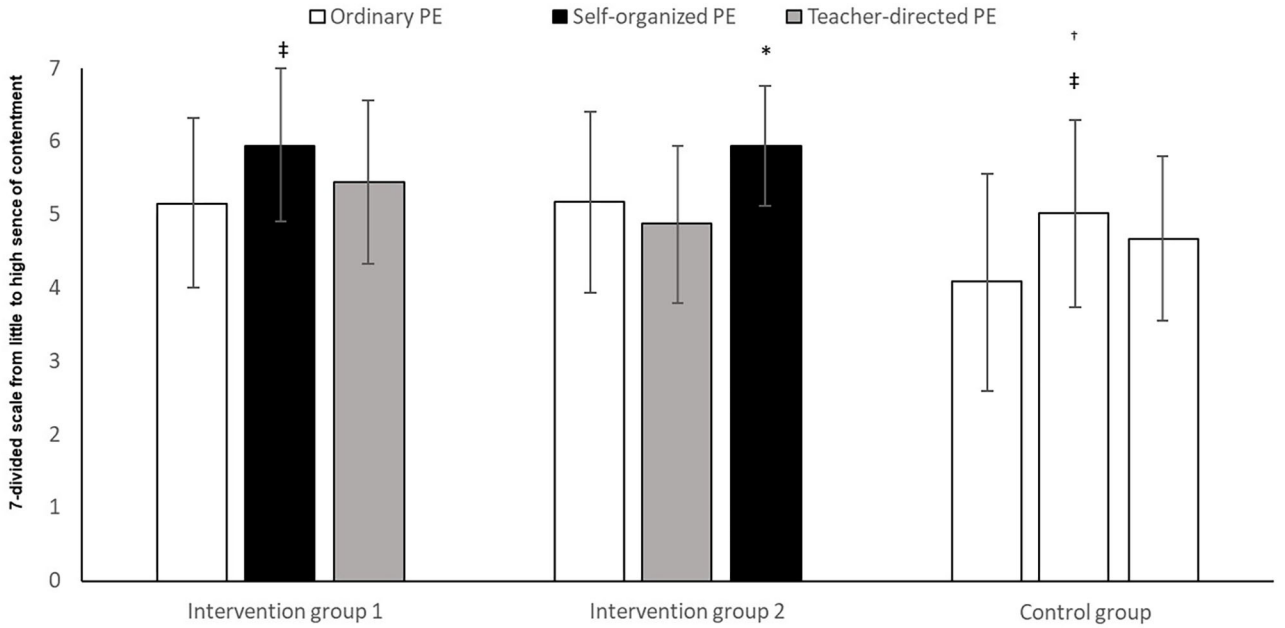

FIGURE 6 | Experience of contentment among pupils after three time periods of ordinary PE, teacher-directed PE, or self-determined PE. *Significantly higher experience of contentment with self-determined PE, compared with ordinary PE and teacher-directed PE ($p < 0.05$). ‡Significantly higher experience of contentment in self-determined PE, compared to ordinary PE ($p < 0.05$). †Significantly lower experience of contentment in the control group, compared with intervention groups 1 and 2 ($p < 0.05$). ‡Significantly higher experience of contentment in T2, compared to T1 ($p < 0.05$).

There was, however, no significant increase between T2 and T3 ($p > 0.05$).

The analysis showed that both intervention group 1 and intervention group 2 had significantly higher MVPA in self-determined PE (**Figure 7**) than in teacher-directed PE ($t = 6.03$, $p < 0.05$ and $t = -5.38$, $p < 0.05$). The control group had significantly lower MVPA in period 1, compared to period 2 ($t = -5.99$, $p < 0.05$).

The analysis showed that both intervention group 1 and intervention group 2 had significantly higher CPM in self-determined PE (**Figure 8**) than in teacher-directed PE ($t = 4.45$, $p < 0.05$ and $t = -4.67$, $p < 0.05$). The control group had significantly lower MVPA in period 1, compared to period 2 ($t = -5.10$, $p < 0.05$).

The observations showed that in the teacher-directed PE and ordinary PE the teacher organized and led the activities: Volleyball, strength training, relays, running technique, bandy, obstacle courses, gymnastic, football and capture the flag. In the self-determined PE, the pupils chose more aesthetic activities, such as dancing, gymnastic and martial Arts. Some of the pupils chose strength training/flexibility training. The majority in the intervention group 2 chose volleyball as an activity.

DISCUSSION

The theoretical basis of this study was to investigate whether a greater degree of self-determination, or autonomy, affected pupils' happiness, mastery, well-being and contentment in PE. The results clearly show that the intervention groups, unlike the control group, experienced significantly greater perception of choice in self-determined PE (autonomy support), in the periods in which they were given it, and that the intervention therefore functioned in keeping with the study's theoretical point of departure (Deci and Ryan, 1985, 2000; Ryan and Deci, 2007). Such a confirmation is important to legitimate our findings in which the experience of co-determination is shown to have a positive influence on happiness, mastery, well-being and contentment in PE. Although not all correlations are significant after strict Bonferroni corrections, the crossover effect in the columns of the various figures shows that they are not incidental.

The observations clearly showed that the PE teachers teaching style in the ordinary PE lessons and the teacher-directed PE, turned out to be approximately the same during the periods with teacher-directed PE and ordinary PE. This was because the PE teacher used a teacher-directed PE style in his ordinary teaching. In both periods (ordinary PE and teacher-directed PE), the PE teacher did not give the pupils any possibility to make choices. Because of these findings, the discussion will be between the self-determined PE (autonomy support) PE style, and the ordinary PE teacher style and a teacher-directed PE style together. A distinction between an ordinary PE style and a teacher-directed PE style do not seem to be meaningful considering our findings.

The results of our study are supported by those of other intervention studies indicating that self-determined instruction gives positive outcomes in pupils' happiness, mastery, well-being, contentment and level of activity (Prusak et al., 2004; Ward et al., 2008; Lonsdale et al., 2009, 2013; How et al., 2013), without having specifically studied these correlations. Also other studies point toward high levels of autonomy as preferred

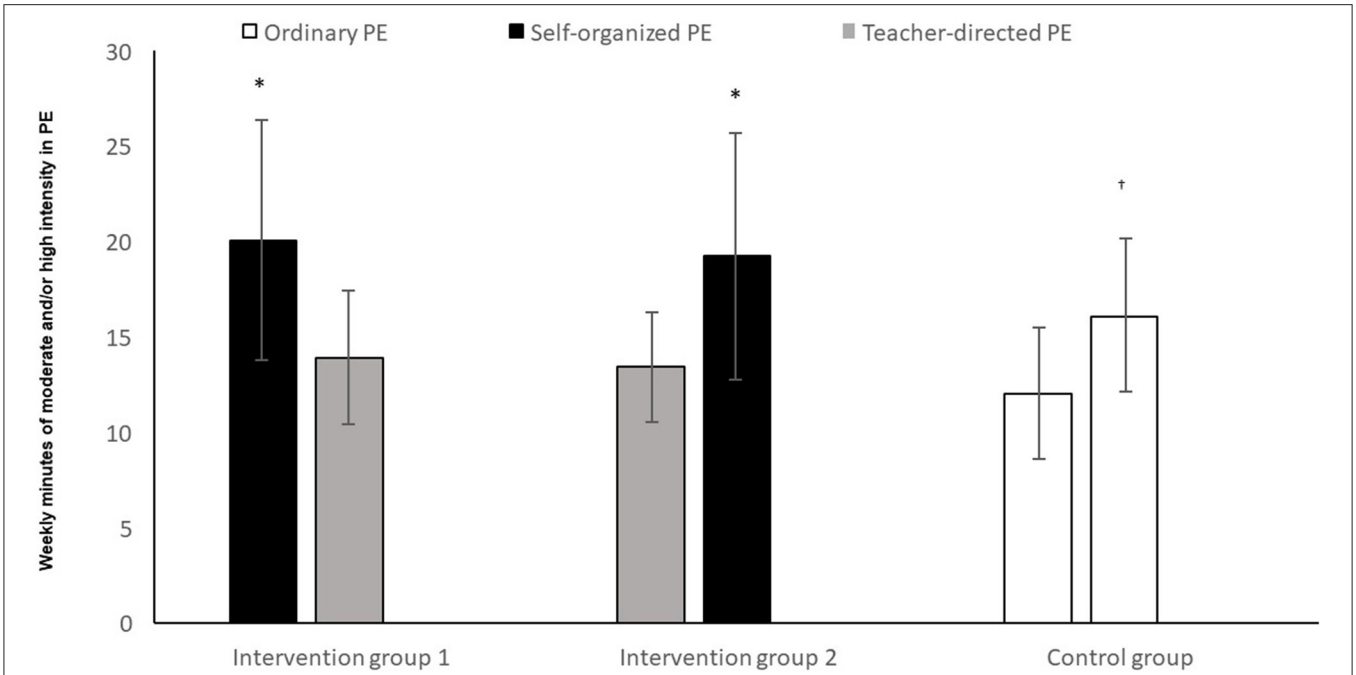

FIGURE 7 | Level of PA among pupils in two time periods of ordinary PE, teacher-directed PE, and self-determined PE. *Significantly higher level of PA with self-determination compared to teacher-directed instruction ($p < 0.05$). †Significantly higher level of activity in T2, compared to T1 ($p < 0.05$).

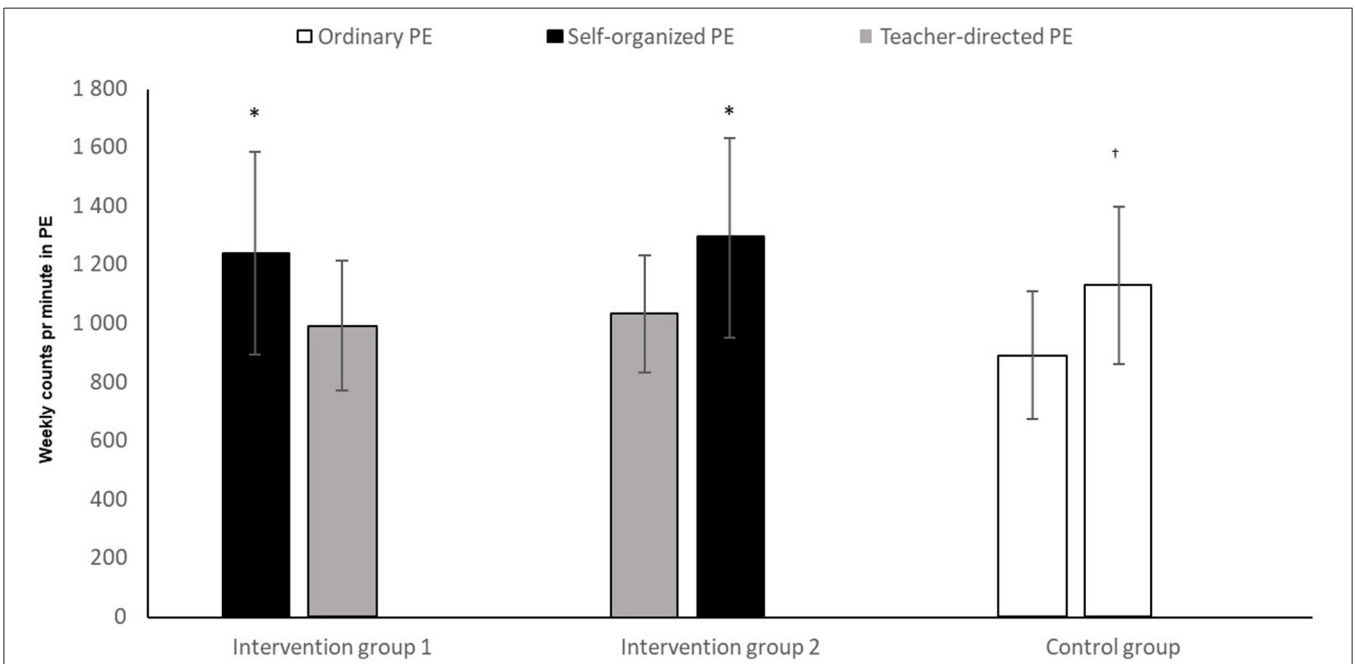

FIGURE 8 | Number of counts per minute among pupils in two time periods of ordinary PE, teacher-directed PE, and self-determined PE. *Significantly higher number of counts per minute with self-determination, compared to teacher-directed instruction ($p < 0.05$). †Significantly higher number of counts per minute in T2, compared to T1 ($p < 0.05$).

for the optimal pattern of outcomes (Van den Berghe et al., 2013, 2015; De Meyer et al., 2016; Haerens et al., 2018). Our finding is problematic according to a study of Haerens et al. (2013). In a study among PE teachers they found that the items that were part of the autonomy-supportive factor, were the least frequently observed in their study. The PE teachers in their study were rarely providing choice to their pupils, and hardly provided opportunities to practice independently. On the

other side, several studies have shown that interventions have been successful in increasing autonomy support among teachers (Tessier et al., 2010; Cheon et al., 2012; Aelterman et al., 2014; Ulstad et al., 2018). Our findings will be discussed further in relation to the study's five independent variables.

Self-Determination and Happiness

The analyses show that one of the intervention groups experienced significantly more happiness in the time when they were given more self-determination, compared to those periods when they had ordinary of teacher-directed PE. The hypothesis that increased self-determination in PE serves to increase pupils' experience of happiness is therefore fulfilled to a certain extent. The findings suggest that by being able to choose those activities that they most enjoy doing, the pupils' find PE more enjoyable and associated with happiness. This is in line with self-determination theory (Deci and Ryan, 2000). The results of Dismore and Bailey (2009) study show that the experience of fun was a critical factor for the creation of happiness in PE, and also Reid (1997) emphasizes the significance of values associated with happiness, as an important factor in the facilitation of PE. Wright (2004) points out that a particular activity places its own demands on the skills needed to accomplish it, but that, at the same time, there was the question of whether it included an element of pleasure. Kretchmar (1994) points out that the happiness one finds in an activity is an inner value. Such an inner value is closely associated with inner motivation. If pupils feel that an activity has an inner value for them, this can lead to increased inner motivation–a point also made by Deci and Ryan (2000).

Self-Determination and Mastery

The analysis shows that although both intervention groups experienced increased mastery in the period with self-determination, compared to the periods with ordinary or teacher-directed PE, these differences were not significant. These results were significant before the Bonferroni corrections, but are no longer significant after (strict) Bonferroni corrections, where the p level for the group differences were near a borderline level ($p = 0.070$). Also the crossover effect we see in the columns belonging to the two intervention groups indicate that increased self-determination can have a positive effect on mastery, and shows a trend even though the differences are not significant in this study. Ulstad et al. (2018), found that motivation derived from autonomy is directly related to perceived competence. When pupils chose activities themselves, it was therefore reasonable to suppose that their inner motivation was stronger than in ordinary or teacher-directed instruction.

The observation notes show that when the pupils chose activities themselves, they chose many activities that the teacher ordinarily would not have included in his teaching (dance, taekwondo, cheerleading, ju-jitsu, climbing). Basketball, handball, football, bandy, strength training, stair training (suppleness), gymnastics, movement training, skipping, volleyball, injury prevention and dodgeball were other activities chosen. One can suppose, following the self-determination theory (Deci and Ryan, 1985, 2000; Ryan and Deci, 2007) and the findings of (Lagestad, 2017), that the pupils chose activities that they felt themselves to be competent in, leading to a greater sense of mastery. We suggest that when pupils themselves choose the activities, they are better able to reveal new aspects of themselves, and competencies the teacher maybe was not aware of. As well as providing the teacher with a wider scope for making an evaluation (something that the teacher pointed to during the observation), earlier research emphasizes the importance of pupils being able to demonstrate in PE activities that they have properly mastered (Lagestad, 2017; Lyngstad et al., 2019; Mikalsen and Lagestad, 2019).

Self-Determination and Well-Being

The analysis showed that one of the intervention groups experienced significantly higher well-being in the period with self-determination, compared to the periods with ordinary and teacher-directed PE. Although the other intervention group experienced the greatest well-being in the period with self-determination, compared to the periods with ordinary and teacher-directed PE, the difference was not significant, and can be seen as incidental. The crossover effect we see in the columns relating to the two intervention groups does however indicate that the difference is not incidental. The hypothesis that increased self-determination raises the level of pupils' well-being is therefore fulfilled to a certain extent. This is in line with the standpoint of the study (Deci and Ryan, 2000), where self-determination theory emphasizes that increased self-determination facilitates well-being through increased internal motivation. This is also in agreement with several previous studies, as Ward et al. (2008), who contend that a greater experience of autonomy will positively affect pupils' well-being, and the findings of Ntoumanis (2005), who suggest that supporting pupils' autonomy, will positively impact pupils' well-being. Furthermore, the findings is somehow supported by a study of (Lagestad, 2017), who indicate that autonomy can positively affect pupils' well-being. This increased well-being resulting from increased self-determination can also be explained by Csikszentmihalyi (1990) "flow theory," which he uses to explain well-being.

Self-Determination and Contentment

The analyses show that in the periods where the intervention groups were able to choose activities themselves, they experienced a greater degree of contentment in PE, compared to the periods with ordinary and teacher-directed PE. Meanwhile, the control group also showed that they experienced significant differences in two of the periods. The crossover effect we see in the columns belonging to the two intervention groups, shows that the significance self-determination has for contentment, is not incidental. The results is somehow supported by (Lagestad, 2017). It is reasonable to suggest that the increased experience of self-determination goes together with autonomy, since the meeting of psychological needs is necessary in order to maintain and promote inner motivation (Ryan and Deci, 2007). When the pupils had self-determined PE, they had the opportunity to practice their chosen activities over a period of time–which was confirmed by the observations. Through such an approach the pupils were able to go into them in

depth, by, for example, acquiring a difficult technique. This is in accordance with what Kretchmar (1994) claims contributes to a long-lasting contentment.

