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Accessible health programs promoting physical activity and fitness level

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Accessible health programs promoting physical activity and fitness level

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Editorial: Accessible health programs promoting physical activity and fitness level

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Editorial on the Research Topic
Accessible health programs promoting physical activity and fitness level

Introduction

This Research Topic (RT) focused on different approaches to promote physical activity (PA), along with the underlying factors that may facilitate or hinder PA participation in diverse contexts and for different populations. The health benefits of PA have been supported by a significant number of studies (1, 2). However, most people in the world still do not meet the PA guidelines (3), and PA promotion is not routinely practiced in the clinical setting (4). An active lifestyle can be encouraged through a deeper understanding of its benefits and of how to effectively implement relevant strategies in usual clinical practice. PA promotion should be viewed as a collaborative effort that spans the person-environment system, while accessible facilities and services are one of the keys to building a more supportive environment, especially for people with disabilities, impairments, or low socioeconomic status. Targeting contributing factors and circumstances could improve public health communication for PA monitoring and promotion. To further develop interventions that target inclusive health programs and create a supportive environment, there is a need to focus on elements that are more practical to change as well as remove barriers to PA. Specifically, increasing the capacity of healthcare professionals and organizations can reinforce the importance of PA behavior in clinical practice pathways (5).

Collectively, this RT aims to provide state-of-the-art evidence on the approaches to the promotion of PA and fitness that can be incorporated into real-world practice. It contains 13 contributions on PA or fitness promotion, including original research (nine articles), reviews summarizing the up-to-date evidence (three articles), and a Delphi study developing evaluation indicators (one article).

Factors influencing PA promotion for people with various socio-demographic characteristics

Health-related lifestyle changes, including PA, are impacted by society, especially during critical periods (e.g., the pandemic). A scarcity of accessible resources and support in

society would impede PA participation and exacerbate the challenges faced by vulnerable individuals. In order to examine the consequences on PA changes of environmental factors such as limited access to exercise options and facilities, Zhou et al. compared the PA levels of middle-aged and older adults in China before and during the social distance restrictions imposed by the COVID-19 pandemic. Consistent with previous studies, their study indicated that groups with a lower level of socioeconomic status had a higher probability of PA reduction and that those with a higher level of income also found it hard to maintain positive PA habits during times of crisis. More importantly, their findings emphasized the importance of patient education for individuals with chronic diseases, as providing PA and exercise therapy prescriptions in the clinical setting has been shown to be beneficial in improving the health outcomes of these patients. This article highlighted the need to develop effective strategies (e.g., remote fitness/PA courses) that target these vulnerable populations, especially when routine PA activities are not accessible as usual.

Lábiscsák-Erdélyi et al. examined the impact of physical activity and its intensity on life satisfaction among Hungarian high school students, considering the role of gender and grade level. Results showed that physical inactivity had a negative effect on life satisfaction for both boys and girls, and was exacerbated by low perceived family wealth. Using vigorous PA intensity as the baseline, their results also suggested that vigorous PA is a simple and effective tool to reduce health inequalities among adolescents.

Liang et al. conducted a systematic review to investigate factors related to inclusive physical education (IPE) to expand PA promotion for students with special education needs (SEN) and in maintaining their health within school environments. The results of this review emphasized the need to target resource support and home-school collaboration, to fully utilize PA programs and facilities guided by trained educators. Their comprehensive summary aids in supporting educators and policymakers, which fills the gap between government policy and the current practice in China.

The development of technology and digitalization can be a two-edged sword. It boosts fitness trends, such as wearable technologies and artificial intelligence, but at the same time leads to an inactive and sedentary lifestyle. In the mini-review by Štajer et al., they attempted to provide a critical assessment of the present fitness trends and their shared effects on modern societies. Their results emphasized the demand for both advancements in knowledge and a more significant commitment of resources to increase PA globally.

To fully understand and increase participation in muscle-strengthening exercise (MSE) for all individuals, Gu et al. investigated potential correlates and the level of MSE for Chinese children and adolescents. They found that a range of demographic factors, including grade group, residence, ethnicity, and parental MSE, was associated with children's MSE. The results highlighted the significance of the development and implementation of school physical activity or sports policies.

Evaluation and implementation of policy, strategy, and program

The floating population is always at a disadvantage to access social welfare and healthcare compared to residents. To more effectively promote equal access to basic public health services for migrants, the national essential public health services (NEPHS) in collaboration with relevant guidance have been developed and implemented; however, awareness and utilization remain low. A study conducted by Xu et al. found that the increased awareness of NEPHS had a beneficial effect on its utilization and the health of Chinese migrants. Their finding re-emphasized the important role of healthcare knowledge education to improve people's health literacy for building positive health-related behaviors, such as PA. Concerning the implementation of NEPHS, targeted services for various individuals along with health education activities are also recommended to maximize the benefits of such services.

Relevant PA policies in specific settings can positively impact PA behavior, particularly in the education system. To better adopt such policies, identifying barriers and facilitators of its implementation are the key steps. Using the Consolidated Framework for Implementation Research (CFIR), a cross-sectional study conducted by Wendt et al. provided insights about determinants of PA promotion policy adoption in the context of German elementary schools, including available resources and accessible knowledge and information.

To overcome the barriers to exercise, accessible community/home-based equipment and programs have constantly been developed. Hu et al. evaluated the generalizability and applicability of an exercise program (X-CircuiT) in terms of intensity and energy expenditure among sedentary people with various age groups. They provided a detailed recommendation of its use and confirmed its usability and positive effect on sedentary middle-aged and older adults.

Inactive adults in the workplace are another target population for the promotion of health and PA behavior. In Germany, companies have implemented workplace health promotion (WHP) to encourage PA. The study by Hoffmann and Schaller is the first to evaluate a communication strategy of PA measures in a cross-company network, using the mixed-methods analysis. They highlighted the importance of health communication strategies reaching the target group to raise people's awareness. The results offered insights into communication strategies to actively promote PA in the work setting, and have strong implications for the design of further strategies.

Sauter et al. investigated the specific effect (i.e., empowerment) of a long-standing health promotion approach in Germany targeting socially disadvantaged women. Their study confirmed the beneficial contribution of this PA project and suggests that establishing cooperative planning groups could be effective in involving socially disadvantaged women in the planning and implementation of PA programs. The findings suggest that focusing on socio-political environments at a local level to strengthen community capacities could sustainably implement programs that foster the health behaviors of minority groups.

Training and evaluation of healthcare professionals

It is always required for healthcare professionals to implement high-level medical care for each patient. Therefore, continuous education is needed to upgrade their skills to better facilitate health services (e.g., PA prescription) implementation. Tung et al. conducted a systematic review of randomized controlled trials to explore the effectiveness of learning transfer in medical education and related training circumstances. Their findings suggested that continuous improvements for medical staff are still warranted to optimize their clinical decisions. Furthermore, a Delphi study conducted by Yi et al. developed evaluation indicators to better recruit and manage instructors to operate sports programs for people with disabilities. They highlighted the importance to evaluate professional sports instructors by incorporating Universal Design principles. Furthermore, public health crises, such as the COVID-19 pandemic, have presented challenges not only for patients but also for healthcare professionals. For example, Dai et al. conducted a longitudinal study to compare various elements of the education (i.e., infection containment control training) for dental residents during the pandemic, which provided meaningful implications for crisis-based training to facilitate their wellbeing.

Conclusion

In conclusion, the studies included in this RT provide comprehensive insights into the various facets of promoting PA in a wide range of settings, catering to the needs and interests of different stakeholders. We hope this RT will inspire researchers to better design and implement new approaches targeting the highlighted contributing factors to build a more inclusive and accessible healthcare environment and to improve PA and fitness levels globally.

Author contributions

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

Conflict of interest

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

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Developing Indicators to Evaluate Instructor Management of Sports Centers for the People With Disabilities Based on Universal Design Principles in South Korea

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This study was conducted to develop evaluation indicators for instructor-led management of sports centers for the disabled using universal design (UD) principles in South Korea. These indicators have been developed through Delphi technique to identify the effectiveness of an instructor's management skills. There were 11 documents related to UD used in the literature review, and seven were related to the evaluation index. Through reading and analyzing the relevant contents of the collected literature and many rounds of the Delphi technique, we selected the method and criteria for deriving the evaluation index. In this study, we developed a method that constitutes an evaluation index. The index comprises one evaluation criterion and four evaluation indices. First, for the sub-items of the "recruitment" category, four principles of UD and one supplementary principle of product performance program (PPP) were applied to create items for the evaluation index. Second, the sub-items of the "education" category comprise three evaluation criteria and 10 evaluation indicators. These were applied to the fourth principle of UD and the first and second by-supplementary principles of PPP. The third category, "welfare," comprised two evaluation criteria and six evaluation indices, and the first by-supplementary principle of PPP was applied to the evaluation indices. The index created for evaluating instructors in sports centers using the method elucidated in this study was adequately reliable. Following a similar method, more evaluation indicators should be developed for evaluations of other functions (such as programs, public relations, safety, and finance) based on the principles of UD.

Keywords: universal design, disability, Delphi technique, instructor management, sports centers

INTRODUCTION

Universal Design (UD) was introduced in the 1970s by Ronald Mace, an American architect and product designer with disabilities (1). UD considers human diversity in the design of products and spaces and follows the design of architects and designers (2). In addition, UD aims to create not only a value system that informs the design of environments but also products that meet the needs of all users (3).

UD is already in use in various fields in our society. It is utilized not only in building centers but also in education, IT, and medicine. In particular, in most developed countries, UD is employed in fields that regularly include people with disabilities and members of the general public to provide spaces accessible and practical for everyone; they do not distinguish between spaces used by people with disabilities and those used by others. In other words, in UD spaces, the whole room, building, complex, or facility seamlessly accommodates all members of a diverse population rather than designating distinct, separate spaces intended for individuals with particular disabilities (1, 4, 5).

In most developed countries, UD environments are being created for use by the disabled and non-disabled together. Likewise, Korean governments are also aware of the importance of UD and are planning to build and expand a sports center for the disabled incorporating UD. It has planned to build 30 centers in 2019, 23 centers in 2020, and 30 centers in 2021. In total, the number of sports centers for the disabled will be expanded to 150 by 2025 (6).

In this background, we aimed to create a continuous legacy along with the successful hosting of the 2018 Pyeongchang Winter Paralympics. The name of the Bandabi Sports Center was created in honor of "Bandabi," the mascot of the 2018 Pyeongchang Winter Paralympics in support of guarantees of the priority rights for the disabled and to support the selection of regional customized models suitable for regional characteristics among gymnasiums, swimming pools, and sports specialized models as integrated sports centers used by non-disabled people. In particular, the Bandabi Sports Center was built as a UD because Rep. Kim emphasized it should be built as a national sports center for both the disabled and the general public without emphasizing the disabled (7).

Based on the UD principle, recruiting and managing instructors who are able to operate sports programs for patrons with disabilities is important for effectively distinguishing gyms that accommodate users with disabilities from what previously were "regular" gyms. In other words, a UD sports facility for the disabled can be considered "well-operated" when all of the instructors recognize and guide the concept of UD.

Over the years, many studies related to UD have been conducted, including some research combining UD with sports (8–10), such as studies of UD-related learning (11–14) and UD-related program and device development (15, 16). Research on spatial architecture incorporating UD (17, 18) and one study on the concept establishment of UD (19) have also been conducted. In addition, research on evaluation indicators for the management of sports instructors included a study on instructorship education ability evaluation (20, 21), a study on policy development (22, 23), and a study on leadership role based on the development of leadership education programs (24). Their research presents various discussions, including the reasons for grafting UD, the advantages and disadvantages of UD, and improvement measures. However, there is a scarce study in the development of evaluation indicators for the management of instructors of sports centers for the disabled incorporating UD.

We found one paper that was contextually similar to the present study: Watchorn et al. (25) considered occupations for inclusion in the discourse about architectural environments incorporating UD. The researchers combined quantitative and qualitative methods to present discourses on the jobs that are necessary and the people who are suitable for the UD occupations. Although many UD environments are incorporated into our society, the researchers concluded that such occupations should be created because there are not yet any suitable people for the various types of jobs necessary to operate UD centers and businesses. However, it can be seen that there are some differences between the available literature and this study: we aimed to clarify how to assess and manage instructors who work with all types of users, able-bodied or otherwise, in UD sports centers. Therefore, in this study, it is time to develop evaluation indicators for instructor management of sports centers for the disabled based on UD in Korea.

Therefore, the purpose was to develop an evaluation index that can evaluate the suitability of hiring and managing instructors in UD-based sports centers for the disabled based on the analysis results. This study examined the opinions on what UD elements should be employed and managed by instructors of sports centers for the disabled based on the UD principle through Delphi technique were collected and analyzed.

MATERIALS AND METHODS

Research Procedure

The indicators for the evaluation of sports instructors at all centers for disabled people to which UD was applied were derived over a total of four stages. As a first step, the extent of incorporation of the UD elements and the method of deriving evaluation indices were determined through literature research. In the second step, 17 chosen experts were subjected to the first modified Delphi technique. Among the seven principles of UD and three supplementary principles of product performance program (PPP), three elements to be reflected in the evaluation index, evaluation criteria, and evaluation index items were extracted and classified. The Delphi panel configuration is shown in **Table 1**.

As the third step, the second modified Delphi technique was carried out to confirm and revise the reflection factors of UD, evaluation criteria, and classification results of evaluation indicators. The final methodology step was to confirm the degree of agreement among experts regarding the evaluation categories, the criteria for selection, and index contents. This was done by using Kendall's Coefficient of Concordance W (Kendall's W) analysis and intraclass correlation coefficients (ICC). The detailed research procedure is shown in **Figure 1**.

Developing Evaluation Indicators

Eleven documents related to UD were used in the literature review, and seven documents related to the construction of the evaluation index. These documents were carefully analyzed, the results helped in setting the scope of evaluation indicators to be reflected in this study. The scope of UD was applied using the Center for Universal Design (1997) and the proposed

TABLE 1 | Delphi panel configuration.

Configuration	Affiliation organization	Position
Disabled sports specialist	Seoul Aquatic Rehabilitation Center	Center director
	Jeongjeong Hall	Sports team instructor for the disabled
	Gwangju Metropolitan City Disabled National Sports Center	Sports team instructor for the disabled
	Goyang City Rehabilitation Sports Center	Center director
	Seongnam City Hanmaeum Welfare Center	Sports team instructor for the disabled
	Jecheon City Eoullim Sports Center	Sports team instructor for the disabled
	Asan National Sports Center for the Disabled	Sports team instructor for the disabled
	Jeonju Eoullim National Sports Center	Sports team instructor for the disabled
	Gwangyang National Sports Center for the Disabled	Center director
	Gumi City Gymnasium for the Disabled	Sports team instructor for the disabled
	Changwon City Gomduri National Sports Center	Sports team instructor for the disabled
	Chuncheon Disabled Sports Center	Sports team instructor for the disabled
	Seoul Gomduri Sports Center	Sports team instructor for the disabled
Senior sports specialist	Seo-gu Senior Welfare Center	Sports team instructor for the senior
	Yeonsu Senior Welfare Center	Sports team instructor for the senior
	Michuhol Senior Welfare Center	Sports team instructor for the senior
	Yeonsu Senior Welfare Center	Center director

Universal Design Product Performance Program (PPP) (26). The modified Delphi technique was assessed as suitable for constructing the evaluation index. Accordingly, a structured questionnaire enquiring about the UD factors was prepared for the method. The validity of this analysis was verified through Kendall's W; the ICC reliability was also verified.

Modified Delphi Technique

Delphi is a technique that requires the collective judgment of experts in the relevant field. As a consequence, the selection of experts is very important in the Delphi investigation process. Regarding the necessary number of experts participating in the Delphi technique, useful results can be obtained with a small group of 10–15 people (27, 28). A total of 17 field experts were selected as Delphi panels. The Delphi process was implemented over three rounds. In the first round, to incorporate the UD principles in the evaluation criteria, the UD content had to be applied to the evaluation index that was shared with the selected panel by e-mail and was further explained through phone calls or in-person interviews. This enabled multiple UD elements to be applied to the program evaluation index of the gymnasium for the disabled. In addition, it was possible to describe the index items required to operate the program. In the second round of the Delphi process, the results extracted and classified during the first round were shared with the experts by e-mail, and additional opinions to be added or modified in the results were recorded through text analysis. In the third Delphi round, a questionnaire was administered using a 5-point Likert scale to assess the suitability of the evaluation index items to confirm the consensus of the panel on the results extracted during the first and second rounds. To verify the suitability and validity of the evaluation indices, frequency analysis, intraclass correlation coefficient (ICC) reliability analysis, and Kendall's W analysis were conducted using SPSS 21.0. These tests confirmed the degree of agreement among the experts regarding the selections made, and the ranking of each item was analyzed to refine the attributes further.

ICC verification indicates the correlation between the evaluators of the measurement tool. ICC provides relatively stable values when the sample size is small (29). When the reliability index is 0.8 or higher, it shows very high reliability, 0.6 or higher means relatively high reliability, 0.4 or higher refers to moderate reliability, and 0.2 or higher means determined to reasonable reliability (30). Although this index cannot be called absolute, it is often used because it is considered useful (31).

Kendall's W is a method used for checking the degree of agreement among evaluators. It is used when multiple evaluators assess the same subject, and it is measured on an equality scale and a ratio scale. The W value represents a number from 0 to 1, and the closer the value is to 1, the higher the degree of consensus, and the closer it is to 0, the more disagreement there is among the experts (32).

RESULTS

UD Factor Reflection Range

UD is a concept created to be applied to architecture or product design, but it was also introduced in learning in 1989 by The National Center for Accessing the General Education Curriculum in the US. The universal design for learning (UDL) was instituted as a new paradigm (33, 34). UDL considers that the difficulty of incorporating the seven UD principles into learning directly and, thus, alternatively provides three core UDL principles (various presentation methods, various expression methods, and various participation methods) to be utilized (35). In this study, the researchers also judged that, as it was, it was too difficult to apply the program to the seven UD principles or the three supplementary principles of PPP to develop program evaluation indicators. Therefore, the expert group selected all seven UD principles and the three supplementary principles that were deemed applicable to the program evaluation index in the first Delphi round. In addition, the UD-based elements constituting the program evaluation index of the sports facility for the disabled were described.

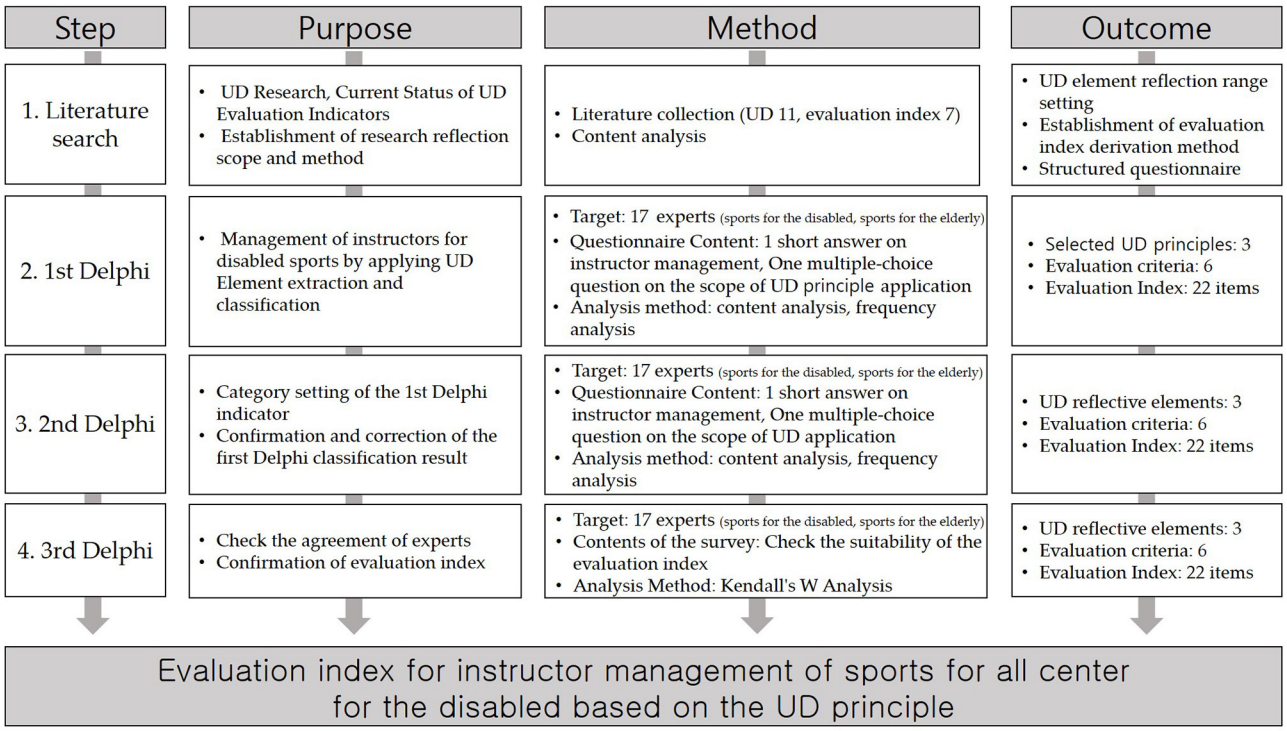

FIGURE 1 | Research Flow.

Selection of Methods for Deriving Evaluation Indicators

Seven studies were selected for creating an evaluation index, and their methods of research and analysis were analyzed. On the basis of this analysis, to derive the results of this study, it was determined that the modified Delphi technique was the most suitable. "Modified Delphi" refers to the case where the content is not structured by the panel, but the researcher uses a structured questionnaire from the beginning (36). The reason for choosing this method was that the UD concept is broad, and the range of differences in interpretation is likely to be large when applied to the sports program aspect. Therefore, it was decided that the Delphi technique should be conducted after first extracting items for the index with the seven UD principles and the three supplementary principles of PPP. Kendall's W was selected as the method of analysis. The same method of analysis was used in a previous study using the Delphi survey, which is known to be the most suitable among the non-parametric tests used with the above-mentioned survey. The closer the W index gets to 1, the stronger the consensus (37).

Delphi Analysis Results

First Delphi

The first Delphi round surveyed the scope of applicability of UD's seven principles and the three supplementary principles to the program evaluation index for the panel and allowed them freedom to describe the essential elements of the Instructor evaluation index. While enquiring about the applicability range of UD's seven principles and three supplementary principles, the first priority of experts was "Product Quality and Aesthetics;" the second priority was the "Perceptible information," and lastly, they prioritized the "Human environmental consideration." Detailed results are shown in **Table 2**.

In addition, the elements that must be included in the index that evaluates the instructor of the sports facility for the disabled were classified into six evaluation criteria and 22 evaluation indices. The detailed results are shown in **Table 3**.

Second Delphi

In the second round of the Delphi process, the evaluation index was classified into three categories by confirming and revising the results of the first Delphi round, wherein two evaluation indices were deleted. With regards to the second deleted indicator, they explained that the "Priority hiring of professional sports instructors for the disabled" has the same meaning as the indicator "Priority hiring experienced sports instructors for the disabled and those who majored in special sports," and hence does not need to be considered.

The panel finally selected three principles as suitable to be applied to evaluate sports instructors (Principle 4: Perceptible information, supplementary principles 1: Product Quality and Aesthetics, 2: People's Health and the Natural Environment). This selection was made out of a total of seven UD principles and three supplementary principles. The panel also confirmed that these deletions were reflected in the evaluation index depending on their meaning and intention. Accordingly, the evaluation index

TABLE 2 | Seven principles of UD and three supplementary principle of PPP.

	Division	Contents
7 Principles	Principle 1: Equitable use	Can anyone use it fairly?
	Principle 2: Flexibility in use	Can you accommodate individual preferences and abilities broadly?
	Principle 3: Simple and intuitive use	Is it easy to understand regardless of users' experience, knowledge, language ability, concentration, etc.?
	Principle 4: Perceptible information	Does it effectively deliver necessary information regardless of users' perceptual ability or surrounding conditions?
	Principle 5: Tolerance For error	Have you minimized the adverse effects and risks of dangerous behavior?
	Principle 6: Low physical effort,	Can you minimize fatigue and use it more effectively and safely?
	Principle 7: Size and space for approach and use	Can users provide an appropriate size and space for contacting, reaching, manipulating, and using regardless of their body size and mobility?
3 supplementary principle	Supplementary principle 1: Product quality and aesthetics	The product acts on the user's various five senses, Are you providing the right "feeling"?
	Supplementary principle 2: People's health and the natural environment	From use to disposal of the product, it may be harmful to humans. Isn't the material used?
	Supplementary principle 3: Product durability and production economics	The purchase price or the cost of use is equal to the performance or quality.

TABLE 3 | UD application in the scope of evaluation index.

	Division	Frequency (rate)
7 principles	Principle 1: Equitable use	3 (5.0%)
	Principle 2: Flexibility in use	1 (2.9%)
	Principle 3: Simple and intuitive use	0 (0.0%)
	Principle 4: Perceptible information	6 (9.8%)
	Principle 5: Tolerance for error	2 (3.3%)
	Principle 6: Low physical effort	3 (5.0%)
	Principle 7: Size and space for approach and use	2 (3.3%)
3 supplementary principle	Supplementary principles 1: Product quality and aesthetics	8 (13.3%)
	Supplementary principles 2: People's health and the natural environment	6 (9.8%)
	Supplementary principles 3: Product durability and production economics	3 (5.0%)
Sum total		34 (100%)

was modified during the second Delphi and was further divided into six evaluation criteria according to three categories (selected principles). These six evaluation criteria were then expanded into an evaluation index of 20 items. The evaluation indicators classified as secondary are shown in **Table 4**.

Third Delphi

In order to verify the validity and reliability of the evaluation indices obtained in the previous round, in the third Delphi round, the panel was asked to respond to a 5-point Likert scale indicating whether the contents of the evaluation index were appropriate. The results are shown in **Table 5**. To establish the statistical strengths of the evaluation index, we checked the average value and standard deviation value of the index. Data on the quantitative part of the questionnaire can be measured using average scores as a standard measure of the indicator's importance.

According to Linstone and Turoff (37), average values can be used to determine whether expert opinions on questionnaire items are consistent and stable (38). Secondly, the ICC index was confirmed by the verification of reliability. Since previous studies have stated that the value of the ICC is valid above 0.2, all items with scores below 0.2 were targeted for removal. Hence, the reliability index of "the performance system" was removed, as it had an ICC value of 0.127. Finally, the results of Kendall's W verification showed that there were statistically significant agreements in five evaluation criteria out of the six. The criteria for evaluation that did not match was the "achievement system." Accordingly, the "achievement system" of "welfare" was removed, and the remaining five criteria were added.

DISCUSSION

This study has developed the evaluation indicators for instructor management of sports centers for the disabled following the UD principle. Using Delphi technique we determined which UD elements should be employed and managed by instructors of UD principle-based sports centers for the disabled. Hence, an evaluation index for assessing the suitability of hiring and managing instructors in UD principle-based sports centers for

TABLE 4 | Classification of primary assessment criteria and evaluation indicators.

Assessment basis	Evaluation index
1. Recruitment of professional instructor	1.1 Recruitment of those who have obtained certificates for daily sports and sports for the disabled for the operation of integrated programs
	1.2 Priority recruitment of experienced coaches, special sports majors, and experienced athletes
	1.3 Preferential recruitment of disabled professional athletes
	1.4 Introduction of a professional recruitment system
	1.5 Stabilizing the working environment by securing regular employees
2. Service requirements	2.1 Establishment of working conditions to ensure physical and psychological stability
	2.2 Appropriate personnel per instructor
	2.3 Conducting work based on the Labor Standards Act and the Occupational Safety and Health Act.
	2.4 Creating conditions for focusing on work
3. Performance system	3.1 Establishing a compensation system through performance management
	3.2 Payment of legal allowances in case of overtime or weekend work.
4. Conservative education	4.1 Reinforcement of Instructors' Capabilities Through Conservative Education
	4.2 Providing service and sex crime prevention training to instructors
	4.3 Management and education of instructors through the Sports Association for the Disabled in the relevant local government
5. Support for capacity enhancement	5.1 Support for certificate of sports instructor for the disabled (expenses for education, training hours)
	5.2 Responsibility for the qualification of judges and instructors of persons with disabilities
	5.3 Establishing an education system to enhance instructorship competency
	5.4 Conduct job-related education (sports safety education, first aid treatment, operation event guidance law, etc.)
	5.5 Continued capacity building training to foster experts
6. Strengthen expertise	6.1 Training for integrated disabled/non-disabled sports instructors in the gym
	6.2 Seminar on Sports for the Disabled, Education Support 6.3 Securing superior human resources

the disabled was created. In this section, we would like to discuss further the meaning of the development of evaluation indicators.

First, the results of a literature survey on UD revealed seven principles and three supplementary rules of commonly used UD. The seven principles were fair use, flexibility in use, simple and intuitive use, recognizable information, tolerance for mistakes, small physical efforts, size, and space for approach and use. The three supplementary rules were the pursuit of quality and psychology, consideration of the human body and the environment, and economic feasibility and validity. In addition, based on previous studies, evaluation indicators were developed through Delphi surveys.

According to previous studies, it can be seen that UD is a necessary element in the present era. In addition, according to UD's definition, it is predicted that it will be applied in various fields (1). Currently, the society we live in is changing into a fast and diverse society (38). In other words, it is important that UD technology, which can be conveniently used together, is applied not only to the hardware field but also to software. Although UD technology has already been applied and actively utilized in various fields other than the field of sports (39–42), it remains to be seen whether it is well applied and operated.

In an environment related to the disabled, even if the centers are good, the impact on the disabled depends on the ability of the instructor (43). Therefore, the management of the instructor who guides the disabled or the evaluation of the instructor's ability should be prioritized (44). In particular, the ability of the instructor is more important for exercise (45). In elite games, the ability of the instructor determines whether the team will win or lose. Similarly, in sports for all, depending on the level of knowledge and various experiences of the instructor, it is possible to continue with fun in sports without injury. A qualified and effective instructor is particularly key for safe and successful exercise for people with disabilities. The disabled have more things to pay attention to than the general public, so expertise in the disabled and experience in guiding the disabled movement is very important.

Therefore, it is necessary to not only select professional instructors but also evaluate them. Various studies related to people with disabilities have also emphasized the importance of evaluation indicators for leadership management (46–51). However, research on the instructor evaluation index of sports centers for the disabled incorporating UD is still insufficient. Therefore, this study would be meaningful to select and analyze questions that fit the instructor management evaluation index through the principle of UD. Moreover, UD will be applied, operated, and expanded in many places throughout our society in the future. Likewise, the practical approach to the development of the instructor evaluation index of sports centers for the disabled based on UD technology is considered an especially important practice.

Second, according to the results of the Delphi survey of the expert group, a large category of evaluation indicators was set

TABLE 5 | Contents of evaluation index and Results of analysis of reliability, and validity of evaluation indicators.

Category	UD	Evaluation conformity	Evaluation index	Mean	SD	rank	ICC	Kendall's W	df	Result processing
Recruit	UD 4 PPP 1	1. Recruitment of professional instructors	1.1 Recruitment of those who have obtained certificates for daily sports and sports for the disabled for the operation of integrated programs	4.538	0.508	3.19	0.533	0.144**	4	selection
			1.2 Priority recruitment of experienced coaches, special sports majors, and experienced athletes	4.461	0.646	3.04				
			1.3 Introduction of a professional recruitment system	4.538	0.508	3.19				
			1.4 Stabilizing the working environment by securing regular employees	4.615	0.637	1.62				
Education	UD 4 PPP 1 PPP 2	4. Conservative education	2.1 Reinforcement of Instructors' Capabilities Through Conservative Education	4.384	0.752	2.23	0.500	0.154*	2	selection
			2.2 Providing service and sex crime prevention training to instructors	4.307	0.617	2.08				
			2.3 Management and education of instructors through the Sports Association for the Disabled in the relevant local government	4.000	0.894	1.69				
		Support for capacity enhancement	5.1 Support for certificate of sports instructor for the disabled (expenses for education, training hours)	4.384	0.752	2.81	0.654	0.177***	4	selection
			5.2 Responsibility for the qualification of judges and instructors of persons with disabilities	4.153	0.880	2.27				
			5.3 Establishing an education system to enhance instructorship competency	4.692	0.470	3.35				
			5.4 Conduct job-related education (sports safety education, first aid treatment, operation event guidance law, etc.)	4.692	0.470	3.38				
			5.5 Continued capacity building training to foster experts	4.615	0.496	3.19				
		3. Performance system	3.1 Establishing a compensation system through performance management	4.538	0.646	2.00	0.809	0.259***	2	selection
			3.2 Payment of legal allowances in case of overtime or weekend work.	4.307	0.735	1.69				
Welfare	PPP 1	Service requirements	2.1 Establishment of working conditions to ensure physical and psychological stability	4.538	0.760	3.38	0.921	0.137*	3	selection
			2.2 Appropriate personnel per instructor	4.461	0.646	2.50				
			2.3 Conducting work based on the Labor Standards Act and the Occupational Safety and Health Act.	4.461	0.646	2.50				
			2.4 Creating conditions for focusing on work	4.615	0.637	2.81				
		Performance system	3.1 Establishing a compensation system through performance management	4.307	0.617	2.19	0.127	0.099	1	remove
			3.2 Payment of legal allowances in case of overtime or weekend work.	4.307	0.928	1.38				

*$p < 0.5$.
**$p < 0.1$.
***$p < 0.01$.

for recruitment, education, and welfare. First, recruitment factors appeared to be important in hiring. The evaluation index in recruitment was found to stabilize the working environment by supporting the hiring of people with daily sports and sports certificates for the integrated program operation; establishing preferential recruitment of experienced athletes and special sports majors; introducing a professional recruitment system; and securing regular employees.

This study was conducted based on sports centers. Therefore, it is of paramount importance to select a professional sports instructor. In particular, the expertise of sports for the disabled is noticeable (52). Professionalism includes obtaining certificates, experiences of professional study related to the disabled, and experiences of working in occupations related to the disabled. However, the most important thing is whether someone has direct experience in the field of sports for the disabled. Due to the extent of the differences in the sports-related characteristics of people with disabilities, the instructors with direct experience teaching sports to the disabled must be hired first (8, 53–56).

In addition, stabilization of the working environment is of paramount importance. In the case of Korea, it continues to raise questions about the working environment of sports instructors for the disabled (57). In order to solve the stabilization of the working environment for disabled people, the Ministry of Culture, Sports and Tourism of Korea has increased its budget since 2015. However, the problem of the working environment of sports instructors with disabilities in Korea has not disappeared and is continuously making claims for improvement (57). Likewise, even if a sports facility for the disabled based on the UD principle is completed, the expansion project of these centers will be ruined if the working environment of employees working there is not stabilized. The utilization rate of people who use this place and the disabled among them will be high. One study argued that disabled people in Korea would actively participate in exercise if they had space to exercise near their residence (58). As shown in the study, space is more important than anything else for the disabled, but if there is no one to guide the disabled in the exercise space, it is judged that this is a result of not seeing a distant future. Therefore, stabilizing the working environment of full-time employees is the most important matter.

In terms of education, conservative education, capacity building, and expertise building are considered most important. The evaluation indicators of conservative education are strengthening leadership capabilities through conservative education, service and sex crime prevention education for instructors, and leader education through sports associations for the disabled in local governments. The evaluation indicators for competency building are sports instructor certification support for the disabled, the duty of the disabled to acquire referee and instructor qualifications, the establishment of an education system to strengthen leadership competency, job-related education, and continuous competency building education. Finally, the evaluation indicators for strengthening expertise are UD instructor training education, UD-related seminars in sports centers for the disabled, and educational support.

In certain organizations, groups, organizations, etc., educational support from members is one of the most important parts (59). In particular, job training is very important in the field of exercise instruction. Its importance is further highlighted in the field targeting the disabled (60). In addition, there are also exercises that people with disabilities can do alone, but in most cases, someone has to assist them. Therefore, it is necessary to be accurately aware of sports safety education, first aid education, and operation education for sports. Even if it is a simple method, it is difficult to master it without experiencing it; thus, operation experience is essential.

There is a growing trend of incorporating UD principles into designs for sports centers for the disabled. UD designs may include elements of the space, centers, and equipment that differ from what is generally expected in "traditional" gyms and sports complexes. Reports from regions overseas where UD principles have long been used in construction emphasize that because UD centers are marked differences compared to general centers, the education of leaders and users must be prioritized to maximize the usability of UD centers (61). The recommended education is, above all, related to expertise. Thus, guidelines are needed for sports centers for the disabled incorporating UD, and evaluations of each center's performance should be based on how well they are following those guidelines.

Above all, in sports centers for the disabled, the instructors' service to facility users is important (59, 62). Even with elite disabled athletes familiar with sports, conflicts with instructors continue to occur (63). Therefore, it is paramount that the kindness of instructors is also evaluated. It is of paramount importance for instructors to demonstrate kindness beyond the times when they are providing movement guidance. If these details are included in education and applied to the evaluation index, both the economic level and the social culture of Korea will advance.

Finally, working conditions and performance systems were important in welfare. The evaluation index for working conditions was found to prepare working conditions to ensure physical and psychological stability, arrange appropriate personnel per instructor, conduct tasks based on the Labor Standards Act and the Occupational Safety and Health Act, and create conditions for concentration of assigned departments. The evaluation indicators of the performance system were found to establish a compensation system through performance management, overtime, and payment of legal allowances for weekend work.

Many office workers worldwide value the welfare of their workplace. This value is also paramount to work-life balance (64–66). Additionally, sufficient rest positively affects and increases work efficiency. In the case of Korea, a five-day workweek is operated. However, it is one of the countries with the highest working hours among OECD countries. The happiness index is one of the low countries (67). This means that life in Korea is not happy. For happiness, the welfare of workers should be prioritized, and it should not be forgotten that well-being jobs have a positive impact on performance in the end.

Therefore, even in sports centers for the disabled based on the UD principle, it is important to evaluate the welfare of workers. Also, instructors in sports centers who work with people with disabilities must provide more guidance (and more frequent

guidance) to their clients compared to instructors who work with the general public. Work that requires more concentration—and more attention to more details—can generate more work stress for these instructors (59, 62). The heightened level of attention and potential stress for instructors in UD sports centers should be included in the evaluation index, and heightened stress should be evaluated. In addition, careful assessment to determine whether an appropriate compensation system has been implemented was found to be an evaluation point that can clearly motivate workers. When each element of the evaluation items are applied well, investments in UD principle-based sports centers for the disabled will increase, and utilization of the UD sports centers will also be increasingly more positive.

CONCLUSION

The purpose of this study was to evaluate and analyze the UD factors related to sports instructors that should be reflected in the assessment and operation of sports centers for the disabled. Using the Delphi technique with experts, we developed evaluation indicators to assess the hiring and training of instructors and measure the instructors' management skills.

The evaluation index developed through the literature review and subsequent rounds of the Delphi techniques consisted of three categories: "recruitment," "education," and "welfare." First, we established the sub-items of the "recruitment" category consisting of one evaluation criterion and four evaluation indices. Supplementary principles, based on the fourth UD principle (recognizable information) and the supplementary principles of PPP (Product Quality and Aesthetics), were also identified as relevant to the study's aims and applied to the evaluation index. Second, we developed the sub-items of the "education" category consisting of three evaluation criteria (remedial education, capacity building, specialization strengthening) and 10 evaluation indices. These were based on the fourth UD principle and the first and second sub-principles of PPP (People's Health and the Natural Environment). The third category, "welfare," comprises two evaluation criteria (work conditions and achievement system) and six evaluation indices derived from PPP's first supplement. The chosen welfare category items were also applied to the evaluation indices.

Based on our findings and the evaluation indices, the recommendations of this study are as follows: First, the work of validating the evaluation indices should be carried out by applying the developed evaluation index to instructors and operators of public sports centers and sports centers for the disabled that offer integrated programs. Second, more evaluation indicators are needed (and should be developed) for other functions—such as programs, public relations, safety, and finance—of sports centers for the disabled based on the UD principles. An awareness education program promoting and clarifying the UD concept and informing the public about the purpose of the centers is needed to ensure the provision of a fair and comfortable environment wherein everyone has access to UD sports centers. Moreover, steps should be taken to guarantee that everyone can easily and conveniently patronize the centers.

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

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

EY and AO: original draft preparation. AO: data analysis. EY and JS: critical review of the contents. AO and JS: data collection and critical review of the manuscript. AO, JS, and EY: supervision. All authors have read and agreed to the published version of the manuscript.

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Correlates of Meeting the Muscle-Strengthening Exercise Guidelines in Children and Adolescent

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This study aimed to explore the potential correlates of muscle-strengthening exercise (MSE) in Chinese children and adolescents. A convenient sample (n = 3733) was recruited into this study. Self-reported questionnaires were used to collect information on sex, grade, ethnicity, residence, family composition, moderate to vigorous physical activity (MVPA), family income, parent's education level and MSE in children and adolescents as well as their parent(s). The prevalence of meeting the MSE guidelines was 62.1%. Children and adolescents who were in primary or middle school were more likely to meet the MSE guidelines ([primary school] OR = 2.33, 95% CI: 1.16–4.68; [middle school] OR = 4.62, 95% CI: 2.27–9.39). Children and adolescents with Han ethnicity had a higher likelihood to meet the MSE guidelines (OR = 1.97, 95% CI: 1.37–2.83). Children and adolescents meeting the MVPA recommendation were more likely to meet the MSE guidelines (OR = 5.41, 95% CI: 3.97–7.37). Relative to those who had a parent not meeting the MSE guidelines, those with either father or mother meeting the MSE guidelines were more likely to meet the MSE guidelines (OR = 1.32, 95% CI: 1.13–1.55). Our study may offer evidence for future MSE interventions in Chinese children and adolescents.

Keywords: physical activity, promotion, muscle-strengthening exercise, school-aged children factors, China

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INTRODUCTION

As a neglected form of health-enhancing physical activity (PA), muscle-strengthening exercise (MSE) epidemiological research is still limited (1), even though the World Health Organization (WHO) recommend that children and adolescents as well adults should engage in MSE (e.g., barbells or dumbbells) a week (2) because of its numerous health benefits, including bone health promotion (3), muscular fitness improvement (3), obesity prevention (4) and mental disorders discouragements (5, 6). At present, however, the relevant studies on MSE focus on the adult population instead of the young population (1). For example, some national surveys (e.g., the USA, Australia, Scotland) merely reported the estimated prevalence of meeting the age-specific MSE recommendation in adults (at least 2 times a week) (2) and these studies indicated that adults had insufficient participation in MSE (3, 7, 8), especially on western adult populations (9). Despite this, a recent systematic review demonstrated that the relationship between MSE and sedentary behaviors, sleep during childhood is still needed more evidence to support (10).

Across the previously published literature, sufficient attention has been laid on correlates of MSE in adult populations rather than other young populations. Specifically, Smith and his colleagues conducted many national surveys to report the levels of MSE and then explore its correlates in adult populations from various countries (11). For example, in German adults, 58.3% of them reported no MSE (5). Among 9345 Australian participants, the prevalence of meeting the MSE guidelines was 18.6 (95% CI: 17.5–19.7), and it is associated correlates included sex, age and self-rated health (8). In the US, the nationally representative data showed that 30.2% of American adults met the MSE guidelines while 57.8% of them had no MSE at all per week (3). This study also suggested that sex, income, education level, obesity and aerobic activity engagements, as well as self-rated health, were significant correlates of MSE (3). Recently, some researchers who are not from western countries have begun to pay attention to this research topic. Specifically, using a sample of Chinese adults from Hubei Province, Lin and Yan (9) found that the prevalence of meeting the MSE guidelines was 28.5%, and its correlates were sex and family composition (single or multiple kids). Based on those studies, it is acknowledged that there is sufficient evidence base to understand the adult population's engagements in MSE.

However, to our knowledge, so far, little is known about the levels and correlates of MSE among children and adolescents (7). Across a limited number of studies, some researchers merely reported the levels and explore the correlates of MSE, respectively, among western countries' children and adolescents, like Australia (11), the US (12) and Canada (13). For example, a recently published study by Smith et al. (11) found that only two factors, including resisting training efficacy and moderate to vigorous physical activity, were associated with MSE in a sample of Australian adolescents ($n = 602$). For the US children and adolescents, boys were more likely to report meeting the MSE guidelines than were girls (adjusted OR = 1.65, 95% CI: 1.43–1.91) (12). In another study consisting of the US samples (Los Angeles Unified School District), the authors also indicated sex is an important correlate of meeting the MSE guidelines (14). In Canada, the health survey data showed that only 53.7% of 45,298 grade 9–12 students reported having more than 3 times of MSE per week (13). The reported levels of MSE and associated factors with MSE across the literature may help researchers better understand insufficient engagements of MSE in children and adolescents, which can, in turn, help design effective interventions aiming at promoting MSE. However, so far, little is known about the MSE status focused on Chinese young people, while a majority of physical activity studies focused on the overall physical activity instead of specific components of physical activity (15, 16). This is a barrier for capturing true levels of MSE and its potential correlates, which provides insights into a comprehensive understanding of physical activity in Chinese young people. The current evidence gaps would be negative to design and implement MSE interventions or promotions. In addition to MSE interventions, recent research has stressed the importance of promotiong physical literacy in children and adolescents. A physically literure individual should engage in sufficient physical activity behaviors, including MSE (17). From the perspective of physical literacy promotion, it is needed to examine which factors would be associated with the components of physical literacy.

To better understand MSE among Chinese children and adolescents, evidence of levels and correlates of the MSE based on empirical studies is required. In this regard, it is recommended that Chinese researchers should explore the correlates of MSE among Chinese children and adolescents. Addressing the evidence gaps in the literature needs a great deal of empirical research. The objectives of the present study were, therefore, to report levels of MSE in a sample of Chinese children and adolescents and its potential correlates (e.g., intrapersonal, interpersonal and behavioral aspects).

METHODS

Study Design and Participants

The study design and methodology has been reported elsewhere (9). In brief, the present study was a cross-sectional aiming to explore parents' impacts on their kids' (children and adolescents) healthy active lifestyles, conducted from May to June 2019 in the Hubei Province of China. Using convenience sampling, three public schools (one primary school, one middle school, and one high school) were invited from each city (13 cities in the Hubei Province; 39 schools were in total invited) to participate in the survey. Finally, 3733 study participants (age range: 10-19 years) and one of their parents (either mother or father) provided valid information for all variables pertaining to this study. The study protocol and procedure were approved by the Institutional Review Board (IRB) of Wuhan University of Technology in March 2019. Participants and their legal guardians provided written consent. To enhance the reliability and validity of the survey, the research staff promised that participants' information will be strictly protected and treated anonymously (only use for research aims).

MEASUREMENTS

Study Outcome (Muscle-Strengthening Exercise, [MSE])

Study participants were asked to report their information on MSE. The question was that "how many times did you do MSE designed to strengthen your muscles last week?". In this context, MSE was defined as "activities to be done involving major muscle groups, like a push-up, weightlifting, curl-up or pull-up" to help participants better understand and fill in the questionnaire easily. Response times for participants were 0-7 days. This measure has been considered reliable and valid in assessing young people's MSE (12, 18). Based on the well-recognized MSE guidelines (World Health Organization, 2020), in this study, the variable of MSE was treated as a binary variable in the statistical analyses (0 = not meet [reporting 0-2 days], 1 = meet [reporting 3-7 days]).