Self-Determination and Activity Level

The analysis shows that in the periods where the intervention groups were able to choose activities themselves, they had significantly higher levels of MVPA compared to the periods of ordinary or teacher-directed PE. The control group showed up to also have significantly different activity levels between the two periods. However, the crossover effect we see in the columns belonging to the two intervention groups suggests that the effect self-determination has on activity level, is not incidental. Our results in this area are in conformity with many other earlier studies, showing that when pupils were able to choose for themselves, their PA level increased (Haerens et al., 2010; How et al., 2013; Lonsdale et al., 2013). On the other hand, Ward et al. (2008) found no connection between self-determined motivation and the level of activity. A study by Janssen and Leblanc (2010) recommended that children and youth 5–17 years of age should accumulate an average of at least 60 min per day and up to several hours of at least moderate intensity PA. Some of the health benefits can be achieved through an average of 30 min per day. More vigorous intensity activities should be incorporated or added when possible, including activities that strengthen muscle and bone. Our study showed that when the intervention groups chose activities themselves, they had significantly higher levels of MVPA compared to the periods of ordinary or teacher-directed PE. Our findings contribute to the knowledge of how to increase children and adolescents' daily activity level. Sigvartsen et al. (2016) demonstrated that by making use of interest-based PE, one profits in the form of health-related gains in life quality. In accordance with studies conducted by Lonsdale et al. (2013) and How et al. (2013), and from our theoretical standpoint in self-determination theory (Deci and Ryan, 1985, 2000; Ryan and Deci, 2007), we will argue that the significantly higher level of activity (in the form of both MVPA and CPM) in the period of self-determination, can be linked to the increased experience of self-determination (autonomy). On the other hand–the control group had also a significantly higher MVPA and CPM in one period than the other. The observation data suggest that this had a clear connection to the higher intensity activities chosen in the control group by the teacher in period 2, compared to period 1. The observation data showed that when the teacher held ordinary or teacher-directed physical classes, the teacher used a relatively large amount of time on: attendance procedures in the gymnasium, instructions, verbal instruction throughout the lesson, ending the lesson and so on–periods of time in which the pupils were passive. The teacher used a lot of time to talk, which can have contributed to the lower level of activity in the ordinary and teacher-directed instruction. When pupils chose the activities themselves, they were more quickly underway with the activity than when the teacher was directing the activity. This is in line with Patterson and Van Der Mars (2008), finding that pupils who were in close interaction with the teacher had the same level of activity as before, whilst those whose instruction took place distanced from the teacher, increased theirs. The PA level in our study are approximately the same as in other studies (Meyer et al., 2013; Chen et al., 2014; Andersen, 2017; Mayorga-Vega et al., 2017). Several of the activities that the teacher chose in teacher-directed PE and ordinary PE, was the same activities that the pupils chose in the self-determined PE. A lot of these activities do not promote to moderate and high intensity (Fairclough and Stratton, 2005b). This suggest that it's the intervention and the self-determination strategy that increases the level of activity, and not change of activities in the different periods. Kalajas-Tilga et al. (2020) found out that to enhance adolescents' MVPA in daily basis, the special focus should be put on increasing their intrinsic motivation toward physical education. When the adolescents' chose activity themselves, both MVPA and CPM were significantly higher than at ordinary and teacher-directed PE. By giving the adolescents' self-organized PE the focus was to increase their intrinsic motivation in PE. Delextrat et al. (2020) concluded that activity type could be associated with the intensity of PA in PE. By giving the adolescents' self-organized PE the purpose was to see if MVPA increased or went down in relation with the activity itself. When the adolescent chose activities themselves there was significantly higher levels of MVPA compared to the periods of ordinary or teacher-directed PE.

Strengths and Limitations of the Study

A randomized selection of control group and intervention groups was made, and the same PE teacher was involved with all groups in all periods. Furthermore, their levels of PA were measured using accelerometers. This is seen as the best way in which to gather activity data about young people (Kolle et al., 2012), even though some activities, such as cycling, are underestimated. It should be noted here, however, that with the exception of one pupil who cycled in one PE lesson, none of the pupils cycled in the intervention period. The level of activity was measured as MVPA and CPM, which are standardized and highly regarded measures of activity level internationally. Another strength of the study is that the same researcher was present in all 24 of the lessons during which measurements were made. In this way the study's protocol was accurately followed, as well as data about each variable being gathered in order to support the data material from the accelerometer measurements and from the questionnaire–a strategy that strengthens the study's validity and reliability. The use of a crossover design also adds to the credibility of the study's findings.

The study is not without limitations. It is striking that the control group experienced a generally lower level of perception of having choice, happiness, well-being and contentment than the intervention groups at baseline. According to both the teacher and the observations, the control group differentiated itself by being less positive to PE than the other classes. This is supported by the statistical analysis which showed that the control group experienced significantly lower happiness, well-being and contentment in PE. In this way, one can imagine that the effect could have been greater if this class had been selected as an intervention class. This because the effect of having choices might have affected the control group in a more positive way more than the intervention groups,

because of their lower baseline levels. Although the concepts of happiness, mastery, well-being and contentment have been formed on the basis of theory and factor analysis, these concepts have not been used and validated in previous research, and the validity of the measurements can be questioned. On the other hand, these four variables are constructed on the basis of logical and theoretical reasoning, where most of the questions in the items have high face validity, and are related according to the factor analyses. Furthermore, according to contentment and activity level, there were significant changes across time in the control group, that seems to indicate that natural fluctuations occur in some of the variables. A cautious interpretation of the findings is therefore needed. The observations showed that the PE teachers teaching style in the ordinary PE lessons and the teacher-directed PE, turned out to be approximately the same during the periods with teacher-directed PE and ordinary PE–and the importance of involving ordinary PE was limited in our study. Finally, we must highlight that past research has shown that perceived choice is only one facet of autonomy. Autonomy support, sometimes termed as "need support," is a lot more than only providing additional choice. Future articles should include research which has adopted dimensions of autonomy support as cognitive, organizational and procedural in the context of physical education.

CONCLUSION

Several studies have looked at self-determination, but none of them have looked specifically at self-determination in the context of happiness, mastery, well-being, contentment, and level of activity. The results from this study suggest that increased self-determination in PE positively affects young people's happiness, well-being, contentment, and level of activity. Even though the pupils' experience of mastery did not increase significantly, the findings here suggest that one cannot assert that self-determination does not affect pupils' mastery in PE. However, it is important to highlight that some natural fluctuations occur in some of the variables in the control group, especially related to PA level, and a cautious interpretation of this finding is therefore needed. Taking this into mind, the findings of this study suggest that it is important that pupils are able to make their own choices in PE, and that PE teacher's practice ought to include periods in which the pupils are able to make their own choices regarding self-organized activities. As suggested by Haerens et al. (2013), the results also suggest the need for PE teacher education programs and continuous professional development programs to include a module on how to teach in an autonomy-supportive way. Further research should be based on intervention studies studying self-determination over a longer continuous period, in classes with both older and younger pupils, but also where self-determination does not necessarily take as its starting point the choice of activities during PE lessons.

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 Norwegian Centre for Research Data (NSD). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

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

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Systematic Review of Psychological and Behavioral Correlates of Recreational Running

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Introduction: The aim of this review was to systematically synthesize the published literature describing the psychological and behavioral correlates of recreational running in adults, defined as running for leisure, with or without a competitive component.

Methods: Quantitative research published in peer-reviewed journals until January 2021 were included. Studies were identified through MEDLINE, PsycINFO, SPORTDiscus, and Web of Science and were included in this review if they (1) were aimed at recreational running, (2) included general adult samples (18 years or older, without a diagnosed medical condition or metabolic disorder), and (3) assessed psychological or behavioral correlates of recreational running.

Results: Fifty-six articles reporting 58 studies met the eligibility criteria and were included. There were 27 cross-sectional studies, 12 longitudinal studies, and 19 trials (8 non-controlled trials, 5 controlled trials, and 6 randomized controlled trials) ($n = 37{,}501$, 18–77 years old, 43% women). Twenty-eight studies assessed antecedents of running behavior, and 25 studies used running behavior as treatment or predictor of a given effect or outcome. Four studies examined both predictors and outcomes of running. Thirty-one studies showed poor quality, while 20 had fair and 7 good quality. Motives were the most frequently studied antecedent of running behavior ($k = 19$), and results suggest that the highest-ranked or more prevalent motives were physical health, psychological motives, and personal achievement. Additionally, perceived control, attitude toward running, intention and subjective norms, self-efficacy, and social support may have also played a role in the adoption of recreational running. Moreover, improvements in mood ($k = 10$) and well-being ($k = 10$) were the most frequently reported positive outcomes of running. Reductions in depression, anxiety, and stress were also reported in included studies.

Discussion: To our knowledge, this is the first systematic review on this topic. The identification of behavioral and psychological correlates of recreational running across populations can contribute to inform and guide a public policy agenda, focused on helping people sustain regular physical activity, through a modality they have chosen and appear to enjoy.

Systematic Review Registration: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=68954, identifier: CRD42017068954.

Keywords: physical activity, exercise, antecedents, psychological outcomes, behavior

INTRODUCTION

Recreational running, defined as running for leisure, with or without a competitive component has increased exponentially (Scheerder et al., 2015). Although determined with different criteria, running prevalence in European countries varies between 31% in Denmark (considering running regularly in the last 12 months), 19% in Belgium (considering running as a leisure-time sports activity) and France, 18% in the Netherlands (considering participating at least once a year in a running activity), 15% in Finland, 13% in Germany, 6% in Spain, and 5% in the UK (considering running for at least four occasions in the previous 28 days, for at least 30 minutes, at moderate or vigorous intensity) (Scheerder et al., 2015). Portuguese adults indicated that running was the preferred leisure-time PA for 18% of men and for 8% of women (Teixeira et al., 2019), and the overall prevalence of recreational runners (considering at least two sessions and 60 min per week) was 10.6% (Pereira et al., 2021). Regarding non-European countries, there was a rate of participation in running and jogging activities of 16% in Australia (ASC, 2016) and 15% in the USA (Running-USA, 2017). Many factors contribute to the growth of recreational running, including the physical and psychological health benefits (Lavie et al., 2015; Nezlek et al., 2018), the low cost, and the fact that it can be performed in various contexts and requires little technical skills. The health benefits of running are vast, including prevention of obesity, hypertension, dyslipidemia, type 2 diabetes (Lavie et al., 2015), reduction of cardiovascular, and all-cause mortality (Lee et al., 2014) but also cancer mortality (Pedisic et al., 2019).

Recreational runners tend to run often, for more than 5 kilometers, and all year long (Bell and Stephenson, 2014), in many cases reporting many hours of training (Zach et al., 2017). This suggests the existence of potentially unique motivational and behavioral factors related with running and training for and completing a recreational race (Zach et al., 2012).

Most of the running-related literature focused on injuries (van der Worp et al., 2015), addictions (Hausenblas et al., 2017), or health-related outcomes (Pedisic et al., 2019), but understanding the interrelated psychological and behavioral attributes that explain *why* some individuals are regular (often avid) runners is also of importance to physical activity and public health research. Identifying running correlates, both antecedents and outcomes can contribute to more effective and tailored intervention approaches to promote the adoption and sustainability of recreational running.

One review has previously examined determinants for running, but with the purpose of developing a self-report questionnaire, and this was conducted using a systematic and comprehensive approach (Masters et al., 1993). Further, that work was published in 1993, and many primary studies (cross-sectional, longitudinal, and experimental) have been conducted since then (e.g., Tjelta et al., 2017; Malchrowicz-Moko et al., 2018).

The aim of this systematic review was therefore to identify and summarize the published literature describing psychological and behavioral correlates of recreational running in adults.

METHODS

This systematic review was conducted in agreement with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Liberati et al., 2009) and the protocol preregistered (PROSPERO: CRD42017068954).

Eligibility Criteria

Studies examining psychological and behavioral correlates of recreational running in healthy adults (18 years or older), excluding preparation for any competitive sports, and without a diagnosed medical condition or metabolic disorder, were included. Studies conducted in samples of recreational runners only, and studies including both runners and non-runners' groups, were included. Observational and experimental design studies were included with no restrictions on the setting (e.g., community). Studies had to report a quantitative estimate for the correlate(s). Study protocols, reviews, and commentaries were excluded. This review was limited to articles written in English and published in peer-reviewed journals.

Search Strategy and Study Selection

Electronic databases (MEDLINE, PsycINFO, SPORTDiscus, and Web of Science) were searched for relevant articles published between the review from Masters et al. (1993), finished in December of 1991 and January 2021, by combining keywords related with behavioral and psychological correlates of running behavior. Searches included a combination of four sets of terms: (i) terms concerning the population of interest (e.g., recreational runners), (ii) terms concerning the running behavior (e.g., jogging, marathon); (iii) terms related to antecedents

TABLE 1 | Full search strategy.

Population	Behavior	Correlates
NOT (injuries OR disease)	("recreational running" OR "recreational runners" OR "jogging" OR "jog" OR "marathon")	(motivation OR reasons OR intention OR regulations OR motives OR goals OR gains OR vitality OR happiness OR wellbeing OR mindfulness OR engagement OR sleep OR "cognitive clarity" OR "cognitive function" OR "body appreciation" OR "body functionality" OR "body attunement" OR affect OR emotion OR emotions OR enjoyment OR depression OR anxiety OR "quality of life" OR self-esteem OR self-worth OR "body image" OR self-efficacy OR attitudes OR "social norms" OR control OR "action plans" OR coping OR stress OR "decisional balance" OR self-schemata OR personality OR knowledge OR health OR barriers OR benefits OR beliefs OR "stages of change" OR "processes of change" OR skills OR diet OR smoking OR alcohol OR music OR meditation OR relaxation OR social OR flow OR "runners high" OR "dietary habits" OR mood OR "psychological health")

of the behavior (e.g., self-efficacy, motives); (iv) and terms representing outcomes of running (e.g., mood, flow) (see **Table 1** for the full search strategy). In addition, reference lists from previous reviews and retrieved papers were hand-searched to find additional studies.

Two researchers independently identified potentially eligible studies based on title, abstract, and references, according to the prespecified inclusion/exclusion criteria. The same two researchers independently reviewed the full text of the potentially relevant studies. All discrepancies were resolved by consensus. A third researcher resolved any remaining disagreements.

Data Extraction

A data extraction form was developed, informed by the PRISMA statement for reporting systematic reviews (Liberati et al., 2009). Data extraction included information about (i) study details (authors, year, country of publication), (ii) participants (age, gender, attrition, and blinding), (iii) study design and setting, (iv) correlates of interest (motivation, reasons, intention, regulations, motives, goals, and gains, as well as vitality, happiness, quality of life, well-being, mood, enjoyment, relaxation, flow, mindfulness, meditation, runners high, engagement, sleep, cognitive clarity or function, body appreciation or functionality or attunement, affect, emotion, depression, anxiety, stress, self-esteem, self-worth, body image, self-efficacy, attitudes, social norms, control, action plans, coping, beliefs, stages or processes of change, skills, decisional balance, self-schemata, personality, knowledge, health, barriers, benefits, diet, smoking, alcohol, music, social, dietary habits, psychological health), (v) intervention length and characteristics, (vi) psychosocial instruments, and (vii) results.

Two researchers independently retrieved the data, and all discrepancies were resolved by consensus. A third researcher resolved any remaining disagreements.

Assessment of the Risk of Bias in Individual Studies

Two researchers independently assessed the methodological quality and risk of bias of included studies using the National Heart Lung and Blood Institute, National Institute for Health (NHLBI–NIH) Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (Thomas et al., 2004). Additional items from the Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies (Armijo-Olivo et al., 2012) were added, in order to analyze study aspects exclusively related to interventions. The final tool comprised 20 items, addressing seven key domains: study design; blinding; representativeness (selection bias and withdrawals/dropouts); confounders; data collection; data analysis; and reporting. Each item was classified as present or absent. A global rating of Good (low risk of bias), Fair, or Poor (high risk of bias) methodological quality was determined based on the present or absence of each item (see **Supplementary Table 2**). Two researchers independently rated each item and overall quality. Discrepancies were resolved by consensus. A third researcher resolved any remaining disagreements.

Data Synthesis

Participants' sociodemographic characteristics, as well as the psychological and behavioral correlates of running behavior/participation, were qualitatively synthetized and presented in tabular form (**Supplementary Table 1**). Correlates were divided in antecedents and outcomes, depending on the purpose of the studies and its theoretical frame.

RESULTS

Study Selection

The literature search yielded 4,225 potentially relevant studies (after duplicates removal). After titles and abstract screening, 4,140 studies were excluded. Common reasons for exclusion were the study design (qualitative study, commentary, or review), not meeting subjects inclusion criteria, and the presence of outcomes related to the preparation for competitive sports (performance-oriented). The full text of the remaining 93 eligible studies was retrieved and reviewed, which, after adding 8 additional records identified through hand search, resulted in the inclusion of 56 articles (see **Figure 1**).

Description of Included Studies

There were 27 cross-sectional studies, 12 longitudinal studies, and 19 trials (eight non-controlled trials, five controlled trials, and six randomized controlled trials). **Table 2** shows the characteristics of the included studies. In total, 37,501 healthy participants took part in all the studies reviewed, with a range of ages of 19–77 years old, and 43% were women. Most studies used samples of regular runners from running groups, communities, or organized events.

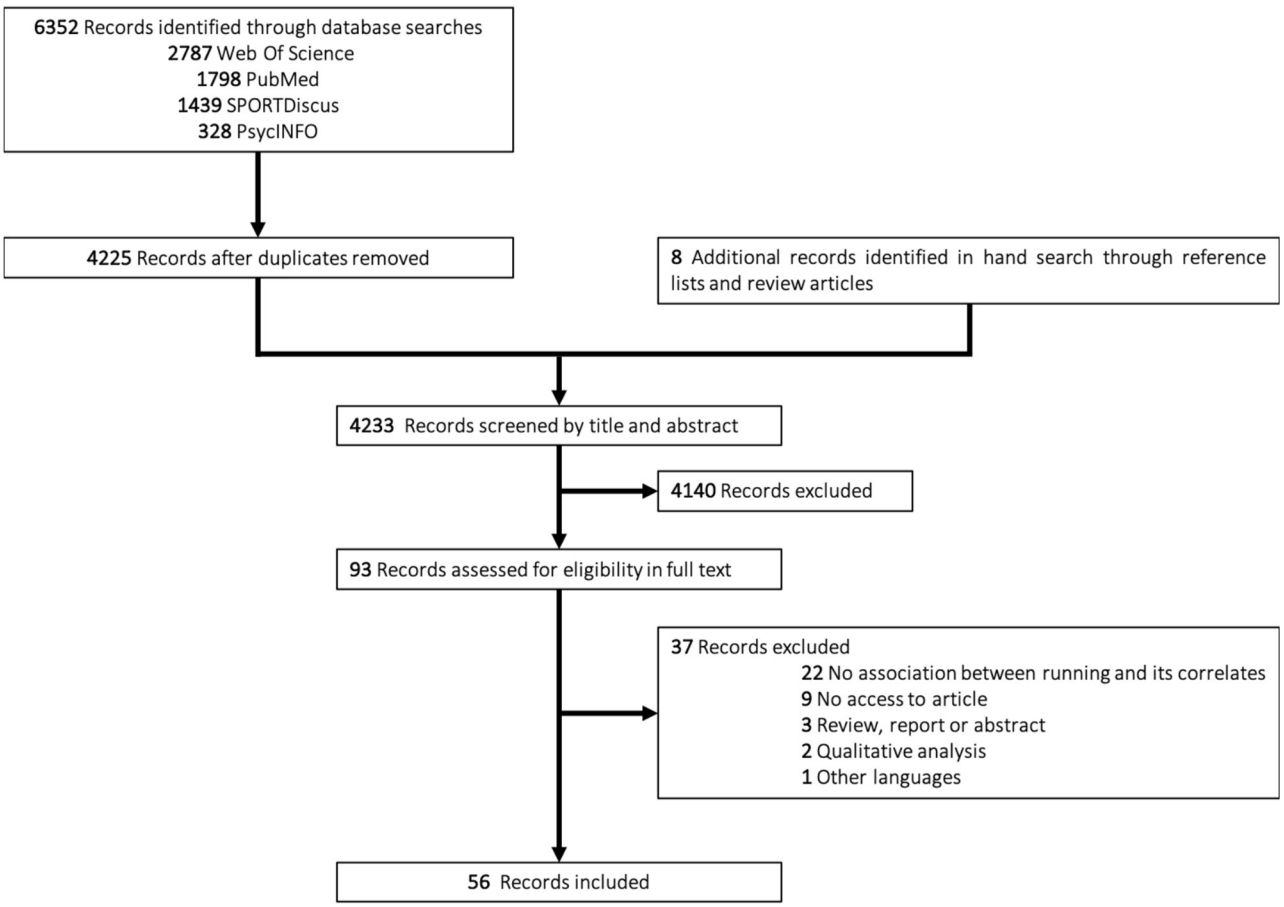

FIGURE 1 | Flowchart of studies.

Quality of the Studies and Risk of Bias

Thirty-one studies showed poor quality, while 20 had fair and 7 good quality. Generally, the research objective was clear (k = 56, 96.6%), subjects were recruited from the same or similar populations (k = 52, 89.7%), exposure and outcome measures were clearly defined, valid, reliable, and implemented consistently across all study participants (k = 52, 89.7%), and the study population clearly specified and defined (k = 37, 78.7%). On the other hand, only two studies presented sample size and power calculations (3.4%), only five had a participation rate of eligible persons of at least 50% at baseline (8.6%), and three had the outcome assessors blinded to the exposure status of participants (5.2%) (Armijo-Olivo et al., 2012) (**Supplementary Table 2**).

Synthesis of Results

This systematic review analyzed the published literature describing the psychological and behavioral correlates of recreational running in adults. Overall characteristics of the included studies are presented in **Table 2**, and in **Table 3** the trend of the association with each correlate can be found. A full description and results of individual studies can be found in **Supplementary Table 2**. In cross-sectional studies, we established *a priori* which correlates were interpreted as "antecedents" and which were "outcomes" largely based on information from the study design and methods but also from popular theories of motivation and behavior change, such as the Theory of Planned Behavior (Ajzen and Driver, 1991) or Self-Determination Theory (Ryan and Deci, 2000). Generally, measures of mood and psychological health (depression and anxiety) were treated as consequences of running although they can also play a role in adoption (and that was the case in some longitudinal studies). Twenty-eight studies reported antecedents of running behavior, and 25 studies reported effects or outcomes. Four studies simultaneously examined predictors and outcomes of running.

Antecedents of Recreational Running

Motives were frequently reported as antecedents of running behavior (k = 19). Studies described motive prevalence among different samples of runners, while others studied motives according to running experience, training, gender, and age. Studies of other predictors, such as intention (k = 4), perceived control (k = 3), attitude toward running (k = 3), self-efficacy (k = 3), social support (k = 3), behavior regulation (k = 3),

TABLE 2 | Characteristics of the included studies.

Study design ($k = 58$)	Number of studies	Antecedents ($k = 32$)	Number of studies	Outcomes ($k = 29$)	Number of studies
CS	27	Motives	19	Mood	10
LG	12	Intention	4	Well-being	10
NCT	8	Attitude toward run	3	Depression	6
NRCT	5	Perceived control	3	Anxiety	5
RCT	6	Self-efficacy	3	Cognitive function	4
Sample size		Social support	3	Affect	4
<100	22	Behavior regulation	3	Self-efficacy	3
100–199	12	Mood	2	Vitality	3
200–299	6	Anxiety	2	Flow	3
>299	18	Depression	2	Stress	2
Participants ($k = 57$)		Subjective norms	2	Perceived health	2
Gender		Self-motivation	1	Life satisfaction	2
Women only	4	Flow	1	Positive orientation	1
Men only	6	Experience	1	Self-esteem	1
Both genders	47	Involvement	1	Enjoyment	1
Age		Shame	1	Fatigue	1
19–44	36	Pride	1	Emotion regulation	1
45–66	8	Action planning	1		
Broad range	11	Health	1		
QA ($k = 58$)		Process of change	1		
Poor	31				
Fair	20				
Good	7				

RCT, randomized controlled study; CCT, controlled clinical trial; NCCT, noncontrolled clinical trial; LG, longitudinal study; CS, cross sectional study; QA, quality assessment.

subjective norms ($k = 2$), mood ($k = 2$), measures of trace anxiety and depression, or state anxiety at the beginning of the program ($k = 2$) were also included. Regarding self-motivation, experience, involvement, action planning, process of change, perceived health, flow during the race, shame, and pride, only one study was found for each variable.

Nineteen cross-sectional studies described or compared motives between groups of runners. Among the highest-ranked motives reported were physical health (Krouse et al., 2011), psychological motives (Tjelta et al., 2017), health orientation (Malchrowicz-Mośko et al., 2020), and personal achievement (Doppelmayr and Molkenthin, 2004). Less frequent or lower-ranked motives were competition (Leedy, 2000), social motives, such as affiliation or social comparison (Malchrowicz-Moko et al., 2018), and also having fun (Tjelta et al., 2017).

Motives such as competition and health (Ogles and Masters, 2000) or personal goal achievement (Pereira et al., 2021) were associated with weekly training distance, while enjoyment anticipated the adoption of regular running (Titze et al., 2005). Although one study found an interaction between high enjoyment and high family support in the prediction of running behavior (Titze et al., 2005), another found no significant main or interaction effects of social condition (Carnes et al., 2016). One study found that effort was greater for participants who usually reported experiencing more pride than others (Gilchrist et al., 2017).

Studies comparing motives between different groups found that age (Ogles and Masters, 2000), gender (Tjelta et al., 2017), experience in running (Masters and Ogles, 1995), training profile (Ogles et al., 1995), and type of event (Doppelmayr and Molkenthin, 2004) were associated with different motives. Younger runners were more motivated by personal goal achievement and competition (Pereira et al., 2021). In opposition, older runners were more motivated by health orientation, weight concern, life meaning, and affiliation with other runners (Ogles and Masters, 2000). Age was positively associated with health orientation and affiliation and negatively correlated with weight concern, personal goal achievement, competition, recognition, psychological coping, life meaning, and self-esteem (Waśkiewicz et al., 2019a). Other authors found that older runners were also more frequently motivated by the exercise itself and experiencing nature, and less by challenge (Tjelta et al., 2017). Nonetheless, older runners who reported competition as an important motive were more likely to have participated in more marathons and trained greater distances per week (Ogles and Masters, 2000).

Regarding gender differences, studies observed that male runners scored higher on competition and challenge (Tjelta et al., 2017) or achievement motives (Whitehead et al., 2020). In agreement, Popov et al. (2019) observed that women scored higher on both mental health improvement and physical health and condition, while men scored significantly higher on the competitive factor. On the opposite, data from another study suggests that women were more likely to endorse psychological coping, self-esteem, and personal goal achievement motives for running (Nikolaidis et al., 2019). Data from other samples showed that compared to men, women scored higher on weight

TABLE 3 | Association between the identified correlates and recreational running.

Antecedents ($k = 32$)	Number of studies	No association	Significant association		Outcomes ($k = 29$)	Number of studies	No association	Significant association	
			Positive	Negative				Positive	Negative
Motives	19	13	6		Mood	10	2	8	
Intention	4	2	2		Well-being	10	1	9	
Perceived control	3	1	2		Depression	6	1		5
Attitude toward run	3	1	2		Anxiety	5	2		3
Self-efficacy	3		3		Cognitive function	4	1	3	
Social support	3	2	1		Affect	4	2	2	
Behavior regulation	3	1	2		Self-efficacy	3	2	1	
Mood	2	1	1		Vitality	3	1	2	
Anxiety	2	1		1	Flow	3	2	1	
Depression	2	1		1	Stress	2			2
Subjective norms	2		2		Perceived health	2		2	
Self-motivation	1		1		Life satisfaction	2		2	
Flow	1		1		Positive orientation	1		1	
Experience	1	1			Self-esteem	1	1		
Involvement	1		1		Enjoyment	1		1	
Shame	1	1			Fatigue	1			1
Pride	1		1		Emotion regulation	1	1		
Action planning	1		1						
Health	1		1						
Process of change	1	1							

concern, affiliation, psychological coping, life meaning, and self-esteem (Ogles et al., 1995; Waśkiewicz et al., 2019a).

A study comparing motives across different levels of running experience suggests that most experienced veterans and runners with mid-level experience scored higher on both competitive and health motives, whereas first-time runners were not characterized by either function (Masters and Ogles, 1995). Others recorded differences in intrinsic motives accordingly with runners' ability. Runners with high and medium ability were most induced by altruism, while runners with low ability were motivated by health (Bell and Stephenson, 2014). A recent study with Polish runners found that running experience was negatively associated with personal goal achievement and self-esteem (Waśkiewicz et al., 2019a), while other found no differences in motives according to running experience (Malchrowicz-Mośko et al., 2020).

Concerning the amount of training and commitment to running, data suggest that weekly distance was associated with personal goal achievement (Pereira et al., 2021). Similarly, runners registered for a marathon event, running more than 45 miles and intending to continue after the race, were more likely to endorse competition, personal goal achievement, and recognition, as motives for continued training; in turn, less serious runners (registered for a 5K race, not having participated in a marathon, training <15 miles per week and intending to continue after the race) endorsed more of a general health orientation (Masters and Ogles, 1995).

Two studies compared motives for participation of a sample of adventure ultramarathon, ultramarathon, and marathon runners. Results revealed significant differences between the three groups of runners indicating less importance of the reason competition, but higher importance of the motives "nature and life meaning" for adventure ultramarathon participants compared to marathon runners (Doppelmayr and Molkenthin, 2004). Ultramarathoners showed higher scores in affiliation and life meaning and lower in the areas of weight concern, personal goal achievement, and self-esteem than runners covering shorter distances (Waśkiewicz et al., 2019b). On the other hand, 5K runners showed highest scores on self-esteem, physical fitness, and achievement motives (Whitehead et al., 2020).

Ogles and Masters (2003) have found a motivational-based (MOMS) five-cluster solution in 1,519 runners participating in one of the midwestern marathons: Running Enthusiast (RE), Lifestyle Managers (LM), Personal Goal Achievers (PGA), Personal Accomplishers (PAc), and Competitive Achievers (CA). Differences between clusters were significant: CA ran more days per week than LM and PGA; LM trained fewer miles than all the other groups; and RE had completed more marathons than LM, PGA, and PAc.

Other Antecedents

Concerning intention as an individual's plan to participate in a single behavior, engage in a behavioral category, or achieve a goal, studies suggest that it was positively associated (Bell and Stephenson, 2014) or predicted future running participation (Luszczynska et al., 2007). Others reported that both cognitive (important, relevant, valuable, means a lot, and needed)

and affective (interesting, appealing, fascinating, exciting, and involving) elements of the personal involvement inventory were predictors of participation among ultramarathon athletes (Mueller, 2012).

According to one study, behavior at baseline and recovery self-efficacy predicted future participation (Luszczynska et al., 2007). Another study showed correlation between baseline self-efficacy with running and between fluctuation in self-efficacy and fluctuation in running (Scholz et al., 2008). Regarding gains (outcomes runners have already experienced), flow felt in the race was positively correlated with the future running motivation (Schler and Brunner, 2009), and vigor (mood scale) showed correlation with future running behavior (Suter and Marti, 1992).

Two earlier studies with the same sample showed that beliefs, attitudes, norms, and behavior control contributed to behavior prediction (Ajzen and Driver, 1991, 1992). Other studies found some associations between autonomous forms of motivation and both event participation and training compliance. Individuals high in autonomous behavior regulations reported significantly higher levels of participation in both marathons and half marathons (Aicher et al., 2017), and runners with higher self-motivation scores complied better with the exercise regimen (Welsh et al., 1991). Later, two other studies showed that ability, defined as 5K race personal record in the past 2 years standardized by age and gender, was positively associated with participation (Bell and Stephenson, 2014), and there were also correlations between the linear trend action planning, and action control, which are self-regulation skills, with the linear trend in running (Scholz et al., 2008). In the Scholz et al. (2008), a positive correlation emerged between baseline coping planning and linear trend in running over time.

Finally, three studies describing runners behaviors found that 85.2% of runners set goals for their chosen events, 80.1% trained alone and with others (Krouse et al., 2011), more than 90% of runners systematically prepared themselves for the competition (Piot, 2015), 73% of the participants prefer to run alone, 69% do other physical activities besides running, 69% use technology during running sessions, and 68% report running in a natural setting (Pereira et al., 2021).

Outcomes of Recreational Running

Studies examining outcomes of recreational running assessed psychological outcomes such as mood ($k = 10$), well-being ($k = 10$), affect ($k = 4$), cognitive function ($k = 4$), self-efficacy ($k = 3$), vitality ($k = 3$), flow ($k = 3$), perceived health ($k = 2$), and life satisfaction ($k = 2$). Likewise, some studies reported reductions in depression ($k = 6$), anxiety ($k = 5$), and stress ($k = 2$). Concerning positive orientation (self-esteem, satisfaction with life, and optimism), self-esteem, enjoyment, physical fatigue, and emotion regulation (deficits), only one study was found for each variable.

Studies aiming to understand the effect of running on mood suggest a main effect for running time, immediately after a short run trial (Berger and Owen, 1998; Berger et al., 1998, 2016; Anderson and Brice, 2011). A previous study compared pre–post changes in mood and found that the running group exhibited significant changes in total mood disturbance, tension, and confusion immediately after the running session (75 min and more than two miles running) (McGowan and Pierce, 1991). Mood benefits after a marathon race included decreases in depression, anger, confusion, tension, and fatigue and increases in vigor (Hassmén and Blomstrand, 1991).

No significant acute (immediately after, 20 and 40 min post-training) or medium (6 and 9 weeks) term effects of running were observed in one study (Walter et al., 2013). Another RCT found no differences between the acute effect of a 30-min run and equivalent time doing stretching (Bernstein and McNally, 2017). One study found long-term (17 years) improvements in mood states of a small group of runners (Morgan and Costill, 1996).

Well-being was suggested as a positive psychological outcome/correlate of running in a cross-sectional study (Galper et al., 2006). Studies reported acute positive effects of running on revitalization, tranquility, positive engagement, physical exhaustion (Szabo and Abraham, 2013), and positive orientation (Gorczyca et al., 2016). Well-being was cross-sectionally related with motives for running (Popov et al., 2019) and also longitudinally associated with the amount of running (distance and frequency) (Nezlek et al., 2018). However, data suggest that the effect of running on well-being diminishes over time (Bonham et al., 2018).

Other Outcomes

Contradictory results regarding the flow/worry ratio were found in two randomized controlled trials by the same author (Elbe et al., 2010). While female runners experienced significantly more flow than football players, no differences were observed in males. Worry was higher in male runners than in male football players, but no differences were observed in female. Regarding depression, an inverse association with running has been cross-sectionally observed for both men and women (Galper et al., 2006; Roeh et al., 2020) but also longitudinally: marathon runners showed lower Beck Depression Inventory scores when compared to controls (Winker et al., 2010). The effect of running on anxiety has been addressed in some studies (Larumbe-Zabala et al., 2019). An RCT showed a negative association between state anxiety at program end and running frequency (Welsh et al., 1991). A long-term longitudinal study observed that anxiety decreased significantly across the 23-year period in one sample, while it increased in another. In addition, the neuroticism score for the combined sample decreased significantly (Morgan and Costill, 1996). Others found that both comedy videos and running exercise resulted in reductions of state anxiety (Szabo, 2003). One longitudinal study found that the probability of mental stress (tense, nervous, impatient, anxious, sleepless) was lowest for joggers, when compared with low, moderate, and high physical activity levels (Schnohr et al., 2005).

DISCUSSION

This review sought to systematically synthesize the published literature describing the psychological and behavioral correlates of recreational running in adults. Because of the limited number

of studies reporting each correlate, it was not possible to meta-analyze the data. However, the identification of antecedents most strongly associated with recreational running, such as intrinsic motives, highlights potential candidates to target in future real-world interventions in this domain. Likewise, the identification of most common psychological benefits of running, for instance mood, can strengthen its perceived value and the likelihood of its adoption.

Antecedents of Recreational Running

The findings from this review show that a typical runner sets goals for specific running events, systematically prepares for competing, and runs for 30–50 km/week in average. Studies reporting motives of runners suggest that the highest-ranked or more prevalent motives were physical health, psychological motives, and personal achievement. It can be argued that, due to the item's narrative, intrinsic and extrinsic motives can coexist in the same dimension; nevertheless, health orientation, personal goal achievement, self-esteem, life coping, and life meaning are predominantly intrinsic motives (Gunnell et al., 2014) and were often present among those who sustain their running behavior. Additionally, participants in some of the studies were long-distance runners, using running as a cathartic behavior, often used as a coping mechanism (Nemec, 2016). They are moved by more intrinsic reasons, such as personal achievement and general physical and psychological health. The study which compared motives across adventure ultramarathon, ultramarathon, and marathon runners hints for a lesser importance of competition but higher importance of the contact with nature and life meaning for adventure ultramarathon participants compared to marathon runners (Doppelmayr and Molkenthin, 2004). It could be explained by the unique characteristics of these highly demanding ultramarathons, in which finishing is the main goal. Similar findings emerged from the study comparing obligatory runners, moved by competition, goal achievement, and recognition, with recreational runners, motivated mainly by health purposes (Ogles et al., 1995). Extrinsic motives, like competition or social motives, such as social comparison were indeed less frequent or lower ranked. Since results come from samples of regular runners, which are in behavior maintenance, these findings are in line with the Self-determination Theory assumptions (Ryan and Deci, 2019) and quite similar to those of previous studies of physical activity behavior correlates (Teixeira et al., 2012; Sheeran et al., 2020).

Although both intrinsic motives and autonomous behavior regulations were predictors of higher levels of running participation (Aicher et al., 2017) and perseverance (Qiu et al., 2020), one study (Gilchrist et al., 2017) found that pride, which is a manifestation of introjected behavior regulation (Ryan and Deci, 2000), can motivate people to put forth immediate (5 weeks) and greater effort and persistence toward long-term goals despite short-term costs.

Results suggest that age influences the main reasons why people run (Ogles and Masters, 2000; Tjelta et al., 2017). Generally, older participants are more autonomously motivated than their younger colleagues. Similar results were registered in the comparison of different levels of running experience. Veterans and mid-level experience runners were mostly driven by health, personal goal achievement, and self-esteem. Results match those found in CrossFit participants (Box et al., 2019), in which older participants scored higher on health-related motives, while younger participants scored higher on social motives relative to their counterparts. Others (Molanorouzi et al., 2015) suggest that young adults are also motivated by affiliation, mastery, and enjoyment whereas middle-aged adults considered psychological condition and others' expectations more important motives for participating in PA, than young adults.

Data from two studies indicates gender differences in the motives for running (Ogles et al., 1995; Tjelta et al., 2017). Men tend to run more for competition and challenge, and women for weight concern, affiliation, psychological coping, life meaning, and self-esteem. Similar results were found in a cross-sectional survey about motives for PA, indicating that females reported higher motivation for appearance and physical condition than males, whereas males were more motivated by competition/ego and mastery than females (Molanorouzi et al., 2015).

It was suggested that gains may play a role in running maintenance, regardless of the nature of the expected benefits. Flow experienced in the race and vigor showed correlation with future running behavior. This supports the assumption that gains can function as a reward of the running activity, acting as moderators of the effects of motives, which leads to the desire to perform the activity again (Ingledew et al., 2014).

Ability, beliefs, attitudes, norms, perceived behavior control, and intention positively predicted running participation (Ajzen and Driver, 1991, 1992). This result agrees with the central idea of the Theory of Planned Behavior (Ajzen and Driver, 1991) that once an individual forms the intention to perform a behavior, he or she is extremely likely to actually behave in that manner and that it predicts how hard people are willing to try, and how much of an effort they are planning to exert in order to perform the behavior. However, many fail to translate their physical activity intentions into behavior. This intention–behavior gap can be explained by (a) explicit trait self-control, (b) implicit executive functions, and (c) their interactions (Pfeffer and Strobach, 2017).