Study Exposures

Each study participant was asked to report the following information. For intrapersonal information, participants reported their sex (boy or girl), grade (4, 5, 6…12), China's ethnic groups (Han or minority), residence (urban or rural),

family composition (single children or multiple children), For behavioral information, each study participants reported that how many days engaging in moderate to vigorous physical activity (MVPA) via the Chinese version of the Health Behavior in School-aged Children (HBSC) questionnaire which has been validated in Chinese (19), and this measure is a well-recognized questionnaire that has been used widely in China's physical activity epidemiological research (20–22). The following item was used: How many days did you engage in MVPA at least 60 min on weekdays over the past week? (0 = none, 1 = 1 day, 2 = 2 days, 3 = 3 days, 4 = 4 days, 5 = 5 days, 6 = 6 days, and 7 = 7 days). Study participants reporting 7 days were regarded as meeting the MVPA guidelines (2, 23). Study participants' parent reported their family income and educational level using a self-reported questionnaire designed for parents (either father or mother). Parent-reported their family income (personal annual income in a family) (<9000; 9001–30,000; 30,001–100,000; >100,000; [Unit: Chinese Yuan]). The same question of assessing children and adolescents' MSE was also used to collect information on parents' MSE. For adults, parent reporting at least 2 days was regarded as meeting the MSE guidelines (2).

Statistical Analyses

First, descriptive statistics were used to report the prevalence of meeting the MSE guidelines (met vs. not met) and exposure variables (sex: male or female; grade group: primary school, middle school or high school; ethnicity: Han or Minority; residence: urban or rural; family composition: single or two or more children; parent's education level: primary school or below, middle school, high school, occupation school, graduate, postgraduate or above; personal income: <9,000 or 9,000–30,000 or 30,000–100,000 or >100,000; children's MVPA guidelines: not meeting or meeting; parent's MSE guidelines: not meeting or meeting; children's MSE guidelines: not meeting or meeting). Second, *Spearman's rho* coefficients were calculated to determine the bivariate associations among study variables (exposures and outcome). Third, to assess the associations between selected factors (study exposure) and whether or not meeting the MSE guidelines, multilevel logistic regression (also called hierarchical regression) was used. This technique takes into account the dependency of observations within a or multiplies clusters (in this case, individual characteristics were nested within schools, and schools were nested within districts). A multilevel logistic regression controls for confounding at the micro-level (individual), but in addition controls for confounding at the macro-level (schools or districts). Based on our data structure of this study, we fitted our data as a three-level structure (level 3: district; level 2: school; level 1: individual), which then uses a multilevel logistic regression analysis with Restricted Maximum Likelihood Estimation (REML) was conducted to examine the associations of MSE with exposure variables. Adjusted odds ratios (ORs) with corresponding 95% confidence intervals (95% CI) were described. Statistical analyses were performed using IBM SPSS 24.0 software (using the Generalized Linear Mixed Models module).

RESULTS

Table 1 shows the sample characteristics of this study. In total, 3733 children and adolescents were included in the analysis (62.3% boys). The percentages of participants from primary schools, middle schools and high schools were 35.0, 30.65, and 34.4%, respectively. Most of the children and adolescents were of Han ethnicity (74.7%), living in an urban area (80.1%) with no siblings (75.5%). Approximately 30.0% of their parents had received university or above education level. And about two-fifths of participants reported family income between 30,000 to 100,000. Less than 20% of children and adolescents met the MVPA guidelines, while 62.1% of them met the age-specific MSE guidelines with gender differences ($p < 0.00$). As for their parents, 45.7% of parents complied with parents MSE guidelines.

The bivariate correlations among study variables are shown in **Table 2.** To be specific, children's MSE guidelines was positively correlated with sex ($r = 0.051$, $p < 0.01$), residence ($r = 0.012$, $p < 0.01$), siblings ($r = 0.062$, $p < 0.01$), children's MVPA guidelines parent's ($r = 0.289$, $p < 0.01$), MSE guidelines ($r = 0.107$, $p < 0.01$), respectively. More information can be found in **Table 2**.

Table 3 shows the results by a multilevel logistic regression, revealing the associations between the potential correlates with meeting the MSE guidelines in the study samples. In detail, compared with those who were in high school, children and adolescents who were in primary school and middle school were more likely to meet the MSE guidelines ([primary school] OR = 2.33, 95% CI: 1.16–4.68, $p = 0.02$; [middle school] OR = 4.62, 95% CI: 2.27–9.39. $p = 0.00$). Children and adolescents with Han ethnicity had a higher likelihood to meet the MSE guidelines (OR = 1.97, 95% CI: 1.37–2.83, $p = 0.00$). Children and adolescents living urban areas were more likely to meet the MSE guidelines (OR = 1.26, 95% CI: 1.06–1.70, $p = 0.01$). Regarding MVPA in children and adolescents, the regression results display that children and adolescents meeting the MVPA recommendation was five times greater than those not meeting the MVPA recommendation to meet the MSE guidelines (OR = 5.41, 95% CI: 3.97–7.37, $p = 0.00$). Relative to those who had parents (either father or mother) not meeting the MSE guidelines, children and adolescents with either father or mother meeting the MSE guidelines were more likely to meet the MSE guidelines (OR = 1.32, 95% CI: 1.13–1.55, $p = 0.00$).

DISCUSSION

The present study aimed to report the prevalence of meeting the MSE guidelines (at least 3 times per week) in Chinese children and adolescents, and then explore its correlates. To our knowledge, this is the first reported study based on samples from the Chinese children and adolescents population. The present study found that the majority of Chinese children and adolescents met the MSE guidelines (prevalence = 62.1%). Besides, this study suggested that grade group (age range: 10–19 years), ethnicity, residence, MVPA in children and adolescents, and parent's (either father or mother) MSE were significant correlates of MSE in Chinese children and adolescents.

TABLE 1 | Sample characteristics of this study.

		Total		Boy		Girl		*p*
		n	%	*n*	%	*n*	%	
Total		3733	100	2324	62.3	1409	37.7	/
Grade group								
	Primary school	1308	35.0	839	36.1	469	33.3	0.00
	Middle school	1141	30.6	742	31.9	399	28.3	
	High school	1284	34.4	743	32.0	541	38.4	
Ethnicity								
	Han	2788	74.7	1416	60.9	1372	97.4	0.00
	Minority	945	25.3	908	39.1	37	2.6	
Residence								
	Urban	2989	80.1	1900	81.8	1089	77.3	0.00
	Rural	744	19.9	424	18.2	320	22.7	
Siblings								
	Single	2819	75.5	1767	76.0	1052	74.7	0.35
	Two or more	914	24.5	557	24.0	357	25.3	
Parent's education level*								
	Primary school or below	102	2.7	67	2.9	35	2.5	0.00
	Middle school	736	19.7	425	18.3	311	22.1	
	High school	915	24.5	544	23.4	371	26.3	
	Occupation school	870	23.3	539	23.2	331	23.5	
	Graduate	903	24.2	595	25.6	308	21.9	
	Postgraduate or above	207	5.5	154	6.6	53	3.8	
Personal annual income#								
	<9,000	614	16.4	369	15.9	245	17.4	0.02
	9,000-30,000	1030	27.6	610	26.2	420	29.8	
	30,000–100,000	1536	41.1	980	42.2	556	39.5	
	>100,000	553	14.8	365	15.7	188	13.3	
Children's MVPA guidelines								
	Not meeting	3051	81.7	1885	81.1	1166	82.8	0.21
	Meeting	682	18.3	439	18.9	243	17.2	
Parent's MSE guidelines*								
	Not meeting	2028	54.3	1296	55.8	732	52.0	0.02
	Meeting	1705	45.7	1028	44.2	677	48.0	
Children's MSE guidelines								
	Not meeting	1413	37.9	924	39.8	489	34.7	0.00
	Meeting	2320	62.1	1400	60.2	920	65.3	

**either father or mother.*
 # annual income per person (Unit as Chinese Yuan).
MSE, muscle-strengthening exercise.
MSE guidelines: children and adolescents should amass 3 times per week; adults should amass 2 times per week.
MVPA, moderate to vigorous physical activity.

There were about 6 out of 10 Chinese children and adolescents who met the well-recommended MSE guidelines. The prevalence of meeting the MSE guidelines in our study is relatively higher than that in a study by Smith, Diallo (11). In Smith et al. (10)'s study, the prevalence of meeting the MSE guidelines was 35.2% (lower than ours: 62.1%). When looking at the prevalence of meeting the MSE guidelines in Canadian (54%) and American youths (51%), our result was still higher than those studies. Possible reasons for the noticeable inconsistencies include different sample characteristics and measurements as well as participants' understanding of muscle-strengthening exercises (18). In addition to the possible reasons, physical education classes may be another consideration. Chinese children and adolescents are required to participate in at least three physical education classes per week, which could provide more opportunities for them to practice muscle-related activities during the physical education classes. This would be an incentive for children and adolescents to report more engagements in

TABLE 2 | Bivariate correlations among study variables.

	1	2	3	4	5	6	7	8	9	10
1 Sex	1									
2 Grade group	0.054**	1								
3 Ethnicity	−0.406**	−0.151**	1							
4 Residence	0.054**	−0.195**	−0.132**	1						
5 Siblings	0.015	−0.240**	0.015	0.207**	1					
6 Parent's education level	−0.072**	0.136**	0.128**	−0.362**	−0.248**	1				
7 Personal annual income#	−0.048**	0.063**	0.071**	−0.164**	−0.148**	0.313**	1			
8 Children's MVPA guidelines	−0.021	−0.120**	−0.047**	−0.054**	0.040*	0.030	0.029	1		
9 Parent's MSE guidelines	0.037*	−0.046**	−0.043**	0.020	0.064**	−0.026	−0.041*	0.073**	1	
10 Children's MSE guidelines	0.051**	−0.186**	−0.084**	0.012**	.062**	−0.010	−0.008	0.289**	0.107**	1

**either father or mother.*
 # annual income per person (Unit as Chinese Yuan).
MSE, muscle-strengthening exercise.
MSE guidelines: children and adolescents should amass 3 times per week; adults should amass 2 times per week.
MVPA, moderate to vigorous physical activity.
**denotes $p < 0.05$.*
***denotes $p < 0.01$.*

MSE compared with other counterparts from western countries. However, this assumption should be tested by future cross-cultural studies. We should admit that using self-reported measures to assess the MSE in children and adolescents may result in an overestimation of MSE, which fails to capture true levels of MSE among children and adolescents. It is needed, therefore, to use the more standardized and more accurate measure to capture the MSE in young people (3, 11). Although it seems that Chinese children and adolescents had better performance in MSE than counterparts from western countries, it is still highly recommended to increase the prevalence of meeting the MSE guidelines in the Chinese young population because of its numerous health benefits (6, 8). When considering promoting physical literacy, encouraging behavior changes would be a possible approach, by which increase physical activity levels (24). As MSE is a kind of physical activity, it would be probably promising that children and adolescents who engage in more MSE regularly may show improved physical literacy.

Consistent with some studies (3), our study found that sex, parental socioeconomic status (e.g., parental education level and family income) were not associated with MSE in children and adolescents. However, although sex was not a correlate of MSE in the final full model, in our study, girls reported a higher prevalence of meeting the MSE guidelines than boys. This finding is contrary to Smith et al. (11) and other studies, which indicated that boys had more engagements in MSE than girls. It is interesting and unexpected that Chinese female children and adolescents reported a higher prevalence of MSE. To our knowledge, it is novel research finding that should be explained in future studies because understanding sex difference in MSE is an important research issue for MSE promotion (11). To our knowledge, the associations of parental education and family income with MSE in children and adolescents are firstly studied by our study. However, unlike the positive associations of parental education and family income with overall physical activity, this study found no association between family income and parents' education level. A possible reason is that Chinese parents with higher parental education levels and more family income do not have sufficient awareness of engagements in MSE or knowledge on health benefits from appropriate MSE (19), which in turn do not encourage or cannot influence their kids' MSE. Moreover, the family composition was not associated with MSE in children and adolescents. To our knowledge, this is the first study to assess the association between family composition and MSE in children and adolescents, and we do not have comparable data with our research findings. It is therefore to further explore whether peer influence can affect MSE in children and adolescents.

In our study, grade group (age range: 10-19 years), residence, ethnicity, MVPA of children and adolescents and parent's MSE were significantly associated with meeting the MSE guidelines. Grade group can be regarded as a proxy measure of age which has been recognized as a determinant of physical activity (25–28). Sufficient evidence has shown an age-related decline in physical activity in children and adolescents in China (22, 29, 30). As a form of physical activity, MSE would be negatively influenced by the increasing age of children and adolescents. Another possible explanation relates to academic activities and loads of Chinese children and adolescents (30, 31). With increasing academic activities and loads, Chinese children and adolescents are exposed to less time and fewer opportunities for physical activities throughout adolescence (20–22, 32), which in turn reduce their engagements in MSE. Future studies should confirm this research finding using a longitudinal study design.

Consistent with previous studies, we found that children and adolescents living in urban residences were more likely to report meeting the MSE guidelines. Such a research finding is also consistent with studies based on adults (3, 7, 9). A possible explanation is that those living in urban areas can more easily access facilities and equipment (e.g., bars) for participation in

TABLE 3 | The association between the potential correlates with meeting the MSE guidelines.

		Beta	aOR	95% CI		*p*
Intercept (Fixed effects)		0.97	2.64	1.03	6.75	**0.04**
Sex						
	Boy	Ref				
	Girl	0.13	1.14	0.96	1.36	0.15
Grade group						
	Primary school	0.85	2.33	1.16	4.68	**0.02**
	Middle school	1.53	4.62	2.27	9.39	**0.00**
	High school	Ref				
Ethnicity						
	Han	0.68	1.97	1.37	2.83	**0.00**
	Minority	Ref				
Residence						
	Urban	0.23	1.26	1.06	1.70	**0.01**
	Rural	Ref				
Family composition						
	Single children	−0.04	0.97	0.79	1.18	0.73
	Two or more	Ref				
Parent's education*						
	Primary school or below	−0.01	0.99	0.53	1.83	0.97
	Middle school	−0.15	0.86	0.57	1.30	0.48
	High school	−0.12	0.89	0.61	1.31	0.55
	Occupation school	0.03	1.04	0.71	1.52	0.86
	Graduate	0.07	1.07	0.74	1.56	0.71
	Postgraduate or above	Ref				
Family income#						
	<9,000	0.14	1.15	0.85	1.55	0.36
	9,000–30,000	0.10	1.10	0.84	1.44	0.49
	30,000–100,000	0.15	1.16	0.90	1.49	0.26
	>100,000	Ref				
Children's MVPA guidelines						
	Meet	1.69	5.41	3.97	7.37	**0.00**
	Not meet	Ref				
MSE in parent*						
	Meet	0.28	1.32	1.13	1.55	**0.00**
	Not meet	Ref				
Random and residual effects		Beta	Std Error		*z*	
District variance (level 3)		0.17	0.22		0.77	0.44
School variance (level 2)		0.82	0.28		2.87	**0.01**
Residual		1.00	/			

aOR denotes adjusted odds ratio.
CI, confidence interval.
**either father or mother.*
#annual income per person (Unit as Chinese Yuan).
MSE, muscle-strengthening exercise; MSE guidelines: children and adolescents should amass 3 times per week; adults should amass 2 times per week; MVPA, moderate to vigorous physical activity.
Bold fonts denote statistically significant ($p < 0.05$).

muscle-related activities, which can increase their engagement of MSE (8, 33). However, this explanation may be fitting with adults, which might not be useful in children and adolescents. Hence, it is needed to answer the differences in MSE of children and adolescents from urban and rural areas. Similarly, ethnicity is another important correlate of MSE in children and adolescents in our study. This finding is consistent with some research findings based on adults (29), which is a novel finding in children and adolescents and cannot be fully explained in this study. In this regard, more studies should be encouraged to explore the mechanism of differences in MSE across children and adolescents with various ethnicities.

Accumulated MVPA is associated with MSE in our study, which is consistent with Smith et al. (11) and Roth et al. (14).

Although this study shares concordant findings with previous studies, it must be noted that the measures of MVPA and MSE were very similar. It may be a reason why there was a positive association between MVPA and MSE. However, the measure for MVPA did not distinguish between aerobic physical activity and MSA. Hence, future studies should use objective or device-based measures to assess MVPA, which in turn explores its relationships with MSE more reliably and accurately (26). Another consideration to further answer the association between MVPA and MSE in children and adolescents is the measurement of MSE. It is well-known that the most widely used measures for MSE are self-reported questionnaires (7). The weaknesses of self-reported questionnaires have been reported (3), which is prone to recall measurement bias. Taken together, to provide a more comprehensive insight into the association between MVPA and MSE in children and adolescents, studying how to use objective or device-based measures to monitor MSE is an alternative and necessary approach.

Parent's MSE is a significant correlate related to MSE in children and adolescents. To our knowledge, it is a novel research finding appearing in the literature for the first time, which can advance our knowledge and researchers' understanding of MSE. However, owing to the novelty, there is no comparable data or evidence that can support or negate this important research finding. To explain this research finding, some hypotheses are proposed that need further confirmations or tests. A parent's MSE can be viewed as a role model. It has been well-documented that parental modeling can act as an incentive to promote physical activity in children and adolescents (34, 35). Many studies have shown that parent's participation in physical activity tends to make their kids engage in more physical activity (36–38), because the parent(s) can play a role model in increasing children and adolescents' physical activity level (36). As a form of physical activity, it is expected that parents' MSE is positively associated with MSE in children and adolescents in our study. In addition to this, there is some evidence that shows children and adolescents appear to imitate their parent's behavior (6, 39). In this regard, it is reasonable that children and adolescents with parent(s) who have sufficient MSE tend to engage in more MSE. However, these assumptions based on previous frameworks to explain parents' influences on children and adolescents' MSE should be further examined comprehensively, to advance our understanding of MSE in young people.

Although this study is one of very few to report the level of MSE in Chinese children and adolescents, as well as its potential correlates, this study also presents some limitations. First, the cross-sectional design could not determine causality. Thus, the real causal relationship of some factors with MSE is uncertain. Second, the self-reported measure was used to obtain information on MSE, which caused recall bias and in turn limited the generalization of our research findings to the wider society. Thus, the application of the research findings to the wider population would need to be done with caution. Fourth, owing to measurement limitations, we were not able to capture more information on MSE like duration, type, or location. This resulted in uncertainties about the profiles of MSE among study participants. Future studies should determine more correlates of MSE among Chinese children and adolescents, to expand on the current research and in turn design more effective interventions for improved health promotion effectiveness.

CONCLUSION

Approximately 60% of Chinese children and adolescents met the recommended levels of MSE. MSE in Chinese children and adolescents can be associated with grade group, residence, ethnicity, MVPA in children and adolescents, as well as parent's MSE. This study can advance understanding of MSE in China. For public health benefits, large efforts should be made to increase young people's participation in MSE by multiple aspects. From the perspective of public health policymakers, it should be acknowledged that the lack of emphasis on MSE in public health policy is one of the potential culprits for the lack of children and adolescents' engagement in MSE. Therefore, stressing the significance of MSE in public health policy is the priority. Especially, policymakers should speed up the development and implementation of school physical activity or sports policies. Future public MSE interventions should prioritize older and minority children and adolescents, those living in rural areas. Also, parents (s) should play a role model in engaging in more MSE for promoting their kids' MSE.

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 Wuhan University of Technology. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

JYG, J-TH, YLL, and JY were involved in the study design and drafted the manuscript. JY and STC performed data analysis. STC and JY were involved in the revision of the manuscript. All authors contributed to the article and approved the submitted version.

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SYSTEMATIC REVIEW
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The Effects of Learning Transfer on Clinical Performances Among Medical Staff: A Systematic Review of Randomized Controlled Trials

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Purpose: This study aimed to evaluate the influence of learning transfer on the clinical performance of medical staff.

Methods: We searched PubMed, Embase, and the Cochrane Library for all associated studies without any language restrictions from the inception until 31 December 2021.

Results: This systematic review screened out 14 eligible studies that met the inclusion criteria. Most of these studies showed that learning transfer contributed to the clinical performance of medical staff. Through education, or when knowledge and skills have common basic principles, learning transfer will be more apparent than for those who learn by themselves and those without simulation training.

Conclusions: The findings of this review support an association between learning transfer and the clinical performance of medical staff. However, it was noted that due to the lack of relevant research and the major differences in the methods and indicators used in previous studies, we are restricted in conducting an effective meta-analysis. Further comprehensive trials will be needed to assess the impact of learning transfer on the clinical performance of medical staff.

Systematic Review Registration: PROSPERO, identifier: 341439.

Keywords: learning transfer, clinical performances, medical staff, systematic review, randomized controlled trials

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INTRODUCTION

It has been widely acknowledged that the system of healthcare is complicated. Hundreds of pieces of clinical data are generated from the healthcare process, such as the patient's history, examination findings, and investigation results. Correct diagnosis can be defined by analyzing these huge amounts of data accurately. With the rapid expansion of the knowledge base of diseases and their management, the complexity of the system of healthcare is inevitably aggravated (1). Clinical performance should meet the highest standards based on adequate knowledge, determination, technology, and attitudes at different levels of clinical practice (2). Medical professionals should be able to implement technical, intelligent, and elevated skilled clinical practices so as to offer reliable and high-quality medical care to each patient (3). In order to improve the clinical performance of medical staff, it is essential to arrange continuing education and to make a great effort to upgrade medical professionals' learning and skills through different educational courses.

For decades, researchers have examined the practical concept of learning transfer. Learning complicated abilities for individuals, according to Gagne (4), requires comprehension based on adequate knowledge, implying that learning is a cumulative process. Transfer of learning, according to Ellis (5), occurs when "experience or performance on one task has an effect on performance on a subsequent one." McKeachie (6) defined transfer as "The application of earlier learning in a condition that is not the same as the learning situation." Learning transfer was later described as the extent to which knowledge (simple or complicated), skills (conceptual, interpersonal, or technical; open or closed), and competencies acquired during training are transferred to the job (7–10). It is also noteworthy that learning transfer, on the other hand, is not a static concept, and its meaning varies depending on how it is defined and utilized before, during, and after the learning process. Learning transfer is mainly across test patterns, implantation and judgment matters, problems involving clinical diagnoses, and mediator and associated word suggestions (11). Transfer of learning is critical in education, as the context of learning varies with the context of the application (12). Medical staff are expected to build a framework of the cognitive foundation from books, lectures, or simulations, draw principles from their prior knowledge and experiences, and apply learning in their workplace, building their ability to manage and solve problems. In nursing, it is reported that the transfer of learning has led to the effectiveness of simulation and debriefing experiences (13–15).

From the clinical viewpoint, the better the learning transfer, the more challenging the appointed assignments could be, and the more active and creative the results. Although the main processes of learning transfer include formal learning activities (e.g., maintenance education or job training programs) and self-directed informal learning activities, a previous study reported low levels of learning transfer among members of an institution (3). In addition, a case-based blended learning (CBBL) framework which utilized the flexibilities of an e-learning platform has highlighted that E-Case-Based Learning is effective in promoting the outcome of performance and is an essential way of learning and discovering (16, 17).

It is valuable to explore the practical implications of the effectiveness of learning transfer used in medical education and related training circumstances. Whether training transfer is associated with clinical services is an essential question warranting investigation. Thus, we conducted this systematic review to further evaluate the influences of learning transfer on clinical performances among medical staff.

MATERIALS AND METHODS

Literature Review

We performed this study in accordance with guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (PROSPERO ID: 341439). We conducted a comprehensive search for relevant studies (without language limitations) from major online databases, such as PubMed, Embase, and the Cochrane Library, from inception to 31 March 2022. Two independent reviewers scanned the literature and included the eligible studies by common consensus after multiple rounds of screening.

Data Sources and Search Methods

The search process included (i) reading the reference section of all relevant research carefully; and (ii) manually searching abstracts of key journals and papers published at major annual conferences. The search terms used were a mix of ("learning transfer" [All Fields] OR "boundary crossing training" [All Fields]) AND ("clinical performance" [All Fields] OR "academic theoretical knowledge" [All Fields] OR "professional practice experience" [All Fields]). We also checked the reference lists of the screened studies to identify other similar studies. The search strategy is shown in **Table 1**. We included experimental studies that examined the influence or effectiveness of learning transfer on the clinical performance of medical staff. The PICOS criteria are used to select the eligible studies. Studies were included if they satisfied the following inclusion criteria: (1) The study was limited to RCTs and humans; (2) All participants are medical staff; (3) The study included both an experimental group and a control group. The experimental group was subjected to a learning lesson while the control group was performed without learning a lesson. (4) The study reported the effect of learning transfer on the performance of medical staff in each group. The exclusion criteria were as follows: (1) unqualified study design, such as non-RCT design, single-arm extension study, observational studies; (2) case reports, editorials, or reviews; (3) duplicated reports.

Data Extraction and Quality Assessment

For all articles included, we extracted the following information from the original articles: first author, publication year, country, database, study duration, study design, study subjects, mean age of study subjects, gender of the study subjects, and outcomes. Two reviewers independently performed an analysis of methodological quality. The quality assessment included the following items: allocation generation and concealment, blinding, follow-up duration, loss follow-up (%), and data-analysis method (intention-to-treat or per protocol). Divergences

TABLE 1 | Search strategy.

Database	Searching keywords
Cochrane library	(1) Learning transfer: 1510 (2) Boundary crossing training: 8 (3) Clinical performance: 79053 (4) Academic theoretical knowledge: 302 (5) Professional practice experience: 1607 (6) #1 OR #2: 1517 (7) #3 OR #4 OR #5: 79921 (8) #6 AND #7: 673
PubMed	(1) Learning transfer: 21039 (2) Boundary crossing training: 772 (3) Clinical performance: 1129461 (4) Academic theoretical knowledge: 894 (5) Professional practice experience: 28844 (6) #1 OR #2: 21800 (7) #3 OR #4 OR #5: 1156646 (8) #6 AND #7: 2116
Embase	(1) Learning transfer: 228 (2) Boundary crossing training: 0 (3) Clinical performance: 12913 (4) Academic theoretical knowledge: 1 (5) Professional practice experience: 11 (6) #1 OR #2: 228 (7) #3 OR #4 OR #5: 12925 (8) #6 AND #7: 2

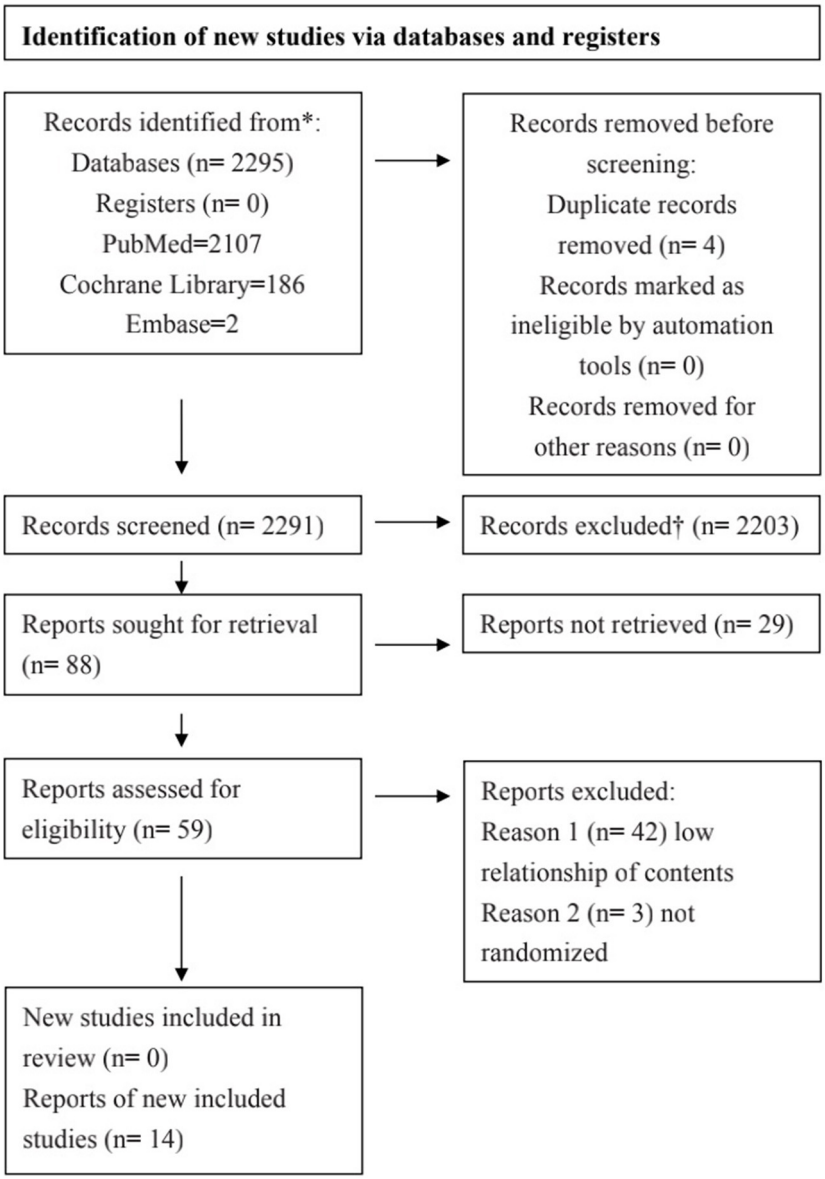

FIGURE 1 | PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram.

were resolved through discussion and consensus. Further, we used version 2 of the Cochrane risk-of-bias tool for randomized trials (RoB 2) to assess the risk of bias for Systematic Reviews of Interventions. Any disagreement was resolved through discussion with a third author. All analyses were performed by Review Manager version 5.4.1.

RESULTS

Study Characteristics

The results of the systematic review are presented in **Figure 1**. We identified a total of 14 studies related to the transfer of learning after a thorough review of all papers. The characteristics of the studies are listed in **Table 2**. Among the studies considered in this paper, seven were conducted in Europe, three were in Canada, two were in the United States, and one each was conducted in Australia and South Korea.

Quality Assessment

Table 3 shows the results of a methodological quality assessment of all included studies. We considered inadequate allocation concealment and sequence generation the most common sources of potential bias. Due to the few studies included and the degree of heterogeneity observed in the study design, interventions, and outcome indices, meta-analysis was considered impractical.

TABLE 2 | Characteristics of randomized controlled trials.

References	Year	Country	Inclusion criteria	Group	Intervention	Study subject	Mean age (years)	Gender (M/F)	Outcome measures
Anastakis et al. (18)	1999	Canada	PGY-1	Text only, bench model training, or cadaver model training	A 3-day period training on six operative procedures using one of three methods and 1 week later exam	23 PGY-1 surgical residents	NA	NA	Both bench and cadaver training were superior to text learning and that bench and cadaver training were equivalent
Jensen et al. (19)	2005	Sweden	Volunteered to participate; One criterion for participating was willingness to verbalize.	The rabbits-and-foxes task and the reindeer-and-lichen task	A learning session with the first task before being tested in the second task and the other only performed the second task	28 undergraduate psychology students	22 (range 18-30)	0/28	A significant transfer effect from the rabbits and foxes task to the reindeer-and-lichen task
Heaven et al. (20)	2005	UK	25 (41%) were community based, 13 (21.3%) worked in a hospital, whilst 23 (37.7%) worked across both domains. The nurses in the study were relatively experienced.	Receive either communication skills training followed by clinical supervision or communication skills training alone	All attended a 3-day communication skills training workshop. Twenty-nine were then randomized to 4 weeks of clinical supervision,	61 clinical nurse specialists	42 ± 7.4	1/60	Each nurse's communication skills with real patients were assessed a three time points. (1) Before training and supervision (baseline), (2) immediately after the supervision intervention (post) and (3) 3 months after the post intervention (follow-up). Only those who experienced supervision showed any evidence of transfer.
Butler et al. (21)	2013	USA	No prior experience performing arthroscopic surgery	Whether trained to perform diagnostic arthroscopy of the knee on anatomic dry models before trained only on cadaveric specimens.	All students were trained to perform diagnostic knee arthroscopy on cadaveric specimens. For the students in the experimental group, the cadaveric session took place between 8 and 21 days following their initial training with the dry models	14 medical students	NA	8/6	The mean number of trials to demonstrate minimum proficiency was significantly lower in the experimental group (2.57) than in the control group (4.57) ($p < 0.01$). The mean time to demonstrate proficiency was also significantly less in the experimental group (37.51 minutes) than in the control group (60.48 min) ($p < 0.01$).

(Continued)

TABLE 2 | Continued

References	Year	Country	Inclusion criteria	Group	Intervention	Study subject	Mean age (years)	Gender (M/F)	Outcome measures
Bjurström et al. (22)	2013	Denmark	The surgeons had different levels of experience with thoracoscopy. Inclusion criteria of the medical students consisted of having no previous experience with endoscopic surgery and having reached their third year or further along	Group 1: the surgeons, performed 2 consecutive attempts of the first 2 training tracks Group 2: performed the test directly without training Group 3: 3 h of independent training using the VT simulator Group 4: the educator-guided students received 3 h of guided, goal-oriented training	A control group and the group of surgeons were tested with no previous simulator training. A self-guided training group and an educator guided training group trained for 3 h on 3 scenarios of increasing fidelity and difficulty before taking a standardized test	10 surgeons and 30 medical students	30 (range 21–65)	30/10	The control group and the self-guided training group performed significantly worse than the experienced surgeons ($P = 0.012$ and $P = 0.010$, respectively)
Ferguson et al. (23)	2015	UK	Students rotating through their orthopedic attachment at the hospital and had no previous experience of arthroscopy	Knee or shoulder arthroscopic	After nine task repetitions over 3 weeks on one model, each participant undertook the simulation task of the other anatomical joint.	18 medical students	NA	NA	There was no immediate evidence of skill transfer, with a significant drop in performance between the final training episode and the transfer task (all parameters $p < 0.003$)
Tolsgaard et al. (24)	2015	Denmark	All participants had an equal knowledge base and minimal practical ultrasound experience and the inclusion criterion required participants to be <4 months from medical graduation	Single or dyad	A 2-h training programme on a transvaginal ultrasound simulator before the transfer test	Medical students	28 (range 23-34)	1/29	The dyad group demonstrated higher training efficiency in terms of simulator score per number of attempts compared with the single-student group ($p = 0.03$).
Rutherford-Hemming et al. (25)	2016	USA	Eligible nurses worked full- or part-time in an inpatient mother-baby unit (post partum) or birthing center	Simulation or online self-study module	Direct observation and completion of a standardized instrument by the observer at 3 time points, using a validated 12-item Neurologic Knowledge Assessment and a 14-item performance skill checklist.	Nurses	49.5 ± 10.5	NA	They had similar mean levels on Neurologic Knowledge Assessment scores in short-term ($P = 0.86$) and longterm ($P = 0.59$), but these mean scores were not significant

(Continued)

TABLE 2 | Continued

References	Year	Country	Inclusion criteria	Group	Intervention	Study subject	Mean age (years)	Gender (M/F)	Outcome measures
Kulasegaram et al. (26)	2017	Canada	Students were generally new to the anatomy and physiology concepts used in the experiment.	The Analogy and No Analogy; the one-, two- and three organ-system conditions.	Each participant learned three physiology concepts using a standard clinical explanation and diagram provided by an expert clinician (AN) or the standard explanation and an analogy illustrating deep structure, and 1-week delay to complete a new transfer test	90 first-year psychology students	NA	NA	The analogy condition had a smaller difference between near and far transfer performance (0.99 vs. 0.91) compared with the no-analogy group (1.21 vs. 0.77); average far transfer score was higher for the two- and three-organ-system groups compared to the one-organ-system group.
Kulasegaram et al. (26)	2017	Canada	Different from experiment 1	The Analogy and No Analogy; the one- and two- organ-system conditions.	Randomized again to practicing with one or two organ systems for laminar flow and Laplace's law, after completing learning, participants took a multiple-choice test to test recall and a similarity categorization test	40 first-year psychology students	NA	NA	There were no significant differences between any groups on MCQ testing
Yang et al. (27)	2018	Germany	Participants were laparoscopically naive medical students and showed a special interest in surgery	Group 1: An appendectomy training on the VRS before the tutorial procedural tasks of LC Group 2: the tutorial procedural tasks of LC directly	Whether training on the VRS before the tutorial procedural tasks of Laparoscopic cholecystectomy	medical students	24.5 (range 21-33)	12/32	Participants in group 1 needed significantly less movements (388.6 $\pm$ 98.6 vs. 446.4 $\pm$ 81.6; $P < 0.05$) as well as shorter path length (810.2 $\pm$ 159.5 vs. 945.5 $\pm$ 187.8 cm; $P < 0.05$)
Genç and Öner (28)	2019	Canada	Participants were excluded if they had previous LP training	Procedural Only, Integrated in Sequence, and Integrated for Causation	A self-regulated simulation-based LP training session and a follow-up session 1 week later	66 medical students	NA	NA	Participants receiving an integrated instructional video performed significantly better on transfer through their intervention's positive impact on conceptual knowledge (all $p < 0.01$)

(Continued)

TABLE 2 | Continued

References	Year	Country	Inclusion criteria	Group	Intervention	Study subject	Mean age (years)	Gender (M/F)	Outcome measures
Beattie et al. (29)	2020	Australia	All participants reported normal or corrected-to-normal vision, normal stereoacuity, and no prior laparoscopic experience (including no formalisedlaparoscopic skills training with a simulator, and no hands-on laparoscopic experience in an operational context, e.g., as a surgical assistant)	The 2D→ 3D and 3D→ 2D groups and he 2D→ 2D and 3D→ 3D groups	Proficiency-based training in six laparoscopic training tasks; testing included two further repetitions of all tasks under test conditions	60 medical students	24.78 ± 3.24(range 19–34)	32/28	The groups trained in 3D demonstrated superior training performance and took fewer repetitions to reach proficiency than the groups trained in 2D. The groups tested in 3D also demonstrated superior test performance compared to those tested in 2D
Anacleto et al. (30)	2021	Portugal	Participants with no previous experience with laparoscopy or laparoscopic exercises.	Group 1 watched the VMT in both trials and Group 2 watched, firstly, the original E-BLUS examination video and, in the second trial, the VMT.	Take five minutes to practice and get familiar with both tasks, after the exercises in the first trial, in both trials and groups, the first exercise to be performed was the PT followed by the NG.	42 final year medical students	NA	NA	After watching the VMT, a decrease in the total number of errors in PT and NG exercises was observed in the participants who previously watched the E-BLUS video ($p = 0.001$ and $p = 0.002$, respectively).
Lee and Son (31)	2021	South Korea	All participants had completed a pre-requisite maternity nursing course and had basic knowledge related to women's health nursing before the study.	One engaged in S-PBL based on Pap smear knowledge and the other participated in a Pap smear demonstration based on Pap smear knowledge	After the intervention, self-confidence, learner satisfaction, and critical thinking were evaluated, using a structured questionnaire to measure learning transfer related to Pap smears, both for the experimental and control group.	Third-year nursing students	22.31 ± 2.42	20/85	Two groups showed that the general characteristics, self-confidence ($t = 0.51$, $p = 0.612$), learner satisfaction ($t = 0.72$, $p = 0.475$), and critical thinking ($t = 1.42$, $p = 0.158$) were homogeneous ($p > 0.05$)

TABLE 3 | Methodological quality assessment of the included studies.

References	Year	Allocation generation	Allocation concealment	Double blinding	Follow-up duration	Loss to follow-up	Data analysis	Other bias
Anastakis et al. (18)	1999	PGY-1 surgical residents	Adequate	No	A 3-day period training and 1 week later exam	0	ITT	—
Jensen et al. (19)	2005	Undergraduate psychology students, all female	Adequate	No	2003∼2005	0	ITT	—
Heavenet al. (20)	2005	Clinical nurse specialists	Adequate	No	3 months	0	ITT	—
Butler et al. (21)	2013	Medical students	Unclear	No	21 days	0	ITT	—
Bjurström et al. (22)	2013	10 surgeons and 30 medical students	Unclear	No	2 months	0	ITT	—
Ferguson et al. (23)	2015	Medical students	Adequate	No	One week	0	ITT	—
Tolsgaard et al. (24)	2015	Medical students	Adequate	No	6 months	20	PP	—
Rutherford-Hemming et al. (25)	2016	Nurses	Adequate	Single blind	2 months	3	PP	—
Kulasegaram et al. (26)	2017	First-year psychology students	Adequate	No	One week	17	PP	—
Yang et al. (27)	2018	Medical students	Unclear	Unclear	10 months	8	PP	—
Genç and Öner (28)	2019	Medical students	Adequate	Single blind	One week	0	ITT	—
Beattieet al. (29)	2020	Medical students	Unclear	Unclear	N/A	0	ITT	—
Anacleto et al. (30)	2021	Medical students	Adequate	No	2018.09	21	PP	—
Lee and Son (31)	2021	nursing students	Adequate	Single blind	2 months	0	ITT	—

Figure 2 presents a summary assessment of bias risk. Butler et al. (21), Bjurström et al. (22), Yang et al. (27), and Beattie et al. (29) did not clearly describe how the research populations are selected. Yang et al. (27) and Beattie et al. (29) did not clearly explain whether the participants were blinded. Yang et al. (27), Tolsgaard et al. (24), Rutherford-Hemming et al. (25), Kulamakan et al. (26), and Anacleto et al. (30) lost a number of research objects to follow-up, and therefore we must assume a high risk of bias. Setting the issue of uncleared blinded participants aside, all but Rutherford-Hemming et al. (25), Genç and Öner (28), and Lee et al. (31) did not blind participants; thus, their assessment of outcomes must be regarded as questionable.

Effective Learning Transfer in the Final Task

Jensen et al. (19) reported a significant transfer effect when performing the second task, as there was a learning session in the first task. Butler et al. (21) reported that medical students were trained to perform diagnostic arthroscopy of the knee on anatomic dry models before training on cadaver specimens. Their average number of minimum proficiency tests and the average time of proficiency were significantly less than for those who only trained on cadaveric specimens. Kulamakan et al. (26) performed two sequential experiments. In Experiment 1, increasing context variation and conceptual analogies both significantly led to higher performance for far transfer. Experiment 2 demonstrated that even though there was a superficial similarity to previous examples, learners' shifts to using structural characteristics to classify new problems were caused by such analogies and context variation.

Yang et al. (27) reported that the participants performed appendectomy training in the virtual reality simulator before the tutorial procedural tasks of laparoscopic cholecystectomy, and needed significantly fewer movements and shorter path lengths than those who started with the tutorial procedural tasks of laparoscopic cholecystectomy directly. Anacleto et al. (30), after watching the video-mentored tutorial (VMT), observed a decrease in the total number of errors in peg-transfer (PT) and needle-guidance (NG) exercises in the participants who had watched the European Basic Laparoscopic Urologic Skills (E-BLUS) video before. Compared with the group in which students participated in a conventional demonstration of a Papanicolaou smear, Lee et al. (31) reported that self-confidence, learner satisfaction, and critical thinking were significantly higher in the simulation problem-based learning (S-PBL) group. After nine task repetitions over 3 weeks on one model, Ferguson et al. (23) reported that when the participants performing the knee and shoulder tasks swapped models, there was no immediate evidence of skill transfer.

The Most Effective Learning Transfer in Different Training Methods

Anastakis et al. (18) reported that bench and cadaver training were both superior to text learning and were equivalent. Tolsgaard et al. (24) reported that compared to the single-student composition, dyads illustrated higher training efficiency in terms of simulator score per number of attempts. Compared with nurses in the online self-study module, Rutherford-Hemming et al. (25) reported that the simulation group showed higher levels in both short-term and long-term skill performance.

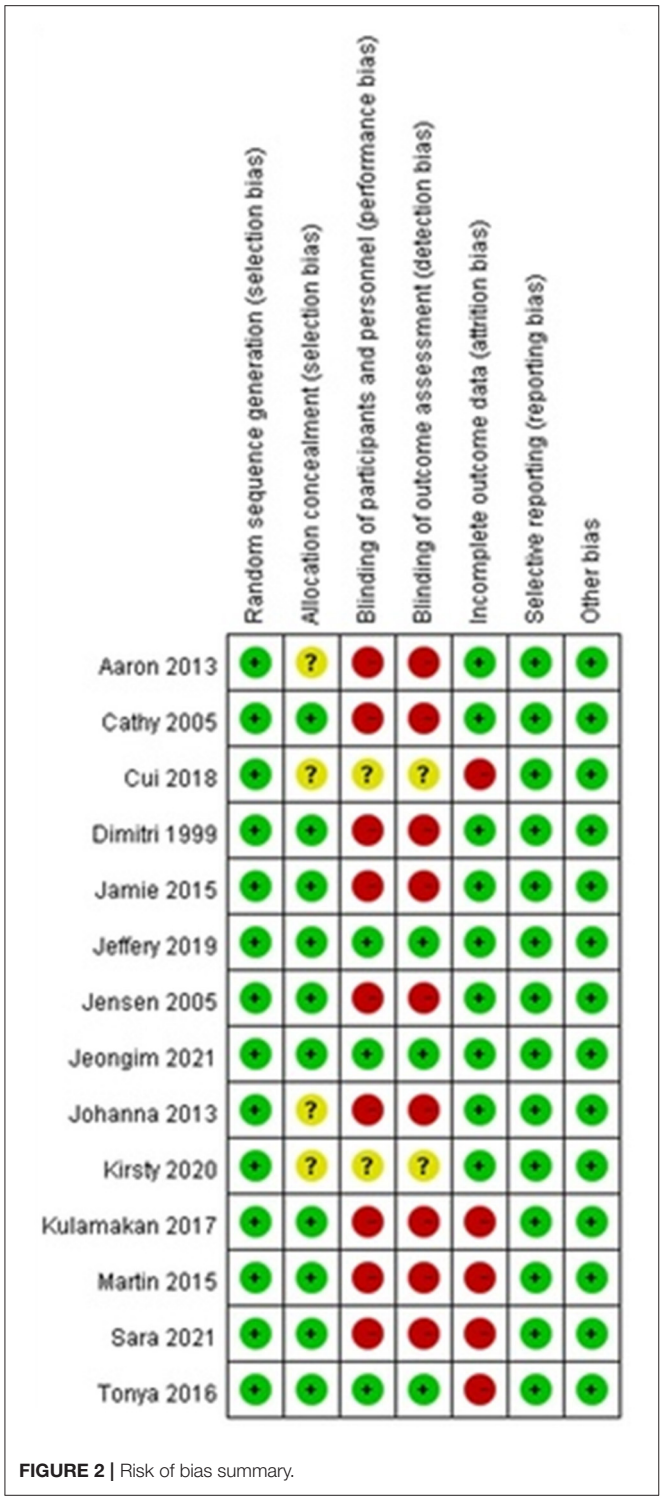

FIGURE 2 | Risk of bias summary.

Genç and Öner (28) reported that participants receiving an integrated instructional video performed significantly better on transfer than the procedural-only video. Beattie et al. (29) reported that groups trained in 3D and tested in 3D demonstrated superior training performance and took fewer repetitions to reach proficiency than the group in 2D.