Previous behavior and self-efficacy predicted future participation (Luszczynska et al., 2007; Scholz et al., 2008). These conclusions agree with the principles of the Socio-cognitive Theory (Bandura, 1982). Conversely, the difference in the strength of effects of intention and self-efficacy on behavior may depend on the particular type of self-efficacy. Among individuals who experienced lapses or who decline in their performance, recovery self-efficacy may be a stronger predictor of physical activity than just beliefs about the ability to maintain behavior, because these beliefs themselves are measured in a way more proximal to actual behavior.

The role of action planning and action control for predicting running behavior was also identified (Scholz et al., 2008),

suggesting that self-regulation skills may play an important role in running maintenance (Sniehotta et al., 2006; Carraro and Gaudreau, 2013; Reyes Fernandez et al., 2015). Both cognitive (need or importance) and affective (sign value or pleasure) elements of involvement showed to be predictors of participation among ultramarathon athletes. Runners are attracted to the sport through emotion (affective), then build self-perceived skill through facts and problem-solving (cognitive) (Mueller, 2012).

Outcomes of Recreational Running

There is considerable research on the relationship between exercise and its positive psychological outcomes. Running psychological benefits are interrelated, so differentiating one from another may not be possible. Among several possible causes, self-efficacy, thermogenic effect of exercise, hormonal response, and unclear neurobiological mechanisms are the strongest essential means (Szabo, 2013; Szabo and Abraham, 2013).

Results suggest a positive effect of running on mood after a single exposure. Methods (instruments, samples, and time frame) from the included studies on mood were quite different, but mood benefits included decreases in depression, anger, confusion, tension, and fatigue, as well as increase in vigor (Rendi et al., 2008; Berger et al., 2016). These results agree with previous reviews about the mood-enhancement effect of exercise (Basso and Suzuki, 2017; Chan et al., 2019) and may be partially explained by some neurosteroid blood level changes (Sonnenblick et al., 2018).

Well-being is a general positive psychological outcome associated with running. There is some evidence of a dose–response relationship. It is clearer regarding frequency than duration, maybe because of the influence of fatigue and physical pain related to long running bouts. It was studied as perceived health, psychological health, revitalization, tranquility, positive engagement, subjective feeling, arousal and positive orientation, and less physical exhaustion and positive orientation (Gorczyca et al., 2016; Bonham et al., 2018). Such findings are coherent with previous evidence that exercise may benefit for people of any age, improving psychological well-being and quality of life (Mandolesi et al., 2018), and can be partially justified by the effect of exercising in a natural environment (Lahart et al., 2019).

In agreement with the flow–exercise relationship found in the literature (Jackman et al., 2019), results from one intervention regarding experiences of flow were unsatisfying (Elbe et al., 2010). Results indicate that all groups experience rather high levels of flow regardless of the kind of sport (running or any other).

The registered reduction in depression, anxiety, stress, and life dissatisfaction were to some extent in harmony with the improvement of positive psychological outcomes and with previous systematic reviews of the effect of exercise on anxiety, depression, and quality of life (Ensari et al., 2015; Morris et al., 2018).

Though results suggest that running is associated with improved cognitive function, evidence is still scarce (Batmyagmar et al., 2019). Immediately upon completing the marathon, runners showed impairment in the explicit memory task, but enhancement in the implicit memory task (Eich and Metcalfe, 2009). Likewise, it seems that nonverbal fluency, attention, and neuromotor performance may be increased in runners or as a result of a running intervention, mediated by increased neurotrophic factor release (Harada et al., 2004). These results match those from two recent meta-analyses (Northey et al., 2018; Falck et al., 2019), suggesting that exercise improves cognitive function in both adults and older adults, reiterating the notion that exercise is a panacea for aging well.

These results generally agree with previous reviews of physical activity and exercise correlates. According to our findings, intrinsic motives, goal-setting, and other self-regulation skills seem to be the key antecedents of regular running. Hence, interventions that nurture intrinsic motives and behavior self-regulation skills may increase the likelihood of sustainable adoption of running. On the other hand, improvements in mood and well-being and reductions in depression and anxiety appear to be the main outcomes. For many other variables, studies remain very scarce preventing us from withdrawing firm conclusions regarding their role in recreational running.

This systematic review provides the first comprehensive approach to identify psychological and behavioral correlates of recreational running across populations. Like in other systematic reviews, the variety of studies available (variables, study designs, measurement methods, populations represented, and so forth) is a substantial limitation. In this review, the heterogeneity of research designs, assessment instruments, correlates, populations, and intervention (running) characteristics hindered the process but simultaneously enriched its results.

Strengths and Limitations

Despite the findings of the review, a number of limitations must be considered. The search strategy was limited to English-language publications, and thus, there is a possibility of a language bias in the systematic review. Unpublished studies and evidence from gray literature were not included, increasing the chance of an incomplete picture of all the studies in this field. Also, due to the heterogeneity of research designs, instruments, correlates, populations, and intervention, it was not possible to conduct a meta-analysis to determine the strength of the correlation between all the correlates and the running behavior itself. Few studies were found for some of the correlates, hindering solid conclusions or interpretations. Finally, many of the included studies had a cross-sectional design, hampering the possibility of causality inference between variables. Future avenues of research could explore further which psychological mechanisms better explain recreational running sustainability and manipulate them but also clarify by which mechanisms running produces its positive outcomes. The popularity of running self-monitoring tools and the possibility to access application programming interface data represent an opportunity to study the association between behavior (measured in multiple data points) and its phycological correlates. To allow the establishment

of causality association, longitudinal research designs are recommended. This information can contribute to inform and guide interventions focused on helping people sustain regular physical activity, through an activity they have chosen and appear to enjoy.

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.

AUTHOR CONTRIBUTIONS

HP contributed in the design, search, data extraction, quality assessment, and manuscript. JE and MM contributed for the search, data extraction, quality assessment, and manuscript. AP, IS, EC, and PT contributed in the design, manuscript, and supervision of the overall process. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.624783/full#supplementary-material

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SYSTEMATIC REVIEW
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What Intervention Techniques Are Effective in Changing Positive Affective Variables and Physical Activity? A Systematic Review and Meta-Analysis

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A recent meta-analysis has demonstrated that positive affective variables (PAVs) partially mediate physical activity (PA) interventions. However, the effectiveness of each intervention technique on PAVs and PA is still unknown. Thus, this meta-analytic review included two primary objectives: (1) to summarize intervention effects on PA and PAVs; (2) to examine each behavior change technique's effectiveness in modifying PAVs and PA. Following PRISMA protocols, we had searched five electronic databases by April 1, 2020. The random-effect model in the Comprehensive Meta-Analysis Version 3 was adopted to perform these meta-analytic analyses. The search identified 1,742 articles, and 37 studies (49 datasets) met our inclusion criteria. Finally, inferential statistics yielded that: the utilization of "teach to use prompts/cues," "facilitate social comparison," and "provide information on consequences of behavior in general" had positive effects on PA or PAVs outcomes; the utilization of "barrier identification/problem solving" and "plan social support/social change" negatively affected on PA or PAVs outcomes. However, there was considerable heterogeneity in the findings. Nonetheless, this paper has considerable implications for guiding future comparative intervention studies to achieve more reliable outcomes.

Keywords: intervention, technique, positive affective variable, physical activity, moderator

INTRODUCTION

Regular physical activity (PA) is highly beneficial for the prevention of premature mortality (Ekelund et al., 2016) and for physical and mental health (Penedo and Dahn, 2005). However, only a minority of modern adults report that their PA participation levels align with most public health guidelines. Besides, a further 50% of exercisers drop out within the first 6 months after initial participation (Finne et al., 2019). Exploring ways to promote and maintain PA is necessary because the benefits are not sustainable without consistent and regular attendance (Annesi, 2003).

The Unfavorable Commonality in Mainstream Physical Activity Change Theories

Current mainstream theoretical approaches used for PA interventions include social cognitive theory (SCT; Bandura, 1998), the theory of planned behavior (TPB; Ajzen, 1991), the trans-theoretical model (TPB; Prochaska and Velicer, 1997), and self-determination theory (SDT; Deci et al., 1994). According to SCT, PA variations are regulated by reciprocal determinations among personal cognitive factors (e.g., self-efficacy, outcome expectations, knowledge), the physical and social environment (e.g., observational learning, normative beliefs, social support, opportunities, and barriers), and behavioral factors (e.g., behavioral skills, intentions, reinforcement) (Bandura, 2004). TPB comprises three core components, namely, attitude, subjective norms, and perceived behavioral control, which together shape individuals' PA intentions and behavior (Ajzen, 1991). The TTM has concentrated on stages of change, processes of change, levels of change, self-efficacy, and temptation (Prochaska and Velicer, 1997). And SDT emphasizes the role of autonomy, competence, and relatedness for PA interventions (Deci and Ryan, 2008). All of these theories share a core attribute that stems from cognitivism. In detail (1) they all emphasize the primacy of imagined end states (behaviors or goals) (Brand and Ekkekakis, 2018) in PA change, and (2) affective constructs are either entirely omitted or subordinated to cognitive devices, while the idea that affective constructs can serve as motivational forces outside of cognitivism (e.g., momentary emotions associated with physical activity situations; Ekkekakis, 2017) is ignored. Consistent with these theories, PA interventions have focused primarily on techniques that provide education about PA's benefits, build perceived ability, and self-regulation to perform PA (Conn et al., 2011; Chase, 2015; Rhodes et al., 2019). However, even as the framework predicting the highest amount of PA variance, the social cognitive theory can only explain, on average, 20% of the variation in PA maintenance (Jekauc et al., 2015). Rhodes et al. (2009a) integrated 34 PA intervention studies, and found that 85% of the findings showed that affective expectations were notable predictors of PA behavior ($r = 0.43$; 95% CI = 0.36–0.46), whereas only 35% of the findings showed that instrumental expectations were significant predictors of PA behavior ($r = 0.25$; 95% CI = 0.21–0.29). Hence, perhaps the failure to separate the affective and instrumental reflections or expectations of the intervention on PA hinders the exploration process of PA promotion (McEwan et al., 2016; Jekauc and Brand, 2017). Therefore, a more refined meta-analysis dedicated to affective variables and PA is inevitable (Jekauc et al., 2015).

Definitions of Positive Affective Variables

In general, "affect is the experiential state of feeling and is a collective term describing feeling states such as emotion and mood" (Gellman and Turner, 2013). Affective states may vary in several aspects, such as their duration, intensity, specificity, pleasantness, and degree of arousal, and they have essential roles in regulating cognition, behavior, and social interaction. As a superordinate category, emotions and moods belong to affect. Emotions and moods differ mainly in (1) their duration: emotions are rather brief and intense experiences, and moods last somewhat longer than emotions, and (2) whether they are directed to a specific cause: emotions are reactions to specific external stimuli (i.e., objects or events) and may arise relatively automatically or after a cognitive assessment of the stimulus; moods are more diffuse in nature (Gellman and Turner, 2013). Furthermore, the concept of attitude is considered to represent relatively enduring beliefs and preferences for a particular organism and is primarily composed of cognitive, affective, and motivational components (Breckler, 1984). Contrary to the caution of theorists, namely that these concepts should be distinguished, affect, emotion, feeling, mood and affective attitude (Ostrom, 1969) are often used liberally in empirical researches (Batson et al., 1992). Thus, this paper integrated them into a generalized term as affective variables. Besides, some other theorists have noted that organizing affective variables by dimension may be more meaningful than considering them by category (Cacioppo and Gardner, 1999; Watson et al., 1999; Shiota and Kalat, 2012). Thus, we generalized non-negative affect, emotion, feeling, mood, and affective attitude and use the term "positive affective variables (PAVs)" to refer to them.

Approach-Avoidance Distinction of Affective Variables and Motivation in Physical Activity

According to existing research, the approach-avoidance distinction is applicable in affective variables (positive and negative affective dispositions) (Watson et al., 1999). The neurological underpinnings have also given evidence of this linkability between motivation and emotion through affective neuroscience (Davidson, 2003). As Larsen et al. (2008) stated, "motivation and valence tend to be correlated, such that positive emotions are associated with approach and negative emotions with avoidance." Consistently, it could also be shown that positive emotions (e.g., enjoyment) during PA and intrinsic motivation for PA possibly share common determinants (Wienke and Jekauc, 2016). Furthermore, several other theoretical and empirical studies also have shown that PAVs are essential determinants of PA behavior or outcomes (Rhodes et al., 2009b). Following the upward spiral theory of lifestyle change, motivation is significantly associated with positive affects experienced during healthy behaviors, and motivational salience subconsciously guides attention to these behaviors and decisions to repeat them (van Cappellen et al., 2018). Further, a recent meta-analysis emphasized that the PAV emerges as a significant mediator between intervention and PA outcomes (Chen et al., 2020). Based on these neuroscientific, theoretical, and empirical fundamentals, enhancing PAVs is more likely to facilitate physical activity than activities that rely primarily on extrinsic motivation, such as those expected to improve health and well-being (Nielsen et al., 2014).

Empirical Studies on Positive Affective Variables and Physical Activity

In recent years, there has been an upsurge of enthusiasm to consider the role of PAVs in PA prescribing more (e.g., Ekkekakis et al., 2013, 2020), but our knowledge of how to change PAVs and subsequent PA remains deficient. So far, Rhodes and his colleagues have conducted three reviews (Rhodes et al., 2009a, 2019; Rhodes and Kates, 2015), which summarized the relationship between affective response/affective judgment (i.e., thoughts about the overall pleasure/displeasure, enjoyment, and feeling states expected from enacting a behavior) and PA. Initially, through 82 correlational studies and 20 eligible experimental studies, Rhodes et al. (2009a) demonstrated a medium-effect size relationship between affective judgment and PA. A significant positive correlation between affective judgments and PA was reported in 83 out of 85 correlational samples, with a pooled r of 0.42 (95% CI = 0.37–0.46). A further meta-analytic synthesis was reported in 2015. It stated that positive changes in primary affective responses during moderate-intensity exercise were associated with future PA intention (Rhodes and Kates, 2015). A recent review explored interventions to manipulate adults' (of healthy and unhealthy populations) affective judgments and subsequent PA, but no technique was considered adequate (Rhodes et al., 2019). We speculate that two main reasons influenced these results. First, it is well-known that many diseases (e.g., Alzheimer's disease) can change emotional regulation (Bucks and Radford, 2004), so it is necessary to distinguish between healthy and unhealthy populations. Second, we presumed that Rhodes et al. (2019) did not distinguish between intrinsic motivation and affect in the literature inclusion (Silva et al., 2010a,b; Moustaka et al., 2012; Kinnafick et al., 2016; Shah et al., 2016) leading to these outcomes. According to Weinberg and Gould (2014, pp. 139), intrinsic motivation includes knowledge, accomplishment, and stimulation, while affect is merely a part of intrinsic motivation (stimulation). Besides, we desired to exclude negative affective variables from this study (Egloff, 1998; Reich et al., 2001). The reasons were: (1) Reich et al. (2001) conducted two experiments based on the two-factor model and the bipolar model, which showed that the cognitively more complex participants reported the mutual independence of positive and negative affect, while those with simpler cognitions reported the polarity of positive and negative affect, which meant that positive and negative affects could be differentiated for exploration; (2) as we described in the previous paragraph, the approach-avoidance distinction was also applicable in the affective variables; (3) Chen et al. (2020) distinguished between positive and negative affective variables and demonstrated the significant mediating role of PAVs in the PA intervention. Overall, we would like to implement a more nuanced meta-analysis to understand how PAVs and PA can be manipulated in healthy populations.

Considering the aforesaid, this paper included two primary objectives. First, to summarize intervention effects on PA and PAVs; second, examine each behavior change technique's effectiveness in modifying PAVs and PA and exploring potential demographic and methodological moderators. That is, we investigated (1) which methodological factors moderated the outcomes of PAVs and PA (e.g., study design, theory framework, intervention duration, measurement, number of intervention techniques used); (2) which demographic characteristics moderated the results of PAVs and PA interventions (e.g., age, gender, population setting, PA level at baseline); (3) which behavior change techniques (BCTs) were the most effective for PAVs and PA interventions.

METHODS

Search Strategy and Inclusion Criteria

The literature search was conducted according to the PRISMA standard protocol (Moher et al., 2009) (see **Figure 1**). A structured electronic search strategy was used to retrieve studies published by April 1, 2020. The databases searched included Web of Science, PubMed, PsycINFO, PsycArticle, and Psychology and Behavioral Sciences Collection. The search terms were: (1) Intervention OR Trial OR Experiment; (2) Physical Activity OR Exercise; (3) Enjoy* OR Affect* OR Emotion* OR Mood* OR Feeling; (4) Mechanism* OR Mediat* OR Predict* OR Process* OR "Structural equation modeling" OR Caus* OR Path* OR Correlat* OR Relationship OR Associat*; (5) NOT (Patient* OR Cancer OR Clinical OR Disease* OR Illness OR Depression OR Rat OR Mouse OR Protocol OR Cell OR Bone* OR Blood OR Rehabilitation OR Disorder* Injur* OR HIV OR Carbohydrate OR Athlete* OR Player* OR Runner* OR Review OR Comment OR Therapy); (6) 1 AND 2 AND 3 AND 4 AND 5. Besides, more than 98 percent of the search results were in English, and very few studies were published in other languages. Hence, we only included studies published in English for the accuracy of data extraction.

The first author completed the search, and the eligibility of each study was determined by the Cochrane handbook for systematic reviews of intervention studies (Higgins et al., 2019b). Studies in which the first author was unsure whether to be included were discussed and determined with the last author. A study was eligible for our meta-analysis if it met the following criteria: (1) experimental studies assessing PAV as a dependent variable; (2) PAV was a target of the intervention; (3) studies whose goal was to increase lifestyle or recreational PA, not for competitive sports (Caspersen et al., 1985; Vanhees et al., 2005); (4) sufficient data to calculate the effect sizes (Hedges' g) of PAVs and PA; (5) participants were healthy individuals (not a clinically defined population and not pregnant). Furthermore, we intentionally chose a minimum duration of PA of 10 min, given that 10 min is the recommended minimum duration of exercise to elicit health benefits (Edwards and Loprinzi, 2019).

Data Extraction and Data Analysis

First, the risk of bias assessment was administered using the STROBE standard tool (Elm et al., 2007). The tool includes questions in a "yes" (1) or "no" (0) format (e.g., did the study report the sources and details of PA assessment; did the instruments have acceptable reliability for the specific age group?). Study qualities were assessed by the first and last authors

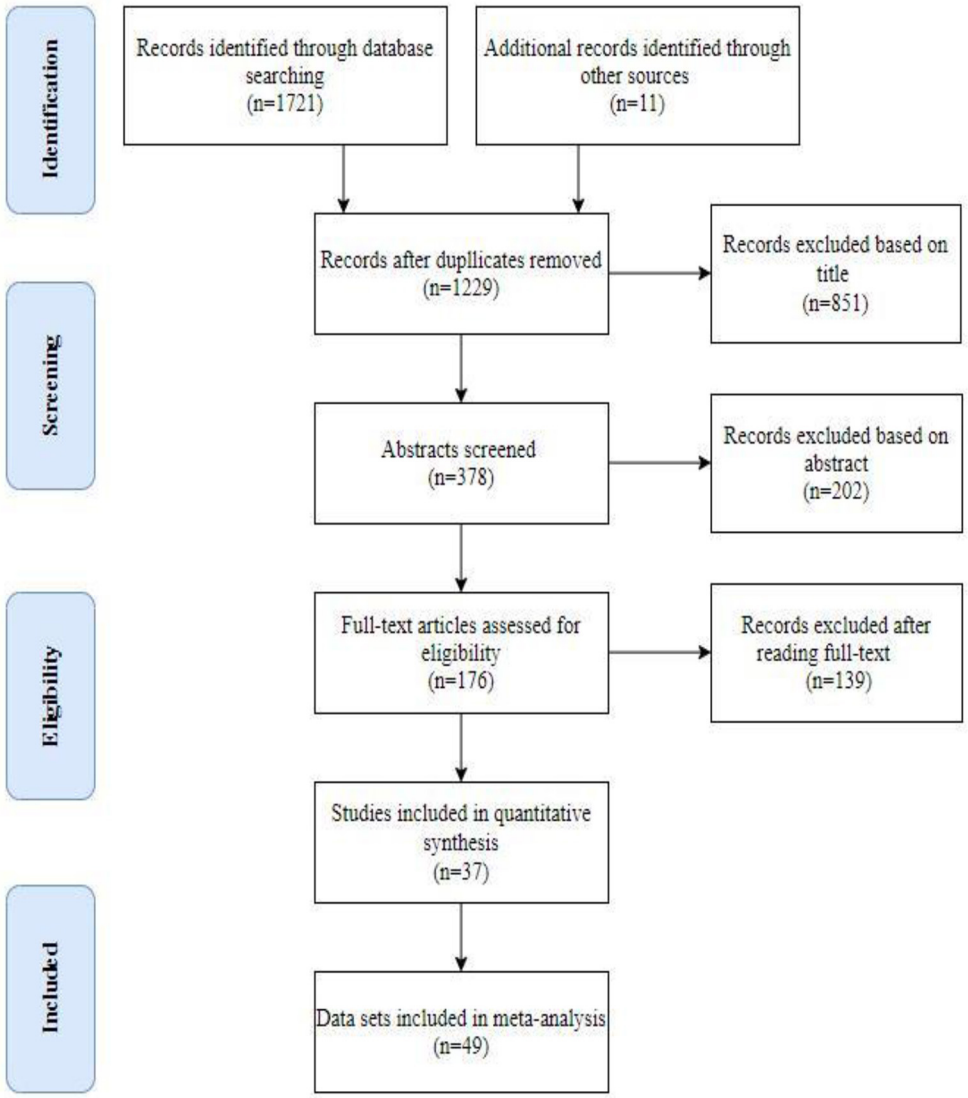

FIGURE 1 | PRISMA flow diagram for articles identified, screened eligible, and included in this paper.

separately, and any differences were resolved through discussion. The studies' quality was then graded as low (scores 0–2), medium (scores 3–4), or high (scores 5–6).

Next, with the supervision and guidance of the last author, the first author completed the extraction of the following data: BCTs; the PAVs' constructs, dimensions, and measurements; PA assessment methods, variables, measures; methodological data (e.g., study design, theory framework, intervention duration, measure employed, number of intervention methods used, primary intervention targeted, PA focus); demographic data (e.g., age, gender, population setting, PA level at baseline). Data for BCTs were extracted based on the 40-item taxonomy by Michie et al. (2011). Coyne et al. (2010) pointed out that several small sample studies can be included in a meta-analysis, but if a meta-analysis includes many small sample studies, it may result in a large bias in its effect size. For this reason, we classified each trial according to whether its sample size was >35 (Kraemer et al., 1998; Coyne et al., 2010) and calculated the sample size as a moderator variable in the calculation.

Finally, we adopted the statistical procedure utilized by Ashford et al. (2010) and Williams and French (2011). The random-effect model in the Comprehensive Meta-Analysis Version 3 (Borenstein et al., 2014) was employed in the calculation. Based on the raw data, we employed Hedges' g to estimate effect sizes (i.e., the adjusted standardized mean difference for both PAVs data and PA data between post-test means in intervention and control group where possible, or pre and post-test means of the intervention group) (Durlak, 2009). With multiple measurement time points, we chose the first measurement taken at the end of the intervention (Higgins

et al., 2019b) because those results could maximally be influenced by different interventions and less influenced by other factors relative to the follow-up measurements. To overcome the potential unit-of-analysis error due to the inclusion of multi-arm studies, several approaches have been proposed by Higgins et al. (2019a). Specifically, when exploring the moderating effects of each methodological and demographic variable, we combined all intervention groups within a study to create a single pair-wise comparison (Higgins and Li, 2019). We then computed the summary effect for this intervention group vs. the control group. However, when performing moderator analyses for BCTs, we included each pair-wise comparison separately, but shared control groups were divided into several smaller groups for the different comparisons to avoid "double counting." Moderator analyses were limited to categories with at least three studies. The findings' heterogeneity was examined using the Q-statistic (Higgins et al., 2003; Hedges and Pigott, 2004); a 5% cut-off was used for significance. The Q coefficient's significance represents the heterogeneity of the dataset beyond what would be expected from sampling error alone, suggesting that additional systematic factors contribute to the variance. Therefore, we performed moderator analyses to explore the causes of heterogeneity by comparing the mean variability of effect size estimates for two groups of studies characterized by the presence or absence of a specific study characteristic (e.g., a specific BCT) (Ashford et al., 2010). Finally, we explored publication bias using Egger's regression intercept (i.e., a statistical test result for funnel plot asymmetry), and a 5% cut-off was used for significance.

RESULTS

Study Flow and Characteristics

The search identified 1,732 articles, of which 1,352 were duplicates or could be excluded based on the titles. Of the remaining 389 articles, there were 183 articles for full-text review, of which 11 were identified by cross-referencing (see **Figure 1**). Finally, 37 studies met our inclusion criteria (see **Appendix 8**), of which ten studies contained two or three subgroups (Focht et al., 2007; Rose and Parfitt, 2007; Schneider and Cooper, 2011; Fitzsimons et al., 2012; Kraft et al., 2015; Wang et al., 2015; Niedermeier et al., 2017; Noradechanunt et al., 2017; Miragall et al., 2018; Gråstén and Yli-Piipari, 2019). Due to the nature of the data to be analyzed, we included each pair-wise comparison separately when investigating BCTs' moderating effects on PAVs and PA and therefore included a total of 49 data sets. In case of multiple comparisons to the same reference group, we split the control group as described above. Meanwhile, the quality of each study is presented in **Appendix 1**. Of the 37 studies, six were rated as high quality, 17 were rated as low quality, and the remaining 20 studies were rated as moderate quality.

Furthermore, the general characteristics of the 37 studies are presented in **Appendix 2**. Then, **Table 2** presents the overall study characteristics of the 37 studies. Concerning the age of the participants, four age intervals were designed to classify the mean age of each study: under 18 years ($n = 15$), 18–35 years ($n = 13$), 36–60 years ($n = 7$), and over 60 years ($n = 2$). In terms of gender distribution, only one group identified its gender as male, 11 studies defined its gender as female, and the remaining 25 studies were mixed gender. For baseline PA, we marked out four classifications as "not meeting PA guidelines at baseline" ($n = 17$), "meeting PA guideline at baseline" ($n = 3$), "mixed" ($n = 9$), and "unreported" ($n = 8$). 33 of the 37 studies stated their theoretical underpinnings, while the other four did not. In addition, 16 interventions were implemented based on multiple theoretical frameworks, and 17 interventions were based on a single theoretical framework (TTM $n = 3$, SCT $n = 3$, TPB $n = 3$, SDT $n = 3$, the dual-mode model $n = 1$, challenge point theory $n = 1$, tactical games model $n = 1$, affective reflective theory $n = 1$, the health promotion model $n = 1$). The intervention duration of the included individual groups ranged from <3 h−4 years, but the majority was between 2 and 6 months ($n = 12$). Only 13 of the 37 studies randomized their subjects. Furthermore, over 55 percent of the interventions were performed in schools, colleges, and university laboratories.

Contents of BCTs

The intervention techniques employed by each intervention group are summarized in detail in **Appendix 5**. According to Michie et al. (2011), the 49 independent intervention groups used 2–17 intervention techniques, of which seven interventions employed no more than three intervention techniques, 23 interventions employed 4–10 intervention techniques, and 20 studies employed more than 10 intervention techniques. Further, **Table 1** presents the frequency of use of each intervention technique across all included studies. The most frequently used intervention techniques were (1) provide instruction on how to perform the behavior (83.67%), (2) provide instruction on when and where to perform the behavior (81.63%); (3) action planning (57.14%), and model/demonstrate the behavior (57.14%). Six intervention techniques were not employed by any of the included studies: (1) shaping; (2) prompt generalization of a target behavior; (3) prompt identification as a role model/position advocate; (4) prompt anticipated regret; (5) fear arousal; (6) stimulate anticipation of future rewards. Five other intervention techniques were rarely used: (1) provide information on consequences of behavior to individual (4.08%); (2) prompting focus on past success (4.08%); (3) agree behavioral contract (4.08%); (4) provide rewards contingent on effort or progress toward behavior (2.04%); (5) provide rewards contingent on successful behavior (2.04%).

Characteristics of PAVs

Appendix 3, **Table 2** presents the constructs, dimensions, and measurements of each study's PAVs. First, PAVs could be categorized into two broad constructs of affects and emotional states (Shouse, 2005), with several studies measuring both of them. The dimensions of affect included "affective valence" and "positive affect," and the measurement methods were "feeling scale (FS)" and "positive and negative scale (PANAS)." Emotional states were further categorized as "enjoyment," "pleasure," "exercise-induced feeling," "affective attitude," and "mood state." There were various dimensions and methods to measure emotional states, and the most frequently measured dimension

TABLE 1 | Frequencies of intervention techniques that were used in the intervention groups in meta-analytic analyses.

Techniques		Number of intervention groups (maximum 49)	Percentages (%)
1	Provide information on consequences of behavior in general	15	30.61
2	Provide information on consequences of behavior to individual	2	4.08
3	Provide information about others' approval	9	18.37
4	Provide normative information about others' behavior	5	10.20
5	Goal setting (behavior)	19	38.78
6	Goal setting (outcome)	6	12.24
7	Action planning	28	57.14
8	Barrier identification/problem solving	18	36.73
9	Set graded tasks	10	20.41
10	Prompt review of behavioral goals	13	26.53
11	Prompt review of outcome goals	3	6.12
12	Provide rewards contingent on effort or progress toward behavior	1	2.04
13	Provide rewards contingent on successful behavior	1	2.04
14	Shaping	0	0
15	Prompt generalization of a target behavior	0	0
16	Prompt self-monitoring of behavior	24	48.98
17	Prompt self-monitoring of behavioral outcome	4	8.16
18	Prompting focus on past success	2	4.08
19	Provide feedback on performance	20	40.82
20	Provide instruction on when and where to perform the behavior	40	81.63
21	Provide instruction on how to perform the behavior	41	83.67
22	Model/demonstrate the behavior	28	57.14
23	Teach to use prompts/cues	6	12.24
24	Environmental restructuring	15	30.61
25	Agree behavioral contract	2	4.08
26	Prompt practice	7	14.29
27	Use of follow-up prompts	3	6.12
28	Facilitate social comparison	4	8.16
29	Plan social support/social change	25	51.02
30	Prompt identification as a role model/position advocate	0	0
31	Prompt anticipated regret	0	0
32	Fear arousal	0	0
33	Prompt self-talk	4	8.16
34	Prompt use of imagery	9	18.37
35	Relapse prevention/coping planning	3	6.12
36	Stress management/ emotional training	24	48.98
37	Motivational interviewing	6	12.24
38	Time management	4	8.16
39	General communication skills training	5	10.20
40	Stimulate anticipation of future rewards	0	0

was "enjoyment." Still, there were also "remembered pleasure," "revitalization," "positive engagement," "vigor," "activation," and "excitement." Accordingly, there were various scales for measuring emotional states, for example, "the physical activity enjoyment scale (PACES)," "the PE enjoyment scale (PEES)," "visual analog scale (VAS) of enjoyment/remembered pleasure," "the interest/enjoyment subscale of intrinsic motivation inventory (IMI)," "single-item enjoyment scale (SES)," "exercise-induced feeling inventory (EFI)," "semantic differential scale of affective attitude (SD)," "profile of mood states (POMS)" and "mood survey scale (MSS)."

Characteristics of PA

In general, there were two broad categories of PA measurements: objective and subjective. **Appendix 4**, **Table 2** shows that objective and subjective measures were about equally divided. The primary four objective measurements were the recording list (equipment usage log/attendance list), pedometer, accelerometer,

TABLE 2 | Overall study characteristics of 37 studies.

Characteristics	*N* of intervention groups (maximum 37)	Percentages (%)
Age		
<18	15	40.54
18–35	13	35.14
36–50	7	18.92
50–75	2	5.41
Gender		
Male	1	2.7
Female	11	29.73
Mixed	25	67.57
Sample size		
<35 participants per condition	10	27.03
≥35 participants per condition	27	72.97
Intervention duration		
≤3 h	6	16.22
3 h–2 months	11	29.73
2–6 months (including 2 months)	12	32.43
>6 months	8	21.62
Number of intervention methods used		
1–3 methods used	3	8.11
4–10 methods used	17	45.95
4–11 methods used	17	45.95
Setting		
School	12	32.43
University	4	10.81
Lab	4	10.81
Community	5	13.51
Other	12	32.43
The physical activity level at baseline		
Not meeting guideline	17	45.95
Meeting guideline	3	8.11
Mixed	9	24.32
Unreported	8	21.62
Positive affective variables measure		
Affect	6	16.22
Emotional state	24	64.86
Affect and emotional state	7	18.92
Positive affective variables_measurements		
The physical activity enjoyment scale	13	35.14
The positive and negative affect schedule	4	10.81
Feeling scale	3	8.11
IMI	2	5.41
Semantic differential scales of affective attitude	2	5.41
Affective attitude Likert scale	1	2.70
Profile of mood states	1	2.70
Single-item enjoyment scale	1	2.70
The PE enjoyment scale	1	2.70
VAS	1	2.70
Multiple	8	21.62
Physical activity measure		
Moderate-vigorous physical activity (objective)	2	5.41
Moderate-vigorous physical activity (subjective)	9	24.32
Steps	4	10.81
Frequency	6	16.22
Intensity	6	16.22
Multiple	10	27.03
Physical activity measurements		
Equipment usage log/attendance list	5	13.51
HR monitoring	5	13.51
Pedometer	4	10.81
Accelerometer	3	8.11
2/3/7 day physical activity recall	3	8.11
International physical activity questionnaire	2	5.41
Leisure-time exercise questionnaire	2	5.41
Other questionaires	8	21.62
Multiple	4	10.81
Not reported	1	2.70
Theory		
No framework explicitly mentioned	4	10.81
Social cognitive theory	3	8.11
The transtheoretical model	3	8.11
Theory of planned behavior	3	8.11
Self-determination theory	3	8.11
Multiple	16	43.24
Others	5	13.51
Study design		
Randomized controlled study	13	35.14
Quasi-experimental study	24	64.86
Study quality rating		
Low (1–2)	7	18.92
Medium (3–4)	24	64.86
High (5–6)	6	16.22

IMI, the interest/enjoyment subscale of intrinsic motivation inventory; VAS, visual analog scale of enjoyment/ remembered pleasure.

and heart monitor. In contrast, subjective measures of PA were diverse. For example, 7-day physical activity recall (7DPAR), 3-day physical activity recall (3DPAR), the short-form of the international physical activity questionnaire (IPAQ), physical activity time-consuming questionnaire (PATCQ), the children's leisure activities study survey (CLASS), 6-point exercise frequency scale (EFS). The PA variables measured by the studies were also highly diverse, for example, moderate to vigorous physical activity (MVPA), leisure-time physical

activity (LTPA), the metabolic equivalent of task (MET), exercise adherence, equipment usage, %Max HR.

Moderating Effect of Methodological and Demographics Variables on PAVs and PA

Meta-analytic moderation results of the 37 studies can be found in **Table 3**. We first reported the moderating effects of demographic and methodological factors on PAVs. Experimental manipulations of PAVs had an overall effect size $g = 0.28$ (95% CI = 0.14–0.41) on PAVs (see **Appendix 6**). The examination of publication bias for the 37 studies was significant [Egger's intercept $t = 1.65$ (35), $p = 0.02$] (see **Figure 2**), and in cases such as this with small samples and large heterogeneity, caution should be exercised (Carter et al., 2019). Using the $n = 35$ criterion proposed by Coyne et al. (2010), small-sample bias was a significant moderator in the PAV ($Q = 6.64$; $p = 0.01$) context, with larger effect size ($g = 0.32$, 95% CI = 0.08–0.57) reported for small sample sizes. Age was also a significant moderator to the findings ($Q = 12.73$, $p < 0.05$), mean age interval located between 36 and 50 years reported the largest effect size ($g = 0.48$, 95% CI = 0.12–0.84). There was also a significant moderating effect of gender on PAVs, with the largest effect size for mixed-gender studies ($g = 0.30$, 95% CI = 0.12–0.48). Similarly, there was a significant moderating effect of intervention duration on PAVs, with the largest effect size for intervention duration between 2 h and 2 months ($g = 0.69$, 95% CI = 0.07–1.31). The theory was also a significant moderator in PAVs intervention, with SDT having the largest effect size ($g = 0.80$, 95% CI = 0.33–1.27). However, neither the intervention setting ($Q = 5.83$, $p = 0.21$) nor the baseline level of PA ($Q = 6.54$, $p = 0.09$) were significant moderators in our PAVs investigation.

Next we would report the moderating effects of demographic and methodological factors on PA. The overall effect size of interventions on PA was $g = 0.30$ (95% CI = 0.10–0.48) (see **Appendix 7**). However, the Egger regression intercept for the PA data was not significant ($t = 1.84$ (35), $p = 0.07$) (see **Figure 3**). The results of meta-analytic moderation analyses showed that small sample bias was not a significant moderator of PA outcomes ($Q = 0.01$, $p = 0.91$). Age was a significant moderator of PA outcomes ($Q = 19.23$, $p < 0.01$), with a maximum effect size reported for the mean age between 18 and 35 years ($g = 0.44$, 95% CI = −0.10 to 0.97). Gender was also a significant moderating variable ($Q = 11.53$, $p < 0.01$), with the mixed gender sample reporting larger effect size ($g = 0.46$, 95% CI = 0.23–0.70). In addition, theory was also a significant moderator of PA outcomes ($Q = 14.80$, $p = 0.02$), with the lagest effect sizes of "others" ($g = 1.03$, 95% CI = 0.18–1.88).

Moderating Effect of Contents Applied in the Intervention on PAVs and PA

We performed 29 meta-analytic moderation analyses based on a refined taxonomy of intervention techniques (Michie et al., 2011; see **Table 1**). It was not sensible to perform moderating analyses for the remaining 11 techniques because fewer than three intervention groups utilized them. Refer to **Appendix 5** for details of the intervention techniques used in each intervention group.