The Effect of Guidance on Learning Transfer

The last two papers addressed in this study discuss the relationship between teacher guidance and learning transfer. While conducting research with 61 clinical nurse specialists as participants, Heaven et al. (20) assessed the three time points and observed that only those who experienced supervision showed any demonstration of transfer. Although neither group promoted more revelation of clues or concerns, people in the experimental group responded more effectively to the revealing clues. Bjurström et al. (22) reported that experienced surgeons performed significantly better than the control group and the self-guided training group. Between the educator-guided training group and the experienced surgeons, there was no significant difference. Nevertheless, having an educator present during training seemed to have a beneficial effect.

DISCUSSION

Clinical Implication

Our study integrated the current findings of 14 studies and illustrated the correlation between the learning transfer and clinical performance of medical staff. However, the experimental items in each article based on learning transfer are not all the same. Therefore, we cannot compare them to determine which methods of learning transfer ensure significant clinical performance for medical staff. In short, we can only understand the transfer of learning in different fields based on a synthesis of current findings.

Previous research showed that learning transfer is considered a major influence on clinical performance (3). Learning in hospital settings encompassed both formal and informal activities. Formal learning means formalized and standardized education, including career staff training, preceptorships, maintenance education, and job training. Nonetheless, owing to the nature of shift work and the organizational complexity and diversity, it is not possible to make sure that medical staff can improve their clinical performance only through formal learning. Informal learning, which consists of communication, interaction with others, role modeling, and team-based learning, is more flexible and plays an important role in developing the medical staff's clinical performance, especially professional practice experience (32, 33). Informal learning is not simply passive inputting of information but involves constructing the meaning of information actively by recording accumulated long-term memory and existing experience. Therefore, it is crucial to decide which approaches should be used in informal learning, supporting continual self-directed learning.

In this study, we found better task performance after medical students were trained in the virtual simulator, which indicates that when knowledge and skills had common basic principles, the learning transfer would be apparent (27). Learners apply the acquired knowledge to the new learning or work, illustrating the importance of learning transfer to the clinical performance of medical staff and cultivating their practical ability and creative spirit. With an effective transfer, learners can learn faster

and better in a limited time and transfer more accurately in the appropriate environment. It seems that learning transfer also depends on the direct instruction of teachers (3, 20), as instruction can more effectively promote learning transfer. The report showed no significant difference between the training group guided by educators and experienced surgeons (22). Nevertheless, strengthening guidance during learning can help students to improve their specific knowledge to general principles as early as possible.

The systematic review found that despite the lack of consistency in the duration of the intervention, practice time, assessment, and outcome measure, there is a significant learning transfer in the final task after interventions such as different training methods and guidance. According to the results, in order to make an effective learning transfer, professionals should focus on the following three points: (1) Look for the similarities between concepts and principles; (2) notice the summary of learning methods, that is, master the method of solving problems in the learning process, and (3) accumulate a wide range of learning experience in all aspects.

Clinical Practice

Owing to the developments of new technologies and the shift in the medical paradigm, E-Learning within the CBBL framework is seen as a very promising tool to prompt the advancement of learning transfer. Turk et al. explored that E-Learning within CBBL framework not only facilitates the creation of up-to-date teaching content but also addresses difficulties in transforming declarative knowledge into procedural knowledge and skill (34). Lütgendorf-Caucig highlighted that the integration of different teaching modalities is beneficial for the knowledge acquisition for clinical decision making in a multidisciplinary environment like oncology (35). It has been also emphasized in other studies that CBBL is an effective way in gaining improvements in performance among medical staff and is essential for associative and procedural learning that is necessary for clinical reasoning processes (36–39). Hence, we would recommend that the concept of interactive CBBL methods should be developed further and applied in other medical fields. To guarantee the high quality and employ correct didactic dimensions in terms of constructing the interactive questions, it may be helpful to create a guideline for question generation with the collaboration of medical education experts from their research field. Meanwhile, in order to provide a diversity of CBBL materials, further scientific, methodological, theoretical, and practice-based breakthroughs must be achieved.

Strength and Limitation

We individually evaluated these studies using assessment tools and covered most of the articles related to learning transfer. However, several limitations need to be addressed. First, few studies included questions on the reliability of the research results and the strength of the conclusions. Second, due to the considerable heterogeneity of research design and outcome variables, it was impossible to perform an effective meta-analysis. Third, the research objects participating in our review may have differed in analysis and generalizability. Finally, there may be interference from other related factors. Although the participants in some studies are similar in age, their sex ratios are quite different; moreover, nearly half of the studies did not clearly indicate this. In addition, there is currently a lack of studies that provide the quantitative results to meet the condition of performing an effective meta-analysis. We recommend that researchers conduct randomized controlled trials to further evaluate this correlation. We also recommend a study comparing the transfers of different interventions to provide more comprehensive and general findings.

CONCLUSION

Current evidence supports an association between learning transfer and the clinical performance of medical staff. However, it was noted that due to the lack of relevant research and the large differences in the methods and indicators used in previous studies, we were unable to conduct an effective meta-analysis. To summarize, medical staff should learn the importance of learning transfer and reinforce this ability through interdisciplinary teamwork and communication. Multi-disciplinary teaching approaches, assessments of existing systems and frameworks, and continuous technical improvements are still warranted in the future to optimize the current method of learning transfer and help medical staff make effective clinical decisions, as well as guarantee persistent satisfaction.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

Y-CT: conception and design. Y-CT, YX, and Y-pY: acquisition, analysis or interpretation of data, and statistical analysis. Y-CT and YX: drafting of the manuscript. T-HT: supervision. All authors have read and agreed to the published version of the manuscript.

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REVIEW
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Let's (Tik) Talk About Fitness Trends

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Several factors that follow the development of society affect physical inactivity, which primarily includes the development of technology and digitalization and the increasing choice of unhealthy lifestyle habits. However, certain shifts in the fitness industry have been noted in the last decade. The development of wearable technologies and artificial intelligence is one of the leading fitness trends and undoubtedly represents the future of the fitness industry. On the other hand, the significant influence of social media and networks affects the development and attitudes of people related to physical activity. Therefore, this review paper evaluates the advantages and disadvantages of wearable technologies and artificial intelligence, the positive and negative effects of social networks, and points out the problems accompanying these new fitness trends. The development of fitness trends follows humanity's needs, and one of the biggest challenges is incorporating these novelties in a mission to improve physical activity levels worldwide.

Keywords: modern technologies, social media, social networking platform, physical activity, wearable technologies

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INTRODUCTION

Physical activity (PA) is a generator for the improvement of quality of life. PA provides a broad spectrum of health benefits, including the decreased risk of early death, coronary heart disease, stroke, hypertension, type 2 diabetes, cancers, weight gain, risk of dangerous falls, anxiety, and cognitive decline (1, 2). Moreover, relatively robust scientific evidence indicates that exercise supports functional capacity in older adults, enhances sleep quality, and decreases the hazard of hip rupture and osteoporosis (3, 4). World Health Organization (WHO) reported that the minimum quantity and quality of PA that needs to be archived is 150 min/week of moderate PA or 75 min/week of vigorous-intensity (5). This only represents the minimum equality of time that one needs to be active, but promoting an even more physically active lifestyle could fill the gap and contribute even more to subjects' health and wellbeing (6).

However, people do not engage in this minimum amount of PA recommended. At this moment, we are facing the pandemic of physical inactivity (PI) and obesity (7). Around 31.1% of adults are physically inactive worldwide, with ratios ranging from 17% in Southeast Asia to about 43% in the Americas and the eastern Mediterranean (8). It was also noted that inactivity raises with age and is more represented among the female population and high-income countries (9). PI was recognized as the fourth leading risk factor for non-communicable diseases and responsible for more than 3 million preventable deaths (10). Additionally, PI also causes economic costs. For example, ∼$50 billion are spent on healthcare systems worldwide yearly, while death attributable to PI costs another $13.7 billion in productivity losses (11).

Several factors influence these results of creating inactive, sedentary community, including the development of technology, digitalization, decrees in motivation, decrease of active commuting, higher rate of depression and anxiety, to name a few. In addition, the consequence of growing levels of PI might be caused by system-level factors (e.g., built environment) influencing PA behavior. It must be recognized that our obesogenic and PI-promoting environments partly cause inactivity. One of the leading challenges of society is how to motivate people and create adherence and discipline to exercise more and change their lifestyle behaviors. Different factors can influence adherence and motivation to exercise. Interestingly increasing influence of Social networks (media) can perhaps represent the silver bullet in closing the gap between PI and PA. Recently, Lakićević et al. (12) published an interesting opinion paper on the use of novelties as a crossroads in fitness. Although the authors of this study approached the problem from several perspectives; the role of the media, social networks, influencers, and novel fitness trends that follow the technological development of society and modern trends remains unclear. Therefore, this mini-review aims to critically evaluate the current trends in fitness their mutual impact on society, and give considerations and future directions of fitness.

SHIFTING IN FITNESS TRENDS

Since 2006, the American College of Sports Medicine (ACSM) has administered an annual worldwide survey of fitness trends (13). This is provided in a mission to help fitness professionals make conceptual decisions to support customer engagement through a positive exercise experience. Although the fitness industry is continuously growing worldwide, PI and obesity epidemics have been at the highest rate in human history (14, 15). In addition, along with the promotion of PA as a key factor in all age populations, the role of fitness experts in fitness has been rapidly and continuously changing (16). This need for novelty has been followed by shifting in fitness for the last 15 years. For example, at the beginning of the twenty-first century, PA was recognized as the ultimate medicine, and there was growing interest in physical exercise (17). Therefore, at the top of fitness trends from 2006 to 2010 we found: promotions of educated and experienced fitness professionals, training for children and obesity, personal training, strength training, among others. Later, high-intensity interval training (HIIT) attracted extensive attention, which is still one of the leading fitness trends. Finally, as mentioned previously, wearable technologies are currently the leading fitness trend and represent the future of fitness industry development.

Excluding wearable technologies, performing new and challenging workouts could increase your enjoyment and interest while enhancing new abilities. Moreover, the need for novelty may represent a need for something that stands out of the routine (18). Exercise adherence could be increased by improving intrinsic motivation, finally resulting in better health outcomes (19). Happiness's underlying aspects fall into two dimensions: endogenic factors and exogenic factors. For the exerciser, PA must provide health benefits and emotional satisfaction. In theory, wellness can be defined as finding a balance between dimensions of life: emotional, spiritual, intellectual, physical, social, and environmental (20). Additionally, emotional wellness can be described as a "person's ability to cope with daily circumstances and to deal with personal feelings in a positive, optimistic, and constructive manner" (21). In order to greater adherence to the exercise model, the emotional aspect must not be neglected (22) New fitness trends must incorporate physiological and psychological aspects in order to attract the attention of exercisers. And it is of key importance that fitness trends follow also technological trends.

MODERN TECHNOLOGIES IN FITNESS

Following modern trends, there are some indications that fitness and physical exercise are changing. There is a certain shift in fitness trends. Based on ACSM leading fitness trend list (13), wearable technology has been the no. 1 trend since it was first introduced on the survey in 2016, except for 2018 (no. 3) and 2021 (no. 2). In the category of wearable technologies, it can be induced all activity trackers, smartwatches, GPS devices most usually used for counting steps, tracking heart rate, calories spent, activity levels, sleeping quality, and many more. It is estimated that the market for this industry is about $100 billion, with only growing potential (13).

The use of wearable technologies has been widely tested in the last 10 years, while the results of these studies have demonstrated mixed effectiveness. Few studies evaluated the effectiveness of wearable devices' on weight loss outcomes and the practice of PA. In the study by Fazzino et al., (23) a significant improvement in moderate-to-vigorous physical PA was noted after 6 months of intervention. In addition, participants maintained higher PA levels after 18 months of follow-up. Similar findings were found in the study by Chiang et al. (24) who evaluated the usage of wearable devices and adherence to PA, more precisely, step counting. After 2 years, the intervention group had statistically significantly percentage of total body weight loss compared to the control group. In addition, Findings in the population of young adults with a BMI between 25 and <40 showed that the addition of a wearable technology device to a standard behavioral intervention resulted in less weight loss over 24 months (25). Moreover, one study promised improved PA levels among medical students using the Fitbit vs. control (26). Contrary to these findings, the combination of smartwatches and health education courses did not enhance PA levels or reduce sedentary behavior among college students (27). In addition, 12 weeks of intervention with wearable technologies did not change the nutritional status or level of PA compared to the control group (28). These diverse observations mirror wearable technology randomized trials in overweight adults, the elderly population, and post-menopausal women (29–31).

One of the concerns of wearable technologies and smartwatches is their accuracy in measuring PA. This leaves room for improvement, but on the other hand, the current accuracy of the device is at a high level considering the general

population's needs. The precision in step counting and self-observed steps using wearable technologies differed slightly, while smartwatches were even more accurate [for more, see review (32)]. The accuracy of wearable technology devices can range between 79.8 and 99.1%, while the coefficient of variation (precision) ranges between 4 and 17.5% (33). Wearables' different features and technology could explain variations in the accuracy of wearable devices. The precision of activity trackers and smartwatches will grow, and innovations in the field of technology may provide us with new possibilities. The development of wearable technologies is undoubtedly one of the growing trends in fitness and can represent a strategy to increase PA among the general population.

Artificial intelligence (AI) and associated computational techniques have recently become the new frontier in developing the landscape of fitness, health care, and promotion of PA (34). For example, AI chatbots, also called virtual conversational agents, engage in conversation techniques to facilitate natural language dialogues with users employing speech, text, or both to simulate human in-person communication (35, 36). Several studies evaluated the effectiveness of AI chatbots on healthy behaviors. For example, an AI chatbot called "Assistant to Lift your Level of activitY" (Ally) increased step-goal achievement (37). However, 30% of participants dropout throughout the study, suggesting a challenge for the chatbot's capability to engage participants. Several other chatbots have shown potential to improve dietary habits (38), promote self-reflection (39), and weight management (40). However, several issues are noted in the mentioned studies. For example, there are unanswered questions about ethical concerns regarding transparency, privacy, and potential algorithmic biases. In addition, details of the development of the chatbot program were not discuses in the studies. AI indeed represents the future directions in modern technologies usage in fitness, and it will be even more abundant in coming years.

THE ROLE OF SOCIAL MEDIA AND INFLUENCES ON PHYSICAL FITNESS

Social media and social networking platform usage have exponentially grown in the last 10 years. Social media can be defined as "websites and computer programs that allow people to communicate and share information on the internet using a computer or mobile phone" (41). In addition, these mediums can help promote healthier behaviors by providing users with the opportunity of learning (42). Through this type of media, YouTubers and influencers have the most influence.

A youtuber can be defined as someone who makes and appears in videos on the website, while an influencer can be defined as someone who affects or changes other people's behavior (43). Fitness is one of the topics covered by YouTube and Instagram users. Through their channels, fitness influencers describe their daily routines, give advice on exercise, diet, propose online coaching and free workouts, and generally (tik) talk about healthy lifestyles and living habits. Some youtube influencers have millions of audiences and represent a powerful and influential medium in transmitting the information. The growing influence of Internet has its foundations in psychology as well.

Earlier media models involved passive consumers theory, where consumers simply absorb media content (44). However, later theories suggest that the media is interactive where the audience actively chooses the information to process based on their own ideas and beliefs (45). This way, the media would strengthen the ideas and behavior instead of modifying them. Internet allows viewers to choose the content according to their preferences and beliefs. Also, entertainment is an integral aspect of the individual level, so discovering innovative practices to engage in PA that children/adolescents enjoy is essential and could incorporate online PA class, performing viral dances and challenges (e.g., TikTok), or PA gaming (46). Due to these possibilities, Internet has become the leading medium in the transmission of information, especially among the younger population.

Prior research reports that higher exposure and greater attention to health in the media could lead to broader knowledge concerning a healthy lifestyle and healthier behavior (47, 48). Contrary to professional athletes, the audience senses influencers as peers and could relate to them (49), and it is this model and this determinant that has proven to be the critical factor in conveying messages (50). Through their channels, fitness influencers promote healthy lifestyle habits and PA. For example, on such channels l, coaching videos, exercise tutorials, motivational speeches, videos featuring past and current experiences of the influencer, can be regularly found (51). Following the viewer's theory of active involvement in media selections based on viewer attitudes and beliefs, it is rational to presume that viewers and followers of fitness influencers are usually interested in healthier lifestyles and fitness, so this type of content can positively impact their overall health behaviors. However, there are also negative sides to social media. For example, some studies have found the unfavorable effects of social networks on body image, body satisfaction, and eating disorders (52, 53). Moreover, it is questionable whether online sharing and promotion of PA throughout website content influences the actual PA performed (54, 55). Understanding how to use social networks and media to promote PA behaviors is limited (56). Moreover, there are limited data that evaluate the role of the influencers in promoting healthier behaviors (57).

Content designed to promote PA, healthy lifestyle habits, and a positive attitude toward fitness are likely to impact the viewer/consumer of online content positively. However, increased attention and careful consideration are advisable while using social networks and youtube channels to inspire the transition toward healthy behaviors. It is a mistake to assume that watching fitness channels can increase PA. Moreover, it could even reduce the intentions of the viewers to exercise (57).

CONCLUSION

PI was defined as a global pandemic in the 2012 Lancet series on PA and health. PI has hazardous health and economic consequences. One of the most important challenges to modern

societies is increasing awareness of PA's importance and a healthy lifestyle. However, there is no silver bullet for PA promotion. Although many efforts have been made to promote PA, the global level of PI is still high. Therefore, it is essential to establish some goals that will follow the needs and development of modern society. On the one hand, the growing influence of influencers and social networks on the promotion of PA is a good strategy, while on the other hand, a cause for concern. The question is how to limit the influence of influencers due to the possible harmful effects of the content of their channel and the accuracy of the information itself. On the other hand, leading healthcare organizations should take the initiative and start educating fitness influencers who impact a considerable number of people, thus providing Internet users with more accurate information. In the end, the development of AI does indeed represent the future of fitness, and we will be able to assess the real benefits and consequences of these technologies in the assessments that lie ahead.

With this short review additional questions arise and need to be answered:

(1) How can wearable technologies be popularized and implemented in PA interventions worldwide?
(2) How can social networks implement PA advertising/promotion strategies at scale?
(3) How can the next wave of technological improvements such as AI be integrated into large-scale PA promotional programs.

Enhancing global health by increasing PA will demand both advancements in knowledge and a more significant commitment of resources.

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VŠ, NT, and PD: conceptualization and writing–original draft preparation. MR and NT: methodology. IM, SP, MR, and NT: writing–review and editing. PD: visualization and supervision. VŠ and PD: funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Awareness, Utilization and Health Outcomes of National Essential Public Health Service Among Migrants in China

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Background: The national essential public health service (NEPHS) has been in operation for more than a decade. Numerous studies examined the utilization of NEPHS by migrants and the factors that influence it, but few examined the effect of NEPHS awareness and utilization on the health of inhabitants, particularly migrants. The purpose of this study is to ascertain the level of awareness and utilization of NEPHS, as well as to examine their health-improving effects on migrants.

Methods: Based on the data from the 2017 China Migrants Dynamic Survey, linear probability model, ordered logit model and the propensity score matching methods were employed to investigate impact of awareness and utilization of NEPHS on the health among Chinese migrants. Mediating effect model were used to identify the mechanism of the impact of NEPHS on health.

Results: The findings indicated that migrants' awareness and utilization of NEPHS are still insufficient. After adjusting for other factors, the study discovered that increased awareness and use of NEPHS had a beneficial influence on migrants' self-rated health. Further heterogeneity analysis revealed significant disparities in the health consequences of NEPHS awareness and utilization across subgroups. The effect of increased awareness and usage of NEPHS on health is stronger for middle-aged and elderly people, women, and low-educated migrants with urban household registration. The estimated results of the mediating effect model supported the mechanism that increased NEPHS awareness among the floating population could encourage its utilization and further improve the floating population's health.

Conclusions: Given that migrants' NEPHS utilization is still low and that NEPHS utilization has a positive effect on health, some targeted strategies, such as a variety of new media communication methods, health education related to occupational disease and tuberculosis prevention, and targeted NEPHS projects for specific groups, such as men, young and middle-aged groups, those with a high level of education, and rural migrants, should be conducted to improve the health of migrants.

Keywords: awareness, utilization, national essential public health service, health, migrants

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BACKGROUND

The country's urbanization and economic development have benefited significantly from the floating population (1, 2). Sustaining economic and social progress has also facilitated population movement (3). China's entire migrant population has been expanding over the last few decades. According to the 7th National Population Census, China's migrant population has surpassed 370 million, a 69.73 percent growth over 2010 (4). The health of this population is jeopardized by high occupational health risks and exposure to substandard living conditions (5, 6), and the existence of the household registration system places the floating population at a significant disadvantage in terms of social welfare and employment opportunities when compared to local residents (7, 8). Additionally, it denies them the same access to healthcare as local residents (9, 10).

To effectively protect the floating population's right to health, China has developed a number of health regulations for migrants in China, and clear arrangements have been established to improve this population's fundamental public health service (11). China began implementing national essential public health services (NEPHS) in 2009; In 2013, the National Health and Family Planning Commission issued *Guidance on the implementation of pilot projects for the administration and equalization of public health services and family planning for migrants*, and the pilot to provide equal access to NEPHS for migrants was launched. To more effectively promote equal access to basic public health services for migrants, the National Health and Family Planning Commission, in collaboration with relevant departments, issued *Guidance on the management of basic public health services and family planning for migrants* in 2014. The guidance emphasized the importance of prioritizing the implementation of six basic public health services for migrants, including child vaccination, prevention and control of infectious diseases, maternal and child health care, health records, family planning and health education (12). Additionally, the Report of the 19th Communist Party of China National Congress made a strong case for expediting the equalization of basic public services and implementing the Healthy China agenda. As demand for basic public health care increases among people, China gradually increases investment in basic public health services. The standard for NEPHS per capita subsidy was increased to 79 yuan in 2021 (13). Currently, basic public health services consist mostly of 14 service components, such as health record establishment. In actuality, national primary health care services are based on the notion of voluntary participation. Effective evaluation of the project's health impact lays the groundwork for continued development and optimization of the NEPHS implementation process.

Although it has been some years since migrants received equitable access to basic public health services. However, existing research indicates that there are still issues such as underutilization and disparity in the use of NEPHS by migrants in inflow areas (14). Numerous studies have been conducted to determine the state of affairs and the factors that influence the floating population's use of specific NEPHS projects. Furthermore, these studies consistently demonstrated that migrants' overall utilization of NEPHS remains low (15–19). Analyses of specific regions have yielded similar conclusions (20–23). Additionally, research have been conducted on certain subgroups of migrants, including those with hypertension and type 2 diabetes, the elderly, and the younger generation. It was also discovered that patients with chronic diseases had a poor level of utilization of NEPHS items such as follow-up evaluation, establishment of health records, physical examination, and health education (24, 25). The elderly and young migrants also have a low degree of utilization of NEPHS (26–29).

Some studies discovered significant differences in NEPHS utilization between local residents and migrants when comparing the two groups (30). The proportion of migrants with urban household registration who establish health records is significantly greater than that of migrants with rural household registration (31). While numerous studies have examined the determinants of NEPHS utilization among migrants, few have examined the health benefits associated with increased awareness and utilization of NEPHS among residents, particularly migrants. Local residents' surveys indicated that the NEPHS project can significantly improve hypertension treatment and control (32). Maternal and child healthcare utilization and outcomes have improved markedly (33). NEPHS implementation improved hypertension and diabetes control, as well as the level of health management in patients with severe mental disorders and children (34). Additionally, NEHS has the potential to close the health disparity between residents by increasing health literacy and influencing poor residents' health-related behavior (35). Furthermore, it can help migrants access healthcare (36).

There are only two studies that we are aware of that examine the effects of NEPHS on migrant health. Both of them, however, use the fact that the city implements NEPHS as an explanatory variable in order to examine the impact on the health of migrants (37, 38). Variables constructed at the city level may not accurately reflect the details of NEPHS utilization by migrants, introducing estimation bias into estimates of the health effect. This paper examined the current state of awareness and utilization of NEPHS among Chinese migrants using data from the 2017 China Migrants Dynamic Survey (CMDS) conducted by the National Health Commission. We examined the effect of NEPHS awareness and utilization on population health, which is one of the contributions to existing research; Additionally, there may be a difficulty in studying the aforementioned effect. Migrants who live closer to a community health facility, those who have chronic diseases, and those who have had recent illnesses or injuries are more likely to use NEPHS. Thus, a direct comparison of the health disparity between migrants who use NEPHS and those who do not may lead to the conclusion that NEPHS worsens migrants' health. As a result, the estimation is skewed. Therefore, the estimation is skewed. As a result, this study controls for the above variables in the benchmark regression on the one hand

Abbreviations: NEPHS, National Essential Public Health Service; CMDS, China Migrants Dynamic Survey; NCMS, New Cooperative Medical System; CURBMI, Coordinating of Urban and Rural Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance; UEBMI, Urban Employee Basic Medical Insurance; FMC, Free Medical Care.

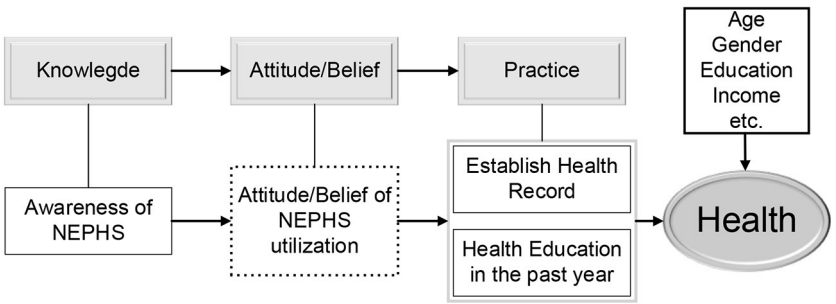

FIGURE 1 | Conceptual framework.

and uses propensity score matching to identify the net effect of NEPHS on the health of migrants on the other hand, which is another contribution of this paper. Finally, in order to examine the distinct effects of NEPHS awareness and utilization on the health of various groups, heterogeneity analysis was used to accurately quantify the impact of NEPHS on the health of various floating populations.

CONCEPTUAL FRAMEWORK

Knowledge, Attitude / Belief, and Practice Theory (KABP) is the most prevalent model used to guide and explain how knowledge and beliefs influence health behavior change (39). According to this theory, health care knowledge and information are the foundation for building positive and accurate beliefs and attitudes, consequently altering health-related behaviors, which can improve an individual's health. **Figure 1** depicts the study's conceptual framework. Clearly, information is the first step in altering an individual's behavior. Only if the floating population has a certain awareness of NEPHS will they be more likely to establish the correct health concepts and attitudes and effectively increase the health level of them. Importantly, it is only possible to utilize the related NEPHS services if they are understood beforehand. By getting health education and establishing health records, individuals can increase their focus on health management and health behavior modification, which has a substantial positive effect on their own health. Based on the preceding analysis, the following hypotheses are proposed:

Hypothesis 1: The awareness of NEPHS can effectively increase the health level of individuals, and the floating population whose health records are established and who receives health education has a higher health level. Awareness of NEPHS can promote the establishment of health records and the potential of receiving health education, so contributing to the enhancement of the health status of the floating population.

It is important to note that NEPHS may influence the self-rated health of the floating population with varying features in a way that results in differences in self-rated health. From the standpoint of age, the risk of illness will increase as persons age, and elderly usually pay greater attention to their health. Therefore, NEPHS has a greater impact on the health state of the elderly than on that of the young. In addition, as a special group, NEPHS provides once-yearly health management services for the aged, such as lifestyle and health assessment, physical examination, auxiliary examination, and health counseling. Consequently, it is likely that the health improvement effects of NEPHS will be more pronounced among the older floating population. From gender perspective, there are intrinsic differences in the health condition of men and women, with women paying greater attention to their health status when they are ill and being more ready to seek assistance for illness prevention (40). Consequently, women are more likely to be impacted by NEPHS. From the perspective of education, people with a higher level of education tend to have higher health literacy and greater health knowledge, so they have greater advantages in self-health management, but their health is less affected by NEPHS for the same reason; In addition, urban areas have more medical resources than rural areas, and there are also differences in the allocation of health human resources between urban and rural areas. Urban floating population enjoys greater accessibility and quality of medical care, thus we anticipate that the health improvement effect of NEPHS will be greater in urban regions. Based on the preceding analysis, we suggest the second hypothesis:

Hypothesis 2: Due to diverse characteristics, the impact of NEPHS awareness and utilization on the health of floating populations is heterogeneous. Specifically, NEPHS has a greater impact on the health improvement of middle-aged and elderly, women, urban floating population with low levels of education.

MATERIALS AND METHODS

Data Source

The data for this study came from the National Health Commission's 2017 China Migrants Dynamic Survey (CMDS). The National Health Commission conducted the survey (formerly the National Health and Family Planning Commission). Sample points were chosen randomly from areas where the floating population was concentrated in 31 provinces (autonomous regions and municipalities) and the Xinjiang Production and Construction Corps. The stratified, multistage, and probability proportional to size sampling method was used to investigate migrants aged 15 and over who had lived in the inflow places for at least 1 month but were not district

residents (county or city). The survey collects data on family members, household income and expenditure, employment status, mobility, and healthcare utilization, among other things. In 2017, a total of 169,989 valid samples of the floating population were collected. Because NEPHS items are primarily distributed to residents who have lived in the area for more than 6 months, samples of residents who have lived in the area for <6 months were excluded from this study. For inclusion analysis, the final valid sample size was 152,695.

Measures

Health Outcomes

Self-reported health status was used as a proxy for individual health. Each respondent was asked in the CMDS, "How do you feel about your health currently?" 1 = healthy, 2 = basically healthy, 3 = unhealthy, but able to take care of themselves, 4 = unable to take care of themselves.

National Essential Public Health Service

Awareness

Each respondent to the CMDS survey was asked if they had heard of the National Essential Public Health Service. This question has two possible answers: 1 indicates yes, and 0 indicates no.

Utilization

In terms of NEPHS utilization, this study referred to previous research (15) and used two binary variables to determine NEPHS utilization: whether to establish health records and whether to receive any health education in the previous year. Respondents were asked whether local health records had been established. There are four options available: 1 indicates that it is established, 2 indicates that it is not established and that it has not been heard of, 3 indicates that it is not established but has been heard of, and 4 indicates that it is unclear. We unified recoded 2, 3, and 4 as 0, indicating that the individual did not establish health records in the local area. Each respondent was asked in turn if they had received health education in the following areas: occupational disease prevention, sexually transmitted diseases/AIDS prevention, reproductive health and contraception, tuberculosis prevention and control, smoking control, mental health, chronic disease prevention and control, maternal and child healthcare/healthy birth, and self-rescue in public emergencies. We combined the binary variables above and coded respondents as 1 if they had received at least one of the health education activities and 0 if they had received none.

Covariates

In accordance with previous studies (38, 41), this study included additional variables affecting the health of migrants in the model. Individual demographic characteristics (gender, age, ethnic minorities, marital status, education level, family size, and household registration), socioeconomic status (including household income, health insurance, and employment status), flow range, presence of chronic diseases in the past year, presence of any disease or injury in the past year, and time to the nearest health facilities are all included. Among them, marital status is a dichotomous variable; 0 indicates that the respondent is single, divorced, or widowed, while 1 indicates that the respondent is married for the first time, remarried, or cohabiting. Education level is a triadic variable, with 1 indicating primary school or less, 2 indicating junior high school, and 3 indicating senior high school or more. Household registration is a binary variable, with 1 indicating rural household registration and 0 indicating urban household registration. The model contained five dummy variables that indicated whether interviewees had participated in the New Cooperative Medical System (NCMS), the Coordinating of Urban and Rural Basic Medical Insurance (CURBMI), the Urban Resident Basic Medical Insurance (URBMI), the Urban Employee Basic Medical Insurance (UEBMI), or Free Medical Care (FMC). When assessing individual employment, we incorporate variables representing individual employment status into the model. These variables are classified as follows: 1 = unemployed, 2 = employed, 3 = employer, 4 = self-employed worker, and 5 = other. Respondents' flow range is a three-category variable, with 1 representing inter-provincial flow, 2 representing inter-city flow within the province, and 3 representing inter-county flow within the city. Respondents were asked if they had a doctor's diagnosis of high blood pressure or type 2 diabetes, with 1 indicating they had one or both and 0 indicating they did not. Similarly, respondents were asked if they had experienced any disease or injury in the preceding year, which we recoded as a binary variable, with 1 indicating yes and 0 indicating no. The time to the nearest health facility represented healthcare accessibility, which is a four-category variable: 1 equals <15 min, 2 equals 15–30 min, 3 equals 30–60 min, and 4 equals more than 60 min.

Statistical Analyses

Descriptive Statistical Analysis and Difference Test

We used descriptive statistics to examine NEPHS awareness and use among Chinese migrants, and then used the chi-square test to determine whether there were significant differences in self-rated health between those who were aware of and used NEPHS and those who were unaware of and did not use NEPHS items.

Regression Analysis

For regression analysis, we used two models: the linear probability model (LPM) and the ordered logit model. Due to the numerous positive properties of self-rated health (42), it can be treated as a continuous variable. To facilitate comparison of propensity score matching estimate results in the following section, this study used LPM results as the benchmark. Meanwhile, our study presents the regression results for the ordered Logit model. LPM's regression model is as follows:

$$Health_i = \alpha + \beta \cdot NEPHS_i + \boldsymbol{X_i'}\boldsymbol{\delta} + \varepsilon_i \quad (1)$$

Where $Health_i$ denotes the individual's self-rated health; $NEPHS_i$ denotes whether the individual is aware of or uses the NEPHS; $\mathbf{X_i}$ denotes other covariates affecting the migrants' self-rated health; ε_i is the error term in the model. β is the coefficient effect that we are interested in, as it reflects the effect of migrants' awareness or use of NEPHS on their self-rated health. Additionally, because self-rated health is an ordered variable, we report the estimated results of ordered Logit model.

Propensity Score Matching

As mentioned previously, to account for the possibility of estimation bias caused by a variety of factors affecting individuals' awareness of and use of NEPHS, this study used propensity score matching to identify two groups of samples with otherwise similar characteristics in order to estimate the average treatment effect (ATT) on the health of migrants.

$$ATT = E\left[y_{1i}|D_i = 1, P(X)\right] - E\left[y_{0i}|D_i = 1, P(X)\right] \quad (2)$$

In Equation (2), D_i denotes the dummy variable of i_{th} migrant's awareness or utilization of NEPHS; $D_i = 1$ indicates that the migrant was aware of or utilized NEPHS; $D_i = 0$ indicates that the migrant was unaware of or did not utilize NEPHS. y_{1i} refers to individual's self-rated health when they are aware of or use NEPHS; y_{0i} refers to the self-rated health when they are unaware or do not use NEPHS. $P(X)$ denotes the probability that migrants are aware of or use NEPHS, also referred to as the propensity score.

For example, to examine the effect of NEPHS awareness on migrants' self-rated health, we first divide the population into those who were aware of NEPHS and those who had not heard of it. The two groups of samples were then matched using four PSM matching strategies (nearest neighbor matching, radius matching, kernel matching, and local linear regression matching). Finally, the treatment group's and control group's self-reported health scores were obtained, as well as the differences between the two groups. A similar approach was used to examine the effect of health education and the establishment of health records on migrants' self-rated health.

Mediating Effect Model

To further test the hypothesis of the mediating effect proposed in the conceptual framework, namely, that the awareness of NEPHS can improve the self-rated health of the floating population by increasing the likelihood of establishing health records and receiving health education in the previous year, we developed the mediating effect model (43). Analysis of the mediating impact has been widely utilized as the primary tool for testing the mechanism (44). The most popular method for confirming the mediating effect is the stepwise regression test. It is a technique for determining the existence of a mediating effect by creating three regression models and evaluating the magnitude and significance of the coefficients of key variables. This study employs the same methodology. Three regression models comprise the stepwise regression test:

$$Health_i = \alpha_1 + \beta_1 \cdot Awareness_i + \boldsymbol{X_i'}\boldsymbol{\delta} + \varepsilon_i \quad (3)$$

$$M_i = \alpha_2 + \beta_2 \cdot Awareness_i + \boldsymbol{X_i'}\boldsymbol{\xi} + \mu_i \quad (4)$$

$$Health_i = \alpha_3 + \beta_3 \cdot Awareness_i + \gamma \cdot M_i + \boldsymbol{X_i'}\boldsymbol{\eta} + \upsilon_i \quad (5)$$

Among them, $Health_i$ refers to the health of the floating population, $Awareness_i$ to the dummy variable representing NEPHS awareness, and $\mathbf{X_i}$ to the other covariates. The mediating variable is M_i. In this study, the variables that serve as mediators are the establishment of health records and the receipt of health education during the past year. The coefficient β_1 in Equation (3) represents the total effect of NEPHS awareness on health, the coefficient β_2 in Equation (4) represents the effect of NEPHS awareness on mediating variables, and the coefficient γ in Equation (5) represents the effect of mediating variables on the health of the floating population after controlling for Awareness. When β_1 is significant, it is possible to verify the statistical significance of 2 and. If both variables are significant, then the mediating effect is significant.

RESULTS

Characteristics of the Study Population

As shown in **Table 1**, the average age of migrants is 37.10 ± 11.00 years; 48.5% are female; 83.75% are married; and 9.19% are members of minority groups. The majority of migrants have completed junior middle school or less, and the proportion of migrants living in rural areas is even higher, at 82.16%. The study population's annual household income per capita was 30360.10 ± 25748.25 yuan, and employees accounted for 46.68%, the highest rate. NCMS, CURBMI, URBMI, UEBMI, and FMC participation rates were 62.30, 4.81, 7.23, 22.28, and 2.19%, respectively. According to the floating range, the majority of migrants are interprovincial, followed by intercity, and intercounty, with 48.47, 33.42, and 18.11%, respectively. Additionally, 5.74% of them had been diagnosed with hypertension or type 2 diabetes by a physician, and 49.14% had suffered from diseases or injuries in the previous year. In terms of healthcare accessibility, the majority of migrants live <15 min from the nearest health facility (83.51%).

Awareness and Utilization of NEPHS

Figure 2 depicted Chinese migrants' specific awareness and use of NEPHS. 59.96% of migrants are aware of the NEPHS, while more than 40% have never heard of it. 30.01% of the population has established health records, while 22.69% of the population has not established health records but has heard about them. 31.14% of migrants who have not established health records and have not been informed about them, and 16.15% of the general population who are unsure whether they have established health records. 75.53% of the population has received some form of health education, while 24.27% has received no form of health education. The participation rate of migrants in each health education activity was depicted in **Figure 2D**. As can be seen, each health education program has a participation rate of <50%. Occupational disease and tuberculosis prevention education have the lowest participation rates, at 33.37 and 33.67%, respectively.

Health Status Among Different Subgroups of Awareness and Utilization of NEPHS

The differences in self-rated health between those who heard about and used NEPHS and those who did not are shown in **Table 2**. The proportion of healthy migrants who have heard of NEPHS is significantly higher than those who have not (83.03 vs. 79.55%). The proportion of those who are basically healthy, unhealthy and unable to take care of themselves was lower among those who are aware of NEPHS (14.63 vs. 16.83%, 2.27 vs.

TABLE 1 | Descriptive statistics of variables.

	Total ($N = 152,695$)
Age	
Mean (SD)	37.10 (11.00)
Family size	
Mean (SD)	3.18 (1.18)
Annual household income per capita (Yuan)	
Mean (SD)	30360.10 (25748.25)
Self-rated health	
Healthy	124,684 (81.66%)
Basically healthy	23,665 (15.50%)
Not healthy, but able to take care of oneself	4,187 (2.74%)
Unable to take care of oneself	159 (0.10%)
NCMS	
No	57,565 (37.70%)
Yes	95,130 (62.30%)
CURBMI	
No	145,351 (95.19%)
Yes	7,344 (4.81%)
URBMI	
No	141,649 (92.77%)
Yes	11,046 (7.23%)
UEBMI	
No	118,673 (77.72%)
Yes	34,022 (22.28%)
FMC	
No	149,348 (97.81%)
Yes	3,347 (2.19%)
Gender	
Male	78,631 (51.50%)
Female	74,064 (48.50%)
National minority	
No	138,662 (90.81%)
Yes	14,033 (9.19%)
Education level	
Elementary and less	26,161 (17.13%)
Junior high school	66,339 (43.45%)
Senior and above	60,195 (39.42%)
Marital status	
Unmarried	24,816 (16.25%)
Married	127,879 (83.75%)
Floating range	
Interprovincial	74,005 (48.47%)
Intercity	51,032 (33.42%)
Intercounty	27,658 (18.11%)
Hukou	
Urban	27,235 (17.84%)
Rural	125,460 (82.16%)
Chronic diseases	
Without	143,933 (94.26%)
With	8,762 (5.74%)
Sickness or injury in the past year	
No	77,661 (50.86%)
Yes	75,034 (49.14%)
Employment status	
Unemployed	27,576 (18.06%)
Employee	71,273 (46.68%)
Employer	7,560 (4.95%)
Self-employed	43,621 (28.57%)
Others	2,665 (1.75%)
Time to the nearest health facility	
within 15 min	127,519 (83.51%)
15–30 min	22,147 (14.50%)
30–60 min	2,647 (1.73%)
More than 1 h	382 (0.25%)

(Continued)

3.46%, 0.07 vs. 0.16%). The chi-square test revealed a significant difference in self-rated health between those aware of NEPHS and those who were not ($P < 0.01$). Similar findings were discovered when it came to health education and the establishment of a health record.

Regression Analyses Results

LPM and ordered logit model were used to investigate the effect of NEPHS awareness and utilization on migrants' self-rated health, **Table 3** summarizes the estimation results for Models 1–3, which used linear probability model, and Models 4–6, which used non-linear ordered logit model. Regardless of the LPM or Ordered Logit model used, after adjusting for the province fixed effect and other covariates, self-rated health was significantly better for migrants who had heard about NEPHS, received at least one type of health education in the preceding year, and established health records in their place of residence. All of the above effects were statistically significant at the 1% level ($P < 0.01$). The LPM findings indicated that awareness of NEPHS could improve migrants' self-rated health by ∼0.038 units on average, and that receiving at least one type of health education in the previous year could improve migrants' self-rated health by ∼0.03 units. Similarly, establishing a health record in the residence area increases self-rated health by an average of 0.035 units.

Robust Test: Propensity Score Matching Estimates Results

Although we controlled for as many covariates as possible that could introduce bias into the benchmark regression, we used propensity score matching to determine the homogeneous individuals between those who knew or used NEPHS and those who did not. By comparing the self-reported health of two groups of homogeneous migrants, the average effect of NEPHS on the migrants' self-reported health could be determined.

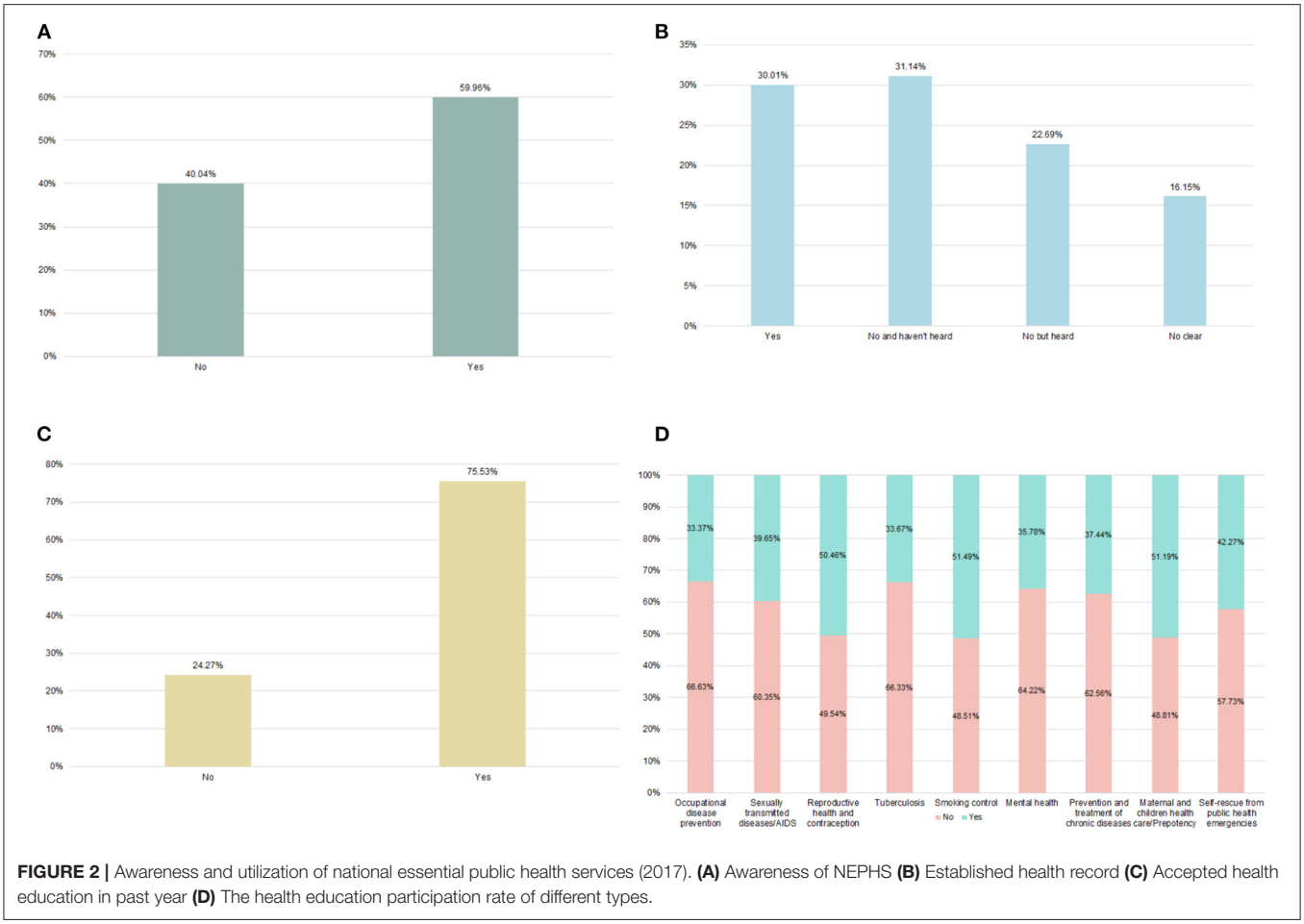

FIGURE 2 | Awareness and utilization of national essential public health services (2017). **(A)** Awareness of NEPHS **(B)** Established health record **(C)** Accepted health education in past year **(D)** The health education participation rate of different types.

According to the results of propensity score matching (**Table 4**), awareness of NEPHS, having received at least one health education in the preceding year, and maintaining health records could significantly improve migrants' self-rated health ($P < 0.01$). NEPHS awareness would improve migrants' self-rated health by ∼0.03–0.039 units on average. Receiving health education has been shown to improve the population's self-rated health by ∼0.022–0.025 units. Establishing health records could improve the floating population's self-rated health by an average of 0.028–0.031 units.

Heterogeneity Analysis

Given that the effects of NEPHS on migrants are likely to be influenced by their age, gender, level of education, and household registration, the study samples were further divided into subgroups based on four variables mentioned above. As before, similar LPM regressions were conducted, and **Table 5** displayed the corresponding estimation results. The NEPHS had significantly different effects on the self-rated health of different subgroups of migrants. Specifically, awareness of the NEPHS, recent health education, and the establishment of health records had a greater impact on the self-rated health of migrants over 45 years old, particularly the elderly, and a relatively smaller impact on the health of migrants aged 15–44 years old. In terms of gender, the three NEPHS variables have a greater effect on the health of female migrants than on male migrants. Migrants with a primary education level or less were more likely to have their self-rated health influenced by NEPHS. Additionally, NEPHS improved urban migrants' health more than rural migrants' health.

Mechanism Analysis

To validate the mechanism of NEPHS on the health of the floating population, we developed a model of the mediating effect. In **Table 3**, we have established Equation (3) for the model of the mediating effect. Here, we estimated Equations (4) and (5) using the establishment of health records and receiving health education in the previous year as the mediating variables, respectively. **Table 6** displayed the estimation results. Model 1 in **Table 3** represented the effect of NEPHS awareness on the self-rated health of the floating population, which is denoted by the coefficient β_1 in Equation (3). In **Table 6**, Model 1 illustrated the impact of NEPHS awareness on the establishment of health record. It is evident that NEPHS awareness could significantly increase the possibility of establishing health record for the floating population ($P < 0.01$). Model 2 estimated the impact of

TABLE 2 | Self-rated health among different subgroups of awareness and utilization of NEPHS.

Variables	Healthy (*N* = 124,684)	Basically healthy (*N* = 23,665)	Not healthy, but able to take care of oneself (*N* = 4,187)	Unable to take care of oneself (*N* = 159)	χ^2
Awareness of NEPHS					
No	47,993 (79.55%)	10,156 (16.83%)	2,087 (3.46%)	94 (0.16%)	381.64***
Yes	76,691 (83.03%)	13,509 (14.63%)	2,100 (2.27%)	65 (0.07%)	
Accepted health education in past year					
No	32,522 (79.19%)	6,856 (16.69%)	1,607 (3.91%)	83 (0.20%)	426.35***
Yes	92,162 (82.56%)	16,809 (15.06%)	2,580 (2.31%)	76 (0.07%)	
Established health record					
No	86,576 (81.05%)	17,118 (16.02%)	3,009 (2.82%)	119 (0.11%)	88.80***
Yes	38,108 (83.07%)	6,547 (14.27%)	1,178 (2.57%)	40 (0.09%)	

*The table reported the frequency and corresponding row percentages for each variable; ***P < 0.01.*

TABLE 3 | The impact of awareness and utilization of EPHS on health status of migrants.

Variables	Model 1	Model2	Model 3	Model 4	Model 5	Model 6
Awareness of NEPHS (Ref: No)	−0.038*** (0.003)			−0.241*** (0.022)		
Health education in the past year (Ref: No)		−0.030*** (0.004)			−0.172*** (0.026)	
Established health record (Ref: No)			−0.035*** (0.004)			−0.249*** (0.027)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared/ Pseudo R-squared	0.200	0.199	0.200	0.148	0.147	0.148

*Robust Standard errors clustered in province level are reported in the Parentheses: ***P < 0.01.*

TABLE 4 | PSM estimation results.

Variables	Matching method	Treatment group	Control group	ATT	Bootstrap standard error
Awareness of NEPHS	Nearest neighbor matching	1.194	1.224	−0.030***	0.004
	Radius matching	1.194	1.228	−0.034***	0.003
	Kernel matching	1.194	1.228	−0.034***	0.003
	Locally linear matching	1.194	1.233	−0.039***	0.004
Health education in the past year	Nearest neighbor matching	1.192	1.214	−0.022***	0.004
	Radius matching	1.192	1.214	−0.022***	0.003
	Kernel matching	1.192	1.216	−0.024***	0.004
	Locally linear matching	1.192	1.217	−0.025***	0.004
Established health record	Nearest neighbor matching	1.197	1.225	−0.028***	0.004
	Radius matching	1.197	1.227	−0.031***	0.003
	Kernel matching	1.197	1.226	−0.030***	0.003
	Locally linear matching	1.197	1.227	−0.031***	0.004

*Standard errors of PSM are obtained by the Bootstrap with a sample size of 500; ***P < 0.01.*

NEPHS awareness on health after controlling the establishment of health record variable and which was statistically significant at the 1% level ($P < 0.01$). NEPHS awareness still had a favorable influence on the self-rated health of the floating population. Similarly, awareness of NEPHS might considerably improve the likelihood that the floating population has received health education in the previous year ($P < 0.01$). Awareness of NEPHS remains to have a beneficial influence on the self-rated health of the floating population when the mediating variable is included in the model ($P < 0.01$).

DISCUSSION

China has proposed the goal of equalization of national essential public health services for the population since 2013 in order to improve the health status of migrants. Due to the mobility

TABLE 5 | Heterogeneity analysis of the impact of NEPHS on health status.

Variables	By age			By gender	
	15–44	45–59	Above 60	Male	Female
Awareness of NEPHS	−0.030*** (0.003)	−0.060*** (0.008)	−0.058*** (0.019)	−0.034*** (0.004)	−0.042*** (0.004)
Health education in the past year	−0.020*** (0.004)	−0.042*** (0.008)	−0.072*** (0.021)	−0.023*** (0.004)	−0.037*** (0.006)
Established health record	−0.033*** (0.004)	−0.042*** (0.008)	−0.046** (0.021)	−0.029*** (0.005)	−0.041*** (0.005)
Variables	**By education level**			**By residence registration**	
	Elementary school and below	**Junior school**	**Senior and above**	**Urban**	**Rural**
Awareness of NEPHS	−0.054*** (0.009)	−0.037*** (0.004)	−0.032*** (0.004)	−0.040*** (0.006)	−0.038*** (0.004)
Health education in the past year	−0.043*** (0.010)	−0.031*** (0.005)	−0.022*** (0.004)	−0.036*** (0.007)	−0.029*** (0.004)
Established health record	−0.047*** (0.010)	−0.037*** (0.005)	−0.029*** (0.004)	−0.038*** (0.007)	−0.035*** (0.004)

*Robust Standard errors clustered in province level are reported in the Parentheses: ***P < 0.01.*

TABLE 6 | The results of mediating effect model.

Variables	Model 1 Established health record	Model 2 Self-rated health	Model 3 Accepted health education in the past year	Model 4 Self-rated health
Awareness of NEPHS	0.361*** (0.010)	−0.030*** (0.003)	0.267*** (0.007)	−0.033*** (0.003)
Established health record		−0.022*** (0.004)		
Accepted health education in the past year				−0.019*** (0.004)
Covariates	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Adjusted R-squared	0.238	0.200	0.162	0.200

*Robust Standard errors clustered in province level are reported in the Parentheses: ***P < 0.01.*

characteristics of the population, it is difficult to conduct NEPHS. The CMDS survey data from 2017 were analyzed in this study to determine the effect of NEPHS awareness or utilization on the health of migrants. Analyses of the current state of awareness and utilization of NEPHS could be used to target areas for improvement in NEPHS implementation. Further investigation of the floating population's health effects and heterogeneity enables evaluation of the NEPHS project's effectiveness, clarification of the NEPHS project's primary improvement direction, and effective improvement of the floating population's health and welfare.

NEPHS's mission is to increase access to and equity in essential public health services. However, our study found that migrants' awareness and utilization of NEPHS are still insufficient, impeding health equity. This is consistent with previous research findings (15, 45, 46). Although the NEPHS project has been in operation for more than a decade, public awareness and utilization of basic public health services remain low. According to a survey conducted in some regions of China, only 0.2 percent of the surveyed floating population was familiar with the entire content of NEPHS items, and there was also an issue of unbalanced development across service items (46). The possible reason is that the floating population's mobility makes it difficult to implement the NEPHS strictly, and the migrants' coverage rate for health records, health education, and health examinations, as well as other services, is mediocre (14). Migrants' ability and initiative to obtain relevant NEPHS information is less developed than that of local residents (23, 47). Simultaneously, the unbalanced allocation of health resources and a lack of human resources for NEPHS contribute to migrants' low awareness and utilization of NEPHS (16, 45).

After adjusting for other covariates, our study demonstrated that increased awareness and use of NEPHS have a beneficial effect on the health of migrants. Our study also indicated that the awareness of NEPHS will promote the establishment of health record of floating population and the likelihood of receiving health education in the last year, consequently increasing their health status. According to the KABP model, the awareness of NEPHS would increase the floating population' s cognition and comprehension of public health services, and then promote them to gradually build a belief that is favorable to their own health. Finally, this positive belief and attitude can be turned into healthy behaviors. By establishing health records and receiving health education, the health literacy of the floating population can be effectively increased, so that individuals attach importance to the monitoring and management of self-health, and thus have a beneficial impact on the health of the floating population.

To a certain extent, awareness of NEPHS reflects the population's health literacy. Several studies found that equalizing NEPHS among migrants *via* a quasi-natural experiment found that equalizing NEPHS could improve the population's health literacy (38). Individuals with a higher level of health literacy have a greater likelihood of being in better health (48). Improving migrants' health literacy increased their chances of establishing health records and receiving additional health education, which had a positive effect on their use of NEPHS (49). This increase

in healthcare utilization would also have a positive effect on health outcomes (50). The establishment of health records can significantly increase awareness of individual health management (45), and also assist health facilities and personnel in monitoring the health of migrants on a regular basis. As a result, it is critical for improving the population's health outcomes. It is self-evident that health education benefits migrants' health. Health education assists the floating population in developing a healthy lifestyle and behavior, and increasing their sense of self-efficacy for behavior change, thereby facilitating their health level improvement (51).

Additionally, our study discovered significant differences in the health effects of NEPHS awareness and utilization across subgroups. The effect of increased awareness and use of NEPHS on health is greater for middle-aged and elderly people, women, and low-educated migrants with urban household registration. Wang et al. found that women establish health records at a higher rate than men, and older immigrants establish health records at a higher rate than younger migrants due to their increased risk of chronic diseases. Additionally, the elderly and women are NEPHS's primary target groups (45). Simultaneously, due to their increased health risks, women and the elderly are more concerned about their own health (52). As a result, the health benefits associated with increased awareness and use of NEPHS are greater for women and elderly migrants. Individuals with a higher education degree are more likely to use NEPHS, which is consistent with our study conclusion (45). By and large, those with a higher level of education have a higher level of health literacy, which means they pay more attention to their health. However, they also have greater access to health knowledge as a result of their higher education level. As a result, NEPHS have a lower effectiveness in improving their health. Additionally, while China is currently reforming its household registration system in order to eliminate social welfare disparities between urban and rural residents, the household registration system continues to have an effect on how urban and rural residents use NEPHS (45). Residents of rural areas have a lower awareness of NEPHS than residents of urban areas (34). Urban migrants, in comparison to rural migrants, are more likely to establish health records (31, 45, 53). Furthermore, NEPHS's health-improving effect is severely limited by a shortage of professional talent and an unbalanced structure of primary health care facilities in rural areas (54).

This study has policy implications, first and foremost, because migrants' awareness of NEPHS is still low, and existing public health publicity methods have been unable to meet resident demand. As a result, a variety of new media communication channels, such as WeChat and other new media, were required to increase the visibility and reach of NEPHS, to fully exploit the subjective initiative in utilizing NEPHS, and to improve NEPHS utilization; Second, health education and public awareness about health issues should be bolstered for migrants. Health administration departments should conduct low-participation health education activities, such as occupational disease and tuberculosis prevention, and utilize information technology to establish health records and fully utilize electronic health records in order to achieve dynamic health management of migrants within the local community. Finally, given the heterogeneity of NEPHS's health effects and the individual characteristics of migrants, targeted NEPHS projects should be conducted for specific groups, such as men, young and middle-aged people, those with a high level of education, and rural migrants, in order to maximize the health benefits of NEPHS.

Additionally, our study has some limitations. Based on the cross nature of the CMDS data, we are unable to accurately determine the long-term effect of NEPHS on health among migrants. Second, due to variable limitations in the data, we are unable to verify the specific mechanism by which NEPHS utilization affects health. Numerous studies have established a link between NEPHS use and health literacy. Our future research will examine whether the use of NEPHS can help individuals improve their health literacy and develop healthy behaviors, thereby improving their health outcomes.

CONCLUSIONS

The purpose of this study was to determine the level of awareness and utilization of NEPHS among Chinese migrants and to assess their health-improving effect. The findings indicated that, despite the fact that NEPHS has been in place for over a decade, awareness and utilization of NEPHS remain low among migrants. NEPHS awareness and use had a significant positive effect on the health of migrants. The awareness of NEPHS could promote its utilization and further improve the health status of floating population. However, there are significant differences in the health effects of NEPHS awareness and use across subgroups. During the implementation of NEPHS, targeted measures such as increasing NEPHS publicity efforts and scope, conducting health education activities with a low participation rate, and focusing on males, young and middle-aged adults, those with a high level of education, and rural migrants should be taken.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: The datasets employed in our study are not readily available because the data is provided by the Migrant Population Service Center, National Health Commission P.R. China and we have signed a legally binding agreement with the institution that we would not share any original data to any third parties. Requests to access these datasets should be directed to XX, xuxinpeng@njmu.edu.cn.

ETHICS STATEMENT

Ethical approval for the study was not required since it was based exclusively on the publicly available data, CMDS. Hence the study subjects were not directly approached.

AUTHOR CONTRIBUTIONS

XX and HY designed the study. QZ and XX led the data analysis and wrote the manuscript. HY, QZ, XX, and QW participated

in the revision of the manuscript and approved the final version for publication.

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Bad for Girls and Boys: Gender Does Not Modify the Negative Effect of Physical Inactivity on Life Satisfaction in Adolescents

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Objectives: Physical activity (PA) has a positive effect on life satisfaction (LS) among adolescents, but the moderating effect of gender and level of PA intensity have been equivocal. Our aim was to examine the pattern of physical activity by grade in high school students, and the role of gender and grade on the association between physical activity and life satisfaction.

Methods: Four repeated cross-sectional online questionnaire surveys between 2011 and 2013 were carried out among all students in one Hungarian high school ($N = 3,450$). Health status and behavior was assessed by the Hungarian online version of the health behavior of school-aged children (HBSC) questionnaire. Regression with robust variance estimator was used to identify determinants of life satisfaction.

Results: Good self-reported health as opposed to bad increased life satisfaction by 0.30 standard deviation; having very well or well-off family as opposed to not well-off increased LS by 0.16 standard deviation; and being inactive compared to being vigorously active decreased LS by 0.1 standard deviation.

Conclusions: Physical inactivity has a negative effect on life satisfaction in boys and girls regardless of grade but compounded by low perceived family wealth.

Keywords: life satisfaction, physical inactivity, gender as modifier, school health promotion, health promotion

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INTRODUCTION

Subjective wellbeing has been a topic of increasing interest in the past half century due to the globally increasing value of the individual, the importance of subjective aspects of evaluating life, and the increasing understanding that human development extends way beyond economic prosperity (1, 2). Life satisfaction (LS) is one important component of subjective wellbeing that captures a subjective evaluation of overall quality of life (1), most frequently measured by the single-item Cantril Self-Anchoring Striving Scale (3) [or Cantril ladder, not to be confused with the Satisfaction with Life Index (4)]. Research on LS has been dominated up to a decade ago by a focus on adults with majority of studies carried out in North America (5). The largest repeated cross-national survey on adolescents, the Health Behavior in School-aged Children (HBSC), introduced

life satisfaction as a mandatory variable in 2001/2002 (6). LS among adolescents has been found to be related to health status across age and gender (7) and has been associated with social relations (8), socioeconomic status (9), and a range of health behaviors, including physical activity (PA) (10). However, the level of intensity of PA associated with positive effect on life satisfaction (11), as well as gender being a moderating variable for PA on LS have been equivocal (12, 13). The relationship between poor physical health and perceived life satisfaction was described by Zullig et al. (14) in 2005. Piko et al. (15) had also found that physically more active students not only have a better self-perceived health and higher levels of life satisfaction but also lower levels of depressive symptoms and less extrinsic values as life goals for their future. Self-esteem was found to be a more important predictor of LS than PA, and it also modified their relationship. However, life satisfaction in this study was assessed by the 3-item "Students' Life Satisfaction Scale," and not by the Cantril ladder (16). High level of physical activity compared to low level was significantly associated with reduced odds of low self-esteem and low life satisfaction among senior high school students in a study by Guddal et al. (17); moreover, high level of PA was also significantly associated with reduced odds of psychological distress.

Our aim was to examine the pattern of physical activity by grade in high school students and the role of gender on the relationship between physical activity and life satisfaction in a pooled adolescent sample of repeated cross-sectional surveys.

METHODS

Description of the Study

An integrated health promotion program was implemented in a high school of Debrecen, Hungary as described elsewhere[1]. Briefly, health education was expanded in the curriculum along with non-compulsory daily classes of physical education (PE); social environment in the school was improved by teaching personality-centered education methods for teachers; and school programs were organized to involve the students' families and the local community, aiming at all students and their parents as well as teachers in the school. A cross-sectional survey among pupils was carried out before the intervention (April 2011, survey 1) that was repeated three times in subsequent years (Fall of 2011: survey 2, Fall of 2012: survey 3; Fall of 2013: survey 4) using identical methods of data collection. All grades from 9 to 12 were included in all survey years.

Variables

Items of the baseline questionnaire had been taken from the Hungarian version (18) of the Health Behavior of School-aged Children (HBSC) 2010 survey (19).

Life satisfaction (LS) was assessed by the 11-step Cantril-ladder ranging from zero (worst possible life) to 10 (best possible life). Self-rated health (SRH) is a standard single item of HBSC that can be answered on a 4-point scale from excellent to poor that was dichotomized into "good" and "bad" categories in our survey. Body mass index (BMI) was calculated from body weight and body height assessed by the pupils.

Physical activity (PA) was assessed by three questions: (1) the number of times out of school per week during which they were active to the point of sweating, answerable on a 7-point Likert scale ranging from "everyday" to "never"; (2) the number of hours per week out of school during which they were active to the point of sweating, answerable on a 6-point Likert scale ranging from "zero" to "7 or more hours"; (3) the number of days participating in physical activity classes in school (which was available in every school day in this school, as opposed to other schools), with three potential answers (everyday, at least three times, or less than three times per week). A composite variable from all three PA variables was created to assess physical activity with three categories. PA was categorized "vigorous" if the pupil had PA at least four times and 4 h per week in leisure time and attended PA class in school every day; PA was "moderate" if the pupil had PA 2–3 times and 2–3 h in leisure time and attended PA class in school at least 3 days but not every day per week, and pupils were classified "inactive" if they had PA less than two times and <2 h per week in leisure time and attended PA class in school <3 days per week. This method produced a variable of physical activity created only for those students whose responses on all 3 single items were consistent (in bold, 38% of students, **Table 1**).

Spearman correlation between the one composite and three single PA variables resulted in significant correlation coefficients (Spearman's rho) reflecting varying correlation as shown in **Table 1**. Negative correlations appropriately reflected the direction of the given scale from vigorous to inactive.

Demographic data included age assessed by grade (9–12), gender (male/female), and type of permanent place of residence (county seat, city, village, farm), which was dichotomized into "city" and "not city." Socioeconomic status of the family was assessed by a single item on perceived family wealth (PFW; "How well off do you think your family is?") answered on a 5-point Likert scale ranging from "not at all well off" to "very well off." PFW was dichotomized into "well or very well" and "less than well." This item correlates with a number of health and health behavior outcomes in the HBSC surveys (6, 20).

Data Collection

A web-based questionnaire was developed for data collection with a standard Linux server using PHP and MySOL support, described in detail elsewhere (see text footnote[1]). The questionnaire could be completed in 20 min. Access to the questionnaire was pre-organized in a scheduled timepoint for groups of those students in the computer room of the school whose guardians consented to their participation. The test was not available outside of scheduled times. The same questionnaire was used in all four surveys.

Data Analysis

Data were automatically logged in a database and downloaded to a Microsoft Excel file. After duplicates, empty records and answers out of the specified ranges were removed and data analysis was carried out in STATA 16.1. Continuous variables were compared by *t*-test and categorical variables

[1]Erdélyi ZS, Somhegyi A, Balajti I, Kósa K. *Daily optional physical education does not counteract increasing inactivity by age among adolescents.* Manuscript submitted.

TABLE 1 | Correlation between variables of physical activity along with number of responses (upper row: correlation coefficient, lower row: significance).

N	Variable	1	2	3	4
3,451	1. Number of weekly activities	1.0000			
3,372	2. Number of active hours per week	−0.8437	1.0000		
		0.0000			
3,446	3. Participation in daily PE class	0.5142	0.5141	1.0000	
		0.0000	0.0000		
1,324	**4. Composite of physical activity**	0.9428	−0.8676	0.5412	1.0000
		0.0000	0.0000	0.0000	

TABLE 2 | Model selection for the best model to predict life satisfaction.

	Life satisfaction					
Outcome	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Variable for physical activity	Composite of PA	Composite of PA	Composite of PA	Number of weekly activities	Number of active hours per week	Participation in daily PE class
Regression	OLS	OLS w/robust variance estimator	Hetero-skedastic linear regression	OLS w/robust variance estimator	OLS w/robust variance estimator	OLS w/robust variance estimator
Adjusted R^2	0.1587	0.1651	–	0.1509	0.1498	0.1413
Akaike information criterion	4,636.927	4,636.927	4,638.927	12,186.44	11,882.01	12,186.76

were analyzed by the chi-square test. Normality test based on skewness and kurtosis was used to test normality of life satisfaction. Though LS is commonly dichotomized (6, 13), we used it as a continuous variable because of problems related dichotomization, the greatest being loss of information (21). Correlation between variables was tested by Spearman's rank order correlation. Association between determinants and outcomes was investigated by simple linear regression, linear regression with the Huber/White sandwich estimator of variance, and heteroskedastic linear regression. The level of significance was set at 0.05.

Model Selection

Model selection was carried out for several reasons. Life satisfaction was not normally distributed (skewness: −1.51, kurtosis: 7.16), but according to Byrne (22), data can be considered normal if skewness is between −2 and +2 and kurtosis is between −7 and +7. Life satisfaction was heteroskedastic for gender ($p = 0.022$), physical activity ($p = 0.008$), subjective family wealth ($p < 0.001$), grade ($p < 0.001$), and subjective health ($p< 0.001$). Heteroskedasticity was accounted for by carrying out linear regression with the Huber-White sandwich estimator of variance (23), as well as multiplicative heteroskedastic linear regression that models the variance as an exponential function of the variables (24). Another reason for model selection was to compare the appropriateness of the composite PA as opposed to the single item-variables of PA. Each model had life satisfaction as the outcome variable and the same set of independent variables as factor variables (gender, type of permanent residence, subjective family wealth, grade, physical activity, subjective health), as shown in **Table 2**.

RESULTS

Description of the Students

The four surveys took place in one high school in the second largest city of the country producing a large pooled sample ($N = 3,450$). Response rates were 77.67% for the baseline survey, 70.41% for the second, 60.41% for the third, and 64.36% for the fourth survey, calculated from the total number of registered students in each survey year. There was no difference in gender distribution ($p = 0.607$), permanent residence ($p = 0.682$), and perceived family wealth ($p = 0.276$) by survey year, so these variables are described for the entire sample. Girls comprised the majority in all grades in all survey years, and response rates were calculated from the total number of registered students in the survey year (**Table 3**).

About 77.6% of the pupils were city dwellers, 22.4% lived in villages or farms, with no significant gender difference in permanent residence ($p = 0.071$). Also, 29.7% of the students lived in families perceived to be well or very well off, 63.5% perceived their families as average, whereas 6.8% of them lived in families not so well or not at all well off. This was not different ($p = b0.199$) from those in 9th and 11th grades in the national HBSC sample of 2014 (25).

TABLE 3 | Description of the students by survey year, grade, and gender.

		Grade 9	Grade 10	Grade 11	Grade 12	Total	Response rate (%)
Year 1	Boys (*N*)	102	86	86	55	329	77.67
	Girls (*N*)	120	144	149	110	523	
	Girls %	54.05%	62.61%	63.40%	66.67%	61.38%	
Year 2	Boys (*N*)	102	87	73	90	352	70.41
	Girls (*N*)	137	127	115	126	505	
	Girls %	57.32%	59.35%	61.17%	58.33%	58.93%	
Year 3	Boys (*N*)	95	44	83	52	274	60.41
	Girls (*N*)	113	60	109	123	405	
	Girls %	54.33%	57.69%	56.77%	70.29%	59.65%	
Year 4	Boys (*N*)	95	44	83	52	274	64.36
	Girls (*N*)	113	60	109	123	405	
	Girls %	54.33%	57.69%	56.77%	70.29%	59.65%	

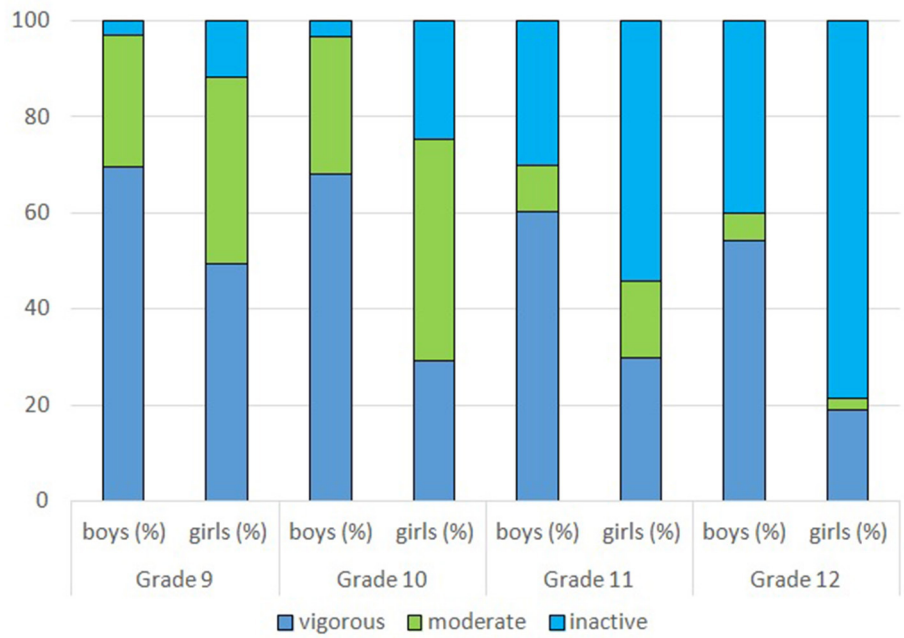

FIGURE 1 | Distribution of physical activity assessed by the composite PA variable by grade and gender.

There was no significant difference by survey year in the distribution of physical activity and life satisfaction (data not shown), but this was not true for grade, so categories of pyhsical activity were analyzed by grade and gender. Physical activity was assessed by three items which were used to classify students into one of the three categories (vigorous, moderate, inactive) of a composite variable as described in Methods Section. Consequently, only those students were classified and shown in **Figure 1** who gave consistent answers to all three questions (38% of those who answered all three single-item questions on PA). The proportion of those who were vigorously active per week showed significant gender difference with male advantage in all grades ($p < 0.001$ for all grades), and decreased from Grade 9 to Grade 12 by 15.31% among boys and by 30.43% among girls. Even more dramatic is the rise in the proportion of inactive pupils by 37.2% among boys and by 67% among girls ($p < 0.001$ for both).

Life satisfaction exhibited no significant gender difference (boys: $p = 0.30$; girls: $p = 0.31$). However, it showed a decreasing trend by grade among boys (9th grade: 8.09 $\pm$ 1.5; 10th grade :7.98 $\pm$ 1.52; 11th grade: 7.88 $\pm$ 1.57; 12th grade 12: 7.64 $\pm$ 1.73; $p < 0.001$) and girls alike (9th grade: 8.12 $\pm$ 1.45; 10th grade: 7.91 $\pm$ 1.50; 11th grade: 7.86 $\pm$ 1.53; grade 12: 7.85 $\pm$ 1.55; $p = 0.018$). There were no significant diffrence between the genders in any grade.

Correlation of Variables

Life satisfaction, gender, type of permanent residence, perceived family wealth, physical activity, body mass index,

TABLE 4 | Correlation of variables in the surveys (upper row: Spearman's rho, lower row: significance).

	1.	2.	3.	4.	5.	6	7.	8.	9.
1. Life satisfaction	1.0000								
2. Gender	−0.0485	1.0000							
	0.1102								
3. Type of residence	0.1197	−0.0227	1.0000						
	0.0001	0.4551							
4. Perceived family wealth	0.2133	−0.1303	0.1256	1.0000					
	0.0000	0.0000	0.0000						
5. Grade	−0.0924	0.1355	−0.0973	−0.0338	1.0000				
	0.0023	0.0000	0.0013	0.2652					
6. Composite of PA	−0.1539	0.3474	−0.0407	−0.0950	0.3756	1.0000			
	0.0000	0.0000	0.1800	0.0017	0.0000				
7. Body mass index	−0.0279	−0.2469	−0.0204	0.0617	0.1101	−0.0583	1.0000		
	0.3584	0.0000	0.5011	0.0419	0.0003	0.0547			
8. Self-rated health	0.3051	−0.0616	0.0971	0.0676	−0.1179	−0.2192	−0.1123	1.0000	
	0.0000	0.0423	0.0014	0.0258	0.0001	0.0000	0.0002		
9. Date of survey	0.0261	−0.0286	0.0462	0.0328	0.0246	−0.1034	0.0330	0.0287	1.0000
	0.3901	0.3467	0.1279	0.2808	0.4188	0.0006	0.2772	0.3444	

self-rated health, and survey years were tested by Spearman correlation (**Table 4**). Body mass index not being correlated with life satisfaction was omitted, but gender was kept for further analysis.

Survey years (date of survey) were not significantly correlated with life satisfaction, but it was further investigated by hierarchical regression defining date as the random effect, and gender, type of residence, perceived family wealth, grade, composite PA, and self-rated health as fixed effects. The hierarchical model was not significantly different from one-level ordinary linear regression (OLS; $p = 1.000$). Next, OLS was carried out including survey dates as independent factor variables of PA, but none of them were significant (survey2: $p = 0.959$, survey3: $p = 0.553$, survey4: $p = 0.390$ compared to survey1), so data from all surveys were pooled for subsequent analysis.

Based on the smallest Akaike information criterion and the largest explained proportion of variance, Model 2 was selected to describe determinants of physical activity by OLS with Huber-White sandwich estimator, which is shown in **Figure 2** (26). Independent variables are arranged by order of decreasing effect on LS according to the standardized beta coefficients: good self-reported health (as opposed to bad) increased life satisfaction by 0.30 standard deviation; having very well or well-off family (as opposed to not well-off) increased LS by 0.16 standard deviation; and being inactive (pa = 3 in **Figure 2**) decreased LS by 0.1 standard deviation (as opposed to being vigorously active). Moderate activity (pa = 2) and other independent variables (city as permanent residence compared to village, girls compared to boys, and grades 10, 11, or 12 compared to grade 9) had no significant effect on life satisfaction as shown by the confidence intervals.

DISCUSSION

Repeated cross-sectional surveys among adolescents of one high school were pooled and analyzed to identify determinants of life satisfaction. The proportion of physically inactive students significantly increased from grade 9 to grade 12, similar to the global trend (27). Self-rated health and living in a well-off family were found to be significant positive determinants, while physical inactivity was found to be a significant negative determinant of life satisfaction in adolescents regardless of gender.

Our findings on the level of physical activity are sadly in concert with that of others. We found a decrease in vigorous physical activity and a worrying increase in the proportion of inactive pupils from grade 9 (15 years old) to grade 12 (18 years old), though the magnitude of change was different by gender. The overall level of physical activity had been low and decreased with age among school-age children in the past two decades according to HBSC data from 32 countries (28). PA also decreased from childhood to adolescence (ages 6–19) across sex in the US National Health and Nutrition Examination Survey (29). A large scale pooled analysis of data from almost 300 studies found that the majority of adolescents around the globe do not get the recommended frequency and intensity of physical activity, and though the prevalence of insufficient physical activity significantly decreased for boys, there had been no change for girls (30).

We identified physical inactivity as having a significant negative effect on life satisfaction with no gender difference. Physical inactivity assessed by various measures was also found among US adolescents to have a negative effect on life satisfaction, but specific for race and gender groups (31). Our study is unusual in the sense that vigorous physical activity was used as the baseline (reference) to which lower levels of PA were

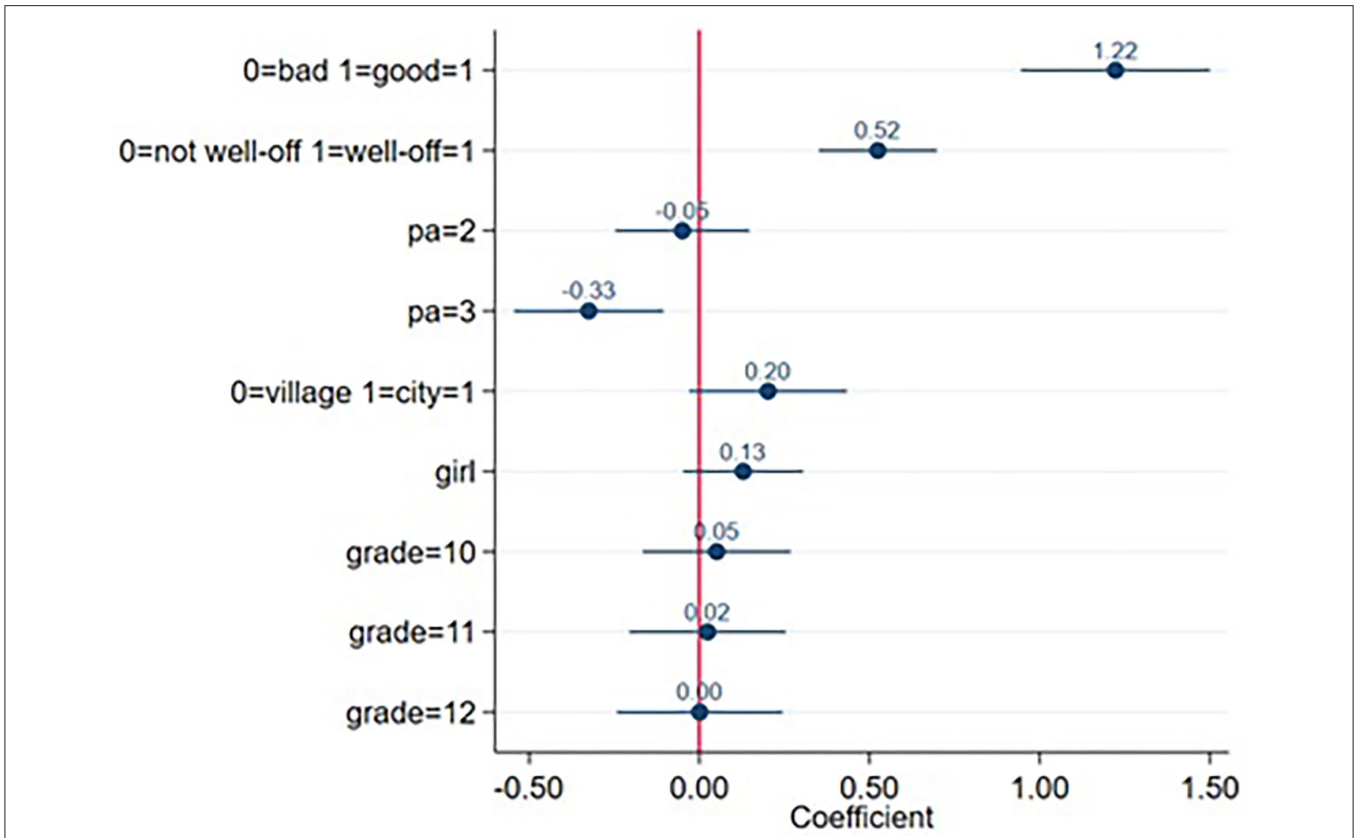

FIGURE 2 | Coefficients and their confidence intervals of independent variables of life satisfaction as outcome in Model 2. Self-rated health: 0: bad 1: good; percieved family wealth: 0:not well-off 1: well-off; physical activity 1:vigorous 2:moderate 3:inactive; permanent place of residence 0:village 1:city;gender: 0:boys 1:girls;grades: 9:9th grade 10:10th grade 11:11th grade 12:12th grade.

compared. This reflects our conviction that vigorous physical activity should be considered the norm among adolescents in line with WHO recommendations (32). However, choosing inactivity as a baseline is more widespread in the literature, so the effects of vigorous activity are more often reported. Data from the 2018 HBSC survey in Lithuania found vigorous PA being a predictor of improved LS in boys but not in girls (13). This study used the same measure of LS as in our surveys, but it was dichotomized and logistic regression was carried out; PA was measured by 2 not clearly differentiating questions, one on frequency and another on duration Another study in Czech and Polish youth (11) applied non-HBSC scales for assessing LS and PA, and used logistic regression to test their association. PA measures were rather cumbersome: transportation and recreation were distinguished, as well as vigorous, moderate activity, and walking that were converted to metabolic equivalent (MET) for tasks without details of the calculation. The study found that girls with the highest life satisfaction reported more PA than girls with the lowest LS, but the results were "not so noticeable" among boys according to the authors. The study is quite difficult to comprehend, but **Figure 2** clearly illustrates the large negative effect of physical inactivity on life satisfaction (not mentioned by the authors). A study on Polish lower secondary school students (16) using non-HBSC measures found evidence for physical activity being a predictor of life satisfaction among 13- to 17-year-olds, which is mediated by self-esteem, this being greater among less affluent pupils. Socioeconomic status impacting life satisfaction was also found in our survey similarl to HBSC reports (9).

Advantages of the study include the relatively homogenous sample of students and repeated surveys using identical methods. Since survey dates had no significant impact on life satisfaction, and data could be pooled producing a relatively large sample, which along with the best-selected model counterbalanced potential problems of estimation related to life satisfaction as outcome variable not being normal and unequal error variance in the OLS model. However, standard errors still being somewhat biased cannot be excluded and conclusions should be limited to pupils in similar high schools. Another limitation is the use of the composite PA which resulted in the loss of information since only some one-third of the full sample was used for modeling. However, involving only those who gave consistent answers on physical activity likely increased the reliability of the results. The limitation of the study occurs as all of the analyzed data are from one high school and most of the students are coming from well-off families. All these findings provide even more arguments for the uptake of vigorous activity among adolescents. Vigorous physical activity is not only beneficial for health (10, 33), but also has a positive effect on life satisfaction in part through self-esteem, which is particularly important

for those youth who live in less affluent families. Vigorous PA may be a simple and effective tool to reduce health inequalities among adolescents.

DATA AVAILABILITY STATEMENT

Data are available from the authors at reasonable written request after authorization by the Data Protection Office of the University of Debrecen, Hungary.

ETHICS STATEMENT

Data in the surveys did not include any information that would have enabled personal identification of the students who completed the questionnaires voluntarily and anonymously after informed consent was obtained from their guardians by the school. Only those students were allowed to fill the online questionnaire who had parental consent. Therefore, no formal approval from an ethical review board was required. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

KK and ZL-E contibuted to the study design, data collection and analyses, interpretation of results, writing of the manuscript. AS and IV-B took part in the study desing and writing of the original article. All authors contributed to the article and approved the submitted version.

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Exercise intensity and energy expenditure of a multicomponent home-based training program: Xiangya hospital circuit training (X-CircuiT)

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Introduction: Our previous studies showed that Xiangya Hospital Circuit Training (X-CircuiT) effectively improved physical fitness and reversed pre-frailty in community-dwelling older adults. This study aimed to explore the generalizability and applicability of X-CircuiT in different aged populations in the context of exercise intensity and energy expenditure.

Methods: We prospectively recruited 72 community-dwelling sedentary adults, twelve adults divided into 6 age groups ranging from 20 to 80 years old and separated by decades. Cardiopulmonary exercise testing was performed to determine peak heart rate (HR_{peak}). An individual HR-oxygen consumption regression equation was fit for each participant, and then a session of remote heart rate monitored X-CircuiT was performed. Exercise intensity (%HR_{peak}) and energy expenditure of X-CircuiT among the six age groups were assessed. Further sub-analysis was conducted by dividing the participants by peak metabolic equivalent (MET) values, <5 METs, 5–7 METs, and more than 7METs to explore the relationship between maximum exercise capacity and exercise intensity of X-CircuiT.

Results: The average %HR_{peak} of X-CircuiT for subjects in the 20–29, 30–39, 40–49, 50–59, 60–69, and 70–80 age groups were 54 ± 6, 59 ± 8, 60 ± 8, 62 ± 5, 66 ± 10, and 67 ± 13, respectively ($p = 0.008$); and the average energy expenditure was 121.9 ± 26.5, 123.3 ± 33.8, 129.2 ± 40.9, 130.9 ± 31.8, 146.8 ± 29.0, and 125.0 ± 28.4 kcal, respectively. The average %HR_{peak} for the warm-up, aerobic, acupoint patting, resistance, and stretching stages in overall subjects was 61 ± 9, 70 ± 10, 70 ± 10, 63 ± 9, and 57 ± 9, respectively. Furthermore, when subjects were divided by peak METs, it was found that the lower the peak METs, the greater the value of the relative exercise intensity indicators. The aerobic and acupoint stages of X-CircuiT could illicit a response of high intensity for those with peak METs <5, moderate intensity in those

with peak METs of 5–7, and low-intensity for those with peak METs of more than 7.

Conclusion: Xiangya Hospital Circuit Training followed the principle of low-intensity warm-up and medium-intensity training with multicomponent exercise training. It is classified as a moderate-intensity exercise for sedentary middle-aged and older adults, or those with a maximum exercise capacity of 5–7 METs, and is classified as a low-intensity exercise for young people.

KEYWORDS

home-based exercise, multicomponent exercise, X-CircuiT, exercise intensity, energy expenditure (EE)

Introduction

Physical inactivity and increased sedentary time, are prominent factors in the etiology of cardiovascular (1) and metabolic diseases, as well as negatively affecting psychological well-being (2, 3). Conversely, routine exercise is effective for the prevention as well as treatment of multiple somatic and psychological health issues (3–6). Despite the overwhelming evidence and well-known benefits of exercise, however, most adults maintain relatively sedentary lifestyles. Moreover, as physical inactivity accounts for approximately 3.2 million deaths a year globally (7), there is an impetus to introduce potential methods to reduce this.

Barriers to initiating an exercise regime are multidimensional and include both internal and external reasons. The most commonly cited external factors often include perceived lack of time and lack of facilities, while internal factors include lack of training knowledge and lack of motivation/effort (8). Furthermore, newcomers to exercise may select singular forms of increased physical activity while perhaps lacking the awareness of the multinational guidelines and recommendations on further facets of the multiple components of physical exercise (9).

The onset of the coronavirus disease 2019 (COVID-19) has presented a new challenge. Lockdowns and travel restrictions have been established, substantially disrupting the physical activity and dietary habits of people (10). During quarantine, barriers to exercise, particularly accessibility to equipment and ease of use, have become ever more prevalent. The resulting increased sedentary time and limited physical activity have led to increased weight and worsening physical and psychological health across multiple populations, such as heightened depression and anxiety (11) among young adults and more so in the middle-aged and older adults (12, 13).

To overcome or mitigate these issues, community or home-based exercises have been promoted by clinicians and entities alike (14), including our team. The Xiangya Hospital circuit training (X-CircuiT) program is a multi-component exercise program developed by the cardiac rehabilitation team, based on the current multinational guidelines, such as components of cardiopulmonary, resistance, flexibility, and neuromotor exercise, as well as stretching (15). X-CircuiT has been used for the past 8 years. It was previously found to safely and effectively improve heart and lung function, muscle strength, and endurance in healthy adults (16) and could reverse pre-frailty in pre-frail older adults (17). Furthermore, due to its ease of practice and instructional video, X-CircuiT was found to have high accessibility and acceptability (17).

Our program consists of five distinct stages: warm-up, aerobic, acupoint patting, elastic band resistance, and stretching training. Within each of these stages, we included elements of flexibility, coordination, and balance and integrated elements of the traditional Chinese neuromotor exercise. Research has established that moderate aerobic exercise and resistance training bring marked improvements in cardiovascular health and mobility (18, 19), and can effectively improve muscle strength, gait function, balance, and quality of life; flexibility training can effectively restore range of motion in various joints and improve functional outcomes (20). Acupoint patting has shown promising results in the treatment of anxiety, depression, and stress disorder (21).

Despite evidence of the use of X-CircuiT, further research is required to elucidate the generalizability and applicability of X-CircuiT in different age and sex populations. Therefore, this study intends to evaluate the intensity and energy expenditure of the X-CircuiT, which may provide the basis for the proliferation of its use.

Methods

Subjects studied

This cross-sectional study enrolled 72 volunteering sedentary adults from the Qing Yuan community, Changsha, China, between 1 August 2021 and 30 November 2021. The inclusion criteria were as follows: (1) age > 18 years; (2)

sedentary adults [defined in this study as spending more than 8 h/day sitting or reclined (22)]; and (3) voluntarily signed informed consent and actively participated in the exercise program. Participants were excluded for any one of the following reasons: (1) the presence of any unstable clinical condition; (2)an inability to exercise or a condition that may interfere with the exercise performance; (3) myocardial infarction in the past 3 months; (4) comorbidities that may influence exercise physiological response or energy expenditure, such as hyperthyroidism; (5) signs of ischemia during exercise testing; (6) high risk of cardiovascular events or injury during community exercise; and (7) current participation in an ongoing exercise intervention. The flowchart of this study is displayed in Figure 1. Subjects were enrolled into one of six groups based on their age: 20–29, 30–39, 40–49, 50–59, 60–69, and 70-80 years old, with 12 adults per group.

Sample size calculation: The preliminary pre-experiment included 12 subjects aged 20–29 years and found that the standard deviation (SD) of exercise intensity (%HR_{peak}) of X-CircuiT σ was 6 and the allowable error δ was 4 (95% *CI*/2). A sample size of 9 people would be needed to achieve an α of 0.05, according to the formula: $n = (Z_{1-\alpha/2}\ \sigma/\delta)^2$. This study was approved by the Ethics Committee of Xiangya Hospital, Central South University (No. 202009264). All subjects signed an informed consent form.

Cardiopulmonary exercise testing

From August to November 2021, all participants performed a cardiopulmonary exercise test (CPET) 1 week before practicing X-CircuiT in Xiangya Hospital, Central South University, to obtain the peak heart rate (HR_{peak}), peak oxygen uptake (VO_{2peak}), and the individual regression equation of HR and VO_2. The standard of procedure for performing CPET has been described previously (23, 24). The HR and VO_2 data collected from the CPET were used to fit the individual regression equation of HR-VO_2, according to which we calculated the VO_2 during X-CircuiT. The reliability and validity of this method has been reported previously (25–27).

X-CircuiT HR monitoring

A cardiac rehabilitation physician who was familiar with X-CircuiT and had relevant teaching experience was responsible for instructing X-CircuiT to the participants. After three sessions of adaptive training, participants were met in the Qing Yuan community gym. Here, participants were tasked to complete a set of standard actions in rhythm with the X-CircuiT DVD, during which the heart rate (HRex) was continuously monitored and recorded *via* a remote electrocardiogram monitoring system (DL-191, Good Friend, Shenzhen, China).