The presence of two intervention techniques increased the variations in PAVs. They were "teach to use prompts/cues" (present $g = 0.73$; absent $g = 0.26$, $p = 0.02$) and "facilitate social comparison" (present $g = 0.98$; absent $g = 0.26$, $p = 0.01$). However, the application of two other intervention techniques could reduce the outcomes of PAVs. They were "barrier identification/problem solving" (present $g = 0.09$; absent $g = 0.45$, $p = 0.01$) and "plan social support/social change" (present $g = 0.19$, absent $g = 0.45$, $p = 0.04$). None of the other 25 techniques included in the moderator analysis differed significantly in their effect size estimates between the two study groups, irrelevant of whether they included a specified technique or not (see **Table 4**).

The presence of three intervention techniques increased the variations in PA. They were "provide information on consequences of behavior in general" (present $g = 0.54$; absent $g = 0.26$, $p = 0.04$), "teach to use prompts/cues" (present $g = 1.33$; absent $g = 0.25$, $p < 0.01$) and "facilitate social comparison" (present $g = 0.97$; absent $g = 0.3$, $p = 0.02$). However, the application of another intervention technique could reduce the outcomes of PA. It was "barrier identification/problem solving" (present $g = 0.19$; absent $g = 0.46$, $p < 0.05$). None of the other 25 techniques included in the moderator analysis differed significantly in their effect size estimates between the two study groups, irrelevant of whether they included a specified technique or not (see **Table 4**).

DISCUSSION

This paper intended to provide a nuanced summary of the characteristics of current research methodologies for PAVs and PA interventions, identify intervention techniques that have been used sparingly, and determine the most compelling theories and techniques in recent researches. Therefore, this investigation had two series of objectives. First, summarize experimental studies targeting PAVs in order to change PA and their characteristics (study characteristics, BCT characteristics, PAV characteristics, PA characteristics); second, investigate the moderating effects of methodology, demographics, and BCTs.

The Characteristics of Demographics and Methodologies

The retrieved studies suggest that 83.78% of the included studies were of moderate or low quality, only about a third were RCTs, and approximately half were small sample studies. Besides, the majority of the retrieved studies were set in schools or universities, and only one study setting was the worksite. Approximately 70% of the studies did not specify subject genders; nearly 30% of the interventions targeted females only, with only one study exclusively targeting male subjects. Approximately 45% of the studies did not report on the subjects' PA level at baseline ("not meeting guideline" or "meeting guideline"), and the role of PAVs for different initial exercise conditions remained to be explored. Besides, PAVs were measured in various formats and dimensions, but no studies explained the differences and commonalities between those different formats and dimensions.

TABLE 3 | Demography and methodology effects of experimental effects on PAVs and PA.

	PAVs							PA						
	k	*g*	SE	95% CI		*Q*	*p*	*k*	*g*	SE	95% CI		*Q*	*p*
Point estimate	37	0.28	0.07	0.14	0.41	202.89	0	37	0.30	0.10	0.11	0.48	412.08	0
Age						12.73	<0.05						19.23	<0.01
<18	15	0.14	0.11	−0.09	0.36			15	0.36	0.17	0.03	0.69		
18–35	13	0.31	0.10	0.11	0.51			13	0.44	0.27	−0.10	0.97		
36–50	7	0.48	0.18	0.12	0.84			7	0.37	0.09	0.18	0.55		
Gender						14.33	<0.01						11.53	<0.01
Female	11	0.07	0.06	−0.05	0.19			11	−0.08	0.15	−0.39	0.22		
Mixed	25	0.30	0.09	0.12	0.48			25	0.46	0.12	0.23	0.70		
Sample size						6.64	0.01						0.01	0.91
<35	17	0.32	0.12	0.08	0.57			17	0.31	0.16	−0.01	0.62		
≥35	20	0.21	0.08	0.05	0.37			20	0.28	0.12	0.05	0.51		
Intervention duration						8.24	0.03						2.59	0.46
≤3 h	6	0.38	0.14	0.09	0.66			6	0.89	0.71	−0.50	2.27		
3 h−2 months	11	0.69	0.32	0.07	1.31			11	0.29	0.12	0.05	0.53		
2– 6 months (including 2 months)	12	0.13	0.08	−0.04	0.29			12	0.00	0.19	−0.37	0.37		
>6 months	8	0.09	0.07	−0.05	0.22			8	0.24	0.08	0.08	0.40		
Number of intervention methods used						6.40	0.04						3.99	0.14
1–3 methods used	3	0.19	0.12	−0.05	0.43			3	0.12	0.17	−0.21	0.44		
4–10 methods used	17	0.49	0.14	0.22	0.75			17	0.55	0.18	0.20	0.90		
>10 methods used	17	0.11	0.06	−0.02	0.23			17	0.16	0.11	−0.06	0.38		
Setting						5.83	0.21						3.21	0.36
School	12	0.08	0.08	−0.06	0.23			12	0.09	0.07	−0.05	0.24		
University	4	0.44	0.30	−0.14	1.03			4	−0.89	0.91	−2.68	0.90		
Lab	4	0.18	0.18	−0.17	0.53			4	0.38	0.16	0.07	0.69		
Community	5	0.49	0.19	0.11	0.87			5	0.53	0.08	0.38	0.68		
Other	12	0.33	0.16	0.02	0.64			12	0.40	0.22	−0.03	0.84		
Physical activity at baseline						6.54	0.09						4.00	0.26
Not meeting guideline	17	0.11	0.07	−0.03	0.26			17	0.23	0.08	0.08	0.38		
Meeting guideline	3	0.69	0.28	0.14	1.24			3	0.62	0.35	−0.07	1.32		
Mixed	9	0.45	0.17	0.11	0.78			9	0.62	0.32	−0.01	1.25		
Unreported	8	0.22	0.15	−0.08	0.52			8	−0.01	0.21	−0.43	0.40		
Positive affective variables measure						0.25	0.88						2.84	0.24
Affect	6	0.25	0.06	0.13	0.37			6	0.23	0.14	−0.05	0.50		
Emotional state	24	0.22	0.09	0.05	0.38			24	0.15	0.10	−0.05	0.34		
Affect and emotional state	7	0.34	0.25	−0.16	0.83			7	0.94	0.47	0.02	1.85		
Physical activity measure						9.11	0.10						5.44	0.36
MVPA (subjective)	9	0.16	0.09	−0.02	0.34			9	0.05	0.19	−0.31	0.42		
Steps	4	0.21	0.09	0.04	0.38			4	0.42	0.23	−0.02	0.86		
Frequency	6	0.84	0.44	−0.03	1.71			6	1.14	0.68	−0.19	2.46		
Intensity	6	0.20	0.13	−0.05	0.45			6	0.18	0.14	−0.09	0.45		
Multiple	10	0.16	0.11	−0.06	0.37			10	0.04	0.08	−0.12	0.20		
Theory						10.32	0.01						14.80	0.02
No framework explicitly mentioned	4	0.39	0.22	−0.04	0.82			4	0.25	0.16	−0.07	0.56		
Social cognitive theory	3	0.01	0.19	−0.37	0.39			3	0.16	0.12	−0.08	0.41		
The transtheoretical model	3	0.27	0.11	0.07	0.48			3	0.38	0.14	0.12	0.65		
Theory of planned behavior	3	0.53	0.45	−0.36	1.41			3	0.27	0.27	−0.26	0.81		
Self–determination theory	3	0.80	0.24	0.33	1.27			3	0.57	0.12	0.33	0.81		
Multiple	16	0.08	0.07	−0.06	0.22			16	0.01	0.12	−0.23	0.25		
Others	5	0.44	0.26	−0.08	0.95			5	1.03	0.43	0.18	1.88		

(Continued)

TABLE 3 | Continued

	PAVs							PA						
	k	*g*	SE	95% CI		*Q*	*p*	*k*	*g*	SE	95% CI		*Q*	*p*
Study design						0.58	0.45						0.68	0.41
Randomized controlled trial	13	0.38	0.19	0.01	0.75			13	0.42	0.16	0.10	0.74		
Quasi–experimental study	24	0.23	0.07	0.09	0.36			24	0.25	0.11	0.03	0.47		
Study quality						0.57	0.75						4.08	0.13
Low (1–2)	7	0.17	0.20	−0.22	0.57			7	0.02	0.12	−0.22	0.26		
Medium (3–4)	24	0.26	0.08	0.11	0.41			24	0.34	0.13	0.09	0.58		
High (5–6)	6	0.38	0.20	0.00	0.77			6	0.39	0.21	−0.03	0.80		

Calculated using combined comparisons (Two arms, Control vs. AB, Control vs. ABC) with a total of 37 data sets. Moderator analysis was only done on moderators present in >3 studies.

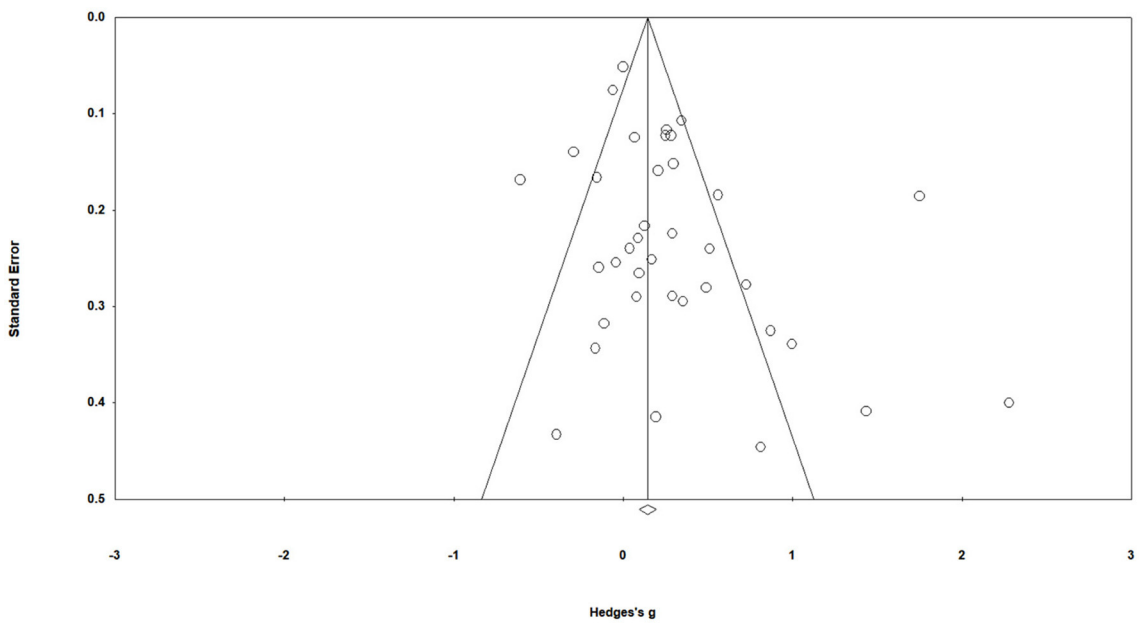

FIGURE 2 | Funnel plot of positive affective variables in this review.

Generally, PA consists of three elements: exercise intensity, exercise duration, and exercise frequency. However, only six of the 37 studies used accelerometers, and the others measured only one or two of the three elements of PA (subject's steps, heart rate, instrument usage, or possible time of exercise). Hence, in future studies, the accuracy of PA measurements could be improved further. Finally, eleven of 40 intervention techniques were utilized by <3 intervention groups, and their effectiveness should be explored better in relevant studies.

Moderating Effect of Methodological and Demographic Variables on PAVs and PA

The differences of effects between intervention and control conditions on both PAVs ($g = 0.29$; 95% CI = 0.15–0.43) and PA ($g = 0.30$; 95% CI = 0.11–0.49) were significant. Due to the studies' non-negligible heterogeneity, these considerable effect sizes should be interpreted with caution. Furthermore, our survey identified the underlying publication bias [Egger's intercept $t = 1.65$ (35), $p = 0.02$] in PAVs context. Given the significant publication bias in PAV, we further detected a larger effect size for small studies. Borenstein et al. (2009) noted that this pattern of larger effect size for small studies might because we retrieved a biased sample of small studies, but it is also possible that the effect size for small studies is larger for entirely unrelated reasons. That is, the presence of a small-study effect (Sterne et al., 2001) in PAVs may contribute to its publication bias. Under these circumstances, we recommend focusing on high-power studies and reducing studies with small samples to obtain more reliable estimates in future meta-analyses. Overall, no significant variations were found across the number

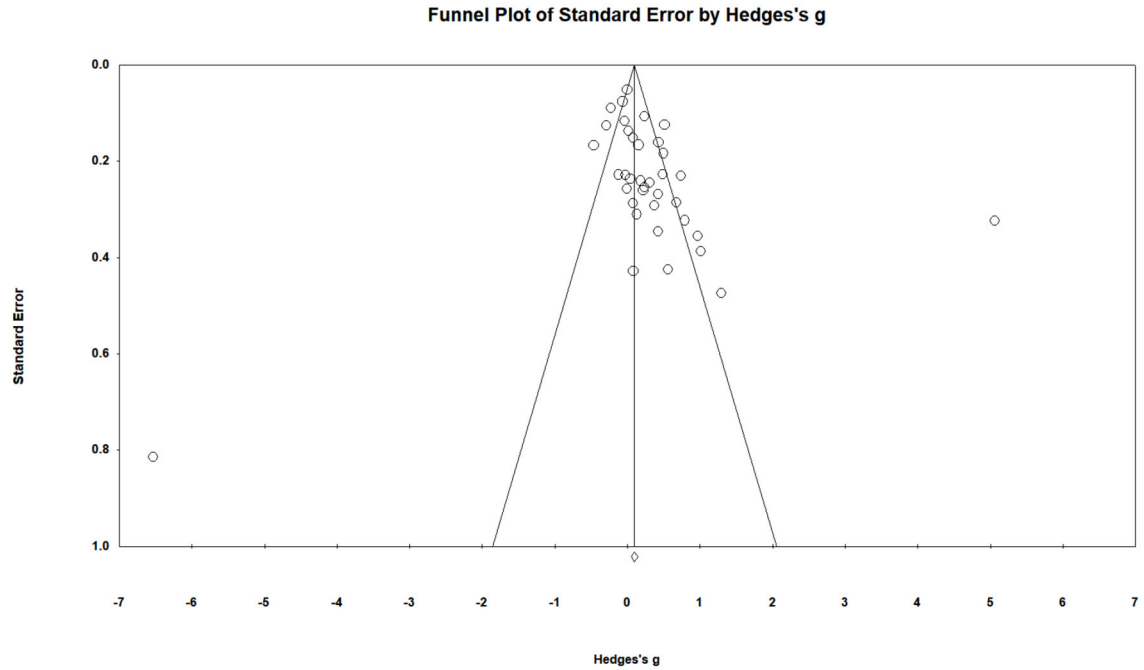

FIGURE 3 | Funnel plot of physical activity in this review.

of intervention methods used, PA at baseline, measurement employed, study design, or study quality assessment. However, age, gender, intervention duration, and theoretical framework significantly moderated the finding of PA. These findings were briefly discussed below.

a) *Age moderated PAV and PA*. Studies at the age interval between 36 and 50 years reported the maximum effect size ($g = 0.48$) in the PAV context, and subjects age between 18 and 35 reported the maximum effect size ($g = 0.44$) in the PA context. These results were consistent with those described by Lundqvist et al. (2013) and Vieillard and Gilet (2013): on the one hand, aging was associated with the maintenance of positive affect and the reduction of negative affect; on the other hand, a stimulus rating task showed that older adults had a considerably smaller range of responses to emotional stimuli than youngers. Besides, Kang et al. (2009) showed that separating interventions for different age groups was significantly more effective than not separating. Maybe one appropriate intervention strategy for one age group may not be appropriate for another age group. Therefore, we recommend selecting samples of approximately similar ages in a single study and administering higher intensity emotional stimulation to the young population in such interventions.

b) *Gender moderated PA*. Mixed samples ($g = 0.30$) reported larger changes than female samples ($g = 0.07$) in the PAV context, and mixed samples ($g = 0.46$) also reported larger changes than female samples ($g = -0.08$) in the PA context. These findings are difficult to interpret because there are not enough male-only samples to compare to mixed samples. Future studies where participant gender is used as an ex post facto variable within the same design are needed to shed light on this finding.

c) *Intervention duration moderated PAV*. The results suggested that interventions shorter than 2 months showed the most significant effect size ($g = 0.69$). Based on this result, we take a long-term perspective and recommend that exercise intervention strategies should not be monotonous and constant over time but should be adjusted about once every 2 months in order to facilitate PAV growth.

d) *Theory moderated PAV and PA*. Interventions with SDT ($g = 0.80$) had the most significant impact on PAV outcomes, while interventions without a theoretical basis ($g = 1.03$) had the most significant impact on PA. SDT posits that there are two main types of motivation—intrinsic and extrinsic—and that both are powerful forces shaping who we are and how we act. When individuals are motivated by intrinsic motivation, they may feel self-directed and autonomous (Ryan and Deci, 2000). This result is understandable due to the numerous conceptual and content similarities between intrinsic motivation and PAVs (Wienke and Jekauc, 2016). Parallel to the aforementioned, the interventions without theory presented the most significant impact on PA, which may reveal the limited predictive power of current theoretical frameworks. These findings highlighted the importance of developing theory underpinnings of PA prediction and intervention.

TABLE 4 | Comparison between PAVs and PA, according to whether a specific technique is present or absent in the intervention.

Technique (moderator)		PAVs								PA							
		Present			Absent			Q	*p*	Present			Absent			Q	*p*
		k	*g*	SE	*k*	*g*	SE			*k*	*g*	SE	*k*	*g*	SE		
1	Provide information on consequences of behavior in general	15	0.29	0.11	34	0.32	0.08	0.05	0.83	15	0.54	0.13	34	0.26	0.09	3.45	0.04
3	Provide information about others' approval	9	0.26	0.15	40	0.32	0.07	0.02	0.73	9	0.18	0.16	40	0.39	0.08	1.35	0.25
4	Provide normative information about others' behavior	5	0.43	0.23	44	0.30	0.07	0.28	0.60	5	0.40	0.26	44	0.35	0.08	0.05	0.83
5	Goal setting (behavior)	19	0.29	0.10	30	0.33	0.08	0.12	0.73	19	0.39	0.11	30	0.32	0.10	0.25	0.61
6	Goal setting (outcome)	6	0.24	0.19	43	0.32	0.07	0.15	0.70	6	0.39	0.22	43	0.35	0.08	0.04	0.84
7	Action planning	28	0.20	0.08	21	0.38	0.10	2.21	0.14	28	0.33	0.09	21	0.38	0.12	0.10	0.75
8	Barrier identification/problem solving	18	0.09	0.10	31	0.45	0.08	7.79	0.01	18	0.19	0.11	31	0.46	0.09	3.43	<0.05
9	Set graded tasks	10	0.16	0.13	39	0.36	0.07	1.87	0.17	10	0.35	0.15	39	0.35	0.08	0.00	0.98
10	Prompt review of behavioral goals	13	0.34	0.12	36	0.30	0.07	0.08	0.78	13	0.65	0.14	36	0.25	0.08	5.67	0.06
11	Prompt review of outcome goals	3	0.43	0.23	46	0.30	0.07	0.28	0.60	3	0.40	0.26	46	0.35	0.08	0.05	0.83
16	Prompt self–monitoring of behavior	24	0.24	0.09	25	0.37	0.09	1.12	0.29	24	0.28	0.11	25	0.42	0.10	0.88	0.35
17	Prompt self-monitoring of behavioral outcome	4	0.15	0.20	45	0.33	0.07	0.75	0.39	4	0.36	0.24	45	0.35	0.08	0.00	0.96
19	Provide feedback on performance	20	0.23	0.10	29	0.37	0.08	1.08	0.30	20	0.27	0.11	29	0.41	0.09	0.86	0.35
20	Provide instruction on when and where to perform the behavior	40	0.31	0.07	9	0.31	0.16	0.03	0.99	40	0.34	0.08	9	0.42	0.18	0.15	0.70
21	Provide instruction on how to perform the behavior	41	0.32	0.07	8	0.27	0.18	0.06	0.80	41	0.36	0.08	8	0.32	0.21	0.04	0.84
22	Model/demonstrate the behavior	28	0.28	0.08	21	0.36	0.10	0.29	0.60	28	0.43	0.09	21	0.23	0.12	1.75	0.19
23	Teach to use prompts/cues	6	0.73	0.20	43	0.26	0.06	5.09	0.02	6	1.33	0.23	43	0.25	0.07	19.80	<0.01
24	Environmental restructuring	15	0.29	0.11	34	0.32	0.08	0.04	0.85	15	0.21	0.12	34	0.42	0.09	1.94	0.16
26	Prompt practice	7	0.26	0.16	42	0.32	0.07	0.13	0.72	7	0.18	0.19	42	0.38	0.08	1.02	0.31
27	Use of follow–up prompts	3	0.19	0.29	46	0.32	0.06	0.19	0.66	3	0.46	0.32	46	0.34	0.07	0.12	0.73
28	Facilitate social comparison	4	0.98	0.25	45	0.26	0.06	7.95	0.01	4	0.97	0.28	45	0.30	0.07	5.45	0.02
29	Plan social support/social change	25	0.19	0.08	24	0.45	0.09	4.11	0.04	25	0.41	0.10	24	0.28	0.11	0.86	0.35
33	Prompt self–talk	4	0.04	0.23	45	0.33	0.07	1.53	0.22	4	0.22	0.26	45	0.36	0.08	0.26	0.61
34	Prompt use of imagery	9	0.35	0.17	40	0.31	0.07	0.05	0.82	9	0.10	0.18	40	0.40	0.08	2.27	0.13
35	Relapse prevention/coping planning	3	0.23	0.23	46	0.32	0.07	0.12	0.73	3	0.52	0.27	46	0.33	0.07	0.47	0.49
36	Stress management/emotional training	24	0.26	0.09	25	0.36	0.09	0.66	0.42	24	0.32	0.10	25	0.39	0.10	0.23	0.63
37	Motivational interviewing	6	0.10	0.19	43	0.34	0.07	1.38	0.24	6	0.33	0.22	43	0.36	0.08	0.02	0.90
38	Time management	4	−0.16	0.25	45	0.34	0.07	3.62	0.06	4	0.08	0.27	45	0.37	0.08	1.08	0.30
39	General communication skills training	5	0.05	0.18	44	0.35	0.07	2.54	0.11	5	0.13	0.20	44	0.38	0.08	1.39	0.24

k indicates the number of intervention groups adopting/not adopting a particular technique. They are calculated using all comparisons (Two arms, Control vs. A, Control vs. B, Control vs. C) with a total of 49 data sets. Moderator analysis was only done on moderators present in >3 intervention groups.

Moderating Effect of Contents Applied in the Intervention on PAVs and PA

We found "teach to use prompts/cues" and "facilitate social comparison" were related to conceivable positive changes in PAV, and "teach to use prompts/cues," "facilitate social comparison," and "provides information on consequences of behavior in general" were related to positive changes in PA. These findings were briefly discussed below:

a) "*Teach to use prompts/cues*" *positively moderated PAV and PA*. The concept of "teach to use prompts/cues" is to instruct people to recognize environmental prompts (e.g., mobile phone reminders) that can be used to remind them to enact an intended behavior. This technique is desired as a planned, systematic delivery of cues to prompt people to do cognitive or metacognitive work on emotional arousal and PA to help people establish task-specific routines, automatic responses, or habits in their daily lives that internalize motivational factors and thus contribute to PA levels (Hayamizu, 1997). The TTM researchers note that teaching to use prompts/cues of PA behavior can facilitate individuals' transition from pre-contemplation stage to contemplation stage or even action stage. However, in explaining why this technique works, this theory only emphasizes consciousness-raising and ignoring PAVs' changes. Therefore, future TTM-based PA intervention studies could additionally consider the role of PAVs.
b) "*Facilitate social comparison*" *moderated PAV and PA*. It is not surprising that this technique enhanced both PAVs and PA, as the technique in line with a critical construct of SDT. The SDT assigns a central role to intrinsic motivation, a construct that is typically operationalized by assessing the degree of enjoyment associated with behavioral preferences (Deci and Ryan, 2008). The concept of "facilitate social comparison" is to draw attention to the performance of others to elicit comparisons. According to SDT, individuals have three necessary psychological needs for intrinsic motivation to adopt and adhere to behaviors: the need for competence, the need for relatedness, and autonomy. We speculate that social comparisons enhance the subjects' sense of competition and the likelihood of perceiving their competence (Kwasnicka et al., 2016).
c) "*Provide information on consequences of behavior in general*" *positively moderated PA*. Its purpose is to provide information on the relationship between PA and its possible consequences in general cases, based on epidemiological data. One possible explanation for the positive effect is that the epidemiological data may have facilitated the valuation of PA as healthy, but this could also be a statistical fluke of the results of multiple comparisons, so further research on this topic is recommended.

In contrast, "barrier identification/problem solving" was negatively associated with PAVs and PA change, and "plan social support/social change" was related to an adverse change in PAVs. These findings were briefly discussed below:

a) "*Barrier identification/ problem solving*" *negatively moderated PAV and PA*. Both Koole and Rothermund (2011) and Gyurak et al. (2011) pointed out the difference between explicit (requires conscious and cognitive effort to initiate and monitor) and implicit (operates without the need for conscious supervision) emotion regulation. Gyurak et al. (2011) also noted that although, by definition, implicit emotion regulation is not intentional (i.e., it is not instigated or guided by explicit intentions), some research emphasizes the goal-directed nature of implicit emotion regulation. This aspect of non-intentionality distinguishes the studies of implicit emotion regulation from most studies of explicit emotion regulation because implicit emotion regulation does not require such explicit instruction, so it is more spontaneous than explicit emotional regulation (Koole and Rothermund, 2011). Given that "barrier identification and problem solving" was defined as prompting the person to think about underlying obstacles and identifying methods to overcome them (Michie et al., 2011), we considered it to be a cognitive variable. In other words, we thought this cognitive variable to be an explicit rather than implicit process, which might have hindered PAVs and subsequent PA growth. In addition, as a common intervention technique based on SCT, we might have to consider its impact on environmental modification and also on affective variables. However, it was also possible that barrier identification was not necessarily ineffective, but instead that the technique was ineffective due to an incorrect implementation method.
b) "*Plan social support/ social change*" *negatively moderated PAV*. Although relatively little research has been done on the relationship between this variable and PAVs, the outcome is understandable. Because planning is an activity that requires the activation of an individual's cognitive resources, we consider this variable also to be an explicit rather than implicit process of emotion regulation. Based on the interaction between cognition and emotion (Liu et al., 2009), we speculate that complex cognition hinders the growth of PAVs. In general, social change is also a common intervention or environmental modification technique based on SCT. Future PA intervention studies using social support/social change need to address the impact on PAVs. However, this could also be a statistical fluke of multiple comparisons, and further research on this is recommended.

At present, new theoretical models of PA change have been developed based on the automatic affective valuation option, such as affective–reflective theory (ART; Brand and Ekkekakis, 2018) and the PA adoption and maintenance model (PAAM model; Strobach et al., 2020). However, they have not yet explored which specific BCTs would be helpful for enhancing positive affective evaluations (PAVs) in the healthy population, and this paper might be considered as a preliminary attempt.

Limitations and Future Research Directions

Although this review followed the Cochrane handbook for systematic reviews of interventions (Higgins et al., 2019b) as normatively as possible, several limitations still exist. First, the included studies were limited by search terms and language, and it was not possible to include all relevant studies. Future studies

should consider including more languages to explore whether there are differences in manipulating positive affect variables and PA across countries or cultural contexts (e.g., Eastern and Western cultural contexts). Second, this study did not include unpublished data. However, given Bellefontaine and Lee (2014) explored the impact of including gray literature and found no significant differences in effect size and methodological quality with or without the inclusion of unpublished studies, we also considered this to be a minor limitation. Third, since it was not possible to split positive and negative affective variables into two, we only excluded negative affective variables. Fourth, due to data limitation, we could not analyze all 40 behavior change techniques listed in Michie et al. (2011), and only 29 BCTs were analyzed. Therefore, rigorous experimental testing using a factorial design that isolates and combines unique techniques is needed. Fifth, this paper focused on exploring the effectiveness of different BCTs, but not the effectiveness of affective change techniques, so more work needs to be done to gain insight into them. Sixth, given the broad age spectrum of the current study population, we expect future studies to narrow their age spectrum to explore age-specific intervention techniques. Seventh, the results might be inflated due to potential unit-of-analysis errors that might exist by using the current analytical methods. According to Cheung (2019) and Higgins et al. (2019a), multi-level meta-analysis and network meta-analysis are probably the best to deal with meta-analysis studies which include several effects from one study. Future studies should consider using them to achieve rigorous estimations.

CONCLUSION

Overall, the primary objective was to summarize the demographic, methodological, and BCTs of each study to review gaps in past experimental designs. Descriptive statistics showed that: at least 11 behavior change techniques were rarely used in included studies; the measurements of PAV dimensions and methods were highly inconsistent across studies; accelerometers were still not widely used in PA measurement. Inferential statistics yielded that: age, gender, intervention duration, and theoretical basis had significant moderating effects on PAV or PA outcomes; the utilization of "teach to use prompts/cues," "facilitate social comparison," and "provide information on consequences of behavior in general" had positive effects on PA or PAV outcomes; the utilization of "barrier identification/problem solving" and "plan social support/social change" negatively affected on PA or PAV outcomes. However, there was considerable heterogeneity in the findings, and the moderator analyses suggested that these effects may be exaggerated by publication and small sample bias. Nonetheless, this paper has considerable implications for future relative intervention studies, and these findings will serve as a base for future such intervention studies.

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

DJ and CC contributed to the study's conception and design. DJ supervised the entire process. CC organized the database, performed the statistical analysis, and wrote the manuscript. EF and AK supported CC in data extraction and data analysis phases. DJ, EF, and CC contributed to manuscript revision. All authors read and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.628993/full#supplementary-material

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Association Between Maternal Body Mass and Physical Activity Counseling During Pregnancy

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Aims: The antenatal period provides an important opportunity for giving advice on healthy lifestyle choices. However, the prevalence of maternal obesity is increasing, and women report that they do not receive counseling. We investigated the information given to pregnant women on gestational weight gain, physical activity, and nutrition during pregnancy in relation with their initial weight status, current gestational weight gain and diagnoses of either pre-pregnancy overweight/obesity or excessive gestational weight gain.

Methods: Cross-sectional survey using a questionnaire. Pregnant participants (n = 141) were recruited from a midwife center. They completed a structured questionnaire on the information they received during their pregnancy and we assessed its relationship with their weight.

Results: We found that many pregnant women did not receive advice about physical activity, gestational weight gain and nutrition (37.5, 53.2, and 66.2%, respectively). Women with weight problems (pre-pregnancy overweight/obesity and excessive gestational weight gain) were less targeted for counseling, although more than 80% of the women viewed receiving information on these topics as positive. Also, being informed of a weight problem was associated with a greater chance of receiving information about physical activity, gestational weight gain and nutrition (all $p < 0.05$). However, verbalization of the weight problems was low (14.0% of women with pre-pregnancy overweight were informed of their status).

Conclusion: Health professionals should dispense more information, especially on PA and particularly for women with weight problems. Verbalization of the weight problem seems associated with more frequent transmission of information.

Keywords: weight problem, physical activity, gestational weight gain, counseling, prenatal care

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INTRODUCTION

Physical activity (PA) prevents excessive gestational weight gain (excessive GWG) (Ruchat et al., 2018) and many of the complications of pregnancy (Hinman et al., 2015), and it is recommended throughout pregnancy (ACOG Committee Opinion No. 650, 2015). However, the quantity is usually insufficient and tends to decline with the trimesters (Coll et al., 2016). Many determinants

Abbreviations: PA, Physical activity; GWG, Gestational weight gain; BMI, Body mass index; ACOG, American College of Obstetricians and Gynecologists.

of this decline have been documented, notably a lack of advice and information on the effects of PA during pregnancy (Coll et al., 2017; Thompson et al., 2017). Health professionals find that most of these determinants are hard to modify within the healthcare framework, but the lack of information, which women have cited to explain their low PA in several studies (Connelly et al., 2015), seems modifiable. More information might thus be a potential public health target.

The pregnancy weight risk may be due to pre-pregnancy overweight (Samura et al., 2016) and/or excessive weight gain during pregnancy (Ren et al., 2018). However, several studies have reported that clinicians do not systematically diagnose or discuss overweight (Duthie et al., 2013; Nikolopoulos et al., 2017). The clinical recommendations for managing obese patients in general include obesity screening and assessment in primary care practice, and health professionals are encouraged to identify those patients who need to lose weight (Kushner and Ryan, 2014). Excessive GWG has been well-documented (Deputy et al., 2015) and is indeed a priority issue, as the recommendation is to control weight gain throughout pregnancy (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine Iom Pregnancy Weight Guidelines, 2009). Yet, according to women's reports, discussions on GWG occur in less than 50% of pregnancies (McDonald et al., 2011; Deputy et al., 2018). Furthermore, few pregnant women reported receiving advice in according recommendation or discussed the risks of inappropriate GWG with health professionals (Morris et al., 2017; Whitaker et al., 2020). The lack of counseling is not without consequence because women who did not report advice by their health professionals on GWG were at higher risk for both inadequate and excessive GWG (Whitaker et al., 2020). Similar to that of GWG—related counseling, the quantity of PA information is insufficient and often inappropriate (Stengel et al., 2012; Lindqvist et al., 2018).

The objective of this study was to investigate the information given to pregnant women on gestational weight gain, physical activity, and nutrition during pregnancy in relation with their initial weight status, current GWG and diagnoses of either pre-pregnancy overweight/obesity or excessive GWG. We hypothesized that weight problems would increase the frequency of counseling for pregnant women. Secondly, we investigated pregnant women's beliefs and attitudes toward PA with the objective of improving the targeting and content of prenatal PA counseling.

MATERIALS AND METHODS

Study Design and Participants

This was a cross-sectional study design, with 141 pregnant women from a midwife center in Guadeloupe. After giving informed consent, the women responded to a structured questionnaire under their midwife's supervision on the counseling they had received and their beliefs about PA during pregnancy. Inclusion criteria were being pregnant; able to read, write and speak French; followed throughout pregnancy in the center where the recruitment took place; and with no contraindication to PA according to the ACOG. All experimental procedures conformed with the Declaration of Helsinki and were approved by the local ethics committee.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and the current local regulations. All participants provided written informed consent. It was emphasized that participation was voluntary and that they could withdraw from the project at any time with no explanation required. No financial support was given.

Data Collection

On the day of data collection, all eligible and available women were invited to participate in the study. The progress of pregnancy in weeks of amenorrhea and trimesters of pregnancy, stature in centimeters, current weight status, age in years, GWG in kilograms at the time of the study, and weight in kilograms as beginning pregnancy were collected from medical records. The women were also interviewed during visits to the midwife center using a questionnaire built for the current study. The information from the participants about PA, nutrition, and GWG was examined. We developed the questionnaire based on questions and results from similar studies (Lindsay et al., 2017; Vinturache et al., 2017). Although the questionnaire did not first undergo a full validation procedure, all question-and-answer options were piloted in 20 pregnant women at various stages of pregnancy for comprehensibility. The content of the questionnaire was revised base on the feedback on the women to improve the readability and understanding. Some questions were duplicated to check for understanding. Some questions were not used for the final questionnaire. In the initial version, open-ended questions were used to optimize the phrasing of the questionnaire.

The questionnaire was composed of a mix of closed-ended questions, semi-closed-ended questions, and 5-point Likert scale questions. It required approximately 10 min to complete.

The frequency of advice received (on nutrition, GWG, and PA) was examined on participants on a scale of 0–5, where 0 represented "never" and 5 "very frequently." Did you receive advice during your consultations on nutrition, GWG and PA?

To assess whether women had received information about their weight problems, closed questions were used. "Were you informed about an overweight/obesity problem before pregnancy by your midwife?", "Were you informed about excessive GWG during pregnancy by your midwife?"

Assessment of Pre-pregnancy Body Mass Index and Excessive Gestational Weight Gain

Pre-pregnancy BMI was calculated using pre-pregnancy weight and height, and the women were categorized as underweight (BMI: <18.5 kg/m^2), normal weight (BMI: 18.5–24.9 kg/m^2), overweight (BMI: 25.0–29.9 kg/m^2) or obese (BMI: ≥ 30.0 kg/m^2). The total GWG was calculated from the maternal weight. Based on the ACOG recommendations (ACOG Committee opinion no. 548, 2013), total GWG was defined as excessive if above the upper limit determined for each BMI class

as 18.0, 16.0, 11.5 and 9.0 kg in pre-pregnancy underweight, normal weight, overweight and obese mothers, respectively. The weight gain was subsequently considered not excessive if within the ACOG recommendations (12.5–18, 11.5–16.0, 7.0–11.5, and 5.0–9.0 kg, respectively).

Statistical Analysis

The demographic characteristics were analyzed as means and standard deviations (SD) for quantitative variables and confidence intervals for qualitative variables. Average and frequency comparisons were used for qualitative and quantitative variables, respectively. Variables evaluated by Likert scales were recoded into dichotomous variables ("expresses an agreement" and "does not express an agreement") because of the small sample size. Odds ratios were calculated when Chi^2 analyses revealed significant associations. The effect of pre-pregnancy overweight/obesity diagnosis or excessive GWG on the frequency of information received (on weight gain, nutrition, and PA) was explored by Chi^2 tests. All questionnaire data were entered into Excel software and imported into SPSS (v24.0). The results were considered significant when the p-value was ≤ 0.05.

RESULTS

Participants

One hundred and forty-one 30.3 ± 6.2-year-old women between 10 and 42 weeks of gestation participated in the present study. They were predominantly married (61.0%) and employed (63.1%). The majority had completed secondary school (70.2%) and 51.1% had at least one child. Before pregnancy, 9.3% (95%CI 4.5–14.1), 50.0% (95%CI 41.7–58.3), 26.4% (95%CI 19.1–33.7) and 14.3% (95%CI 8.5–20.1) were lean, normal weight, overweight and obese, respectively. The expected maximum weight gain throughout the pregnancy was 8.2 ± 7.7 kg and by the time of the study, 13.5% (95%CI 7.8–19.2) showed excessive GWG. Nevertheless, 77.3% (95%CI 70.4–84.2) considered themselves in good health. The distribution of BMI into classes before pregnancy was as follows: 9.3% (95%CI 4.5–14.1), 50.0% (95%CI 41.7–58.3), 26.4% (95%CI 19.1–33.7), and 14.3% (95%CI 8.5–20.1) in lean, normal, overweight and obese women, respectively. A significant relationship between being pre-pregnancy overweight or obese and excessive GWG was evidenced ($p < 0.05$, **Table 1**).