X-CircuiT action plan

Xiangya Hospital Circuit Training consists of five stages lasting a total of 46 min. The instructional video and guide of X-CircuiT have been demonstrated previously (17). Briefly, each session began with a 4.5-min warm-up incorporating full coordinated upper and lower movement and dynamic stretching. This was followed by the aerobic stage, which along with the acupoint patting was divided into "elementary-level, intermediate-level, and advanced-level" sections based on the increased complexity of movement incorporated.

The aerobic stage (6.5-min) consists of 5 main movements, such as lateral steps, lateral cross-steps, knee-ups, forward lunges, and front steps. The Acupoint patting (6-min) involved coordinated aerobic movements along with open palm strikes directed at the Jian Jing (located on the shoulder) and Ba Liao (lower pelvic region), Ying and Yang meridians located on the inside and outside of the arms, respectively, Hegu (between the 1st and the 2nd metacarpal bones) and Houxi (when the fist is half-closed, the point is located in a depression proximal to the head of the fifth metacarpal bone), abdomen and lower back channels, and acupoints located in the leg.

The fourth stage of the circuit is the elastic band resistance training (15-min) targeting the large upper and lower limbs muscle groups, biceps, triceps, and quadriceps. The action sequence includes elastic band pull-aparts, front and lateral raises, elbow flexion/bicep curl, and elastic band lateral leg abductions. The elastic bands were color-coded, pink, orange, green, and blue (Sanctband elastic band), increasing tensile resistance in turn. Subjects were individually assigned an elastic band color based on the load-repetition relationship of resistance training, and we selected 50–60% of 1-RM, that is biceps curl to fatigue by repeating 17–20 repetitions. Valsalva movements were avoided during elastic band resistance training (17).

The final stage, flexibility training (14-min), focused on the stretching of major muscles, such as the pectoral muscle group, erector spinae, latissimus dorsi, trapezius, and major muscle groups in the leg. The main actions included dynamic and static stretching shoulder flexion, shoulder abduction, shoulder extension, and trunk stretch.

Exercise intensity and energy expenditure of X-CircuiT

The common indicators of exercise intensity were HR and VO_2, and their derivative variables, such as metabolic equivalents (METs), percentage of achieved HR to HR_{peak} (%HR_{peak}), percentage of achieved VO_2 to VO_{2peak}

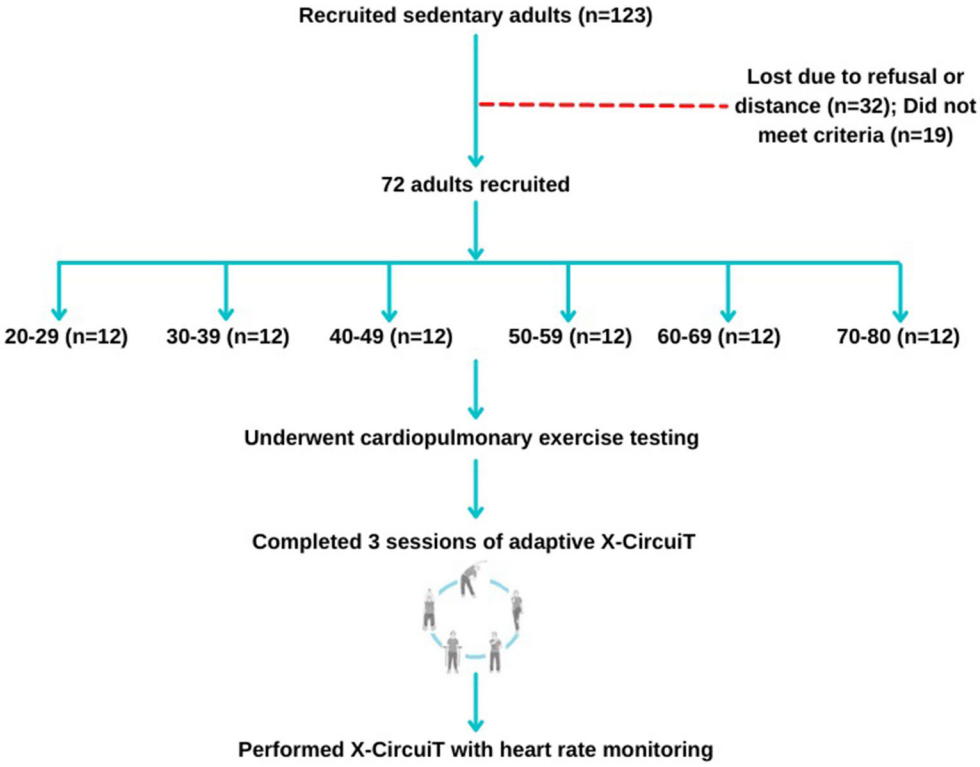

FIGURE 1
Participant recruitment, randomization, and study progress.

($\%VO_{2peak}$), and percentage of HR reserve and VO_2 reserve (%HRR and $\%VO_2R$). VO_2 during the X-CircuiT (VO_2ex) was calculated by the individual HR-VO_2 equation, VO_2 in L/min = coefficient × HRex in bpm + constant. The derivative variables of HR and VO_2 were calculated by the following equations: (i) METs = VO_2ex in L/min × 1,000/body weight in kg/3.5; (ii) $\%VO_{2peak} = (VO_2ex/VO_{2peak}) \times 100\%$; (iii) $\%VO_2R = (VO_2ex - VO_{2rest})/(VO_{2peak} - VO_{2rest}) \times 100\%$; (vi) $\%HR_{peak} = (HRex/HR_{peak}) \times 100\%$; and (v) $\%HRR = (HRex - HR_{rest})/(HR_{peak}-HR_{rest}) \times 100\%$. We followed the American College of Sports Medicine (ACSM) criteria to classify the level of exercise intensity (27, 28). Energy expenditure was calculated by the equation of calories = [METs × body weight in kg × 3.5]/200 × exercise time (29).

Maximum exercise capacity and exercise intensity of X-CircuiT

For a secondary sub-analysis, participants were split based on their maximum exercise capacity to explore its relationship with the exercise intensity of X-CircuiT. Three groups were formed based on peak MET values, <5 METs, 5–7 METs, and more than 7 METs.

Statistical analysis

Continuous variables, such as demographics, exercise intensity, and energy expenditure of participants are presented as mean ± standard deviation (SD), while categorical variables, such as sex, and whether overweight as a number (percentage). Differences between groups, divided by age, sex, and peak MET values, were analyzed using independent sample *t*-tests or analysis of variance (ANOVA) for continuous variables, while the chi-square test was used for categorical variables, according to the type of distribution. Statistical analyses were performed using the SPSS v. 25.0 (IBM Corporation, Chicago, IL, USA) and GraphPad Prism v.7.0 (GraphPad Software Corporation, California, USA) and statistical significance was set at $\alpha = 5\%$.

Results

Demographics and characteristics of subjects

The demographics and characteristics of the 72 subjects enrolled in the study are presented in Table 1. The difference between the six groups in HR_{peak}, VO_{2peak},

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TABLE 1 Demographics of the participants.

	Total (n = 72)	20–29 yrs (n = 12)	30–39 yrs (n = 12)	40–49 yrs (n = 12)	50–59 yrs (n = 12)	60–69 yrs (n = 12)	70–79 yrs (n = 12)	P-value
Female, n (%)	41 (59)	6 (50)	9 (75)	8 (66)	7 (58)	6 (50)	6 (50)	0.75
Body weight, kg	61.8 ± 10.6	58.6 ± 8.4	60.1 ± 10.5	62.8 ± 12.5	65.9 ± 8.9	62.7 ± 11.2	60.1 ± 12.2	0.57
Height, cm	163 ± 9	165 ± 10	165 ± 10	163 ± 8	163 ± 9	161 ± 7	160 ± 9	0.70
BMI, kg/m^2	23.2 ± 2.9	21.6 ± 1.5	22.0 ± 1.9	23.5 ± 3.2	24.7 ± 2.2	24.2 ± 4.0	23.5 ± 3.1	0.08
Overweight, n (%)	25 (35.7)	1 (8.3)	2 (16.7)	4 (33.3)	7 (58.3)	5 (41.7)	6 (60.0)	0.05
CPET parameters								
HRrest, bpm	72 ± 10	72 ± 10	75 ± 12	74 ± 11	75 ± 9	68 ± 7	68 ± 8	0.42
HRpeak, bpm	153 ± 22	170 ± 11	166 ± 19	163 ± 8	153 ± 17	135 ± 20	126 ± 20	<0.001
Peak VO_2, L/min	1.50 ± 0.50	1.83 ± 0.61	1.48 ± 0.46	1.62 ± 0.59	1.45 ± 0.30	1.47 ± 0.42	1.07 ± 0.32	<0.001
Peak VO_2, ml/kg/min	24.1 ± 6.2	30.6 ± 6.9	24.3 ± 4.1	25.4 ± 5.3	21.9 ± 2.7	23.6 ± 6.6	17.8 ± 4.3	<0.001
Peak METs	6.9 ± 1.7	8.5 ± 2.0	7.0 ± 1.2	7.2 ± 1.5	6.2 ± 0.8	6.7 ± 1.7	5.1 ± 1.2	<0.001
Peak RER	1.16 ± 0.09	1.15 ± 0.07	1.20 ± 0.09	1.15 ± 0.12	1.15 ± 0.10	1.18 ± 0.09	1.14 ± 0.06	0.61
Peak workload, watts	111 ± 39	144 ± 47	122 ± 43	118 ± 32	105 ± 27	92 ± 20	73 ± 25	<0.001

BMI, body mass index; CPET, cardiopulmonary exercise testing; HR, heart rate; VO_2, oxygen consumption; METs, metabolic equivalents; RER, respiratory exchange rate.

VO_{2peak} per kg, peak workload, and peak METs value was significant ($p < 0.001$ for each comparison), with a trend for gradual decrease with age (Table 1). The differences between the six groups in sex, weight, body mass index (BMI), HR_{rest}, and peak respiratory exchange rate are displayed in Table 1. No significant difference was observed in blood pressure and peak VO_2 pulse between the six groups.

X-CircuiT heart rate response

Figure 2 shows the trend of HR response to X-CircuiT. HR gradually increased from the warm-up to the aerobic exercise stage, and then gradually decreased following the acupoint patting stage. The warm-up, aerobic, acupoint patting, resistance training, and flexibility training showed a heart rate of 92 ± 12, 106 ± 13, 105 ± 13, 95 ± 13, and 86 ± 11 beats per min (bpm), respectively. The average HR of the whole set was 95 ± 12 bpm, the HR fluctuated between 83 and 107 bpm, and the highest HR occurred at the 8 min and 30 s timepoint (107 ± 12 bpm), during the advanced-complexity part of the aerobic exercise stage, the lowest HR occurred at the 40th min (83 ± 11 bpm), during the flexibility training knee raise. This trend remained true across age groups (Figure 2B) and sex (Figure 2C).

X-CircuiT exercise intensity

Oxygen utilization in L/min during the X-CircuiT was calculated by the individual linear regression equation previously shown (18, 19). Figure 3 shows that under the continuous activity of X-CircuiT, the aerobic exercise stage had the greatest intensity, followed by the acupoint patting stage, gradually falling in intensity thereafter with the flexibility training stages having the lowest exercise intensity. In addition, for the 40–80 age group, whether regarding absolute exercise intensity (METs) or relative exercise intensity (%HR_{peak}, %VO_{2peak}, %HRR, and %VO_2R), the warm-up and flexibility stages were low-intensity exercises, while aerobic exercise and acupoint patting stages were of moderate-intensity. The absolute and relative intensities of each stage are presented in Figure 3. There were no statistical differences in absolute exercise intensity between the six age groups ($p > 0.05$), while the differences between the indicators of relative exercise intensity (%HR_{peak}, %VO_{2peak}, %HRR, and %VO_2R) were statistically significant ($p < 0.05$). Figures 3A,B shows a comparison between the six groups in %HR_{peak} and %VO_{2peak}, respectively. Each stage of X-CircuiT was statistically significant ($p < 0.05$), and the %HR_{peak} and %VO_{2peak} were observably greater with increased age. Figures 3C,D shows that the %HRR, and %VO_2R in X-CircuiT's aerobic exercise and acupoint patting stages were significantly different with increased age ($p < 0.05$).

Figure 4 shows the relationship between the maximum exercise capacity of participants and the exercise intensity of X-CircuiT. We found that the lower the peak METs, the greater the relative exercise intensity indicators (%HR_{peak}, %VO_{2peak}, %HRR, %VO_2R, and $p < 0.05$), while the aerobic training stage of the >7 METs group showed greater absolute exercise intensity than the other two groups ($p < 0.05$). The relative intensity and absolute intensity of aerobic training and acupoint patting stages of the <5 METs group (n = 11, 8 women), are all high-intensity,

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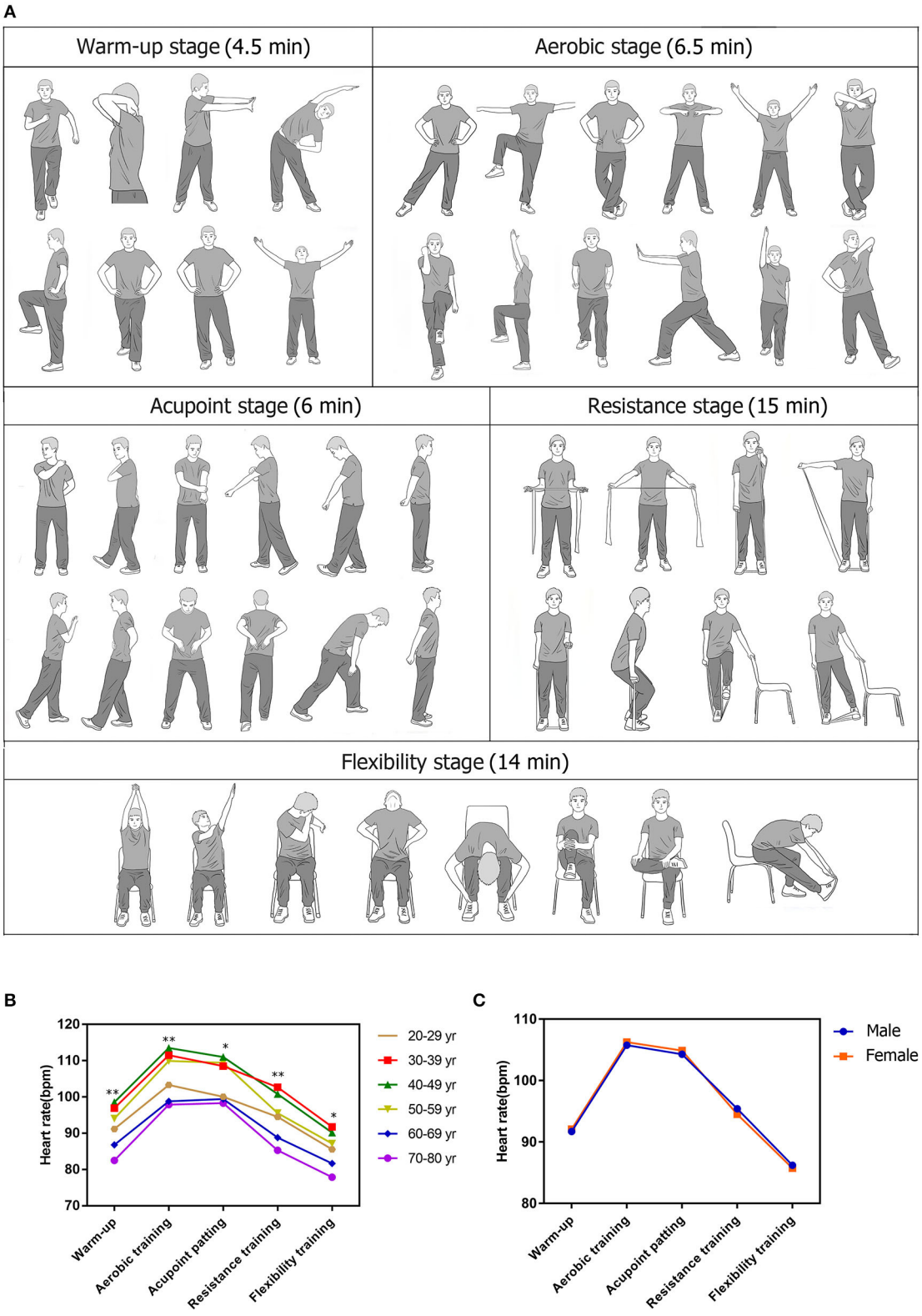

FIGURE 2
Actions, heart rate (HR) response of Xiangya Hospital Circuit Training (X-CircuiT). **(A)** shows an excerpt of X-CircuiT actions; **(B,C)** presents the heart rate response of X-CircuiT in the different age or sex groups, respectively. *Indicates the difference between groups $p < 0.05$; **indicates the difference between groups $p < 0.01$ (ANOVA) in **(B)**; An independent sample *t*-test in **(C)**.

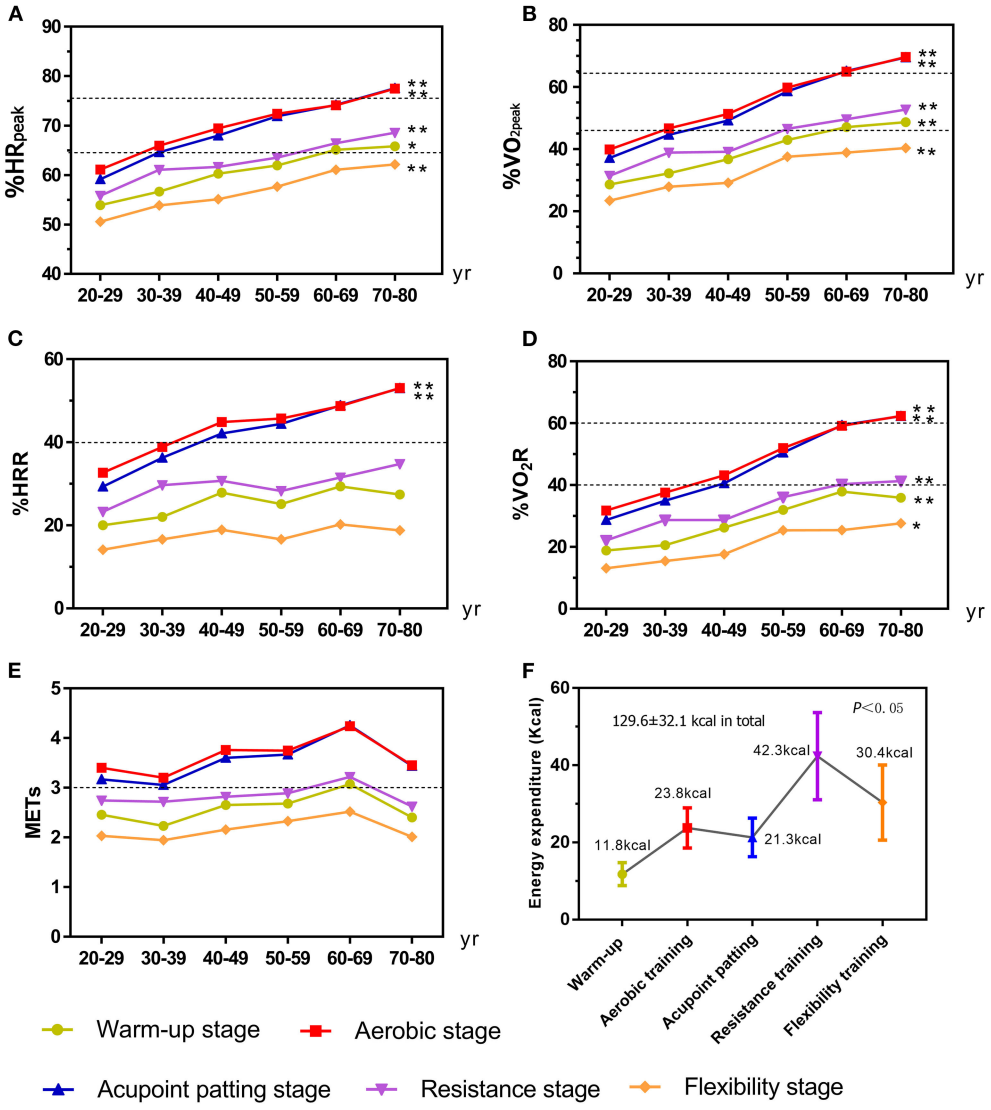

FIGURE 3
The exercise intensity and energy expenditure of the X-CircuiT program between different age groups. **(A)** Shows the peak heart rate percentage (%HR_{peak}); **(B)** Shows the peak oxygen intake percentage (%VO_{2peak}); **(C)** Shows the heart rate reserve percentage (%HRR); **(D)** Shows the oxygen uptake reserve percentage (%VO_2R); **(E)** Shows metabolic equivalent (METs); and **(F)** Shows the energy expenditure of each stage and the whole set of the X-CircuiT. The dotted lines are the medium intensity exercise (lower line) or high intensity (higher line) exercise boundary. *Indicates the difference between groups $p < 0.05$; and **indicates the difference between groups $p < 0.01$ (ANOVA).

of the 5–7 METs group ($n = 33$, 25 women), moderate-intensity, and for the >7METs group ($n = 28$, 9 women), low-intensity.

We found absolute exercise intensity (METs) of X-CircuiT was greater among men than in women. However, no significant differences were found between sex in relative exercise intensity (%HR_{peak}, %VO_{2peak}, %HRR, and %VO_2R) (Figure 5).

Energy expenditure of X-CircuiT

As shown in Figure 3F, under the continuous activity involved when undertaking X-CircuiT, the energy expenditure of the warm-up, aerobic training, acupoint patting, resistance training, and flexibility training was 11.8 ± 3.0, 23.8 ± 5.2, 21.3 ± 5.0, 42.4 ± 11.3, and 30.4 ± 9.7 kcal, respectively. The energy expenditure of the overall X-CircuiT program was 129.6 ± 32.1 kcal.

Discussion

Xiangya Hospital Circuit Training is a multi-domain exercise program that was previously shown to be accessible, effective, and safe in improving function in older adults (16, 17).

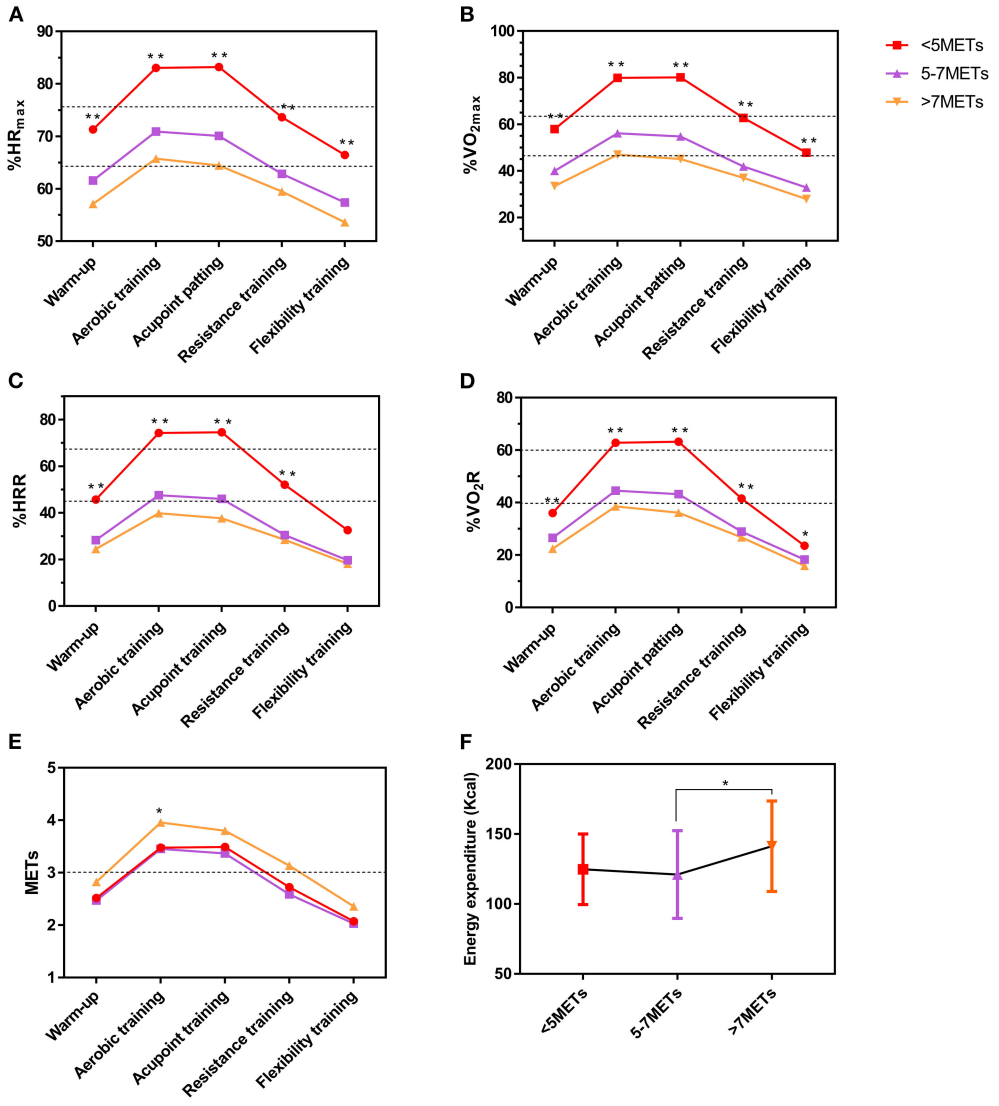

FIGURE 4
The exercise intensity and energy expenditure of the X-CircuiT program between different peak METs value groups. **(A)** Shows the peak heart rate percentage (%HR_{peak}); **(B)** Shows the peak oxygen intake percentage (%VO_{2peak}); **(C)** Shows the heart rate reserve percentage (%HRR); **(D)** Shows the oxygen uptake reserve percentage (%VO_2R); **(E)** Shows metabolic equivalent (METs); and **(F)** Shows the energy expenditure of X-CircuiT. The dotted lines are the medium intensity exercise (lower line) or high intensity (higher line) exercise boundary. *Indicates the difference of the corresponding stage between groups $p < 0.05$; and **indicates the difference between groups $p < 0.01$ (ANOVA).

It has an accompanying video and is tailored for practice at home or in the community. It has shown high acceptability in adults and may be a tool to improve sedentary behaviors and promote healthy lifestyles.

In the present study, we found X-CircuiT to be a moderate-intensity exercise for sedentary adults that elicits an energy expenditure and intensity similar to that of brisk walking or light dance, meeting the requirements of a low-intensity warm-up and cooldown and moderate-intensity aerobic training as recommended by multinational guidelines (28, 29). It can be concluded that the absolute exercise intensity and relative exercise intensity of the warm-up and flexibility training stages of the X-CircuiT are categorized as low-intensity exercise. Broken down into age brackets, the aerobic exercise and acupoint patting stages constitute moderate-intensity exercise in the middle-aged and older brackets, and low-intensity for young people. Furthermore, the X-CircuiT aerobic and acupoint patting stages are classified as moderate-intensity exercises for people with a maximum exercise capacity of 5–7 METs.

The absolute intensity of X-CircuiT is not related to age. However, the relative intensity of exercise is closely related to age, meaning that the older the age, the greater the relative intensity of exercise. This may be explained by the physiological effects of aging, where aerobic capacity is reduced, which is

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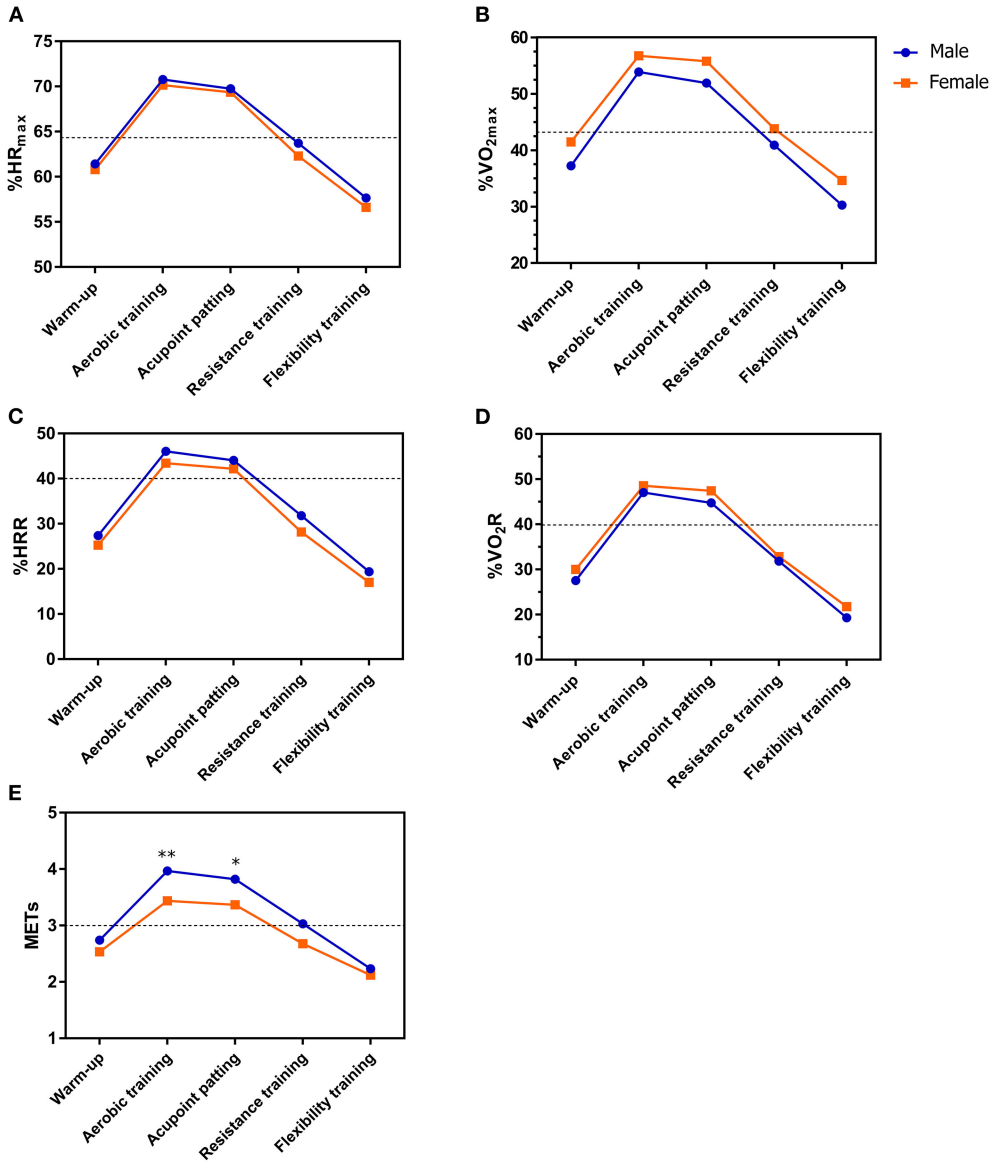

FIGURE 5
The exercise intensity of X-CircuiT in different sex groups. **(A)** Shows the peak heart rate percentage (%HR_{peak}); **(B)** Shows the peak oxygen uptake percentage (%VO_{2peak}); **(C)** Shows the heart rate reserve percentage (%HRR); **(D)** Shows the oxygen intake reserve percentage (%VO_2R); and **(E)** Shows metabolic equivalent (METs). The dotted lines are the medium intensity exercise (lower line) or high intensity (higher line) exercise boundary. *Indicates the difference of the corresponding stage between groups $p < 0.05$; and **indicates the difference between groups $p < 0.01$ (an independent sample *t*-test).

highly related to the training load, in that if the same form of exercise is completed, the lower the aerobic capacity, the greater the training load would be (29). To test this theory, participants were also grouped based on peak METs rather than age. As predicted, the relative intensities of those with lower peak METs were significantly higher than those who achieved greater peak METs.

Relative exercise intensity is more accurate than absolute exercise intensity and more suitable as a prescription for exercise in older populations, taking into account the difference in individual exercise capacity levels (29, 30). In addition, the absolute intensity of X-CircuiT was sex-dependent, and the absolute intensity of men was greater than that of women, while the relative intensity of exercise was sex-independent. This may be because men's weight and BMI is larger than women's, and their coordination is inferior to women's, all of which increase their exercise intensity.

The benefits of exercise are well known, but it takes a certain amount of exercise. The American College of Sports Medicine recommends that adults maintain and promote health by performing no <150–300 min of moderate-intensity aerobic exercise per week combined with muscle-strengthening activities two times a week (28). As such the basic recommendations are categorized by cardiorespiratory exercise, resistance exercise, flexibility exercise, and neuromotor exercise.

Therefore, according to the results of this study, and following the fundamentals of intensity, volume, and frequency, it is recommended to carry out X-CircuiT 7 times a week in which the aerobic and acupoint patting stages would need to be repeated two times or combined with other forms of moderate-intensity aerobic exercise (e.g., walking) to reach 150 min per week, and carrying out elastic band resistance training one time every other day.

Limitations

This study has certain limitations. First, although this study calculated and collected a certain sample size based on the results of the previous pre-experiments, the sample size is still relatively small, and a larger sample size will be included in the later stages to more accurately measure the intensity and energy expenditure of X-CircuiT. Second, this study measures the intensity and energy expenditure of motion under the continuous movement of the program rather than individual stages, and the heart rate and oxygen consumption between the parts may affect each other. However, in clinical application, these can be applied as a whole, and the acupoint patting stage can be applied separately. So the later stage will measure the intensity and energy consumption of the X-CircuiT acupoint patting stage.

Conclusion

Xiangya Hospital Circuit Training conforms to the principle of low-intensity warm-up and medium-intensity training and could be recommended as a community/home-based exercise program for sedentary adults. Therefore, X-CircuiT should be used as a regular exercise program for sedentary middle-aged and older adults or those with an exercise capacity of 5–7 METs, and can be used as supplementary training in young adults.

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 Ethics Committee of Xiangya Hospital, Central South University (No. 202009264). The patients/participants provided their written informed consent to participate in this study.

Author contributions

SL and YD conceived and were involved in securing funding for the study, had full access to all the data in the study, and had the final responsibility for the decision to submit for publication. PH performed project administration, data collection, and analyses. SL and YD supervised the writing of the original draft. WZ, KX, XG, ZC, YS, and BY provided assistance in coordinating the study and aided in data collection. JR-G was involved in writing—review and editing and visualization. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

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"For me, it's just a piece of freedom"—Increased empowerment through physical activity promotion among socially disadvantaged women

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Introduction: Community-based participatory research (CBPR) is an effective health promotion approach for reaching socially disadvantaged groups. However, there is limited evidence on how such interventions and their effects can be reproduced across time and place. The present study examines the effects of BIG (i.e., movement as an investment in health), a long-standing German CBPR project. Since 2005, BIG has aimed to empower women in difficult life situations to increase control over their health determinants and reduce social inequalities by promoting physical activity. One of BIG's key features is its implementation in several German municipalities since 2005. This study explores (a) whether participation could change women's empowerment, and (b) how increased empowerment affects other areas of women's lives.

Methods: With a total of 63 interviewees (i.e., 40 participating women, 7 trainers, 3 project coordinators, and 13 stakeholders), we conducted 53 semi-structured qualitative interviews in five BIG communities between 2007 and 2011. Some interviews were conducted with two people simultaneously. The interview guide contained questions on various dimensions of empowerment (e.g., project engagement, increased self-efficacy, and developed competencies). Framework analysis was used for the analytical process.

Results: BIG contributed to women's empowerment in various ways, including increased self-efficacy, social network promotion, competency development, and increased motivation to change physical activity behavior. Women who took on added tasks and became more involved in project planning also strengthened their organizational empowerment. Furthermore, increased empowerment had a positive influence on the women's quality of life, family, and professional lives.

Conclusion: The novel findings helped in understanding the effects of a complex empowerment-based approach that promoted physical activity among women in difficult life situations. Future research should focus on the long-term effects of these programs and their transferability to other sites. Further effort is necessary in the area of public health policy.

KEYWORDS

physical activity, empowerment, community-based participatory research, women's health, low socioeconomic status, ethnic minority, qualitative research, health promotion

Introduction

Regular physical activity (PA) is vital for maintaining health and wellbeing. It reduces the risk of overweight and obesity (1); has positive effects on the musculoskeletal system, mental health, cardiovascular, and metabolic systems; and has a preventive effect against some cancers (2, 3). The WHO recommends that adults engage in at least 150 min of moderate-intensity PA per week (2).

However, women with low socioeconomic status (SES) (commonly measured by education, income, and occupation) face barriers that hinder them from sustainably implementing these recommendations in their daily lives (4). In developed countries, regular PA follows a socioeconomic gradient, whereby women with higher education or income are likely to be regularly physically active than those who are more disadvantaged (5, 6). For example, in Germany, national survey data showed that 48.9% of women with low SES are physically inactive (including sports), compared to 18.9% of women with high SES (7). Furthermore, German data also showed that women are less physically active than men and that women with a migration background are significantly less physically active than women without a migration background (8). Various barriers hinder socially disadvantaged women from participating in PA offerings: (a) on an individual level, for instance, lack of knowledge of PA benefits and offerings, and language competencies; (b) on a social level, for example, lack of support in becoming physically active, religious cultural norms that hinder participation in PA offerings, family duties including childcare; and (c) on an environmental level, barriers such as lack of nearby locations and low walkability to PA offerings (4, 9–12).

Supporting socially disadvantaged women to become more physically active can therefore be seen as an important public health goal, as physical inactivity is one of the biggest public health problems of the twenty-first century (13). Thus, the development of need-based, low-threshold programs that address all three barrier levels described above is essential for reaching this particularly vulnerable group. Such programs are best accepted when the target group becomes involved in the planning and implementation of programs that consider their values and practices in sustainably engaging them in PA (14). Therefore, participation, and empowerment are two effective concepts for achieving social equity among people in difficult life situations (15, 16). Participatory approaches focus on equal cooperation between professionals and citizens in sharing knowledge, and experiences, thereby building capacities for collectively achieving common goals (17). Participation and empowerment are strongly linked. Participation is an essential concept for strengthening people's ability to act upon their own health. Empowerment is usually understood as a multilevel social process through which (disadvantaged) individuals, organizations, and communities work together to change their social and political environments to determine events that negatively influence their lives and health (18). There are three levels of empowerment in the literature that are intimately linked: individual (or psychological), organizational, and community empowerments (18, 19).

Several studies have shown that participatory interventions have a positive impact on health behaviors, health consequences, self-efficacy, and perceived social support outcomes across various conditions (20, 21). However, there is limited evidence on how such interventions and their effects can be reproduced across time and place (20). Thus, there is a special need to investigate the potential broader influence of participatory research through longitudinal study designs to better understand the value and transferability of highly context-specific health promotion projects and their effects on different sites (22, 23).

In this study, we examined the effects of the BIG (*Bewegung als Investition in Gesundheit*, i.e., movement as an investment in health) project, a long-standing German community-based participatory research (CBPR) project (24). Using a participatory approach, BIG aims to empower women in difficult life situations to increase control over the determinants of their health and reduce social inequalities (25). One of the key features of BIG is that it has been implemented in several municipalities in Germany since 2005. All municipalities used the same approach, which allowed for comparing processes and outcomes at the individual sites. Therefore, a large qualitative dataset was collected, making it possible to gain insights into how an empowerment-based participatory project can expand across communities and what its effects are. Previous work from Rütten et al. (25) and Röger et al. (26), have examined the effects

of the BIG approach on women's individual, organizational and community empowerment using data from the first BIG community (25, 26). This study builds on existing evidence from these and other previous works. It employing a more comprehensive dataset from more BIG communities in rural and urban areas with different population sizes. To answer the research question, theoretical empowerment approaches used in previous BIG-studies have been employed (25, 26). Thus, this study will update and extend previous research on BIG and provide new in-depth insights into how to increase women's empowerment using a participatory approach designed to improve health and health behavior and reduce social inequalities.

The study explored women's views on the following:

- Whether participation in the BIG project could improve women's empowerment and
- How may increased empowerment affect other areas of women's lives?

Methods

The data set: The BIG project

The BIG project was originally developed in 2005 by the Department of Sport Science and Sport, Friedrich-Alexander-Universität Erlangen-Nuremberg, Germany (FAU) (27). The aim of the BIG project was to promote PA among women in difficult life situations (e.g., having a low household income, having a migration background, being unemployed, relying on welfare aid, or being a single mother) using community-based participatory research methods (28). Women actively participated in the planning and implementation of low-threshold exercise classes (e.g., free of charge, complementary childcare, proximity to place of residence). BIG was built upon the "cooperative planning approach" (29, 30), which equally involved women, researchers, and community-level policy and practice stakeholders (e.g., mayors, sports club representatives, and trainers) in the planning of PA offerings. Since all members of the cooperative planning provided specific resources (e.g., funds, access to sport facilities, contact information for the target women), it was possible to implement these programs at the community level. Cooperative planning encouraged women to express their interests and needs regarding PA offerings, thus empowering them to take control of their own health while gaining self-efficacy (26, 31). Since 2005, BIG has spread to 19 sites in Germany. Of these, four sites are currently starting the project. In seven communities, the project has been running for several years, and in nine communities, BIG was implemented (for about 4 years); however, the project could not be sustained. In 2019, across all sites, ∼800 women regularly took part in about 60 different exercise classes (27).

The present study was conducted as part of a federally funded follow-up for the BIG project, termed NU-BIG, with the goal of assessing the long-term effects of BIG projects across all sites. The detailed study design of the NU-BIG is described elsewhere (24).

Design

For the purpose of this study, all available qualitative data from 2005 to 2011 were pooled. For the comprehensive data analysis, we used 53 interview transcripts from five BIG communities [including interviews from pilot community A, see also Rütten et al. (25) and Röger et al. (26)], with a total of 63 interviewees (see Table 1). Interviews were initially conducted for process or outcome evaluation of the various BIG communities. Original data were generated between 2007 and 2011, usually 1–2 years after implementation of the project had started. Interviews were conducted with: (a) women who participated in BIG classes only (n = 18 interviews with 27 women; two group interviews); (b) women who participated in BIG classes and also joined the cooperative planning meetings (n = 12 interviews with 13 women; one group interview); (c) trainers of BIG classes (n = 7); (d) project coordinators who were responsible for planning and promoting BIG classes (n = 3); and (e) stakeholders who joined the cooperative planning meetings and/or helped in implementing the BIG program (n = 13). All interviews were held at comfortable places for the interviewees (e.g., café, mosque, research offices).

Interviews were conducted by research assistants from the Department of Sport Science and Sport of Friedrich-Alexander-Universität Erlangen-Nuremberg, who also provided scientific support for the implementation of BIG at individual project sites. All interviews were audiotaped and transcribed verbatim. The interview guides consisted of eight fixed sets of questions, which considered the following concepts from health promotion in particular. First, social capital, defined as (a) an individual's membership of a social group (relational aspect) and (b) the benefits an individual derived from the social network (material aspect) (32, 33). Second, self-efficacy, defined as an individual's belief in their own capacity to control certain behaviors (34). The eight sets of questions are: (a) relevance of BIG, (b) motivation to participate, (c) sports biography, (d) comparable women-only offerings in the hometown, (e) organization and low-threshold nature of the classes offered, (f) initiated behavioral changes, (g) relationship between participating women, (h) suggestions for program adaption.

Ethical considerations

The Ethics Committee of the Friedrich-Alexander University Erlangen-Nuremberg granted ethical approval for this follow-up study (approval number: 247_20 B). All

TABLE 1 Overview of interview data.

	Community A	Community B	Community C	Community D	Community E
Project term	Since 2005	Since 2008	2008–2017	2008–2017	Since 2011
Status	Ongoing	Ongoing	Discontinued	Discontinued	Ongoing
Community size (inhabitants)	112.385	152.270	117.000	72.137	74.048
Interviewees					
Women participating in BIG classes only	$n = 10$	$n = 3$	$n = 1$ (group interview with nine women)	$n = 3$	$n = 1$ (group interview with two women).
Women additionally participating in cooperative planning meetings	$n = 7$	$n = 3$	–	–	$n = 2$ (one group interview with two women and one single interview).
Trainers	–	$n = 2$	$n = 2$	$n = 3$ (one male)	–
Project coordinators	–	–	$n = 1$	$n = 1$	$n = 1$
Stakeholders	–	$n = 7$ (one male)	$n = 3$ (two males)	$n = 3$ (two males)	–
Date of interviews	2007	2009	2010	2010	2011

interviewees gave informed consent for the interview, the audio recording, and the scientific use of their accounts. All transcripts were anonymized so that no inferences could be drawn about the interviewees or others mentioned in the interview.

Analytical process

Interview data were analyzed using the framework method (35). This approach provides a systematic model for mapping and interpreting qualitative data. Thus, it was considered appropriate for developing an insightful, in-depth understanding of women's experiences within BIG and the project's impacts on their daily lives (36). The analysis consisted of five systematic and interconnected steps.

Step 1—Familiarization: This was done on the interview data by rereading the narratives several times, which was particularly important, as coders were not involved in the data collection process.

Step 2—Coding: We followed a combined deductive–inductive coding strategy. For this strategy, codes were based on the empowerment theory of Rappaport (18), Zimmerman (19) and Laverack (37), using the three domains of empowerment (individual, organizational, and community), as described in Table 2. The first author (A.S.) coded three interviews with several codes for each level of empowerment (e.g., organizational empowerment used the following codes: "participation in cooperative planning meeting," "equal say," and "advocate matters of personal importance"). To ensure reliability, the generated codes were discussed with a second coder (a master's student, experienced in analyzing qualitative data) until consensus was reached, while continually returning to the coded quotes to check for meaning and context, as recommended by Pope et al. (38). In the second step, the transcripts were coded inductively by the first author, with emphasis on newly occurring phenomena that were not included in the established levels of empowerment, but which were essential in answering the research questions.

Step 3—Constructing the framework: The set of codes was discussed with the research group (A.H-M., K.A-O., A.T., H.Z., S.L., A.H-J.) to form a working analytical framework that was best suitable for addressing the research questions in a meaningful way.

Step 4—Applying the analytical framework: All transcripts were coded by the two coders using the analytical framework. Step 5—Charting and interpreting data: Similar codes were combined to develop themes. All developed themes and the relationships between them were reviewed by members of the research team to check whether the themes were coherent and captured the most relevant data features.

The analytical process was conducted in German. Only the quotations used in this paper were translated into English. The translation was checked by several authors for meaning and content to ensure that no information was lost during the translation process.

Results

Individual empowerment

Feeling more confident and gaining self-efficacy through class participation facilitate women's PA.

One of the main findings across all communities was that the women experienced increased self-efficacy. The majority of women who regularly participated in the classes

TABLE 2 Framework showing themes based on empowerment theory.

Level of empowerment	Description	Interview guide question	Themes
Individual	Process of change with intrapersonal, interactional and behavioral components and which is related to increased self-efficacy, perceived competencies or skill development (18, 55).	• Have you experienced any changes as a result of participating in the BIG project? • How has the BIG project affected your everyday life? How would you describe your everyday life before BIG and now with (or after) BIG? • Do you now have more knowledge about your capabilities to be physically active? • Do you also participate in sports apart from BIG offerings?	• Feeling more confident and gaining self-efficacy through class participation facilitate women's PA. • Receiving fellowship and social support within the BIG community. • Joining planning processes helps strengthen personal competencies and skills. • Class enjoyment and improved PA foster motivation to set and attain new goals and implement further health-related behaviors.
Organizational	Processes and structures that enhance members' skills and provide them with the mutual support necessary to effect community level changes. Fosters individuals to improve organizational effectiveness by effectively competing for resources, networking with other organizations, or expanding influence (19, 55).	• Was there an exchange of experience/knowledge with other participants? How would you personally rate this exchange? • Did any new opportunities arise for you as a result of attending the cooperative planning meetings? • To what extent were you able to contribute your own ideas to the cooperative planning meetings/the BIG classes?	Low-level participation and shared decision making can foster women's involvement.
Community	Links interactions between individuals and organizations working together in an organized fashion to improve local living conditions and thereby initiate changes in a larger social system (37, 55).	With which BIG partners did you have contact (members of local organizations, exercise instructors, women from the target group)?	Collective problem assessment helps to create "safe spaces" to practice PA.

highlighted that they soon underwent a personal change by experiencing progress in their own PA abilities, especially women in swimming classes. After a few sessions, the women felt more confident while exercising and began to believe in their own abilities. Through increased self-efficacy, the women felt proud and empowered to set new goals and continue the training, for example, getting a swimming certificate, trying new sports classes, or swimming in the open sea.

> *"Before [BIG], I was so jealous that my children could swim, and I just sat on the beach [...]. And now I have achieved this. I am so proud of myself that I have learned how to swim."* (Woman, Community A).

> *"[After a while] the women in the swimming class were brave enough to go into deeper water. In the first sessions, I had to hold them by their swimming pants. Later, they dared to swim back and forth without any assistance. When they get to this point, they are really motivated. The swimming teacher thinks about training them to get a swimming certificate."* (Project Coordinator, Community E).

However, according to the professionals involved in the project, increased self-efficacy for some women seemed to be limited to their own sporting activities within BIG classes. Additional training to become an intercultural sports assistant was only taken up by some women but rejected by others. Low confidence was identified by the interviewed

professionals as the reason for the women's rejection of completing this additional training and perhaps running courses themselves in the future. Also, a lack of incentives to invest time and energy in this further training were named as additional barriers.

> *"When I suggested this [training as an intercultural sports assistant] to them, they looked at me in surprise. The first thing they wanted to say was, "Are you at the right address?" When I tried to convince them that they could actually do it, they were very thoughtful and went home. The next day or a week later, they said, "Well, we can't do it.""* (Expert, Community D).

Receiving fellowship and social support within the BIG community helps to continue PA classes and foster mental wellbeing.

Another dimension of empowerment addressed by the BIG project in all communities was the experience of community and social support. In particular, unemployed, or widowed women who had little contact with others valued the possibility of getting in touch with other women in the classes. They described these contacts as enrichment for their everyday lives and as a way out of their social isolation at home. Belonging to a community strengthened these women's feelings of importance and self-worth, as they were now heard and seen by others and had the opportunity to bond with others. The BIG community was considered important not only to motivate each other to participate in PAs but also to have a place to talk about everyday problems and topics of importance to women.

> *"[At the end of] most BIG classes, there is still time to talk and motivate each other. That is very important to them [women]. In the meantime, problems are discussed after the classes. That's why the women like coming there so much."* (Trainer, Community C).

> *"Some of our participants are widowed. They no longer have many opportunities to be sociable or to go out. BIG helps them overcome this hole by having a reason to leave the house."* (Trainer, Community D).

H The participating women obtained benefits through their membership in the BIG project because the women supported each other. Participating mothers, for example, benefited from the childcare provided, which was often done by other women. This support allowed mothers to join BIG classes on a regular basis and take time out from their demanding everyday lives to do something for themselves.

> *"Of course, it's been good for me, because it's an hour I have for myself. It's my first child, and you're like a supermom. You concentrate only on your child. Thus, it's a nice thing to say: I'm doing something for myself again. That is simply a piece of freedom for me."* (Woman, Community E).

Furthermore, taking over childcare increased the childsitter's empowerment as well, as it gave them a meaningful task and helped some to find part-time employment. Thus, in several cases, BIG not only empowered the participating women but also benefited the women who contributed to the project.

> *"I also wanted to join the swim class, but I'm a professional child nurse and they were looking for child care [for the swim class]. So, I took the job, because for me it's more important that my friends [with children] can join the class. And for me, it was a good opportunity to have a part-time job."* (Woman, Community B).

However, women of Muslim faith in particular reported partnership conflicts because of their participation in BIG classes and lack of support from their husbands. Some women lost weight and gained more self-confidence due to their changed appearances. In some cases, husbands viewed their wives' new body image with skepticism and reservation. Although some women felt empowered by their new confidence in asserting their needs and activities, others reported feeling uncomfortable with these marital conflicts and decided to stop the BIG program in favor of a harmonious partnership.

> *"Yes, the relationship with my husband [has changed]. In the past, I always did everything right for him. And now I can say, "Cook your own dinner, I'll be home later today.""* (Woman, Community A).

> *"My family and husband come first. It's better than starting a fight just because of losing weight."* (Woman, Community C).

Joining planning processes helps strengthen personal competencies and skills.

Interviewees who also participated in the cooperative planning group meetings reported gaining additional competences. Working together with different interest groups and managing the organizational work fostered the women's project management skills, social skills, and self-confidence.

> *"I learned a lot about how to deal with different people, especially with the women in the BIG classes, the trainers, with you, the scientific staff and with all the different institutions involved. How to proceed in a cooperative planning process—quite simply, how to write emails, letters, and so on."* (Woman, Community A).

Additionally, participating in BIG seemed to be a great way to improve the women's German language skills. As the project progressed, the most common change was the transition from being shy to becoming confident when talking to others in German. Interviewees valued the new opportunities to communicate their thoughts to other planning group members and to have a say. They felt empowered to become actively involved in the planning and implementation processes.

> *"I felt very good whenever I came to this meeting [cooperative planning]. I could talk to all these people. I was able to express my ideas; they were heard, and they were taken into account. I participated, and it made me feel good."* (Woman, Community A).

These new language competencies also empowered many women to lead their daily lives more independently (e.g., by handling administrative issues, such as going to public offices without a translator or applying for a job) and made it easier for them to (re)enter the labor market.

> *"I haven't worked for 8–9 years because I stayed at home with my children [. . .] I didn't feel comfortable talking to people. The BIG project helped me a lot. Now, I'm doing an internship twice a week. If it wasn't for BIG, I wouldn't be able to speak with people."* (Woman, Community B).

Class enjoyment and improved PA foster motivation to set and attain new goals and implement further health-related behaviors.

Interviews with the women in the target group and the narratives of the trainers and coordinators demonstrated a change in the women's motivation and enjoyment in participating in the various classes. This change was described as regular and enthusiastic class participation. It was also conveyed in the women's booking of further classes the following semester, even when class fees could not be fully covered. The professionals explained this behavior by the positive changes the women experienced by attending classes (e.g., increased fitness, increased wellbeing, and body positivity). Furthermore, improved abilities, such as swimming skills, enabled the women (especially the Muslim women) to do joint activities with their children in the water. They also felt empowered to act if their children needed rescue in an emergency.

> *"I often notice that the women continue booking [further classes], even if the course fee is no longer covered by the health insurance. Because they simply notice that it's good for them. Less pain, more mobility, and improved general fitness."* (Trainer, Community C).

> *"Of course, I would like to learn more [...] For example, other swimming styles. Diving is also important. If I am with my child at sea and he sinks, I have to learn how to rescue him."* (Woman, Community A).

Interviewees also reported that the women integrated PA into their daily routines as the project progressed. Daily transportation was more often by bike or foot, and leisure time activities with friends or family were also increasingly linked with PA. For some women, this became an opportunity to find new joint hobbies with their partners.

> *"Before [BIG] I have never done any sports at all. Now, I ride my bike or walk when I have to go somewhere [. . .] I am not so averse to PA anymore."* (Woman, Community A).

> *"We [my husband and I] also do something together from time to time. I guess, if I wouldn't go to the BIG class now, he would have done his sport, and I would have watched or had no connection to him at all. But now we can do [exercises] together."* (Woman, Community A).

A few women also reported that they felt motivated to change other health-related behaviors, such as their diet, due to participation in BIG. Furthermore, participation in the BIG project seemed to have positive effects on their general wellbeing and mental health. This was also reflected in their interactions with family members, who often noticed and commented on their wives' or mothers' changed state of mind.

> *"For example, some had problems with depression, they have become more balanced [since BIG]. And of course, this has an effect on the family and also on the children [. . .] some women told me, their husbands appreciate BIG because every time their wives come home after class, they are in a good mood."* (Trainer, Community C).

Organizational empowerment

Low-level participation and shared decision making can foster women's involvement.

Across all communities, interviewees valued the openly structured and interactive format of many classes. In this way, the women felt that their needs and wishes were being

considered in every class, as they could always express their wishes and needs to the trainers.

> *"The trainer is very responsive to us and we are able to express our wishes, what we would like to do [in the class]"* (Woman, Community D).

However, regarding involvement in the cooperative planning group meetings, women, stakeholders, and coordinators involved in the CBPR process reported several difficulties. In particular, in the beginning, when the women had lower language levels, uncertainties about expressing their views in front of other people, especially decision-makers (e.g., mayors), reduced some women's empowerment in becoming actively involved in the planning process. Furthermore, the format of the cooperative planning meetings, with its official character and the "academized" topics, were rated by some as unfamiliar and uninteresting for lay people. Many of the interviewed women were not averse to participating in planning processes or having a say in decisions. However, in most communities, informal formats, such as monthly breakfasts, made these women feel more comfortable raising their wishes and concerns and exchanging ideas with others. This was due to easier language speaking ability, flat hierarchies, and more familiar locations (e.g., district meetings and family centers).

> *"The [cooperative planning] meetings were okay. I always took part, but I couldn't talk much because somehow the mayor was there and the head of the sports department. And you don't know what to say [. . .] Because it could be that I just say words wrong, and then it sounds stupid. So I preferred to say nothing at all."* (Woman, Community A).

> *"In general, it was difficult to convince the women to go to the town hall and participate in the cooperative planning [...]; many women simply didn't want to come. They either don't have time, or it's an excuse, or they don't feel like dealing with it and planning something. It has proven to be easier to organize a women's breakfast event or a homogenous group meeting. Something that is more sociable."* (Project Coordinator, Community E).

Community empowerment

Collective problem assessment helps to create "safe spaces" to practice PA.

For women of the Muslim faith, the prospect of PA classes based on their needs helped activate their empowerment. They soon developed a high level of problem awareness and problem-solving skills to obtain access to public swimming pools and create class environments that suited their religious and cultural regulations. This included measures such as covering windows and doors in swimming pools to protect them from male glances and advocating special swimwear for Muslims in the swimming pools. In cooperation with different community organizations and initiatives, women-only indoor pool hours could be established in most of the participating communities. This served as an addition to the PA classes.

> *"Other women from our Turkish community told us about it [the BIG project]. Together, we went to the city administration and explained to them that we also wanted to have a women-only indoor swimming class [in our neighborhood]. She gave us registration forms, which I filled out, and soon afterward, it started."* (Woman, Community E).

Discussion

Principal findings

In this study, we examined the effects of BIG, a CBPR project, aimed at empowering women in difficult life situations through PA promotion to gain more control over their health. We analyzed qualitative interviews from five communities with participating women, project coordinators, and stakeholders using a multilevel empowerment framework (19, 39). An important finding from this study is that, within the BIG project, the transfer of this empowerment-based CBPR program from one community to another is possible, even though the transfer of such complex interventions is described as difficult (40). All five communities achieved initiated changes at all three levels of empowerment, with the greatest changes observed in individual empowerment. Our findings could confirm existing evidence from Rütten et al. (25) and Röger et al. (26). By using a larger set of data from different communities, we could show that some of the effects of the BIG project are not exclusive for pilot community A [see also Rütten et al. (25) and Röger et al. (26)], but could also be found when transferring the project to other sites. Women who also participated in the cooperative planning meetings had even greater effects on their individual and organizational empowerment, as they were able to contribute their ideas and thus influenced the course of the project. These women reported additional skill development, such as organizing meetings, improving their German language speaking skills, and interacting with agencies from other institutions. This skill development even helped some back into the workforce (25, 26). The results of our study also show that some women feel a certain ambiguity toward the BIG project. Although women were proud of their increased empowerment and the "safe" environment they built up together, for some women (especially those of the Muslim faith), increased self-confidence were viewed critically by their spouses. Consequently, some felt that they must decide whether to continue their participation in PA classes or quit in favor of a harmonious family life.

Comparison with other studies

To our knowledge, the BIG project is the first CBPR project to use an empowerment approach to promote PA among disadvantaged women. Other studies used empowerment approaches mostly for other groups, other health promotion fields, or other intervention strategies different from the cooperative planning process, with most having an educational character (41–43). A few CBPR projects have identified several effects of empowerment at the individual level, such as greater confidence in an individual's abilities, acting as a role model for family members, receiving social support from peers, and becoming motivated to change certain health behaviors (44, 45). Nevertheless, CBPR projects using an empowerment approach face many challenges. In our study, for example, the women valued the opportunity to actively participate in the project. However, it often seemed challenging to convince women (especially those with migration backgrounds) to participate regularly in formally structured planning group meetings. Fröberg et al. (46), for example, showed that in their empowerment-based school intervention, the involved students had less interest in discussions and goal-setting strategies and could not be convinced of the relevance of an active everyday life to their later health. Consequently, their 2-year intervention study showed no positive effect on the student's sedentary behavior or PA. In the BIG project, this barrier was partially resolved by all communities through organizing more informal meetings for the involved women (e.g., women's breakfast sessions), with a low threshold, where project topics could be discussed easily.

Other approaches can be found in the literature on how to attract socially disadvantaged groups of people to participate in CBPR projects. For example, a Lebanese CBPR project with the aim of improving the reproductive and mental health of women in disadvantaged communities in Beirut established a local committee in which women in the target group had the opportunity to explain their living circumstances and express their needs (47). The research team attempted to listen to the women with time and care to build trust, which was seen as a major factor in successfully recruiting them for the project trial. Nevertheless, some women lost interest in participating in the committee. Out of 20 women, only six women maintained interest over the remaining 2 years. Still, the remaining women felt empowered and ownership of the study. Most women were unemployed for most of their lives. They saw in their participation a meaningful and productive use of their time.

Overall, with regard to engaging people from minority communities, it is valuable to find peer champions who feel empowered to publicly speak for their peer groups in stakeholder group meetings or project committees and to get others involved in the planning process. Israel and colleagues, for example, set up field offices in their CBPR project and hired local community members as staff who were similar to the project participants (e.g., culture, and language) (48). Staff positions could include field coordinator, interviewers, and intervention staff. This ensured that the target group could be addressed and involved in all steps of the project in a culturally sensitive way. Avery et al. (44) used a similar approach, employing lay health promoters as trust builders. Trust and interpersonal interaction are important facilitators of empowerment processes, especially for people with migration backgrounds. The lay health promoters had continuous dialogues with the community members and helped with participant recruitment and language interpretation. In particular, the participating women benefited from knowing their neighborhood lay health promoters, as they trusted that the promoters' recommendations (e.g., for PA activities) would be culturally sensitive.

While we did not explicitly include "trust" in our interview guide, it seemed that, especially for women of the Muslim faith, trust in a need-based workout space (e.g., no men present, and protected from others' views) was crucial for reaching these women and encouraged long-term participation. These results are consistent with the findings of a previous pilot study on Community A (49).

Strengths and limitations

We conducted a secondary analysis of existing data (25, 26) which was supplemented and updated by additional interview data to answer the research question underpinning this current study. Due to this in-depth and rich data material shows how the provision of need-based PA offerings and the dynamics of interactions between the participants strengthen the women's individual empowerment in terms of self-efficacy, competencies, power, and social capital (e.g., advancing social networks, bonding with other women, experiencing group solidarity, and belongingness).

The comprehensive and rich dataset with interviews of involved women, trainers, coordinators, and planning group members from different project sites enables a triangulation of different perspectives. This has made it possible to obtain a comprehensive picture of the effects of the BIG project on women's empowerment and the broad effects on women's everyday lives. Given the flexible and emerging nature of CBPR projects, it is noteworthy that the BIG approach was transferable to all five communities and initiated changes in all three levels of empowerment at all sites. Despite this, effects at the organizational or community levels were less visible.

Although data collection for this study occurred several years ago, and situations at the various sites may have changed somewhat, the data under investigation helped in answering an essential research question by focusing on how to strengthen a vital aspect of health promotion. In addition, the participants invested time and effort in providing this data. We believe that

it would be unethical not to use this information to increase the evidence base in this field, inform future research, and provide practical implications for health promotion.

However, the findings from this study may not simply be transferable to other countries because of specific German situations or cultural contexts. The evaluation of empowerment-based CBPR projects is also difficult. Furthermore, the operationalization and measurement of these concepts have proven to be challenging in health promotion research and practice, given that there are varying conceptualizations of empowerment and participation (50). Thus, we used a classical empowerment approach based on the concepts of Rappaport and Zimmermann to analyze our findings. Using other concepts of empowerment may highlight other aspects of the data.

Implications for future research and practice

Our results suggest that when intending to foster empowerment processes through local PA interventions among socially disadvantaged women, establishing cooperative planning groups could be effective in involving women in planning and implementation processes. The findings of this study highlight that women's participation in such groups empowers them and gives them more self-confidence, which can help in various areas of their lives. However, our study also shows that not all women benefit equally from participating in cooperative planning groups. In particular, women with very low language levels may find it difficult to participate in these meetings. In addition, the participation of authority figures may pose barriers to participating actively or at all. For this reason, more informal formats, such as women's breakfasts, may also be suitable for this target group, where women may be able to talk more freely about topics that interest them and affect their lives. The results of such low-threshold meetings could then be integrated into the cooperative planning processes, for example, by the facilitating researchers. Further, including a peer champion to motivate others to join the planning process and who feels encouraged to speak for the peer group in the meetings might help overcome the challenge of engaging people from the target group in the project.

For some participating women, obtaining family support was challenging, as partners were skeptical about the program or viewed women's new self-confidence negatively. Including family-based intervention strategies might be a way to better convince spouses of the purpose and value of PA classes. Furthermore, it might be an avenue for supporting PA in the home environment and during leisure time with family members.

Using the concept of empowerment in a CBPR project is always accompanied by methodological difficulties, as there is a degree of uncertainty about how the concept should be understood and operationalized (50). Researchers may struggle due to the variety of possible indicators used to measure empowerment and to define whether empowerment is to be seen as a process or an outcome (51, 52). Some even argue that one cannot empower others. Instead, the target group must empower itself and define empowerment indicators (39, 53). Thus, for better clarity of project goals, to more actively involve the target group in the research process, and to increase their commitment to the project, the target group should be involved in preliminary methodological considerations (54). This would allow the target group to determine the domains that should be addressed later.

Conclusion

We examined the effects of a CBPR project (BIG) designed to empower socially disadvantaged women through PA promotion at five different project sites. Interviews from five project communities showed that the BIG approach and some of its key effects were transferable to other sites. The findings highlight that empowerment can be reached on an individual level. According to the women's perceptions, participating in PA classes strengthened their self-efficacy and confidence in their own abilities, expanding their social networks and affecting their PA behaviors and those of their families. For women who also participated in the cooperative planning meetings, empowerment processes were also initiated on an organizational level, and project participation had a greater impact on their private lives, such as reentry into the workforce and greater self-reliance in everyday life. In sum, this study reveals novel findings that help us understand the effects of a complex empowerment-based approach that promotes PA among women in difficult life situations. Future research should focus on the long-term effects of empowerment-based CBPR programs and their transferability to other sites. This will also warrant further efforts in the area of public health policy, such as long-term funding for effect-proven research interventions on a broad scale. Furthermore, governments need to provide resources to create socio-political environments at a local level to strengthen community capacities in identifying health needs in their communities and to sustainably implement programs that foster the health behaviors of minority groups.

Data availability statement

The data generated and analyzed in this study is available upon reasonable request from the corresponding author alexandra.sauter@ukr.de.

Ethics statement

The studies involving human participants were reviewed and approved by Ethik Kommission der Friedrich-Alexander-Universität Erlangen-Nürnberg. The patients/participants provided their written informed consent to participate in this study.

Author contributions

KA-O and HZ initiated the study. AS analyzed the data, designed the study, and drafted the manuscript. AH-J participated in writing the manuscript. AH-M supports the provision and processing of the data. AH-M, KA-O, HZ, AT, SL, and AH-J contributed to study conception, data analysis, and critically revised the manuscript. AF conducted interviews and critically revised the manuscript. All authors read and approved the final manuscript.

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Conflict of interest

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

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A socio-ecological approach to inclusive physical education in China: A systematic review

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Background: Since the implementation of inclusive education in China, students with special education needs (SEN) have increasingly been integrating into mainstream schools, like physical education classes. However, inclusive physical education (IPE) in China has developed slowly, and gaps can be found in the knowledge of the factors that inhibit or promote the participation in IPE of students with SEN.

Objectives: The purpose of this systematic review was to provide a comprehensive summary of the factors related to inclusion in IPE of students with SEN, by applying a socio-ecological model (SEM). Five databases were searched: ERIC, SPORTDiscus with Full Text, Education Full Text (H.W.Wilson), PsychINFO and CNKI in March 2022, to find studies that identify factors regarding IPE in China. Two researchers independently screened studies and summarized relevant data.

Results: Fourteen studies were included in the detailed review. By applying the SEM, multi-level factors were identified, ranging from intrapersonal to societal levels that positively or negatively influenced IPE participation in students with SEN. This review indicates that multi-level factors affect the IPE participation of students with SEN in China.

Conclusion: The findings will help assist educators and policymakers to develop effective IPE for Chinese students with SEN.

KEYWORDS

inclusive physical education, students with special education needs, systematic review, China, socio-ecologic model

Introduction

Inclusive education is an approach that aims to eliminate social exclusion, on the premise that education is a foundation for society. It has been accepted as a core education policy worldwide (1, 2). The concept of inclusive education was developed under the influence of the Salamanca Statement (3), indicating the fundamental idea of inclusive education is that "every child has the fundamental right to receive education, and must be given the opportunity to achieve and maintain an acceptable level of

learning; those with special education needs (SEN) must have access to regular schools which should accommodate them within a child-centered pedagogy, capable of meeting these needs" (p. 3). Following the development of this educational philosophy, empirical studies have documented the benefits of inclusive education, such as improving the academic learning of students with and without SEN (4, 5), enhancing their social interactions (6) and helping them to achieve a more positive self-concept (7). Through the philosophy of inclusive education and followed by the relevant implementation of legislation and policies as well as the evidence-based research in this area, students with SEN are able to be well-educated in mainstream schools.

Inclusive physical education (IPE) has been promoted as a fundamental human right (8). Previous studies have highlighted the importance and benefits of IPE for students with SEN (9, 10). Three systematic reviews regarding IPE have examined the factors that affect their participation during IPE among students with SEN. Block and Obrusnikova (11) reviewed 38 relevant studies conducted between 1995 and 2005 and summarized six aspects influencing IPE: (a) support from peer tutors, teaching assistants and adapted PE specialists, (b) effects of typically developing (TD) peers, (c) attitudes and intentions of children without SEN, (d) social interactions, (e) academic learning time of students SEN during PE, and (f) training and attitudes of PE teachers. Qi and Ha (12) reviewed 75 published articles between 1990 and 2009 and generated facilitating factors for IPE, including educational stakeholders' perspectives on IPE (in- and pre-service teachers, teacher education providers, students without SEN and parents of students with SEN) and effective inclusive strategies (peer tutoring, support from paraprofessionals and PE specialists, collaborative team approach, embedded instruction, and cooperative learning). In addition, analyzing 112 articles published between 2009 and 2015, Wilhelmsen and Sørensen (13) found six main research themes guided by the approach of stakeholders, including in- and pre-service PE teachers, PE teacher educators, SEN coordinators and teaching assistants, children with and without SEN, parents and physical, educational policymakers. These systematic reviews indicate that more studies have focussed on educators' attitudes toward inclusion, particularly in Western countries (13). Qi and Ha (12) and Wilhelmsen and Sørensen (13) only included 7 and 14 studies from Asia, respectively, including only two studies conducted in 2015 from Mainland China.

Inclusive education in china

As a part of the global movement of inclusive education, China embraced the concept of inclusive education in 1987 as the primary option for students with SEN (14). In 1988, China included inclusive education in government policy as *Learning in Regular Class* (LRC), called *Sui Ban Jiu Du* in Chinese at the national level (15). The LRC initially offered educational options to the students with three types of disabilities, including intellectual disability, visual impairment and hearing impairment in rural areas of China where few special schools and teachers were available because of limited financial resources and public transportation (15, 16). With the gradual development of the LRC model, more school-aged children with SEN enrolled in mainstream schools with their TD peers on an annual basis (17). For example, the number of students with SEN in mainstream schools increased from 129,400 in 1992 to 304,000 in the 2017 (18). These students included children with visual impairment, hearing impairment, physical disability, intellectual disability, speech disability, psychosocial disability and multi-disability (19). However, China's progress in developing inclusive education has been inadequate, and an inclusive education system has yet to be established in China (20, 21). One recent review summarized several practical problems of LRC implementation in China, including (a) inadequate funds, resources and personnel for accepting students with SEN; (b) unprepared mainstream teachers' knowledge and training in inclusive education; (c) inadequate curriculum modification; (d) TD peers' unfavorable attitudes toward students with SEN; (f) inappropriate home-school collaboration system; and (e) ineffective evaluation system on students with SEN in the regular classroom (17). Thus, there is a huge gap between the government policy on inclusive education and the current practice of LRC in China.

In China, PE is a crucial subject in the national school curriculum and is provided for students from the 1st year of primary school up to high school, including students with SEN attending mainstream schools. IPE, however, has developed slowly in China (22). A previous review of IPE in China only focused on four factors affecting IPE participation, including its regulations or policies, teachers' preparation programmes, teachers' attitudes and available curriculum and equipment (22). In addition, their review neither systemically screened articles nor was it grounded with a theoretical framework to summarize the results. Therefore, it is needed to adopt a theoretical framework to illustrate the factors affecting IPE in China.

Socio-ecological model (SEM)

SEM (Figure 1) provides a theoretical framework to understand diverse factors that influence PA participation at the individual, social, and environmental levels (23). Intrapersonal factors are the center of the model that focuses on an individual's impairment, attitudes, and knowledge. The interpersonal factors are second-level factors, which refer to social relationships involving teachers, peers and family members. The third level focussed on organizational factors, such as the PE courses and

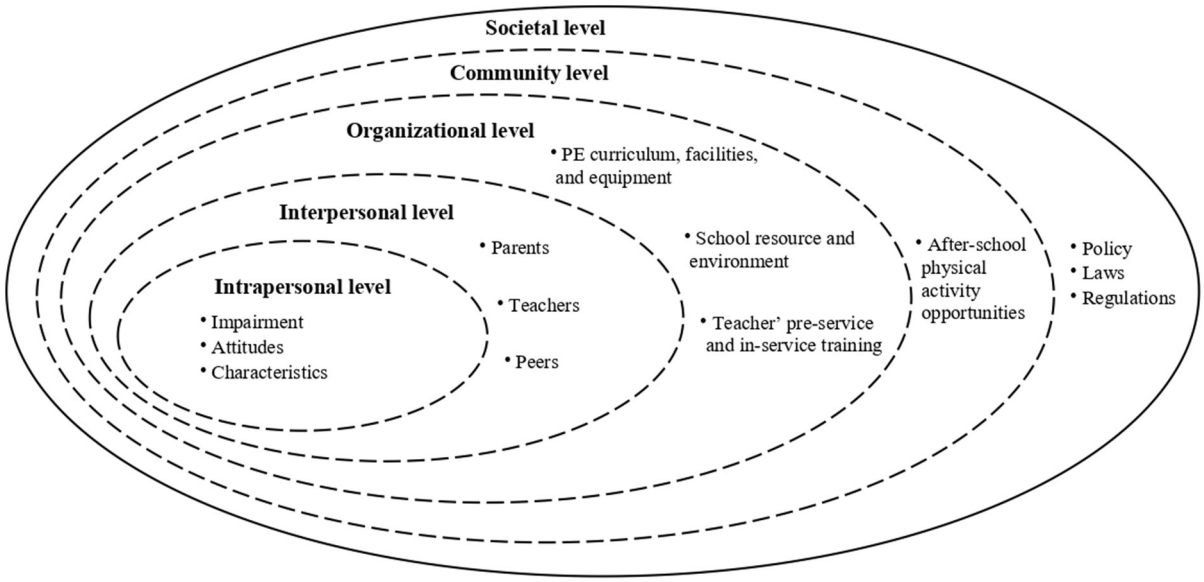

FIGURE 1
Socio-ecological model. Adapted from McLeroy et al. (23).

PA programmes offered by schools and available PE equipment and PA facilities. Community factors are located at the fourth level, such as community-based PA programmes and extra-curricular PA opportunities offered by local PA organizations. The outermost level of SEM is the societal level, which involves public policies, laws, and regulations at various levels (23).

SEM has been widely used in various studies to identify what inhibits or facilitates participation in PE classes of individuals with and without SEN in different settings. These studies have focussed on children and adolescents with autism (24), university students with disabilities (25), children and adults with physical disabilities (26), and school PE programmes (27). Although SEM has been adopted for individuals with disabilities to understand their PA behaviors, no studies have yet applied this model to students with SEN in IPE, and to identify the factors affecting the implementation of an inclusive approach. There has been a limited review of research on IPE, specifically in China. This systematic review aimed to identify factors that affect the IPE participation of students with SEN in China at different levels using SEM. The research question guiding this review was which factors within SEM are salient in including children with SEN in IPE in China.

Methods

Search strategy

Electronic searches were conducted in Education Full Text (H.W. Wilson) (via EBSCOhost), SPORTDiscus with Full Text (via EBSCOhost), Eric (via EBSCOhost) and APA PsychINFO (via OVID) from inception through May 2020 and updated searching in March 2022 to identify all relevant published articles regarding the IPE in China. The search was limited to "English," "human-related," and "peer-reviewed" articles. The initial investigation was undertaken using three key terms: inclusive education, physical education, students with SEN. The search keywords for each primary term were developed from the search strategies of previous reviews related to inclusive PE and expert opinions in the fields of PE and inclusive education. In each database, each primary term and associated synonyms were identified, based on the following paradigm: "([Inclus* OR Integration* OR Exercise* OR Mainstream* Adapt* OR Special education OR Educat* OR Teach* OR Learning in the regular classroom OR LRC]) AND ([Physical education OR School sport OR School-based sport OR PE]) AND ([Students with SEN OR Students with disabilit* OR Students with special education needs OR Students with special needs])." Furthermore, to include all studies related to IPE in China, location limits were not added to the screening process in four English databases. Because limited research about Chinese IPE was found through English databases, one widely used Chinese database, namely the China National Knowledge Infrastructure (CNKI), was also used in the study to search for relevant resources. The same search terms were translated to Chinese, such as "suibanjiudu," "quannajiaoyu," "canjirentiyu" and used in CNKI. Also, a manual search strategy was used by two independent reviewers to identify relevant articles.

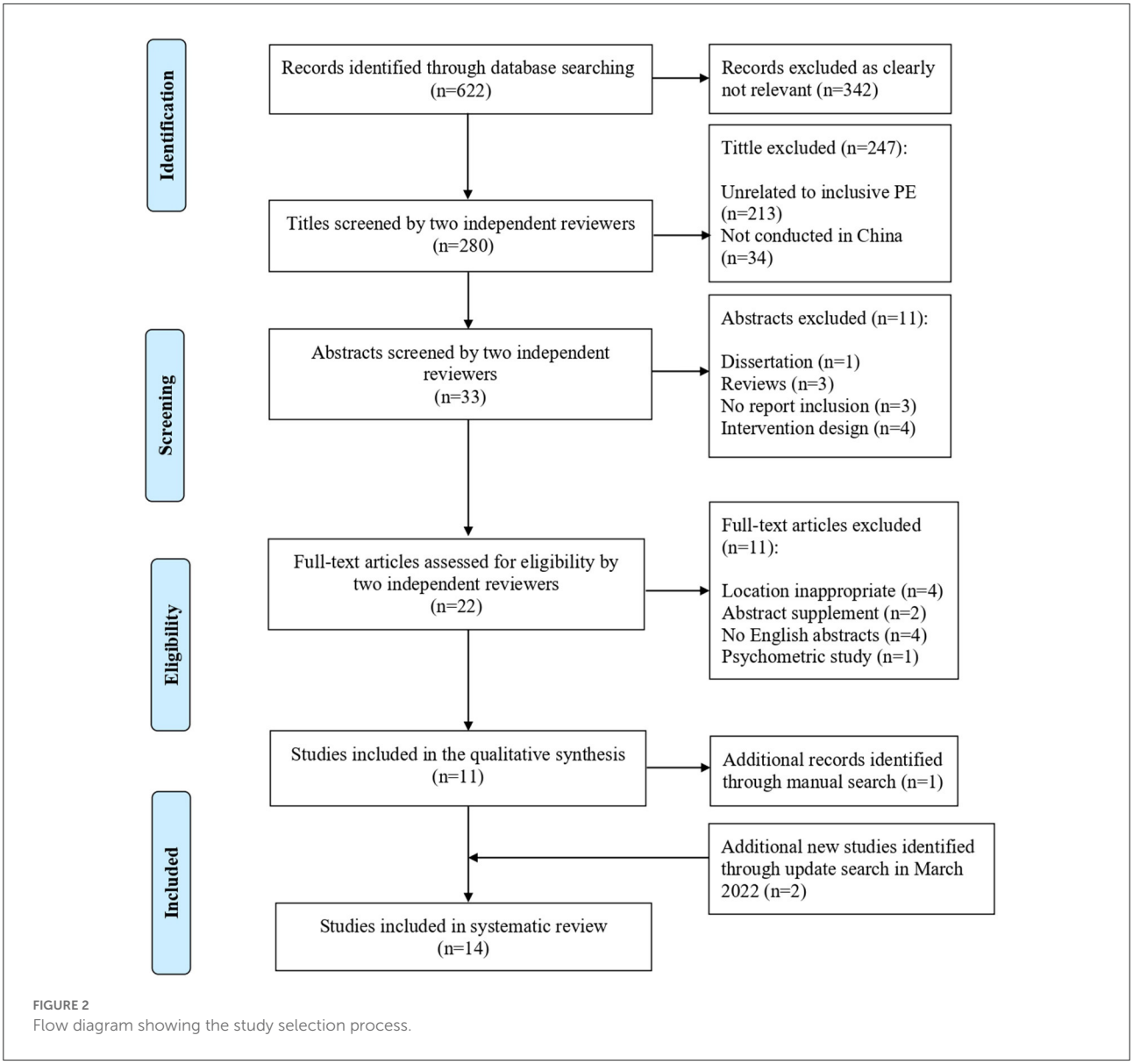

FIGURE 2
Flow diagram showing the study selection process.

Inclusion and excuusion criteria

Studies were included if they:

- were original empirical study;
- contained descriptions of research methodology;
- focussed on the inclusion of students with SEN in IPE
- were studies conducted in Mainland China;
- were peer-reviewed articles with full-text available;
- were written in English or Chinese with English abstracts.

Studies were excluded if they:

- focused on students with disabilities in special schools;
- were literature reviews, systematic review, narrative review, case/government reports, conference papers, book chapters and validating new instruments;
- focused exclusively on PA in other environments (e.g., recess, lunchtime, after school, home);
- were studies conducted in other regions/countries rather than Mainland China.

Data selection

A total of 622 articles were found in the initial search of the five databases described. Figure 2 illustrates the number of articles screened and those that met the inclusion criteria. To ensure the accuracy of the systematic search process, two reviewers who are familiar with the field of inclusive education and PE research independently conducted the multi-step search

process. They screened the titles, abstracts, and full texts to make an initial assessment. Furthermore, if two independent reviewers disagreed with the screening papers, the third reviewer would discuss those particular papers with two reviewers and make a final call. Thirty-three abstracts met the inclusion criteria. After screening the abstracts, twenty-two articles were selected to conduct full-text screening, and 11 articles met the inclusion criteria. In addition, one manually-searched article with an agreement of two independent reviewers met the inclusion criteria. The updated search (up to March 2022) yielded an additional two studies that het the inclusion criteria. Finally, 14 articles were selected for the systematic review.

Data extraction

Data were extracted using a standardized form, including the relevant data about bibliographic details (author and year), participant characteristics (target sample, sample size, age range, sex, school placement, location), study design, research purpose, theoretical framework, research methods, major findings, and factors related to IPE within SEM.

Quality assessment

The McMaster Critical Review Form for quantitative and qualitative studies (28, 29) was used to evaluate the methodological quality of the included articles based on the Guidelines for Critical Review Form-Quantitative Studies and Qualitative Studies (30). The scoring criteria developed by Imms (2008) was employed to interpret the methodological quality. The three key criteria in the included quantitative studies were evaluated: sample, measurement, and analyses (31). The four key criteria in the included qualitative studies were scored: credibility, transferability, dependability, and confirmability (32). Each criterion was scored with one star (no evidence can meet any criteria); two stars (some evidence can meet the criteria, or the report is unclear); three stars (the evidence in the study can meet the criteria) (31, 32). All included studies were independently evaluated by two reviewers (XL & MH). Discrepancies between the two reviewers were resolved by discussion until consensus was finally reached.

Data analysis

To identify factors as being "related" or "not related" to IPE participation of children with SEN, those potential factors showing a statistically significant association with the IPE participation for quantitative methods and the authors' discussion for qualitative studies were reviewed so that these could be generated and coded as IPE-related factors.

Results

Descriptive characteristics of included studies

A descriptive summary of the included studies is presented in Table 1. Of the 14 papers, six studies (43%) were published in peer-reviewed English journals after 2015. The included studies were mainly conducted in developed areas of China, such as Shanghai and Beijing, all of which used a cross-sectional design. In addition, 11 included studies (79%) recruited pre-and in-service PE teachers as their primary research participants, whereas four studies (33%) focussed on students with SEN, and three studies (21%) included students without SEN. Furthermore, only five studies (36%) in the English journal adopted a theoretical framework to analyse the findings; half of the Chinese journal studies adopted self-edited questionnaires and did not provide detailed information about respondents (e.g., age, sex, and educational background).

Quality assessment

Qualitative studies

Three studies used a qualitative research design (33–35). Only one study, (34), scored the maximum ranking in all four quality assessment criteria. The study conducted data triangulation from multiple sources using multiple research methods (survey, observation, & interview). The study also provided clear and detailed information on participants' data analysis and used three layers of strategies for data trustworthiness. Two studies provided evidence to meet one or two criteria of the quality assessment (33, 35). This is because they did not report detailed information of the sample, the trustworthiness of interview data and adopted a limited method for data triangulation.

Quantitative studies

Eleven studies mainly used a quantitative research design (36–46). Overall, the quality of quantitative studies was lower than the qualitative studies. Few studies met all three criteria of quality assessment. All studies adopted a questionnaire as the significant approach to collect data, provided unclear information of participants and participants in all nine studies were recruited through convenience sampling. In addition, two

TABLE 1 Summary of participants' characteristics and quality assessment of included studies.

Author and year	Participants	Placement	Data collection location	Sample size	Sex	Age range (Mean, SD)	Quality assessment		
								Sample	Methods	Analysis
Quantitative methods										
Wu et al. (36)	The student with PD; PE teachers	University	All China	1619 students; 374 PE teachers	NR	NR	*	*	*	
Hao et al. (37)	In-service PE teachers, school administrators	Primary school	Beijing, Northern China	342 PE teachers; 371 school administrators	NR	21-56	**	*	*	
Han (39)	PE teachers	Primary, and secondary school	Beijing, Northern China	194	130M, 64F	21-50	**	*	*	
Liang et al. (40)	School leaders, in-service PE teachers	Primary school	Hebei Province, Northern China	65 school administrators; 72 PE teachers; 93 students with SEN	NR	NR	*	*	*	
Liu et al. (41)	Students with and without SEN	Primary school	Hangzhou, Southern China	60	34M, 26F	9-12	**	*	*	
Liu and Zhang (42)	Pre-service PE teachers	University	Tianjin, Wuhan, Shanghai, Guangzhou, Xi'an	1124	888M, 236F	NR (21.7, 1.6)	**	*	*	
*Wang et al. (33)	PE teachers	Primary, Secondary, High school	Shanghai, Eastern China	195	124M, 71F	22-52 (33, 6.71)	**	*	*	
Wang and Liu (45)	Pre-service PE teachers	University	Xi'an, Tianjin, Shenyang, Chengdu	644	375M, 269F	NR	*	*	*	
Liu and Wang (45)	Pre-service PE teachers	University	Shenyang, Chengdu, Haikou, Xiamen, Wuhan, Xi'an, Tianjin, Quanzhou	490	289M, 201F	NR	*	**	**	

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TABLE 1 Continued

Author and year	Participants	Placement	Data collection location	Sample size	Sex	Age range (Mean, SD)	Quality assessment			
								Sample	Methods	Analysis
*Wang and Qi (46)	Students with and without SEN	Primary school	Shanghai, Eastern China	872	461M, 411F	8-13 (10.79, 1.03)	**	*	**	
*Wang et al., (38)	Pre-service PE teachers	University	Beijing, Shenyang, Chengdu, Wuhan, Shanghai, Xiamen	490	289M, 201F	NR (21.3, 0.23)	**	*	**	
Qualitative methods							**Credibility**	**Transferability**	**Dependability**	**Confirmability**
*Wang et al. (33)	PE teachers	Secondary and high school	N/A	5	3M, 2F	24–55 (38.4, NR)	**	*	**	**
*Qi and Wang (34)	PE teachers, students with and without SEN	Secondary school	Shanghai, Eastern China	3 students with SEN; 42 students without SEN; 1 PE teacher	29M (including students with SEN and PE teacher),17F	NR	***	***	***	***
*Wang et al. (33)	Students with SEN	Secondary school	Shanghai, Eastern China	20	13M, 7F	12–16 (13, 1.13)	**	**	**	**

*, English paper; M, male; F, female; SD, standard deviation; NR, not reported, no data provided; a, no criteria were met within that component; b, only some criteria were met within that component; c, all criteria were met within that component.

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TABLE 2 Summary of included studies and IPE related findings.

Author and year	Research purpose	Theoretical framework	Method	Major findings	Factors related to IPE in SEM				
					Individual	Interpersonal	Organisational	Community	Societal
Wu (36)	Investigate the current situation of the acceptance of students with physical disabilities in PE class in universities	NR	Questionnaire; Interview	Nearly all surveyed students are satisfied with PE class, but PE teachers lack training and knowledge of APE to arrange diverse activities for students	NR	NR	• Completion of the school support system+; • PE curriculum modification+	NR	NR
Hao et al. (37)	Investigate the attitudes and working condition of in-service PE teachers on LRC in Beijing	NR	Questionnaire; Interview	In-service PE teachers in Beijing hold negative attitudes to LRC and reported diverse barriers to practice	NR	NR	• Heavy teaching load-; • Lack of resource room-	NR	NR
Han (39)	Investigate the factors that influence the attitudes toward teaching students with SEN in inclusive PE	NR	Questionnaire (PEATID- III)	Teachers who had a bachelor's degree in special education are more willing to accept students with SEN in inclusive PE.	• Severe disability conditions of the students-	• Teachers had a positive experience in teaching students SEN+; • Teachers knew special education+	NR	NR	NR
Liang et al. (40)	Explore the current situation of inclusive PE in inclusive schools in Hebei Province	NR	Questionnaire	School leaders and PE teachers hold negative attitudes toward including students with SEN in general PE	• Students with SEN were unwilling to participate in PE-; • Disability type (PD)-; • Lack of participation interests-	• Teachers' negative attitudes toward inclusion-	• Lack of resource rooms-; • None curriculum modifications-; • Low attendance rate-	NR	• Lack of policy and financial support-

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TABLE 2 Continued

Author and year	Research purpose	Theoretical framework	Method	Major findings	Factors related to IPE in SEM				
					Individual	Interpersonal	Organisational	Community	Societal
Liu et al. (41)	Investigate the effects of implementing inclusive PE between students with and without SEN	NR	Questionnaire	Students without SEN hold negative attitudes toward inclusive PE due to lack of professional TA during class	NR	• Unprepared parental involvement-	• Competitive PE content-; • None game rules modification-; • Safety concern-	NR	NR
Liu and Zhang (42)	Investigate the self-efficacy of pre-service PE teachers on teaching students with SEN in inclusive PE	NR	Questionnaire	Pre-service PE teachers showed low levels of self-efficacy in teaching students with SEN duo to lack of knowledge on APE.	NR	• Teachers knew APE and had internship experience+; • Teachers had negative attitudes toward inclusion-	NR	NR	NR
*Wang et al. (43)	Examine the behavioural beliefs of PE teachers about teaching students with SEN in inclusive PE; Identify the factors that contribute to their beliefs	Behavioral Belief	Questionnaire	Beliefs of Chinese PE teachers vary according to the disability conditions. Teachers who had taken adapted-PE courses have positive beliefs about including students with SEN	• Disability conditions of the students (e.g. PD, emotional and behavioural problems)-	• Teachers had taken adapted-PE courses+; • Teachers had a positive experience in teaching students SEN+; • Rejection of TD peers-	• Lack of school support-	NR	NR

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TABLE 2 Continued

Author and year	Research purpose	Theoretical framework	Method	Major findings	Factors related to IPE in SEM				
					Individual	Interpersonal	Organisational	Community	Societal
*Wang et al. (43)	Examines the teaching behaviour of PE teachers in teaching students with SEN; Identify factors that determine their teaching behaviours	Theory of planned behaviour	Observation; interview	PE teachers try to create a positive learning environment for students with SEN, but they lacked personnel support, failed to modify their instruction, and sometimes excluded the students with disabilities from cooperative activities	NR	• Teachers' positive attitudes and behavioural intention+; • Lack of professional training on adapted PE-; Teachers' professional responsibilities and sense of achievement+	• Lack of school support-; • Safety concern-; • Large class size-	NR	NR
Wang and Liu (44)	Explore the self-efficacy of pre-service PE teachers who studied PE and APE toward inclusion.	NR	Questionnaire	Students who studied PE had higher self-efficacy scores than students studying APE	• Disability type (ID, PD, VI) -	• Had work experience with students with SEN**00**	NR	NR	NR
Liu and Wang (45)	Investigate the self-efficacy of college students who studied PE toward inclusive PE compared with students in America	NR	Questionnaire	Students who received related course knowledge in inclusive PE and work experience in students with SEN had higher self-efficacy scores	• Disability type (ID&PD)+	• Knew inclusive PE+; • Had work experience with students with SEN+	NR	NR	NR

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TABLE 2 Continued

Author and year	Research purpose	Theoretical framework	Method	Major findings	Factors related to IPE in SEM				
					Individual	Interpersonal	Organisational	Community	Societal
*Qi and Wang (34)	Examine the social interactions between students with and without SEN in inclusive PE in the Chinese context; Explore contextual factors that may determine their social interaction	The social model of disability	Observation; interview	Students with SEN have almost no social interaction with classmates without SEN in inclusive PE classes	• Students' disability types (e.g. autism)-	• TD peers' negative attitudes-	• Frequent individual PA programs during inclusive PE class-	NR	NR
*Wang (35)	Explore the perceptions of students with SEN on inclusive PE in the Chinese context; Identify the personal, physical and social context factors that facilitate or inhibit PE inclusion	Social-relational model of disability	Interview	Majority of students with special needs had negative attitudes to their inclusion, and restricted participation in physical education activities was common	• Disability conditions (e.g. PD) -; • Low self-efficacy of students with SEN-	• Lack of teacher support-; • Peer acceptance+ or isolation-	• Unprepared school environment-; • Unmodified PE facilities-; • Lack of curriculum & instruction modification-	NR	NR

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TABLE 2 Continued

Author and year	Research purpose	Theoretical framework	Method	Major findings	Factors related to IPE in SEM				
					Individual	Interpersonal	Organisational	Community	Societal
*Wang and Qi (46)	Examine the general and sport-specific attitudes of elementary school students toward including students with disabilities in physical education and identifying student-related variables that determine such attitudes	NR	Questionnaire (CAIPE-R)	The Chinese students showed unfavourable general and sport-specific attitudes toward PE inclusion	NR	• Having a student with disabilities in PE+ • Sex (i.e. female)+; • Student-perceived competiviveness-	• Rules modification-	NR	NR
*Wang et al. (38)	Explore how perceived social support could affect the self-efficacy of PE major students who are expected to face students with different types of disabilities	Self-efficacy theory	Questionnaire	APE studies and internships positively affected self-efficacy among Chinese PE majors who would be facing students with different types of disabilities	NR	Perceived social support+	• APE courses and interships+	NR	NR

*, English paper; PEATID III, Physical Educators' Attitude Toward Teaching Individuals with Disabilities III; NR, no report; +: positive association; -, negative association; **00**, inconsistent association; PD, physical disability; ID, intellectual disability; VI, visual impairment; CAIPE-R, Children's Attitudes toward Integrated Physical Education – Revised Scale; APE, Adapted physical education.