The Relationship of the Women With the Information

The women most frequently reported that the main source of information was press/books/internet [51.8% (95%CI 43.6–60.0)], followed by family and friends [28.4% (95%CI 21.0–35.8)] and last by the medical professions [19.8% (95%CI 13.1–26.4)].

Most of the women [88.6% (95%CI 83.4–93.8)] thought PA was an important topic and 83.2% (95%CI 77.0–89.4) and 84.4% (95%CI, 78.4–90.4), respectively, thought they had enough time and felt comfortable enough to ask questions about PA in the consultations. However, 74.5% (95%CI 67.3–81.7) would have liked to know more. Regarding the advice given, 25.5% (95%CI 18.2–32.7) and 31.2% (95%CI 23.6–38.8) reported difficulties in following the advice on PA and nutrition, respectively.

Gestational weight gain was considered an important topic by 65.2% (95%CI 57.3–73.1) of the women. Most [87.2% (95%CI 81.7–92.7)] thought receiving information on their weight was positive, and 56.1% (95%CI 47.9–64.3) reported trying to control their weight gain.

Information Received by the Women

In sample, 53.2% (95%CI 45.0–61.4) reported receiving information on GWG, 66.2% (95%CI 58.4–74.0) on nutrition, and 37.5% (95%CI 29.5–45.5) on PA from their health professionals. Respectively, 67.2% (95%CI 59.5–74.9) and 65.0% (95%CI 57.1–72.9) of the women said they were aware of the impact of PA and nutrition on GWG. With regard to weight gain, 26.7% (95%CI 19.4–34.0) were informed of a weight gain not to be exceeded. When asked about the maximal weight gain that they had been advised not to overpass, 88.7% (95%CI 83.4–93.9) reported a gain that was in the range of the IOM recommendations. Among the women who received PA information, 89.4% (95%CI 84.3–94.5) reported that their doctor spoke positively about PA. PA was assumed to be positive for the mother and the fetus by, respectively, 90.1% (95%CI 85.2–95.0) and 80.7% (95%CI 74.2–87.2). The frequency of reporting the PA benefits for their baby's health was higher in women who had received information about PA, whereas the frequency of reporting PA as dangerous was lower (**Table 2**). Results not displayed were higher than $p \geq 0.323$.

Which Women Received Information About Weight?

Fourteen percent (95%CI 8.3–19.8) of the women who were overweight or obese before pregnancy had been informed of their status, and 31.6% (95%CI 28.1–44.0) of the women who had gained too much pregnancy weight by the time of the study had been informed about it. Not all the women received information about GWG but giving information tended to increase with pregnancy progression: 27.8% (95%CI 20.4–35.2), 48.3% (95%CI 40.0–56.6) and 65.1% (95%CI 57.2–73.0) for the first, second, and third trimesters, respectively ($p = 0.005$).

Women who felt at ease about asking questions (see **Table 2**) and women who were informed that they had gained too much weight during pregnancy were more likely to receive information about GWG (see **Table 3**). Women with pre-pregnancy overweight or excessive GWG did not receive information about GWG more frequently than the other women (see **Table 3**).

TABLE 1 | Excessive gestational weight gain (GWG) for body mass index (BMI) respondents ≥25 and ≥30, respectively, before pregnancy, vs. respondents with BMI <25.

	BMI ≥ 25 pre-pregnancy OR (95%CI)	BMI ≥ 30 pre-pregnancy OR (95%CI)
Excessive GWG	2.89 (1.06–7.88)	3.39 (1.09–10.49)

TABLE 2 | Distribution of information on physical activity and gestational weight gain.

	Received GWG information			Received PA information		
	Yes (%)	No (%)	OR (95%CI)	Yes (%)	No (%)	OR (95%CI)
At ease asking the midwives questions	91.9	77.3	3.33 (1.20–9.18)*	92.0	80.0	2.87 (0.90–9.05)*
Received information about her nutrition	93.2	36.4	23.80 (8.43–67.16)**	96.1	47.1	27.56 (6.39–120.67)**
Informed of excessive GWG	20.0	6.1	3.87 (1.21–12.34)*	29.4	3.5	11.38 (3.10–41.79)**
Received PA information	60.3	11.1	12.13 (4.86–30.30)**			
Received GWG information				86.3	34.1	12.13 (4.86–30.30)**
Declared that PA is good for baby's health				88.2	75.0	2.50 (0.93–6.69)*
Declared less frequently that PA is dangerous				21.6	37.6	1.91 (0.82–4.43)*

*$p < 0.05$; **$p < 0.01$.

Which Women Received Information About Physical Activity?

Information about PA was more frequently received as the pregnancy progressed, with 16.7% (95%CI 10.5–22.9), 32.8% (95%CI 25.0–40.5) and 48.3% (95%CI 40.0–56.5) of the women being informed for the first, second and third trimesters, respectively: $p = 0.016$.

The analyses failed to evidence any tendency of PA information to be more frequently received by women with pre-pregnancy overweight or excessive GWG (**Table 3**). However, women who were informed that they had gained too much weight during pregnancy were more likely to receive information on PA and nutrition (**Table 3**).

DISCUSSION

The objective of this study was to investigate the information that pregnant women receive with regard to their initial weight status, pregnancy weight gain and weight diagnosis. We hypothesized that weight problems would increase the frequency of counseling for these women. The results highlight that many pregnant women did not receive advice about PA, GWG and nutrition. In addition, women who had a pre-pregnancy weight issue were less targeted for counseling.

A Little Discussed Subject

The proportion of women who declared that they had received information on gestational weight gain or physical activity by a medical professional was quite low, even though it increased as the pregnancies progressed. In the third trimester, only 65.1 and 48.3% of the women said they had heard of gestational weight gain and physical activity, respectively. These frequencies may be surprising, given the importance of these two parameters over the course of a normally progressing pregnancy and childbirth, but they approximately reflect the frequencies found in the literature, with values ranging from 21 to 52% for gestational weight gain (McDonald et al., 2011; Whitaker et al., 2016b; Morris et al., 2017) and from 50 to 63% for physical activity (de Jersey et al., 2013; Whitaker et al., 2016b). This may have had direct consequences on the women's physical activity practice during pregnancy as some studies have shown that the desire to exercise during pregnancy is higher among women followed by obstetricians who discuss PA during prenatal visits (May et al., 2013; Nascimento et al., 2015). Potential explanations for the insufficient prenatal counseling have been much explored and discussed in the literature. Is this subject too delicate, uninteresting/useless, or too complex?

A Delicate Subject

One explanation is that health professionals might be apprehensive about raising the issue of weight with pregnant women and being perceived as judgmental, especially when the women are overweight (Holton et al., 2017). This idea is interesting as our study showed that the pregnant women considered talking about their gestational weight as positive.

Moreover, our results indicated that very few women who were overweight or obese before pregnancy declared that they had been informed of their weight status, although BMI calculation seems to be a common practice (Kushner and Ryan, 2014). The overweight women in this study, as in the available literature, were nevertheless overexposed to the risk of excessive gestational weight gain (Samura et al., 2016). It has been reported that pre-pregnancy overweight is not systematically diagnosed (Duthie et al., 2013; Nikolopoulos et al., 2017). Stotland et al. (2010) pointed out that health professionals may tend to be more reactive than proactive regarding gestational weight gain problems. Based on the findings in focus groups, they described a common approach to weight gain counseling that could be summarized as "waiting for the cue." But the cue waited for is mainly a question from the patient. This echoes our observation that the women who felt at ease asking questions more frequently received information. This could contribute to the relative discrepancy between the prevalence of pre-pregnancy overweight and excessive GWG and the proportion of women who actually reported they had been informed about their weight problems.

An Uninteresting/Useless Subject

Although health professionals believe that gestational weight gain, nutrition, and physical activity are important and are likely to have an impact on the health of women and their babies (Stotland et al., 2010), the literature suggests that physicians may lack the skills, confidence, and resources to change their patients'

behaviors (Stotland et al., 2010; Leiferman et al., 2012; Power and Schulkin, 2017). They may therefore provide information on physical activity less frequently than they should or could.

Studies have reported that health professionals might perceive their advice on weight control as ineffective (Stotland et al., 2010; Power and Schulkin, 2017). For example, they might feel unable to convince pregnant women that it can be dangerous if they gain too much weight or do not maintain a certain level of physical activity, even at the expense of other resources. Our results converge with this observation because the internet/books and family and friends were, respectively, the first and second sources of women's information about their pregnancy, as reported in the literature (Dalhaug and Haakstad, 2019).

This question of confidence is important since it appears that the most confident physicians are more likely to inform their patients that excessive weight gain increases the risk of pregnancy complications and has possible consequences for their baby (Power and Schulkin, 2017). Also, our results showed that the women who received information about PA more frequently considered it beneficial for their baby's health and less frequently as dangerous. This suggests that advice has an impact on women's beliefs and can reassure them about practicing PA during pregnancy. It is important to note that the perception of PA as dangerous and the conviction that it is a source of safety problems have been documented as two barriers to PA in pregnancy (Harrison et al., 2018).

It has also been observed that accessible and consistent information about the positive effects of PA is likely to contribute to adequate PA behaviors during pregnancy (Weir et al., 2010), particularly as the baby's health is a major motivating factor for lifestyle change (Jelsma et al., 2016).

Health professionals may also think that women do not have much control over their weight and that PA would only put them in a situation of probable failure (Stotland et al., 2010), but our study revealed that only a quarter of the women said they had a hard time following the PA advice they received.

Professionals might also assume that pregnant women are uninterested (Whitaker et al., 2016a) in issues of weight, nutrition and physical activity, and they might anticipate that women will not follow their advice (Leiferman et al., 2012). Such assumptions are important to consider, as more than half the pregnant women in our study reported trying to control their weight, supporting the idea that woman do care about the issue of gestational weight.

Furthermore, our results indicated that although 65% of the pregnant women declared knowing the impacts of PA and nutrition on gestational weight gain, almost three quarters of them reported that they would have liked to know more. It should be noted that in our study, gestational weight gain was considered as an important topic by 65.2% of the women. Our results are in accordance with those of Lindsay et al. (2019) who reported that their weight and weight gain during pregnancy were constantly on their minds for about half of the pregnant women. These statements are probably related to their impact on their health and that of their newborn (Lindsay et al., 2019). In addition, other data in the literature show that gestational weight gain is an important topic for women, in particular by the active search for information on GWG (54.9%) (Willcox et al., 2015), and weighing themselves weekly or fortnightly (57.7%) (Swift et al., 2016).

A Complex Subject

Health professionals may think they are not sufficiently trained for counseling. They have reported a lack of training in antenatal PA counseling (De Vivo and Mills, 2019; McLellan et al., 2019), and a large majority of those who actually receive a form of training might consider it insufficient (Leiferman et al., 2012).

Our results showed that the women who had the most chance of receiving information were those who felt comfortable asking questions. This indicates that in order to obtain information, women should be able to ask for it; however, they are generally less proactive in seeking advice from health professionals (Walker et al., 2019).

The literature suggests that a non-negligible proportion of health professionals might not be familiar with the PA recommendations in pregnancy (McGee et al., 2018). This is a problem, as a lack of knowledge about the recommendations has been reported as one of the main barriers to PA for women during pregnancy (Connelly et al., 2015).

In addition, some women may experience only limited counseling from midwives because these latter lack sufficient knowledge on this topic (Lindqvist et al., 2018). Thus, the lack of training and knowledge noted above might contribute to the tendency for the women in our study to primarily rely on sources other than health professionals to gather information about their pregnancy. This tendency to seek information elsewhere rather than from medical professionals is understandable in the sense that PA an important subject for pregnant women, as demonstrated in this study and by others (Lindqvist et al., 2018). Yet this could be a cause for concern because other sources might not offer evidence-based advice and could reinforce incorrect beliefs among pregnant women (Shub et al., 2013; Cannon et al., 2019).

A "Waiting for the Cue" Approach

Special attention to women with weight problems has been signaled in the current recommendations (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine Iom Pregnancy Weight Guidelines, 2009). We thus hypothesized that the higher needs of women with excessive GWG or pre-pregnancy overweight would be associated with an increased likelihood of receiving counseling. However, our results did not indicate this, in line with previous observations (Stengel et al., 2012; Lindsay et al., 2017; Nikolopoulos et al., 2017). The finding that women with special needs do not receive counseling underlines the lack of management of women with weight problems (Kominiarek et al., 2018). However, we observed that the women who felt at ease asking questions during consultations more frequently received information about PA and that women diagnosed by health professionals with excessive GWG were more likely to be talked to about their physical activity. We, as others (Stotland et al., 2012; Arabin et al., 2018), failed to evidence this association in women with a pre-pregnancy diagnosis of overweight. The diagnosis of excessive GWG could be seen as the cue

TABLE 3 | Likelihood of receiving information on gestational weight gain, physical activity, and nutrition according to the pre-pregnancy BMI (normal or not), gestational weight gain (GWG; excessive or not), and information on excessive GWG (received or not).

	Pre-pregnancy BMI ≥ 25			Informed of BMI ≥ 25			Excessive GWG			Informed excessive GWG		
Received information	**Yes (%)**	**No (%)**	**OR (95% CI)**	**Yes (%)**	**No (%)**	**OR (95% CI)**	**Yes (%)**	**No (%)**	**OR (95% CI)**	**Yes (%)**	**No (%)**	**OR (95% CI)**
GWG	52.6	54.2	0.93 (0.47–1.84)	34.8	39.7	0.81 (0.40–1.64)	57.9	52.5	1.26 (0.46–3.31)	78.9	49.2	3.87 (1.21–12.34)*
PA	34.5	40.0	0.72 (0.38–1.61)	33.3	39.2	0.77 (0.36–1.64)	29.4	38.7	0.66 (0.21–2.0)	83.3	30.5	11.38 (3.10–41.79)*
Nutrition	64.9	67.9	0.87 (0.42–1.79)	34.5	43.5	0.68 (0.32–1.43)	77.8	64.5	1.92 (0.59–6.22)	79.3	20.7	0.60 (0.52–0.70)*

*$p < 0.05$.

we mentioned above, with health professionals adopting a rather reactive approach regarding weight management in pregnancy. This raises the issue of diagnosing weight problems. We found that the women who were informed of their excessive GWG more frequently received information about PA, but not necessarily the women with a diagnosis of pre-pregnancy overweight/obesity. Yet, this diagnosis, which has an impact on patients' health behaviors (Banerjee et al., 2016), consequently seems to offer both the opportunity (a cue) to talk about PA in pregnancy and a preliminary step toward counseling. It is therefore concerning to observe that less than a third of the women with pre-pregnancy overweight had been informed of it. We also observed that the diagnosis of excessive gestational weight gain was associated by a fairly high OR (11.38) with receiving PA information. This supports the hypothesis of a "waiting for the cue" approach, with many providers waiting until patients have excessive GWG before addressing the issue and its determinants (Chang et al., 2013).

Finally, although pre-pregnancy overweight diagnosis was not associated with more frequent weight management counseling, it was associated with lower excessive gestational weight gain. This diagnosis thus seems to be associated with different behaviors in pregnant women (May et al., 2013) that the present study was not designed to explore.

Information/Advice Pregnant Women Would Like to Receive

Talking about weight problems and addressing PA and healthy eating should be included in antenatal care (Jelsma et al., 2016), and women would like to have this information relatively early in pregnancy (Grenier et al., 2020).

Women would like advice and information on the recommendations for PA (Coll et al., 2017), because there is unclear advices (Findley et al., 2020). The health professionals should give counseling for example on type and intensity to practice PA during pregnancy. The experience reported by pregnant women such as "Exercise is necessary for our health," but "I do not know about the exercises that can be performed during pregnancy" (Fathnezhad-Kazemi and Hajian, 2019) shows a real need for information on their physical activity. Safety discussions at the PA should be approached more often by health professionals. Indeed, pregnant women would like that health professionals lift their fears (Findley et al., 2020), and to know if the practice of physical activity is safe for their health and that of their fetus. Moreover, knowing the benefits in terms of maternal and fetal health is a major motivating factor for practicing PA (Jelsma et al., 2016; Harrison et al., 2018), results also reported in women overweight (Denison et al., 2015; Grenier et al., 2020). Although walking appears to be an easy to implement and often claimed PA for pregnant women (Connolly et al., 2019), health professionals should be discussed appropriate environment to practice. Pregnant women would like to know if there are places to practice for pregnant women, for example "There is no good gym in our neighborhood. I like to go to the gym but I cannot" (Fathnezhad-Kazemi and Hajian, 2019; Grenier et al., 2020).

Regarding weight information, women want to know if they gain too much weight during their pregnancy. In addition, the recommended weight gain based on their initial weight also seems an important topic for them (Stengel et al., 2012). Women desired advice on GWG from their providers specifically tailored for them (Stengel et al., 2012), because the weight − related information in pregnancy are "vague" and "insufficient." Indeed, Pregnant women would like weight gain goals during pregnancy (Flannery et al., 2020).

Although nutrition appears to be the most frequently provided information in our study, pregnant women generally seem a little disappointed to see that the issue is rarely discussed (Grenier et al., 2020). Generally, women not receiving adequate nutrition education during pregnancy (Lucas et al., 2014). Nutrition advice from a dietician would be appreciated, regarding what (not) to eat and weight management (Jelsma et al., 2016). They want to understand the benefits dietary change during pregnancy (Rundle et al., 2018).

Limitations

This study has a number of limitations that should be taken into consideration when interpreting and extrapolating the findings. First, the cross-sectional design intrinsically weakens the search for in-depth understanding and causal links. The second important limitation is a non-validated questionnaire, although structured on the basis of the existing literature and pre-tested. It should be recalled that all the data regarding the information received by the women were self-reported. Essentially, this meant that the data reflected the women's

points of view and it cannot be assumed that they reflected the practices of the medical professionals (Duthie et al., 2013; Lozada-Tequeanes et al., 2015). In addition, self-reported data may lead to potential misclassification due to recall biases or social desirability (Sattler et al., 2018).

CONCLUSION

Overall, pregnant women receive little counseling on PA and GWG, and this is particularly so for those with weight problems, who are more exposed to excessive GWG. Our results provide additional evidence that the diagnosis of a weight problem impacts behavior and beliefs. Better training for health professionals would increase their knowledge and the frequency of the counseling they give pregnant women to convince them to engage in PA (Malta et al., 2016). It seems an important target and investment for public health policies and policymakers.

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

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The study was conducted in accordance with the Declaration of Helsinki and the current local regulations. The patients/participants provided their written informed consent to participate in this study. It was emphasized that participation was voluntary and that they could withdraw from the project at any time with no explanation required.

AUTHOR CONTRIBUTIONS

SR and SS designed and set up the study protocol. SR, SS, and SA-J analyzed and interpreted the data and contributed to successive drafts and the revising of the manuscript. SR, SS, OH, EJ, and SA-J read and approved the final manuscript. All authors contributed to the article and approved the submitted version.

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