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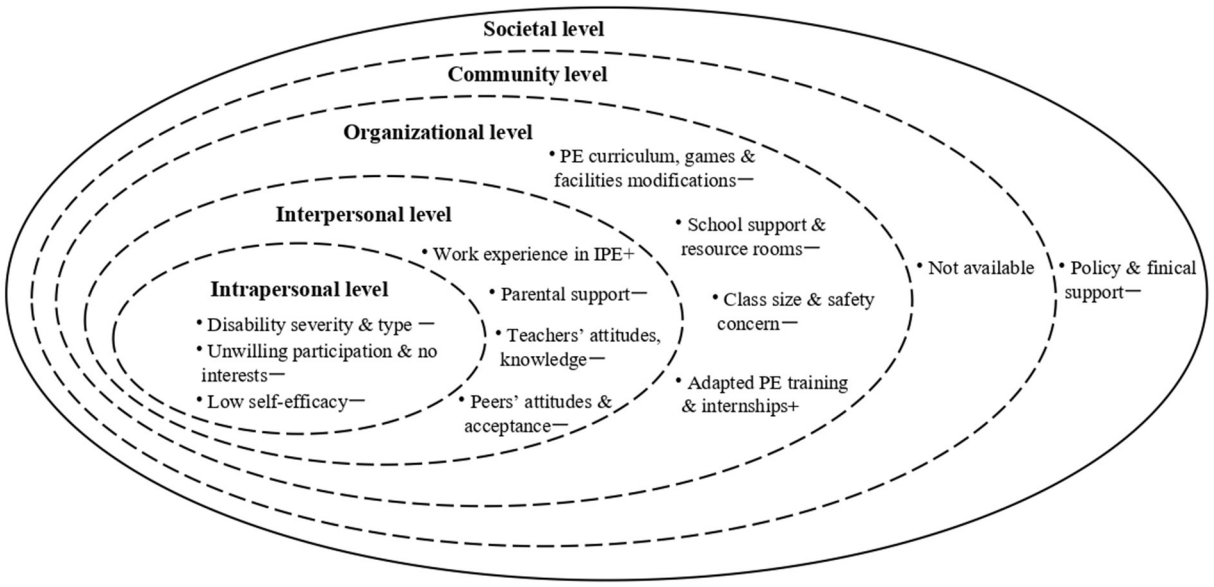

FIGURE 3
Factors affecting the IPE participation for students with SEN within the social ecological model in China. +, positive association; -, negative association.

studies (37, 40) did not report the reliability or validity of outcome measures.

Factors affecting IPE participation of students with SEN

Multi-level factors that affected the IPE participation of students with SEN within the Chinese context are summarized in Table 2. At the intrapersonal level, disability type was considered a critical factor affecting the IPE participation of students with SEN (34, 35, 39, 40, 43–45). PE educators frequently reported that students with physical disabilities had difficulty participating in IPE (35, 40, 43, 44). Also, the low self-efficacy of students with SEN decreased their interest in IPE participation (35, 40). At the interpersonal level, pre-and in-service PE teachers played a crucial role in IPE participation, including their negative attitudes toward teaching students with SEN, limited knowledge and training on adapted PE that impeded the implementation of the IPE (33, 38–40, 42, 43, 45). Besides, TD peers' negative attitudes, peer isolation and peer's perceived competitiveness also limited the IPE participation of students with SEN (34, 35, 43, 46). But, one recent study found that girls had more favorable IPE attitudes than boys (46). At the organizational level, limited school support for PE teachers and curriculum or rules modification for students with SEN hindered the IPE engagement of students with SEN (33, 35, 37, 40, 41, 43, 46). At the community level, no related research has focussed on the community-based inclusive PA programmes that affected the IPE participation of students with SEN. At the societal level, only one study reported that school leaders and PE teachers indicated that they lacked the policy and financial support to implement IPE (40). The factors affecting IPE participation in China have been summarized in Figure 3.

Discussion

This review aimed to explore the factors affecting IPE participation of students with SEN in China. In compliance with the SEM, the factors affecting IPE participation can be divided into five levels ranging from the intrapersonal to the societal level.

At the intrapersonal level, the types of disabilities of students with SEN were given more focus on inclusive PE in China. PE educators indicated that students with PD could not actively participate in IPE classes (35, 40). Early researchers in China also stated that students who suffered from severe disabilities should be taught in special schools (47). These findings are echoed by other studies in different regions and countries that a student's disability type and severity impacted IPE participation (12, 48, 49).

At the interpersonal level, teachers have been the primary focus. Research on attitudes toward IPE in China indicated remarkable differences between pre-and in-service teachers. For example, in-service teachers philosophically supported IPE classes in the general (33, 39, 43), but they were concerned

about their limited knowledge and teaching skills and receiving insufficient support from teaching assistants and the teaching equipment (33, 40, 43). Pre-service teachers held a negative attitude toward including students with SEN in IPE classes (42, 45). This was because 64.5% of pre-service teachers had no experience in special or inclusive education courses, and only 15% of them had academic knowledge and practical experience in teaching students with SEN in IPE classes (42). Avramidis and Norwich (50) pointed out that the successful implementation of any inclusive policy is largely dependent on educators being positive about the policy. Therefore, there is a need to introduce countermeasures to help physical educators address their concerns to adopt a more positive attitude toward IPE. Secondly, pre-and in-service PE educators frequently reported that they had a difficult time providing high-quality PA programmes for all students as having limited knowledge and insufficient training or internships regarding IPE (33, 43, 45, 46). Concerning pre-service education programmes, the first teacher preparation programme for adapted PE at the undergraduate level was offered in 2001 at Tianjin University of Sports to train specialized PE teachers (22). Other adapted PE programmes at high levels have subsequently been implemented at Shandong Sport University (2004), Xi'an Physical Education University (2006), Liaoning Normal University (2006), Guangzhou Sport University (2008), Quanzhou Normal University (2009), and Wuhan Sports University (2012). In addition, Beijing Sport University (2014) and Fujian Normal University (2008) have accepted master's and doctoral students in adapted PE to cultivate professional educators. Although these universities have established programmes to accept students ranging from the undergraduate to the doctoral level, the number of graduates has been limited, and this number cannot meet the annual demands of various schools. No regular teacher training on adapted PE or IPE has been provided for in-service PE teachers regarding the in-service professional training. Moreover, the Ministry of Education (MOE) has stated that it will organize national-level training as per curriculum standards and that the Education Department of the local people's government should offer training exercises for principals and teachers in special schools and resource teachers in mainstream schools based on the newly released *Health and Physical Education Curriculum* for the blind, deaf and intellectually challenged primary and junior high school students (51). However, detailed action plans have not been published. In addition, the '*Special Education Promotion Plan (2017–2020)*' mentioned that professional training of no <360 h should be provided for special education teachers within 5 years (51). The MOE has launched a series of policies and plans to strengthen teacher training to promote teacher quality. Still, a regular top-down in-service training system has not been established for adapted PE or IPE teachers. Teacher education plays a key role in guiding the implementation of inclusive education by teachers (52). Brown et al. (53) also mentions that if special education-related courses are integrated into general teacher training courses, teachers who participated in such courses would have 60% more confidence to face students with SEN than students who did not receive special education training courses. Therefore, the MOE in China should organize and provide regular and systematic in-service teacher training programmes for promoting teacher professionalization. Lastly, peer rejection was also reported by PE educators and students with SEN (34, 35, 40, 43). In addition, Wang et al. (33) indicated that given the lack of professional support (teaching assistants, adapted PE specialists) in China, general PE teachers have no choice but to accept peer tutors as a Supplementary material. Qi and Wang (34) reported that students with SEN have no social interactions with their TD peers during IPE classes. In contrast, students without SEN express negative attitudes toward interacting with students with SEN during IPE classes. Peer support has been regarded as one of the key factors for implementing the IPE (54). Previous studies reveal that trained peer tutors have positive implications on IPE teaching (54, 55). Therefore, researchers and PE teachers need to design intervention programmes that focus on peer support during IPE, promoting PE participation for all students.

At the organizational level, a lack of support from school was one of the main barriers to inclusive PE participation. Firstly, we found that PE teachers lacked adequate professional support, such as teaching equipment, adapted physical activity specialists, resource rooms and teaching assistants within IPE settings (33, 35, 37, 40, 43). One earlier review also confirms that students with SEN received inappropriate PE services in inclusive schools due to deficiencies in support staff and facilities in the Chinese context (22). Limited equipment and teacher aides tended to be the main challenges that physical educators encountered during their daily work. Wang (35) reported that students with SEN used the same equipment as their TD peers and that the equipment size and color became an obstacle to their participation in inclusive PE.

Meanwhile, students' safety in PE classes was a significant concern for PE teachers as insufficient professional support services had been provided for teachers (33, 35). The lack of teaching assistants and education specialists substantially limits the PA participation of all children, given that the teachers have to spend time and energy ensuring the safety of students with SEN (56). Large class size has been identified as a major barrier for PE teachers in planning their classes (33). A teacher-student ratio with a class size of fewer than 30 students and one or two students with SEN within an inclusive setting is considered manageable for teachers (48, 56). Furthermore, certain PE teachers have indicated that no guidance or syllabus was provided for them to prepare for the course; thus, PE teachers had no modifications in instructions and game rules to help them include students with SEN in the IPE classes (35, 36, 40, 41). In 2007, the MOE (57) issued the *Blind School Compulsory Education Curriculum Experimental Programme*, the *Deaf School Compulsory Education Curriculum Experimental*

Programme and *School for Children with intellectually challenged Compulsory Education Curriculum Experimental Programme*, which established a curriculum standard for teachers who work with children with disabilities, for reference. However, these curricula focus on Chinese, Mathematics and Life Skills, with no specific teaching guidelines for PE classes.

Moreover, with the limited participation of frontline teachers, these curricula have certain inappropriate content and have ignored the needs of students attending mainstream classes (58). In 2016, the MOE launched the latest revised version of *Compulsory Education Curriculum Standards for Deaf Schools, Compulsory Education Curriculum Standards for Blind Schools* and *Compulsory Education Curriculum Standards for Schools' Intellectually Challenged Children*. As the central area of compulsory education, *PE and Health* have been included in the curriculum standards for children with disabilities. Curriculum modification or teaching flexibility is crucial in IPE for pupils with SEN (59). The tailored teaching guidelines or curriculum standards for IPE teaching preparation can help PE educators prepare to teach content, which can promote active play for all students.

At the community level, we found that none of the studies have examined the effects of regular community-based PA engagement on IPE participation in students with SEN. One possible explanation is that there are a limited number of inclusive PA programmes held by PA organizations. For example, the Special Olympics was introduced in China in 1985. The Special Olympics China has organized some PA programmes for people with intellectual disabilities to promote social inclusion in collaboration with the CDPF since 1998 (60). But only 20% of participants can join in Unified Sports and most Special Olympic Programmes, which were primarily organized by special schools (60). This may explain why fewer community-based PA programmes can be introduced to promote social inclusion. Schools and parents are encouraged to arrange more PA programmes, to help students with SEN enjoy more significant social interaction with their TD peers and gain diverse experience in PA, which might lead to an interest in IPE participation with their TD peers.

At the societal level, one study found that PE teachers and school leaders lacked the policy and financial support to implement IPE (40). Li and Sam (22) also list some policies related to IPE to indicate that there are no specific policies or laws to support the implementation of inclusive PE. Supportive, inclusive education policy at a national level is the major driving force for ensuring the global development of inclusive education (61). Clear policies that mandate specific standards and guidelines on the time allocation of PA and PE programmes have positive implications for the promotion of PA (62). Although the Chinese government has issued LRC policies and practiced them for nearly 20 years, the contents related to IPE are limited. For example, in 2010, the Chinese government published an influential policy document, '*Guidelines for Mid- and Long-term Education Reform and Development (2010–2020)*'. This document positioned inclusive education as an emergent priority for education development and created governmental momentum for the inclusive education (63). Furthermore, the Chinese government has given increasing attention to '*Health for All*' and has issued a series of policies to implement health promotion in recent years. For example, the '*Health China Initiative (2019–2030)*' clearly required that primary and secondary students needed to exercise for 2 h each day, namely 1 h at school, and 1 h after school (64). More key laws and policies related to IPE in China have been summarized in Appendix. Therefore, workable policies, laws, and school regulations supporting IPE programmes, especially those focusing on inclusive PA promotion with detailed teaching assessments and guiding principles, can be expected.

This is the first systematic review to examine the factors affecting IPE participation within the Chinese context, grounded with SEM as a theoretical framework. Students with SEN have been included in IPE classes playing with their TD peers, and multi-level factors affecting their IPE engagement were identified. There are several limitations of this review. First, few studies focused on the IPE in China, and only six studies were published in English, which provided limited information to the international readers. Second, included papers emphasized the pre-and in-service PE teachers; few studies focused on the students with SEN. Although the intrapersonal level was the focus of the SEM, we could not identify enough factors at this level from the aspect of students with SEN. Thirdly, questionnaires were the most frequently used quantitative research methods in included studies, which may cause information bias or recall errors. Lastly, for studies focusing on students with SEN, interviews and observation dominated the research methods, making it challenging to understand whether students with SEN are active to meet the physical activity guidelines during the IPE classes. Therefore, objective measurement tools (i.e., accelerometer) should be considered to record PA levels of students with and without SEN during the IPE classes.

Conclusion

We believe that the focus on IPE in China is limited. However, there is an opportunity to expand a PA promotion for students with SEN to enable them to maintain their health in inclusive settings. In addition, efforts to overcome the barriers to PA encountered by students with SEN require a comprehensive approach, especially with high-quality IPE intervention programmes. To the best of our knowledge, it is the first time that SEM has been adopted in IPE to investigate the factors that hinder or promote IPE in China. We find that the Chinese government has made great efforts to encourage the development of inclusive education and focussed more on PE and health-related programmes in recent years. However, IPE still attracts little attention from researchers. Our

findings suggest that more attention and efforts to Chinese IPE development should be emphasized at organizational and community levels. From the organizational level, high-quality pre-service and in-service IPE teachers' training, IPE curriculum modification guidelines and school resource support should be provided for school IPE educators. From the community level, home-school collaboration needs to be strengthened so that parents can provide after-school PA programs and utilize community PA facilities guided by school IPE educators to help their children with SEN to be more active. Lastly, we recommend that PA and IPE researchers in China develop more tailored curriculums in IPE and provide extra-curriculum PA interventions focusing on students with SEN to help them include in the whole school.

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

XL and CS proposed and designed the review, searched, and collected the literature. XL, ML, and CS analyzed and interpreted the literature. XL drafted the manuscript. ML, YW, XW, XH, and CS contributed to the revision and approval of the submitted and final version of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.902791/full#supplementary-material

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Perceived impact of the COVID-19 pandemic on infection containment training and mental state of dental residents in China: A longitudinal study

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Background: COVID-19 has presented a challenge for dental settings and dental schools: how to continue providing dental care and maintain education during the pandemic while remaining healthy. We highlight the necessity of infection containment control training for dental residents and rethink the tasks of safeguarding trainees' health and cultivating their abilities to deal with public health crises in the future. This paper may also serve as a health policy reference for policy makers.

Objective: The study aimed to compare the formats, frequency, contents, emphasis, and test scores of infection containment control training pre- and post-pandemic. Besides, after the COVID-19 outbreak, we assessed the increased anxiety level, communication difficulties, and confidence of dental residents impacted by the pandemic.

Methods: A total of 251 dental residents in Stomatological Hospital of Chongqing Medical University were recruited to complete a questionnaire of their routine involvement in infection control training before and after the COVID-19 outbreak. A self-designed 10-point Likert scale was used to assess the increased anxiety level, communication difficulties, and confidence in facing with the future public health crisis impacted by the pandemic.

Results: After the outbreak, although more trainees chose online assessment than offline assessment, most of them (74.90%) still preferred in-person training rather than online training. Contents that trainees had been focusing on were affected by the COVID-19 outbreak. Thereafter, they were more inclined to learn crisis management. Over half of the participants (56.17%) participated in training more frequently after the outbreak. However, postgraduate students participated in training less frequently than others after the outbreak ($p < 0.01$). First-year trainees accounted for the majority in the population who emphasized considerably on infection control training and whose test scores had increased after the outbreak. In addition, the percentage

of women scoring increasingly in post-pandemic assessment was significantly higher than that of men. In this study, the average increased anxiety level caused by COVID-19 was 5.51 ± 2.984, which was positively related to communication difficulties with patients caused by the pandemic. The trainees whose homes were located in Hubei Province showed higher increased anxiety levels (8.29 ± 2.93) impacted by the pandemic than the trainees from other provinces ($p < 0.05$). However, the former's confidence in coping with future public health crises was not significantly different from that of others ($p > 0.05$).

Conclusions: Owing to the impact of COVID-19, the contents that the trainees focused on, frequency, emphasis, and test scores of infection containment control training were changed. Some recommendations have been provided for policy makers to attach importance to crisis-based training to cultivate dental residents in the post-pandemic era.

KEYWORDS

COVID-19, pandemic, dental residents, infection containment control, training

Introduction

The emergence of the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes the corona-virus disease (COVID-19), has led to a global pandemic (1). Consequently, it has contributed to a colossal loss of lives and has also resulted in considerable impact on the healthcare industry globally (2). Owing to the characteristics of dental settings and COVID-19 transmission routes (3–5), infection risk may be high between dental care professionals and patients (6, 7). Accordingly, measures were implemented to reduce the infection risk, such as limitation on or postponing non-emergency healthcare appointments and treatments (8), focusing on hand hygiene (9), requiring dental professionals to use personal protective equipment (PPE) (10, 11), and patient check-in registration at the reception area (12). However, the first case of a dentist testing positive for COVID-19 was reported on 23 January 2020. Eventually, transmission to eight other oral healthcare professionals was reported (13). A survey showed that 50–70% of dental professionals admit to experiencing high stress and anxiety levels as a result of the COVID-19 pandemic (14, 15).

The most significant challenge for dental schools is attempting to balance the important task of safeguarding the health of students and ensuring continuity in education (16). Dental residents are not a separate entity but future dentists, thereby prompting us to identify the importance of infection control containment training. Stomatological Hospital of Chongqing Medical University has a long-term project on infection containment control training every 3 months before and after the COVID-19 outbreak. In addition, no less than two lectures are held by training specialists monthly, in which infection containment control topics are included. These training and lectures are open to dental residents. During the COVID-19 lockdown from February to June 2020, we adopted "smart strategies" to reduce its impact, such as distance education and online learning tools to teach infection prevention. However, the effect of these strategies was uncertain, and associated changes may further result in possible stress and anxiety on the part of dental residents. Since the start of the COVID-19 pandemic, there has been limited information on how dental residents can handle infection to be able to continuously provide dental health care. A comprehensive description of the impact of COVID-19 on infection containment control training of dental residents in China has yet to be reported.

The purpose of this study is to explore perceived impact of the COVID-19 pandemic on infection containment training and mental state of dental residents in China. The COVID-19 emergency-battle experience was a natural call to the competencies of dental residents. Hence, we gained valuable experience in adapting and improving educational methodologies for dental residents during this public health crisis.

Materials and methods

Study design

In the study, we mainly used pre- and post-pandemic design. Infection containment control training of dental residents is a long-term project of Stomatological Hospital of Chongqing Medical University before and after COVID-19. A link of a self-designed questionnaire, including training formats, frequency, contents, and emphasis, was used to collect suggestions from

trainees. A test was used to assess training effectiveness after each training. Besides, to acquire the increased anxiety level, communication difficulties, and confidence in facing with the future public health crisis impacted by the pandemic, we added three extra questions in the post-pandemic questionnaire.

Questionnaire

The pre- and post-pandemic questionnaire was developed in Chinese and further revised by two epidemiologists. We conducted a pre-survey and collected 30 samples for reliability and validity tests. The reliability of Cronbach's alpha coefficient of the questionnaire was 0.83. The KMO validity statistical test (KMO =0.916) and the Bartlett sphericity test ($p < 0.0001$) were also used.

The pre-pandemic questionnaire included the following components: (1) 6 questions about demographic characteristics of the participants; (2) 7 questions about form, frequency, contents, and emphasis; (3) 1 question about suggestions on training and tests. Moreover, the post-pandemic questionnaire included 3 additional questions on the following aspects: the level of anxiety, confidence, and difficulties of communicating with patients related to COVID-19. A 10-point Likert scale was used: 0 = lack, 5 = medium, and 10 = very high level.

. Do you think the COVID-19 increased your anxiety level? If yes, please score:__; if no, please turn to the next.

. Do you think the COVID-19 increased the difficulties of communicating with patients? If yes, please score:__; if no, please turn to the next.

. Owing to the participation in the entire process of fighting COVID-19, do you have confidence in coping with public health emergencies in the future? If yes, please score:__.

Sampling

Due to a non-random sampling survey, the sample size was at least 10–20 times of the number of variables. Assuming that the questionnaire has 16 variables and a 10% non-response rate approximately, the estimated sample size was about 188–377. All 258 dental residents from Stomatological Hospital of Chongqing Medical University were expected to participate in the study and complete the investigation. All the trainees had the opportunity to refuse participation when the questionnaire was distributed.

Ethics committee approval and informed consent process

The aim of the study was explained in detail before the participants were recruited. Ethics committee approval of the Stomatological Hospital of Chongqing Medical University was obtained (CQHS-IRB-2021-17). All the participants were asked to provide their written informed consent. Inclusion criteria were as follows: residency in stomatology, active participation in the research, and informed consent. The participants who missed more than two questions were excluded.

Measurements on training and COVID-19 impacts

An assessment was conducted after each infection containment control training. This study compared test scores of training pre-pandemic in November 2019 and post-pandemic in January 2021. The format of the offline test was consistently used pre-pandemic, while the online test was adopted post-pandemic. The results of the assessment were announced to the trainees 1 week after the test. The full mark was 100 in each examination, and 60 was a pass score. The higher score the trainees got, the better training effectiveness they had.

Statistical analyses

SPSS-20.0 was used for statistical data analysis. Chi-square, ANOVA, and Spearman correlation tests were used to control confounders. All tests were performed at a significance level of $\alpha = 0.05$.

Results

Demographic characteristics of study population

A total of 251 (97.29%) of all dental residents completed the questionnaire; the other 7 participants were excluded from data analysis, owing to missing more than two questions. The age range was between 18 and 31 years, with mean age of 25.41 ± 1.8 years. Most of the 238 (94.82%) participants were in their second decade of life. Demographics of the survey participants are listed in Table 1. A total of 101 (41%) participants were male, and 150 (58.98%) were female. The proportions of the participants attending the first, second, and final years were 43.43% ($N = 109$), 22.31% ($N = 56$), and 34.26% ($N = 86$), respectively. No differences were found among the participants of different years in terms of age, gender, training year, status, and specialization. A total of 7 trainees were from Hubei province (whose homes were located in Hubei province) where the first case of novel type of pneumonia was reported in December 2019.

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TABLE 1 Characteristics of participants.

Variables		Total $N = 251$
Age	≦25	142 (56.57)
	≧26	109 (43.43)
Gender	Male	101 (40.24)
	Female	150 (59.76)
Training year	1	109 (43.43)
	2	56 (22.31)
	3	86 (34.26)
Hometown	Chongqing	110 (43.82)
	Hubei	7 (2.79)
	Others	134 (53.39)
Status	Postgraduate	125 (49.80)
	Others	126 (50.20)
Specialty	Conservative dentistry	90 (35.86)
	Oral and maxillofacial surgery	45 (17.93)
	Prosthodontics	46 (18.33)
	Orthodontics	38 (15.14)
	General dental practice	32 (12.75)

Comparison of training and test pre- and post-pandemic

Although "smart strategies" had been adopted to compensate for learning constraints nationwide post-pandemic, most trainees (74.90%) still preferred in-person training (Figure 1A). However, the difference was not significant compared with that pre-pandemic ($p > 0.05$). Before the COVID-19 outbreak, the top three topics that the trainees were most concerned about of infection control training were occupational safety, standard prevention, and oral diagnosis and treatment. Meanwhile, prevention and control policy of COVID-19, infectious diseases management, and standard prevention were the top three topics after the pandemic (Figure 1B). An interesting finding was that, although online training could not replace in-person training, the trainees preferred online testing to offline testing, and their preferred testing software was Ding Talk (China), followed by Chaoxing Digital Library (Beijing). These software platformats were commonly used in distance education in China's universities during the pandemic (17–19). The most suitable test length of time is 20–30 min (Figures 1C,D).

Awareness of infection control training following the COVID-19 outbreak

After the outbreak, most of the participants (141; 56.17%) attended training of infection control more frequently than before the outbreak. Prior to the pandemic, participants who had participated in training one time a year had the highest proportion (91; 36.1%), while the highest proportion (79; 31.3%) attended over three times a year in the post-pandemic period. Training frequency of postgraduate students was significantly lower than that of others after the outbreak ($p < 0.01$).

The COVID-19 pandemic has significantly impacted trainees' emphasis on infection control training. We found that frequency of participation in infection control training was related to emphasis and test scores (Table 2). The impact of COVID-19 on the emphasis of infection control training was distributed as follows: increase, 167 (66.53%); no change, 80 (32.1%); and decrease, 3 (1.19%). Further comparison indicated that significant difference in emphasis on infection containment control training was found among trainees in different training years ($p < 0.05$): trainees from the first and second years accounted for the most (78; 46.71%) and least (29; 17.37%) proportions, respectively, in increasing population. Pearson chi-square results are shown in Table 3.

For the pre- and post-pandemic test scores, there was significant difference between gender and training years ($p < 0.05$): women accounted for the majority (77; 64.71%) in the increase in population, while men accounted for the majority (8; 80.00%) in the decrease in population. Test scores of the 1st-year trainees were most affected by COVID-19: The proportions of increase in population (61; 51.26%) and decrease in population (5; 50.00%) were significantly higher than those of the trainees from other training years, as shown in Table 4.

Impact of COVID-19 on anxiety and confidence of dental residents

During the COVID-19 pandemic, social restrictions resulted in difficulty of patients in understanding what dentists are explaining (20). In addition, usage of personal protective equipment (PPE) obscured dentists' facial expressions, which is important for dentists to earn the trust of patients (21), thereby possibly causing anxiety to dental residents.

In the present study, average increase in anxiety caused by COVID-19 was 5.51 ± 2.984. Increased anxiety levels of trainees whose homes were located in Hubei Province (6.00 ± 3.83) were higher than that of Chongqing and other provinces, and the difference was significant ($p < 0.05$) (Table 5). Owing to the participation of dental residents in the entire process of fighting COVID-19, we were concerned with the impact on their confidence in coping with public health emergencies in the future. In this study, an interesting finding attracted our attention; although residents whose homes were located in Hubei Province argued that COVID-19 brought anxiety, they also had the highest average confidence score (10.29 ± 0.76) in coping with future public emergencies (Table 5).

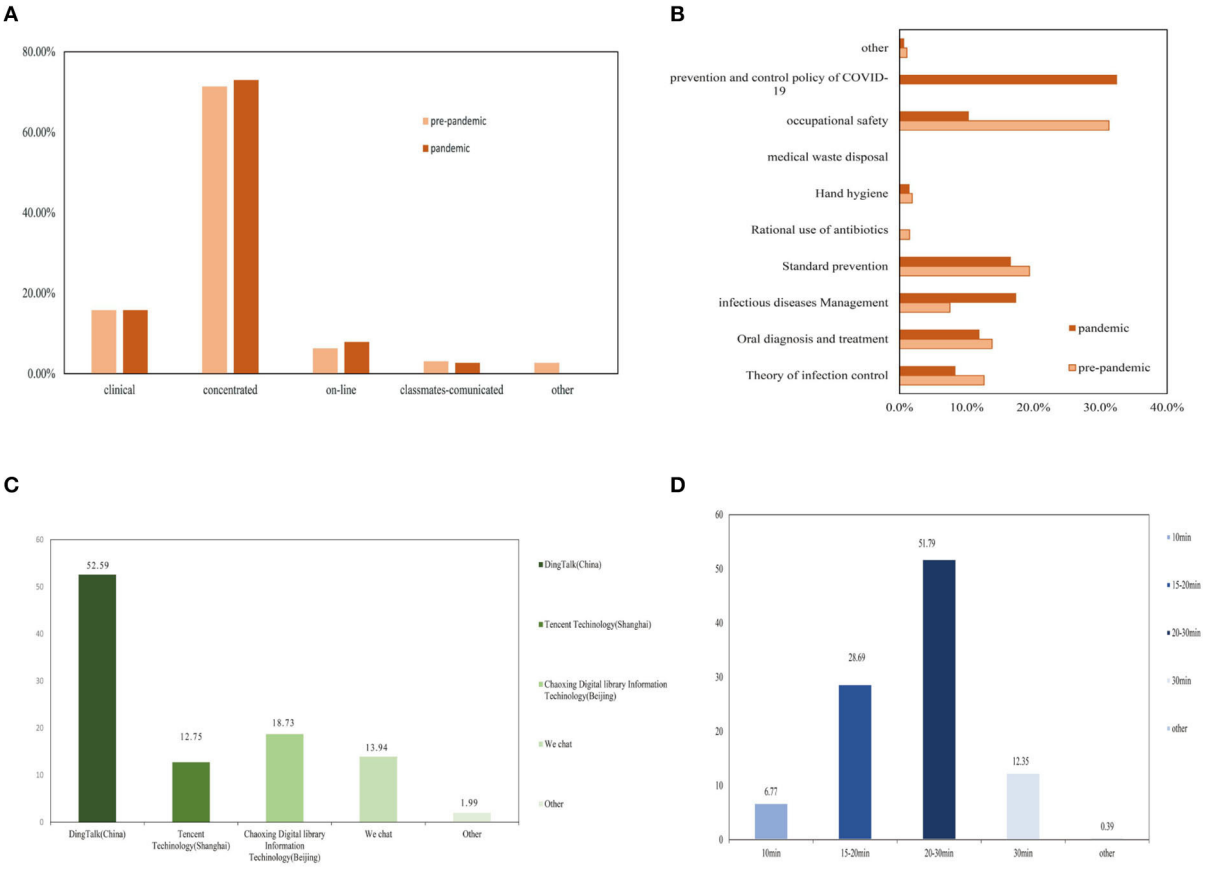

FIGURE 1
Trainees' most popular training formats **(A)** and contents **(B)** pre-post pandemic; Trainees' favorite online-test software **(C)** and suitable test length of time **(D)**.

TABLE 2 Spearman correlation analysis of frequency, emphasis, and the test score.

		Emphasis	Test score
Frequency	*p*	0.027*	0.000*

*Significant at $\rho < 0.05$.

Discussion

The COVID-19 pandemic has influenced every aspect of life (22). The World Health Organization (WHO) declared the pandemic a public health emergency of international concern (PHEIC) (23). Owing to spatters and aerosols generated during dental treatments, dental healthcare professionals (DHPs) are exposed to a high risk of the spread of infectious diseases. Reports indicated that over two-thirds of general DHPs from 30 countries are anxious and scared by the devastating effects of COVID-19 (24). DHPs are in a state of anxiety and fear, owing to the COVID-19 pandemic (14). Anxiety stems from the epidemiological factors of COVID-19 and, also, from the economic factors caused by income reduction, with some DHPs, including dental residents, reporting concerns with their professional future (24, 25). Dental residents are not a separate entity but future dentists. In the fight against COVID-19, they face challenges and also assume responsibilities. How to continue providing dental care during the pandemic and remaining healthy appears to be a challenge. Hence, infection control training objectives and contents have constantly attracted medical educators.

The main aim of this crisis-based study was to assess the infection control training pre- and post-pandemic and mental state of dental residents impacted by the COVID-19. Given the sudden changes in quarantine time from February to March 2020, we cut off in-person exposure in all aspects, including routine practice, teaching conferences, and academic activities. We applied several innovative solutions to mitigate the loss, including online practice questions, a flipped classroom, and teleconferencing or video (26). Given the importance of containment infection of COVID-19 in the dental setting, we

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TABLE 3 Emphasis of trainees on infection control training pre–post-pandemic.

Variable		Emphasis of trainees on infection control training pre–post-pandemic			Total	χ^2	ρ
		Increase	No change	Decrease			
Gender	Male	62 (37.13)	36 (44.44)	3 (100.00)	101 (40.24)	5.724	0.057
	Female	105 (62.87)	45 (55.56)	0 (0.00)	150 (59.76)		
Training year	1	78 (46.71)	30 (37.04)	1 (33.33)	109 (43.43)	9.719	0.045*
	2	29 (17.37)	27 (33.33)	0 (0.00)	56 (22.31)		
	3	60 (35.93)	24 (29.63)	2 (66.67)	86 (34.26)		
Specialty	Conservative dentistry	61 (36.53)	29 (35.80)	0 (0.00)	90 (35.86)	5.46	0.707
	Oral and maxillofacial surgery	26 (15.57)	18 (22.22)	1 (33.33)	45 (17.93)		
	Prosthodontics	30 (17.96)	15 (18.52)	1 (33.33)	46 (18.33)		
	Orthodontics	28 (16.77)	9 (11.11)	1 (33.33)	38 (15.14)		
	General dental practice	22 (13.17)	10 (12.35)	0 (0.00)	32 (12.75)		
Hometown	Chongqing	78 (46.71)	30 (37.04)	2 (66.67)	110 (43.82)	6.905	0.141
	Hubei	2 (1.20)	5 (6.17)	0 (0.00)	7 (2.79)		
	Others	87 (52.10)	46 (56.79)	1 (33.33)	134 (53.39)		
Status	Postgraduate	76 (45.51)	48 (59.26)	1 (33.33)	125 (49.80)	4.455	0.108
	Others	91 (54.49)	33 (40.74)	2 (66.67)	126 (50.20)		

*Significant at $\rho < 0.05$.

TABLE 4 The test score of infection control training pre–post-pandemic.

Variable		Test score of infection control training pre–post-pandemic			Total	χ^2	ρ
		Increase	No change	Decrease			
Gender	Male	42 (35.29)	51 (41.80)	8 (80.00)	101 (40.24)	7.908	0.019*
	Female	77 (64.71)	71 (58.20)	2 (20.00)	150 (59.76)		
Grade	1	61 (51.26)	43 (35.25)	5 (50.00)	109 (43.43)	10.69	0.030*
	2	17 (14.29)	37 (30.33)	2 (20.00)	56 (22.31)		
	3	41 (34.45)	42 (34.43)	3 (30.00)	86 (34.26)		
Specialty	Conservative dentistry	43 (36.13)	44 (36.07)	3 (30.00)	90 (35.86)	7.204	0.515
	Oral and maxillofacial surgery	19 (15.97)	23 (18.85)	3 (30.00)	45 (17.93)		
	Prosthodontics	20 (16.81)	22 (18.03)	4 (40.00)	46 (18.33)		
	Orthodontics	20 (16.81)	18 (14.75)	0 (0.00)	38 (15.14)		
	General dental practice	17 (14.29)	15 (12.30)	0 (0.00)	32 (12.75)		
Hometown	Chongqing	53 (44.54)	53 (43.44)	4 (40.00)	110 (43.82)	0.648	0.958
	Hubei	4 (3.36)	3 (2.46)	0 (0.00)	7 (2.79)		
	Others	62 (52.10)	66 (54.10)	6 (60.00)	134 (53.39)		
Status	Postgraduate	52 (43.70)	67 (54.92)	6 (60.00)	125 (49.80)	3.467	0.177
	Others	67 (56.30)	55 (45.08)	4 (40.00)	126 (50.20)		

*Significant at $\rho < 0.05$.

proposed Ding Talk, Tencent, Chaoxing, and We Chat apps to carry out infection control training in place of person-to-person training. Eventually, we found that online training could not substitute for person-to-person training, which was consistent with a commentary from the US (27). Whether before or after the COVID-19 pandemic, person-to-person learning is the most effective learning form. Moreover, an interesting phenomenon attracted us: Although in-person training was not replaceable,

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TABLE 5 Impact of COVID-19 on increased anxiety, difficulties of communicating, and confidence of facing with the public health emergency.

	Variable	Increased level of anxiety	*p*	Difficulties of communicating	*p*	Confidence	*p*
Gender	Male	6.12 ± 3.29	0.95	5.76 ± 3.19	0.28	9.15 ± 1.63	0.422
	Female	6.09 ± 3.02		5.35 ± 2.84		8.97 ± 1.84	
Grade	1	6.34 ± 3.22	0.553	5.53 ± 2.80	0.516	9.20 ± 3.09	0.267
	2	5.82 ± 3.04		5.86 ± 3.05		8.73 ± 3.17	
	3	5.99 ± 3.09		5.27 ± 1.94		9.03 ± 1.68	
Specialty	Conservative dentistry	6.12 ± 2.95	0.656	5.32 ± 2.88	0.646	8.90 ± 1.85	0.14
	Oral and maxillofacial surgery	6.58 ± 3.42		5.91 ± 3.12		9.56 ± 1.50	
	Prosthodontics	6.11 ± 3.21		5.17 ± 2.85		8.80 ± 1.77	
	Orthodontics	5.50 ± 3.06		5.53 ± 2.98		9.29 ± 1.68	
	General dental practice	6.09 ± 3.22		5.97 ± 3.32		8.75 ± 1.80	
Hometown	Chongqing	5.58 ± 3.18	0.019*	5.24 ± 3.00	0.418	9.15 ± 1.72	0.085
	Hubei	8.29 ± 2.93		6.00 ± 3.83		10.29 ± 0.76	
	Others	6.42 ± 3.02		5.72 ± 2.93		8.89 ± 1.80	
Status	Postgraduate	6.24 ± 3.13	0.492	5.61 ± 3.05	0.62	9.15 ± 1.74	0.315
	Others	5.97 ± 3.13		5.42 ± 2.92		8.93 ± 1.78	

*Significant at $\rho < 0.05$.

online testing was considered an alternative to online testing by the trainees. The most recommended kinds of software were Ding Talk and Chaoxing Digital Library Information. The length of test time that most dental residents suggested was 20 to 30 min. In the post-COVID-19 era, the hybrid teaching model of person-to-person training and online assessment may be applied to the infection control training of dental residents. Prior to the outbreak, contents that the trainees focused on were occupational safety, standard prevention, and oral diagnosis and treatment. However, anterior to the outbreak, the prevention and control policy of COVID-19 was the first top topic that the trainees were most concerned about. Changes in the training contents indicated that infection containment training should be expanded to competence in crisis management to fill in the training gap.

Frequency, emphasis, and test scores increased in the post-pandemic period compared with the pre-pandemic period, and the three aspects were positively correlated. In terms of frequency, most of the participants (141; 56.17%) had attended training more frequently post-pandemic than pre-pandemic. However, training frequency of postgraduate students was significantly lower than others after the epidemic. The possible reason is that they experienced more stress from scientific research beyond dental practice than others. In the future, we should take infection containment training as a compulsory curriculum in dentistry for postgraduate students. Given the assessment results, gender and training year-matched comparison difference was significant. Women accounted for a larger proportion than men in the population, whose test scores increased after the outbreak. This result was consistent with a report that female participants are predominant in the awareness of the role of dental professionals in preventing the COVID-19 outbreak (28). The possible reason is gender differences in study habits and interest in school (29, 30). The trainees in the 1st year accounted for the most number of the trainees whose emphasis degree and test scores increased after the outbreak. This result was due to the training objectives of Stage 1 (31). By contrast, the freshman trainees had less stress in terms of graduation and employment than seniors.

Increased anxiety levels of dental residents caused by COVID-19 were related to increased difficulties in terms of dentist–patient communication. These difficulties may include postponing elective treatments, use of face shields, limited face-to-face interaction, owing to social distancing regulations, inquiring whether or not patients have symptoms, and taking contact history. Fear and anxiety are considered negative emotions, but they may cause patients to reflect deeply and lead to growth (32). The average increased anxiety level of dental residents whose homes were located in Hubei Province was 8.29 ± 2.93, which was significantly higher than those of the residents from other districts. However, the confidence of dental trainees whose homes were located in Hubei Province was higher than that from other provinces. This result was consistent with a research from China (33). Lastly, these results relatively showed that the trainees whose hometown were Hubei Province reflected deeply on the COVID-19 pandemic.

Some limitations existed in the study. Firstly, the sample size was limited by the enrolled number of the trainees of Standardized Training for Oral Residents in Stomatological Hospital of Chongqing Medical University. The findings may not be generalized and straightforward to different populations of China. Secondly, the bias of the questionnaire was another limitation, because the participants may tend to give socially desirable answers, which may not reflect the reality; further research studies are worth continuing. Lastly, due to the sudden outbreak of the COVID-19, there were no items about the anxiety and confidence impacted by the outbreak in the pre-pandemic questionnaire. However, considering the mental state of the trainees is also the focus of us; three added questions were posted in the post-epidemic questionnaire, which seems susceptible to subjectivity.

Conclusions

"Smart strategies" may help bridge the educational gap for dental residents during this unprecedented circumstance but could not replace person-to-person learning. Data should also be assembled into long-term infection control protocols to run a reliable dental practice. The impact of COVID-19 on infection containment control training is multifaceted, including the contents, frequency, emphasis, effects, and increased anxiety levels. On the bases of experiences from Stomatological Hospital of Chongqing Medical University, dental schools were suggested to expand their curricula, including competencies in pandemic and crisis management. Although the confidence of the trainees whose homes were located in Hubei Province in facing future public health emergencies has not been substantially affected by COVID-19, they had the most increased anxiety levels caused by the pandemic. Professional psychological counseling is absolutely necessary for trainees in public health emergency, particularly for those under immense pressure in pandemic situations.

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 Human Research Ethics Committee at Stomatological hospital of Chongqing medical university approved the protocol (2021.17). The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

LD and JS: study design. DJ: data collection. XZ: statistical analysis. QW: data interpretation. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.900641/full#supplementary-material

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Influence of social distancing on physical activity among the middle-aged to older population: Evidence from the nationally representative survey in China

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Background: Group-based physical activity is an important positive factor assisting the middle-aged to older population to be regularly physically active, especially inside a society with a large population and highly sociable environment. However, when group-based physical activity is restricted during a public health crisis such as the infectious disease pandemic, the influence of social distancing on physical activity among this vulnerable group needs to be recognized.

Objectives: This study aimed to investigate the influence of social distancing on physical activity among the middle-aged to older Chinese population at the national level.

Methods: Data from a nationally representative social follow-up survey (China Family Panel Studies, CFPS) for 2018 and 2020 were used. Physical activity level in year 2018 was set as the baseline to be compared with that for each individual in 2020, when China implemented social distancing during the COVID-19. Chinese population with an age greater than 45 years were included, and three levels of physical activity were established. Logistic models were developed to identify sociodemographic characteristic that may be associated with a higher probability of worse PA behaviors during the social distancing.

Results: Over 46% respondents could be described as being Physically Inactivity during 2018 and this proportion increased to 67.2% in 2020. Respondents who live in the Northeast or rural regions, having a spouse, being employed, having a low level of education, and being of low-income level showed a higher decrease in physical activity compared to other groups. However, individuals living with chronic diseases emerge as being more likely to maintain positive habits with respect to physical activity in this context.

Conclusion: Social distancing during the COVID-19 pandemic has significantly influenced the extent of physical activity among middle-aged to older Chinese residents. This is especially true in respect to middle-aged

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and elderly people who are at increased risk of chronic diseases. Given this, there is a clear need to consider effective modalities for physical activity in the context of social distancing based on home quarantine and city lockdown. Furthermore, specific health-related strategies need to be considered in relation to different regions and populations.

KEYWORDS

physical activity, social distancing, middle-aged to older population, health promotion, health education, China

Introduction

The promotion of physical activity is becoming increasingly important among the middle-aged to older population, especially for those who live with chronic diseases. Based on the social character of participation, group-based sports are associated with better health outcomes compared to individual activities (1). Moreover, peer-support interventions were also shown to be effective at increasing older people's physical activity levels (2–4). Evidence from previous studies has shown that social support could improve physical activity in the elderly population, and compared with family members, the most useful form of social support appeared to come from others, such as receiving suggestions from health professionals, and getting demonstrations from exercise experts (5, 6).

However, the COVID-19 pandemic has given rise to an unprecedented public health crisis, with many of its implications being life-altering. Across the world, to limit the spread of COVID-19, stringent restrictions have been imposed on social contact, often achieved through the implementation of social distancing and home quarantines. Although better access to exercise parks and facilities had been found to be related to a greater amount of physical activity among older adults (7, 8), both indoor and outdoor activity facilities were closed due to the city-wide lockdown in many countries during the pandemic.

Therefore, these restrictive measures resulted in lifestyle changes, such as increased sedentary behavior, reduction of physical activities, and other unhealthy behaviors. Physical inactivity is one of the leading risk factors for chronic disease mortality, often causing the premature deterioration of health in humans. Regular daily exercise can improve individuals' health by strengthening their immune systems and counteracting certain co-morbidities such as obesity, diabetes, and serious heart conditions that make individuals more susceptible to severe COVID-19 illness (9). In addition, performing physical activities during the COVID-19 pandemic is also associated with lower levels of depressive experience and anxiety (10). However, evidence in existing studies have identified that COVID-19 home quarantine with social distancing had a negative effect on physical activities (11–16).

In 2020, to tackle the COVID-19 pandemic, China implemented aggressive strategies with respect to social prevention and containment (17). However, the most common physical activities among the middle-aged to older population in China are traditional Chinese sports, such as Tai Ji Quan and Yangko exercises (also called social dancing or square-dancing) (18–20). These two kinds of physical exercise are usually practiced in groups in community centers or parks and develop social interaction among participants at the same time (21–23). Therefore, there is a clear need to consider changes in physical activity among Chinese middle-aged to older populations during the quarantine time. However, few existing studies have focused on the matter of changes in physical activity across the period before and during the pandemic among middle-aged to older Chinese populations at the national level. Moreover, most of the available studies on the impact of social distancing on physical activity have considered only small samples using online surveys. It is on this basis that the present study considers Chinese nationally representative data to study the influence of social distancing on physical activity. Given that the middle-aged to older population constitutes a high-risk group with respect to chronic diseases, it is this population that is considered in relation to this matter.

Based on the existing research, this study assumes that the lock down may affect the physical activity of the middle-aged to older population in China to a large extent. For different subgroups of the middle-aged to older residents, the degree of influence is not completely consistent. Those with higher social status and higher education level have a higher awareness of self-care and thus are more likely to maintain good exercise habits during the pandemic. Identifying vulnerable groups may help promote physical activity during the pandemic.

Materials and methods

Material

This study used data from the China Family Panel Studies (CFPS), which is a nationally representative, comprehensive,

longitudinal social survey of the Chinese population. The database covered a wide range of topics and included integrated modules for education, regions, health, and other information (24). To ensure quality among the data, CFPS made use of multistage and stratified random sampling methods. First, 25 provinces in China were divided into five sampling frames, samples of each sub-sample frame are extracted in three stages: administrative district/county, administrative village/committee, and household. In the first two stages of sampling, the official administrative division data is used. In the third stage, the map address method is used to build a sampling box, and the cyclic equidistant sampling method with random starting points is used to sample households.

Strict quality control protocols are in force at the stage at which the project is implemented, and database construction is performed professionally. CFPS surveys are conducted every 2 years, with the most recent once being conducted in 2020. The time of data collection were Jun 2018 to Mar 2019 and Jun 2020 to Mar 2021. The Biomedical Ethics Review Committee of Peking University approved CFPS, and all participants were required to provide written informed consent. The ethical approval number was IRB00001052-14010.

Sample

Each respondent was assigned a unique ID code that is consistent from year to year, making it possible for the present study to be conducted with panel data spanning multiple years. According to the age classification from the "National Standard for Physical Exercises Guideline 2020" by the General Administration of Sport of China, the sample group for this study comprised participants aged 45 years and older, all of whom were surveyed by CFPS in 2018 and 2020, with a sample size of 9,763 cases each year (25).

Dependent variables of physical activities

In the CFPS, the respondents were asked how often and how long they participated in physical activities on average per week. The responses to these questions were grouped into the following categories: never participated in physical activities; participated but less than once per month on average; once or twice a week on average; three to four times a week on average; five times a week or more. All the respondents not falling into the category of the first group "never participated in physical activities" were asked "how many minutes of physical activity at a time", and the specific duration (in minutes) would then be noted by the respondents.

The "Healthy China Action" blueprint advises individuals to engaged in three times of physical activity per week, with each lasting at least 30 min (26, 27). According to the recommended physical activity standards in this blueprint, we divided physical exercise habits into the following three categories: physical inactivity (less than once a week); regular physical activity (more than three times a week, each time lasting longer than 30 min); irregular physical activity (other cases). This classification has also been used in the previous study (28).

The dependent variable in this study was the change in physical activity habits during the period of social distancing in 2020, compared with that in 2018. In detail: For the physically inactive subset at baseline (2018), the criterion is whether the given individuals engaged in greater levels of physical activity (1 if the frequency of physical activities in 2020 is not 0; 0 otherwise). For the subset of irregular physical activity at baseline, the criterion is whether they engaged in a lower level of physical activity (1 if the frequency of physical activities in 2020 is 0; 0 otherwise). Finally, for the subset of regular physical activity at baseline, the criterion is whether they engaged in less frequent physical activity (1 if the given individual did not reach the regular physical activity in 2020; 0 otherwise).

Independent variables

Social economic status variables were used as control variables, including the respondent's personal characteristics, social status, health status, location, etc., and in the manner evident in the classification of these variables in the existing literature (19, 29). The specific rules governing this classification are provided in Table 1.

Statistics analysis

We established two timepoints: (1) 2018 baseline; (2) during COVID-19 social distancing in 2020. The baseline represents the state of physical activity before COVID-19 social distancing, and the year of 2020 represents the state during the COVID-19 social distancing. A logistic regression was constructed below to ascertain the factors associated with changes in physical activity during social distancing, especially in the case of individuals with different physical activity at the baseline. Formula 1 shows the model settings:

$$ln\frac{P}{1-P} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_i X_i + \varepsilon$$

Where the P is the probability of physical activity behavior change as described in the Materials and Methods Section (previously physically inactive population engaged in higher levels of physical activity; previously irregular

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TABLE 1 Recode rules regarding independent variables.

Variables	Definition	Assignment
Region	Multiple classes of dummy variables: Jiangsu Province, Zhejiang Province, etc.	Four classes of dummy variables*: 0 = West: Xinjiang Uygur Autonomous Region, Tibet Autonomous Region, Ningxia Hui Autonomous Region, Inner Mongolia Autonomous Region, Gansu Province, Qinghai Province, Shaanxi Province, Yunnan Province, Sichuan Province, Guizhou Province, Chongqing Municipality, Guangxi Zhuang Autonomous Region, 1 = Middle: Shanxi Province, Henan Province, Anhui Province, Hubei Province, Hunan Province, Jiangxi Province 2 = East: Beijing, Tianjin, Shanghai, Hebei Province, Shandong Province, Zhejiang Province, Jiangsu Province, Guangdong Province, Hainan Province 3 = Northeast: Heilongjiang Province, Jilin Province, Liaoning Province
Urban/rural	Two classes of dummy variables: Urban/Rural	Two classes of dummy variables: Urban/Rural; 0 = Urban, 1= Rural
Gender	Two classes of dummy variables: Male/Female	Two classes of dummy variables: Male/Female; 0 = Male, 1= Female
Age	Continuous variables range over 45 years old	Three classes of dummy variables: 0 = Middle-aged individuals range from 45 to 59 1 = Early elderly individuals range from 60 to 74 2 = Late elderly individuals range over 75
Marital status	Five classes of dummy variables: Unmarried, Married, Cohabiting, Divorced, Widowed	Two classes of dummy variables: 0 = With spouse at present: Married, Cohabiting 1 = No spouse at present: Unmarried, Divorced, Widowed
Work status	Two classes of dummy variables: In working condition, Not in working state (retired)	Two classes of dummy variables: 0 = In working condition, 1 = Not in working state (retired)
Education level	Eight classes of dummy variables: Illiterate, Kindergarten, Elementary school, Junior high school, High school, College, Bachelor's degree, Master's degree, Doctorate	Three class of dummy variables: 0 = Primary Education: Illiterate, Kindergarten, Elementary school, 1 = Secondary Education: Junior high school, High school, 2 = Higher Education: College, Bachelor's degree, Master's degree, Doctorate
Self-assessed income level	Five classes of dummy variables: High-income, Upper-Middle-income, Middle-income, Lower-Middle-income, Low-income	Five classes dummy variables: 0 = High-income, 1 = Upper-Middle-income, 2 = Middle-income, 3 = Lower-Middle-income, 4 = Low-income
Chronic diseases	Two classes of dummy variables: with chronic diseases/without chronic diseases	Two classes dummy variables: 0 = With chronic diseases, 1 = Without chronic diseases
Self-assessed health status	Five classes of dummy variables: Excellent; Very good; Good; Fair; Poor	Five classes dummy variables: 0 = Excellent; 1 = Very good; 2 = Good; 3 = Fair; 4 = Poor

*Provinces are located in regions in accordance with the divisions published by the National Bureau of Statistics of the People's Republic of China.

TABLE 2 Demographic-related and other characteristics of middle-aged to older participants in CFPS (2020).

Characteristics	*N*	%
Region		
Northeast	1,549	15.9
East	3,260	33.4
West	2,563	26.3
Central	2,391	24.5
Rural/urban		
Rural	5,058	51.8
Urban	4,705	48.2
Gender		
Female	4,815	49.3
Male	4,948	50.7
Age		
Middle aged (45–59)	5,247	53.7
Early elderly adult (60–74)	3,839	39.3
Late elderly adult (75-)	677	6.9
Marital status		
Have spouse	8,645	88.5
No spouse	1,118	11.5
Work status		
None	2,942	30.1
Yes	6,821	69.9
Education level		
Primary education	5,417	55.5
Secondary education	4,216	43.2
Higher education	130	1.3
Income level		
Low	996	10.2
Low-middle	1,611	16.5
Middle	4,334	44.4
Upper-middle	1,456	14.9
High	1,366	14.0
Chronic disease		
None	7,428	76.1
Yes	2,335	23.9
Self-assessed health status		
Excellent	1,191	12.2
Very good	1,135	11.6
Good	3,844	39.4
Fair	1,442	14.8
Poor	2,151	22.0

physical activity population developed worse habits regarding physical activity; previously regular physical activity population developed worse habits regarding physical activity). X_i represents the social-economic status such as age, gender. Heteroskedastic robust standard errors were calculated. The OR and the *P*-value are presented in the Results Section.

The significant level α in this study was set at 0.05 and the statistical analysis was carried out using Stata Version 16.0 (Stata/SE, StataCorp LLC, TX, USA).

TABLE 3 Physical activity among the middle-aged to older Chinese population (2018 and 2020).

Level of physical activity	2018		2020		P
	N	%	*N*	%	
Physical inactivity	4,525	46.4	6,565	67.2	<0.001
Irregular physical activity	1,775	18.2	1,669	17.1	
Regular physical activity	3,463	35.5	1,529	15.7	
Total	9,763	100.0	9,763	100.0	

Results

Sample characteristics

The characteristics of the samples in this study are summarized in Table 2. Middle-aged adults (45–59) accounted for more than half of the sample, followed by the early elderly group (60–74), accounting for 39.3%, and then the late elderly group (over 75 years), accounting for only 6.9%. 88.5% respondents of the sample reported having spouses, and 69.9% of the respondents reported having jobs. About 55.5% of respondents of the sample reported having received primary education, with the proportion with secondary education accounting for 43.2%. In terms of income level, 44.4% of the respondents reported that they were in the middle-income group, and 14.0% respondents reported income levels placing them in the high-income group. 76.1% of respondents had one or more chronic diseases.

Physical activity before and during the COVID-19 social distancing

Table 3 displays data relating to physical activity among the middle-aged to older Chinese individuals during 2018 and 2020. 46.4% were physical inactivity at baseline, with the proportion increased to 67.2% during the social distancing. The proportion of irregular physical activity decreased from 18.2% in 2018 to 17.1% in 2020. Meanwhile, 35.5% of the respondents reported exercising regularly at baseline, but only 15.7% reported maintaining their habit of engaging in regular exercise during the social distancing. Compared to 2018, the surveyed year preceding the social distancing of COVID-19, the

TABLE 4 Multiple logistic regression results changes in physical activity during COVID-19 social distancing among people with different physical activity at baseline (OR).

Characteristics	Model 1 Physical inactivity in 2018		Model 2 Irregular physical activity in 2018		Model 3 Regular physical activity in 2018	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Regions						
East (ref.)	—		—		—	
Northeast	0.88 (0.67, 1.16)	0.374	1.35 (1.01, 1.81)	0.040	1.24 (0.98, 1.56)	0.074
Central	1.37 (1.11, 1.69)	0.003	0.94 (0.74, 1.20)	0.643	0.83 (0.67, 1.02)	0.074
West	1.44 (1.16, 1.78)	0.001	1.03 (0.80, 1.33)	0.810	1.13 (0.90, 1.40)	0.287
Urban/rural						
Urban (ref.)	—		—		—	
Rural	0.53 (0.45, 0.62)	<0.001	1.65 (1.34, 2.03)	<0.001	2.16 (1.79, 2.60)	<0.001
Gender						
Male (ref.)	—		—		—	
Female	1.16 (0.98, 1.37)	0.085	1.05 (0.86, 1.28)	0.626	0.87 (0.74, 1.03)	0.114
Age						
Middle age (45–59) (ref.)	—		—		—	
Early elderly adult (60–74)	1.09 (0.92, 1.31)	0.322	1.04 (0.84, 1.29)	0.716	0.99 (0.83, 1.19)	0.917
Late elderly adult (75-)	0.82 (0.56, 1.22)	0.329	1.12 (0.69, 1.82)	0.659	1.38 (1.00, 1.90)	0.052
Marital status						
With spouse (ref.)	—		—		—	
No spouse	1.30 (1.02, 1.67)	0.035	1.10 (0.79, 1.52)	0.564	0.87 (0.68, 1.12)	0.292
Work status						
Not working (ref.)	—		—		—	
Working	0.57 (0.46, 0.69)	<0.001	1.35 (1.07, 1.71)	0.013	1.60 (1.33, 1.94)	<0.001
Education level						
Primary (ref.)	—		—		—	
Secondary	1.68 (1.42, 2.00)	<0.001	0.54 (0.43, 0.66)	<0.001	0.58 (0.48, 0.69)	<0.001
Higher education	3.55 (1.57, 7.99)	0.002	0.24 (0.14, 0.39)	<0.001	0.46 (0.27, 0.78)	0.004
Self-assessed income level						
Low Income (ref.)	—		—		—	
Low-middle income	1.47 (1.06, 2.03)	0.020	1.31 (0.89, 1.93)	0.175	0.74 (0.53, 1.03)	0.072
Middle income	1.37 (1.02, 1.84)	0.036	1.21 (0.84, 1.74)	0.308	0.67 (0.50, 0.90)	0.008
Upper-middle income	1.48 (1.05, 2.08)	0.026	1.29 (0.86, 1.95)	0.220	0.61 (0.44, 0.86)	0.004
High income	1.39 (0.98, 1.97)	0.068	1.74 (1.12, 2.71)	0.014	0.72 (0.50, 1.03)	0.069
Chronic disease						
With chronic disease (ref.)	—		—		—	
Without chronic disease	1.17 (0.96, 1.44)	0.122	0.69 (0.54, 0.87)	0.002	0.87 (0.71, 1.05)	0.145
Self-assessed health status						
Excellent (ref.)	—		—		—	
Very good	0.77 (0.55, 1.08)	0.072	0.85 (0.58, 1.24)	0.397	1.02 (0.73, 1.44)	0.890
Good	0.95 (0.73, 1.23)	0.184	0.77 (0.57, 1.05)	0.100	0.82 (0.62, 1.09)	0.170
Fair	0.81 (0.59, 1.11)	0.685	0.98 (0.67, 1.43)	0.902	1.04 (0.74, 1.45)	0.830
Poor	0.76 (0.56, 1.03)	0.132	1.25 (0.85, 1.84)	0.249	1.28 (0.92, 1.78)	0.146

Model 1 demonstrated whether individuals who were physical inactivity in 2018, and increased their physical activity during the social distancing ($\chi^2 = 189$, $P < 0.001$, *Pseudo* $R^2 = 0.0511$, *Degree of freedom* $= 4,446$); Model 2 demonstrated whether individuals engaged in irregular physical activity in 2018 but subsequently became physical inactivity ($\chi^2 = 151$, $P < 0.001$, *Pseudo* $R^2 = 0.0483$, *Degree of freedom* $= 1,761$); Model 3 demonstrated whether individuals engaged in regular physical activity in 2018 but decreased physical activity in 2020 ($\chi^2 = 264$, $P < 0.001$, *Pseudo* $R^2 = 0.0745$, *Degree of freedom* $= 3,425$).

decrease of physical activity emerged as statistically significant for 2020 ($P < 0.001$).

Results of multiple logistic regression on changes in physical activity

From a regional perspective, it emerges that it is more likely that the physical inactivity individuals who started performing physical activities during social distancing were from Central (OR 1.37, $P < 0.01$) and Western China (OR 1.44, $P < 0.01$). However, in Northeast China, people who used to be irregular physically active were 1.35 times more likely to reduce their physical activities than those in the Eastern region.

Living in a rural area is clearly another risk factor. The rural residents who used to engage in regular physical activity emerged as being 2.16 times more likely to have reduced their physical exercises during the social distancing period than those in the urban area. The probability of people engaged in irregular physical exercise reducing their physical activity level was 1.65 times higher than those in urban areas. At the same time, the urban residents who did not exercise before social distancing were 1.89 times more likely to increase their participation in physical activity than the rural residents.

Those without a spouse or unemployed who did not exercise before the social distancing were more likely to participate in physical activities during the social distancing period (OR, 1.3 and 1.75, respectively). And those noted as working and as having an exercising habit were more likely to reduce their participation in physical activities (OR, regular exercise 1.6, irregular exercise 1.35).

Education is an important protective factor. Compared with those noted as having received only primary education, the group whose members received secondary or higher education were associated with a higher probability of engaging in increased physical activities and a lower probability of engaging in reduced physical activities. Additionally, middle-income individuals who did not participate in physical activities before the COVID-19 social distancing were more likely to perform physical activity than those in the low-income group, as well as being less likely to reduce their levels of physical activity.

People with chronic diseases were more likely to maintain good physical exercise habits than those without. After controlling for other variables, the effects of gender and age on physical activity change during social distancing among the middle-aged to older Chinese people were not significant.

Multiple logistic regression results on changes in physical activity are presented in Table 4.

Discussion

In this study, we analyzed the influence of social distancing on physical activity among the middle-aged to older Chinese population during the COVID-19 pandemic by using nationally representative samples. We followed-up and monitored the physical activity status of participants before and during the social distancing of the COVID-19 pandemic. In general, we found that physical activity has significantly decreased during the COVID-19 pandemic, with social distancing reducing to a significant extent residents' engagement in physical activity. Such reduction in physical activity levels in China is consistent with the findings of previous studies in other countries. However, we also found significant differences in terms of the effect of social distancing on physical activity across regions and sociodemographic characteristics.

From the regional perspective, levels of physical activity were more severely affected in Northeast China, a result consistent with observations made in a previous study (30). In the coldest climate regions in China, the closure of winter sports facilities based on social distancing rules in the Northeast offers a straightforward explanation for the increased levels of physical inactivity among the residents.

We found that the decrease in physical activity of rural residents was more significant during the social distancing period. This result was inconsistent with previous studies conducted in other countries (31–34). In addition, as the ability of individuals to access, process, and understand health information to make decisions, health literacy is extremely important for population health within the social distancing context (35). Considering that the lack of health-related knowledge and lower levels of health literacy are common among the elderly in rural areas as compared with their urban counterparts in China, this provides another potential reason for physical activity reduction among the rural elderly population during the COVID-19 social distancing period (36, 37).

Our study highlights that having a spouse, being employed, having a lower level of education, and having a lower level of income are all related with a higher probability of having negative habits during the pandemic. Having chronic diseases appears to be associated with a higher probability of maintaining more positive habits of physical activity.

It is also the finding of our study that the groups characterized by low levels of education or low levels of income are associated with a higher probability of decreasing physical activity. This result was consistent with previous literature (38, 39). Employed individuals emerge as being more likely to reduce their physical activities, this may be because those who are currently employed might have reduced their commuting-related physical activities due to their employment occurring within their own homes (40).

We unexpectedly found that people with high levels of income emerged as being associated with a failure to maintain positive physical activity habits during the period of social distancing. According to the previous studies, the middle-aged group with a high level of income was the main group of fitness centers consumption, particularly in the high-level income population; they prefer to pursue more professional and personalized one-to-one "private services" (23, 41). By way of an explanation for this stage of affairs, it might be the case that high earners were used to exercising in high-end fitness centers and the locking down for social distancing of such centers led to a disruption in such individuals' exercise habits.

After controlling for gender and age, we proposed that chronic disease played a protective role in physical activity. This finding was inconsistent with previous study findings that people who have lifestyle-related chronic conditions such as diabetes and high blood pressure have been less active during the pandemic than those without such chronic diseases (42). These results may relate to certain health-related promotional policies in China in recent years, including health education in accordance with the characteristics of different target groups within the population (26). In fact, doctors will provide targeted education to patients who are diagnosed with chronic diseases, and physical activity is a common health education prescription (26). In addition, the proportion of the Entire-population Family Doctors Service Contracts rose from 28.33% in 2015 increased to 75.46% in 2020 (43). Such an increase in the proportion of family doctors' coverage could have led to greater access to health education and exercise prescription among middle-aged to older people, especially those with chronic diseases.

There were several limitations in the current study that must be acknowledged. First, due to certain data-related constraints, only data relating to frequency and duration of physical activity were consulted, making it impossible to identify what kind of physical activities might be associated with a stronger impact on residents' exercise. Furthermore, regarding the observation that people who are physically inactivity in daily life with no spouse increased their physical exercise during the social distancing period, due to the limitation of the data, we were not able to conduct a deeper exploration of the characteristics of this group, nor to formulate an explanation for this pattern. This finding needs further research.

Conclusion

To control the spread of the infectious virus, restrictions such as social distancing and lockdowns have been imposed worldwide, and so there is a need to examine the consequences changes in living environment and the limiting of lifestyles options has imposed. As with the health education programs that have been provided during the pandemic period, there is also a need for remote network services such as in-home physical activity tutorials and online fitness coaching courses. Our findings reported here suggest that in order to maintain healthy behaviors during social distancing, there is a specific need to develop effective strategies for the promotion of physical activity that targets members of vulnerable populations when quarantine or restriction approaches are implemented.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: CFPS repository: http://www.isss.pku.edu.cn/cfps/.

Ethics statement

The studies involving human participants were reviewed and approved by the Biomedical Ethics Review Committee of Peking University approved CFPS, and all participants were required to provide written informed consent. The ethical approval number was IRB00001052-14010. The patients/participants provided their written informed consent to participate in this study.

Author contributions

WZ conceived the study, performed the data compilation and formal data analysis, interpreted the findings, and wrote the manuscript. LZ conceptualized, drafted, and wrote the manuscript and interpreted the findings. TW contributed to the literature search and interpretation. QL performed the data analysis. WJ conceived of the study and participated in its design and coordination and helped to draft the manuscript. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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Conflict of interest

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

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Evaluation of the communication strategy for promoting physical activity in a cross-company network in Germany: A mixed-methods analysis

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Introduction: The workplace is considered a promising setting for reaching physically inactive adults, but participation quotes in workplace health promotion (WHP) remain low. Regarding the low participation in WHP, the question emerges concerning the importance of health communication strategies. This paper presents the results from the evaluation of the communication strategy of a cross-company network for promoting physical activity and derives findings for the successful communication of measures.

Materials and methods: Quantitative and qualitative data sources were used to evaluate the communication strategy. The methods applied included individual semi-structured interviews ($n = 14$) and the monitoring of the usage of digital communication channels.

Results: The analysis revealed that the usage of the digital communication channels within this study was subjected to major fluctuations and a variety of factors must be considered when communicating physical activity measures in a cross-company network. It is important to engage in appropriate communication management that explicitly takes the interpersonal communication and the organizational circumstances into account.

Conclusion: This study revealed which factors may have an influence on the successful communication of physical activity measures in the context of WHP in cross-company networks. Thus, it makes an important contribution to the transfer of science and practice as it captured relevant questions from the field of WHP.

Trial registration: German Clinical Trials Register (DRKS)-ID: DRKS00020956; Date of registration: 18 June 2020, https://drks.de/search/de/trial/DRKS00020956.

KEYWORDS

workplace health promotion, physical activity, health communication, strategies, mixed-methods, cross-company networks

Introduction

The importance of promoting physical activity in the population is undisputed (1) and the workplace is considered a promising setting for reaching physically inactive adults (2). Overall, workplace health promotion (WHP) and occupational safety are becoming increasingly important (3). Being it due to aging workforce or influences such as the coronavirus pandemic (3). To promote the health of employees, companies in Germany have the option of offering behavior- and environmental-related measures such as courses, information campaigns, or consulting services, supported by the statutory health insurance funds (4–6). Mostly, WHP measures are complex interventions in complex settings (7, 8) and especially, the implementation of organizational WHP measures implicates challenges (9).

In the pre-coronavirus year 2019, health insurance funds spent about 240 million euros on implementing such measures in German companies, representing an increase of 164 million euros compared to 2015 (10, 11). Moreover, the number of employees reached increased from 1.3 million in 2015 to 2.3 million employees in 2019 (10, 11). Thereby, most of the behavioral-related measures implemented in German companies focused on physical activity. In the context of environmental-related measures, interventions relevant to physical activity ranked second behind measures for the health-promoting design of work activities and conditions (10).

Despite the increased expenditure of health insurance funds and the number of employees reached, it is currently assumed that only 7% of all employees subjected to social insurance contributions in Germany were reached with WHP, in 2019 (10, 12).[1] Additionally, previous research has indicated that the participation quotes in WHP measures are still low (13, 14) or even declining (15). Thereby, the reasons for non-participation can be manifold (13, 16–20). According to Nöhammer et al. (17) and Walter et al. (21), suitable information and strategic planning of the communication process seem to be important for participation in WHP measures.

Regarding the low participation in WHP, the question emerges concerning the importance of health communication strategies. According to Baumann and Hurrelmann (22), health communication refers to "the conveying and exchange of knowledge, experiences, opinions and feelings that are related to health or illness, prevention or the health care process, the health economy or health policy [. . .]" [22, p. 13]. Thereby, from the authors' perspective, communication can take place on an interpersonal, organizational, or societal level and can be direct-personal or mediated by the media (22). Specifically, digital health communication has increased significantly in recent years and enables new potential for health promotion (23–25). It also plays a major role in the physical activity communication (26). Thereby, low usage data and high attrition rates are still a common problem (27, 28). Basically, health communication can be seen as a growing and complex interdisciplinary field of research that includes, among others, communication science, psychology, sociology, medicine, or social marketing (22, 29–31). Therefore, an examination of this subject area is conceivable based on a variety of theories as well as approaches from the most diverse research fields (31). However, research on health communication needs to be expanded (31), especially in the field of prevention and health promotion (32).

In order to raise people's awareness about the importance of health, many communication campaigns have been implemented in recent years in Germany (33). For example, the Exercise (Trimm)—campaign of the German Sports Association, aimed at promoting the physical activity behavior of major demographic groups (34). Overall, research has found medium evidence of mass-media campaigns in the context of physical activity promotion (2, 35–38). Thereby, the importance of an evidence-based conception and systematic implementation as well as the target group-oriented design of campaigns is highlighted (39–41). As Bonfadelli and Friemel (39) noted, campaigns can pursue three strategies to achieve their goals: a cognitive strategy, an affective strategy, and a social strategy. Ideally, campaigns should address all the levels in order to accentuate different motives and gratifications (39). The literature (39, 41) emphasizes that the consideration of theoretical models and theories of communication is crucial for the successful planning and realization of health communication campaigns. There are a large number of models that provide explanations for the attention paid to campaign messages, how they are processed, and how they influence the behavior of the target group (33, 39). In the context of behavior change, this includes, for example, the Transtheoretical Model (42), which makes it possible to define goals, target groups, and messages depending on the stage of behavior change (39). Referring to the communication theories, the Elaboration-Likelihood-Model (43) has practical relevance, since it postulates that the influence of media-mediated messages can vary depending on the situation (39, 41).

Basically, there is a large body of literature concerning theories on the development and evaluation of communication campaigns [cf. (39)]. Nevertheless, less attention has been paid to a systematic health communication approach in the workplace setting (44), and hardly, no theories exist to date on the systematic use of communication tools in WHP (21). With their model for the systematization of communication tools, Walter et al. (21) provided an initial approach for practitioners in WHP on how communication tools can be used in a targeted manner. As Faller (45) has noted, the aims of communication in WHP are to announce the measures, increase the employees' knowledge about health, and motivate them to participate. Thus, the goals of health

1 https://www.destatis.de/DE/Themen/Arbeit/Arbeitsmarkt/Erwerbstaetigkeit/Tabellen/insgesamt.html

communication in WHP are comparable to those of health marketing (45), which is based on a systemic approach (45–47). However, from the perspective of the employees, information about WHP measures in the company is often insufficient or not comprehensible enough (48, 49), so that additional research is required to explore this research domain in more detail.

The present study was part of the model project "KomRueBer," which aimed to conceive, implement, and evaluate a cross-company network offering a multi-component intervention promoting physical activity of employees in small- and medium-sized companies (50, 51). The study was composed of two parts, with the first part focusing on the development of the cross-company network and a multicomponent intervention for promoting physical activity (50). Subsequently, the multicomponent intervention was implemented and evaluated, with the evaluation based on an impact model (logic model) and a focus on process evaluation (51). In Germany, the establishment of cross-company networks is an acknowledged approach to specifically support health promotion for employees in small companies (6, 50). The literature (52) recommends a consolidation of four up to twelve companies with a total of at least 100 employees. The organizational and administrative effort increases with the size of the network (52), which consequently also applies to the communication processes. Basically, communication is a challenge in networks, but it contributes to the success if it is done professionally (53). To the authors' knowledge, to date, no studies have been conducted on the communication of physical activity measures in such cross-company networks.

The aim of the present paper was to present the results from the evaluation of the communication strategy of the cross-company network promoting physical activity. It is intended to contribute to the output level in the context of the impact model-based evaluation of the KomRueBer study. Given the importance of strategic planning of communication processes for participation in WHP and on the other hand, still limited research concerning systematic approaches to health communication in the workplace setting, this article also aims to provide important insights on how employees can be systematically informed about physical activity measures. Particularly, in the context of cross-company networking, there is a serious research gap, in which this article should contribute to clarify. The related research questions were as follows: (1) How is the usage of the digital communication channels (media) within the communication strategy to promote physical activity in the cross-company network? (2) How do the stakeholders of the cross-company network assess the communication strategy for promoting physical activity? (3) What are the facilitating factors for and barriers to successful communication of physical activity measures in the cross-company network?

Materials and methods

The study was conducted in a technology park in Germany with about 90 companies and an estimated 2,000 employees. In total, seven companies formed the core of the cross-company network and actively participated in the KomRueBer project. Ethical clearance for the KomRueBer project was obtained from the Ethics Committee of the German Sport University Cologne (reference number: 068/2020). The study was conducted in compliance with the Declaration of Helsinki and is registered in the German Clinical Trials Register (DRKS00020956). A mixed-methods design was applied to evaluate the communication strategy. We choose this approach to develop a better overall interpretation of the communication strategy. Data for the present evaluation were gathered from April 2020 to September 2021.

The KomRueBer communication strategy

The KomRueBer communication strategy comprised the systematic development of messages and communication channels for promoting physical activity measures and their dissemination on site. Likewise, the communication strategy included the entire communication management to make the measures and the project known. The messages and communication channels were developed by an agency in collaboration with the KomRueBer project team and conveyed three messages in terms of content:

- Message 1: "We create movement. Any kind of movement is good. It makes you stronger, it makes you more self-confident, it is fun! We enable movement in your workday: As an employee in the technology park (name of the town) we—together with our project partners—are creating simple proposals, which will pick you up from where you are. Movement which motivates you."
- Message 2: "We are many. And we are determined to champion all the good that movement brings. Within a partner network, with loads of ideas, proposals and joy, we are committed to encourage movement for the many. We are on your side. You are one of us. You are in the right place."
- Message 3 / Slogan: "There is movement in this."

Table 1 shows the communication channels used to disseminate the messages and information about the project and its measures.

The KomRueBer communication strategy addressed employees on site, contact persons of the companies collaborating and not collaborating in the KomRueBer project, and the management of the technology park. Employees could seek information by registering for the newsletter or visiting the

TABLE 1 Communication channels within the KomRueBer project.

Communication channel (media)	Type of media	Application area
Posters	Print	Announcement of the project and measures on site
Business cards with contact name of the project	Print	Distribution at on-site events so that employees have a direct point of contact for the measures and project
Banner	Print	Drawing attention to the project at events on site
Website	Digital	Central information and registration platform for the physical activity measures
Newsletter tool	Digital	Personalized e-mail marketing to inform about new measures

website, where all physical activity measures were presented. Likewise, the project was advertised on posters on site. Figure 1 illustrates the communication paths for the dissemination of information in the cross-company network. We defined communication paths as the forwarding of information about the project and its measures *via* company representatives to their employees. In total, two supplementary communication paths were used for the dissemination of information.

On the one hand, new information was sent from the project team to the contact persons (generally one to four persons of each company) of the actively-participating companies (distribution list of the participating companies), while on the other hand, a distribution list of the operator of the technology park—which was addressed to all companies on site (generally addressed to one contact person)—could be used occasionally. This also made it possible to reach companies and their employees that were not directly involved in the KomRueBer project. The recipients were asked to forward the information to the employees in the respective company.

Quantitative study design

To answer research question 1 (How is the usage of the digital communication channels of the communication strategy to promote physical activity in the cross-company network?), the number of users of the website (people who interacted with the website) and the number of subscribers of the newsletter were monitored. Usage data of the website were collected after consent to cookie use based on google analytics. The number of users was monitored weekly from 6 April 2020 (week 1; release of the website) to 22 August 2021 (week 72). In addition, the number of physical activity measures offered, project management activities (e.g., dispatch newsletters), or external factors (e.g., imposition of coronavirus-lockdown, holiday period) were assessed. The newsletter subscribers were recorded by the program Sendinblue (Sendinblue GmbH, Berlin, Germany). The subscription was at no charge and it was necessary to agree to the applicable privacy policy prior to subscribing. The number of subscribers was gathered between 25 June 2020 and 19 July 2021. For this purpose, the total number of recipients was recorded for each week. Monitoring data were displayed descriptively [frequency (n), mean (mean), standard deviation (±SD)].

Qualitative study design

Semi-structured interviews were conducted to answer research questions 2 (How do the stakeholders of the cross-company network assess the communication strategy for promoting physical activity?) and 3 (What are the facilitating factors for and barriers to the successful communication of physical activity measures in the cross-company network?). The first author (C.H; PhD. candidate and trained in qualitative research) conducted the semi-structured interviews from August to September 2021. The researcher and interviewee knew each other through the project. Due to the prolonged pandemic situation, the interviews were realized by video conference. The interviews were conducted in German, anonymized using a code and digitally recorded. During the interviews, pictures of the media and the messages were displayed, so that the participants could regard them calmly again. Handwritten field notes—taken during and after the interviews—completed the data collection. Demographic data were collected after the interview has been completed.

Sample

The study population comprised different stakeholders in the project (exercise providers, company representatives, network partners from public, economy, and society/politics). The recruitment was conducted through the first author *via* mail or telephone. Each of the project's 18 stakeholders was asked if they were interested in participating. In total, fourteen of them expressed their willingness to participate. No feedback was received from four stakeholders. Informed consent was taken from each participant before the interview was conducted. In total, four male and ten female stakeholders participated in the interviews. The sample comprised two company representatives, eight network partners, and four exercise providers. In total, four participants had a double role (one network partner and exercise

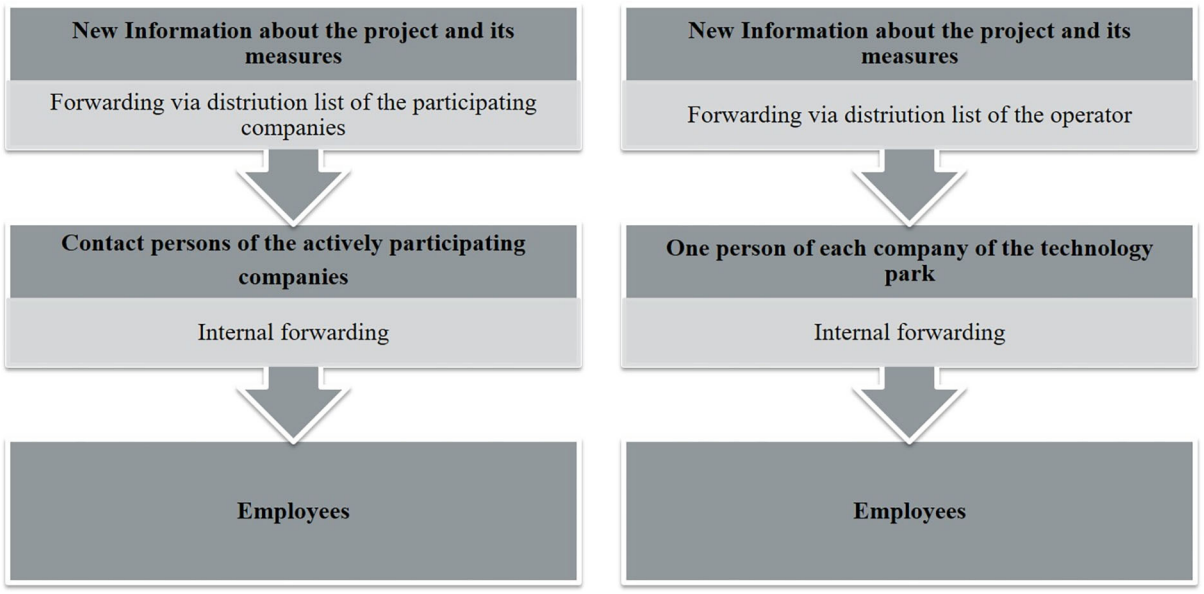

FIGURE 1
Communication paths for the dissemination of information.

provider; three company representatives and network partner). The age of the participants ranged between 33 and 60 (mean 47 ± 8). The interviews lasted from 35 to 70 min, with an average interview duration of 50 min (±11).

Interview guide

The conception of the interview guide was based on the McGuire's model of persuasion (54). In addition, the results of the monitoring of the usage data of the digital communication channels were incorporated into the development of the interview guide. The questions were collected collectively in the project team and the interview guide pilot was tested internally. Table 2 shows the topics and key questions. Supplemental questions were used to support the conversation. The order of the questions was adapted flexibly to the course of the interview, if necessary.

Transcription and data analysis

The transcription was conducted according to the rules of Dresing and Pehl (55). Each transcript was double-checked, whereby the interviews were analyzed by two researchers according to structured content analysis (56). Latter is comparable to the framework method (57). Based on the interview guide, the main categories were formulated deductively. In addition, main categories were derived from the text material inductively. Subsequently, the text material was assigned to the main categories before sub-categories were determined inductively in the next step. The interviews were analyzed using MAXQDA 20 software (VERBI GmbH, Berlin, Germany).

Results

Usage of the digital communication channels

Figure 2 shows the website users per week over time. The average number of users per week was 37 (±58.8), ranging between 425 (week 47) and 2 users/week (week 39).

Figure 3 illustrates the total number of newsletter subscribers over time. The maximum number of subscribers of the newsletter was recorded in weeks 51 and 52 with 36 persons. The first newsletter subscribers were registered in week 12 (2). Since week 26 three subscribers and since week 34 nine subscribers were recorded. In week 41, the number of subscribers increased up to 28 and dropped again to 15 subscribers within 1 week. An increase to 34 subscribers was registered in week 50 and to 36 subscribers in week 51. From week 53 to week 62, the number of subscribers was again 34, before declining again to 33 persons after week 63. Thus, the highest number of new registrations (19) was in project weeks 41 and 51, whereby the highest number of unsubscriptions (13) was in project week 42.

Table 3 shows the project activities in the same period and external factors (e.g., holiday periods, lockdown periods due

TABLE 2 Topics and key questions of the interview guide (translated from German).

Topic	Key question(s)
Existence of appropriate framework conditions to be exposed to the messages and the project	"From your point of view: how would the ideal announcement of this project have looked in this cross-company setting without Corona?"; "How do you rate the access routes?"; "How do you assess the communication channels for the target group of employees in a cross-company environment?"
Structuring of cross-company communication including facilitating factors and barriers	"From your point of view, how would the ideal cross-company communication be structured?"
Evaluation of messages and media in terms of their generation of attention, arousing interest, and comprehension.	"How successfully does the design of the messages catch your attention?"; "How strongly do the statements personally affect you?"
Overall evaluation of the communication strategy	"What do you think much does this communication strategy motivate movement among the present employees?"; "In hindsight, how do you evaluate the amount of information within the framework of the project?"

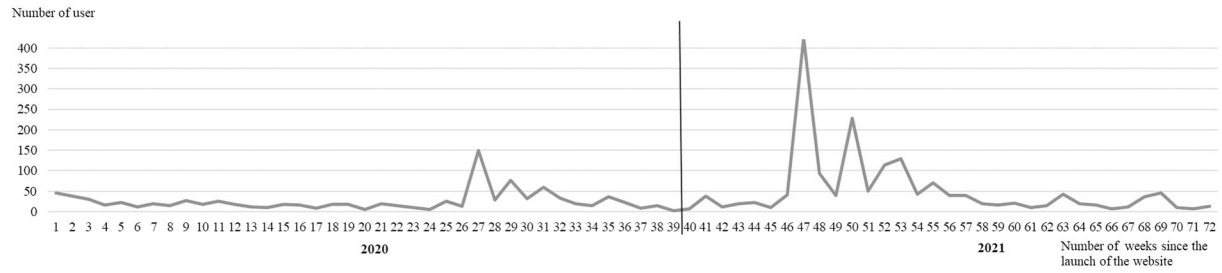

FIGURE 2
Website users per week over time.

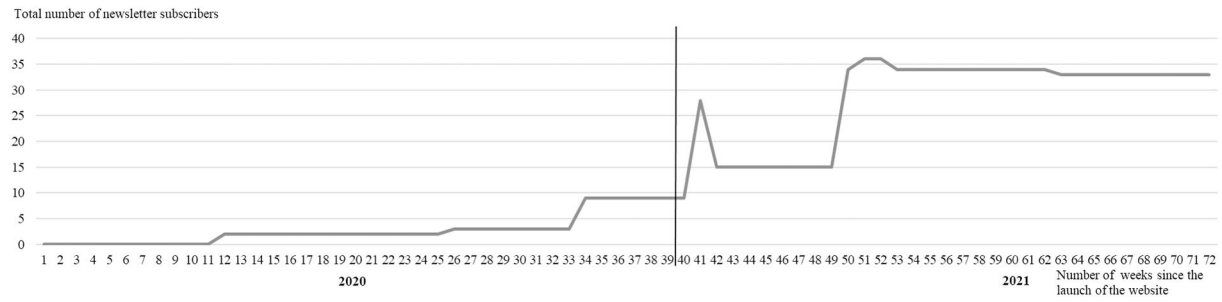

FIGURE 3
Total number of newsletter subscribers over time. Note: 0 between week 1 and 11 caused to later starting of newsletter dispatch compared to activation of the website.

to coronavirus pandemic). Only those weeks in which project activities took place or external factors were recorded are listed. The distribution list of the operator of the technology park was used three times to inform about new physical activity measures for the cross-company network (weeks 9, 18, and 27). In addition, the company representatives of the companies actively participating in the project were informed eighteen times about new physical activity measures (weeks 1, 7, 8, 12, 16, 26, 30, 31, 35, 41, 46, 50, 54, 55, 57, 63, 68, and 69). Overall, twelve newsletters were dispatched (weeks 12, 26, 35, 41, 46, 50, 54, 55, 57, 63, 68, and 69) and three steering groups of the KomRueBer project were implemented (weeks 29, 43, and 62). Besides, the project was presented at one company meeting (week 32) and within a course measure (week 49). Social media was used once by an exercise provider to inform about the measures (week 47).

TABLE 3 Project and communication management and external factors in the course of the project.

Month	Project week	Project and communication management	External factors
April	1	Dispatch of project start flier *via* mail to company representatives	First lockdown since mid-March; School vacations
	2		School vacations
	4		Mandatory wearing of masks
May	6		Relaxation of coronavirus lockdown
	7	Reference to project website *via* mail to company representatives	
	8	Announcement of new measures *via* mail to company representatives	Further relaxation of coronavirus lockdown
June	9	Announcement of new measures *via* distribution list of the operator	
	11		Opening of canteens and cafeterias
	12	Announcement of new measures *via* mail to company representatives; Dispatch of the first newsletter	
July	13		School vacations
	14		School vacations
	15		Further relaxation of coronavirus lockdown; School vacations
	16	Mail to company representatives with further information about the recent measures	School vacations
	17		School vacations
August	18	Announcement of new measures *via* distribution list of the operator	School vacations
September	26	Announcement of new measures *via* mail to company representatives; Dispatch of the second newsletter	
October	27	Announcement of new measures *via* distribution list of the operator	
	28		School vacations
	29	Steering meeting with the company representatives	School vacations
	30	Mail to company representatives with further information about the recent measures	End of October; appeal for home office working
November	31	Mail to company representatives with further information about the recent measures	Partial coronavirus lockdown; among others closure of fitness studios
	32	Presentation of the project in a works meeting within one company	
December	35	Announcement of new measures *via* mail to company representatives; Dispatch of the third newsletter	
	38		School vacations
	39		School vacations
2021			
January	41	Announcement of new measures *via* mail to company representatives; Dispatch of the fourth newsletter	Beginning of January; tightening of the coronavirus lockdown
	43	Steering meeting with exercise provider	End of January; mandatory home office working
February	46	Announcement of new measures *via* mail to company representatives; Dispatch of the fifth newsletter	Extension of coronavirus lockdown
	47	Instagram post about an exercise provider's measure	
March	49	Presentation of the project within the framework of one measure	
	50	Announcement of new measures *via* mail to company representatives; Dispatch of the sixth newsletter	
April	52		School vacations
	53		School vacations

(Continued)

TABLE 3 (Continued)

Month	Project week	Project and communication management	External factors
	54	Announcement of new measures *via* mail to company representatives; Dispatch of the seventh newsletter	
	55	Announcement of new measures *via* mail to company representatives; Dispatch of the eight newsletter	
May	57	Announcement of new measures *via* mail to company representatives; Dispatch of the ninth newsletter	
June	62	Steering meeting with the company representatives	Beginning of June; reopening of fitness studios
	63	Announcement of new measures *via* mail to company representatives; Dispatch of the tenth newsletter	End of June; end of mandatory home office working
July	67		School vacations
	68	Announcement of new measures *via* mail to company representatives; Dispatch of the eleventh newsletter	School vacations
	69	Announcement of new measures *via* mail to company representatives; Dispatch of the twelfth newsletter	School vacations
August	70		School vacations
	71		School vacations
	72		School vacations

Appraisal of the communication strategy from the stakeholders' perspective

Concerning research question (2), five main categories were identified: *(a) communication paths, (b) communication channels, (c) design of the media, (d) messages, and (e) overall communication strategy*. Table 4 shows the main categories, their definitions, the related sub-categories and characteristics.

Within the main category "*communication paths*," *three* sub-categories could be defined: "advantages," "disadvantages," and "improvement suggestions." Advantages comprise positive aspects of the distribution lists (e.g., established, low costs, and firm contact persons). As disadvantages (unfavorable aspects of use of the communication paths), interface problems, potential information flooding, and uncertainty regarding the degree to which the target group has been reached were mentioned. Suggestions for improvement—meaning ideas to optimize the communication paths—included extending the list to several representatives of one company and establishing a separate sender, so that information could be directly assigned by the recipients.

"Communication channels" was divided into four sub-categories. The "general appraisal" was that the combination of poster, website, and newsletter is useful. For the sub-categories of "appraisal of the newsletter" and "appraisal of the website," the interviewees again mentioned advantages and disadvantages. As advantages of the newsletter, the accessibility of the interested employees and the reminder functionality were named, whereas the need for an active registration, flood of e-mails, an e-mail address as a prerequisite, and the possibly limited up-to-dateness were mentioned as disadvantages. Named advantages of the website were the continuous information and the up-to-dateness while the need for an active access of the employees was assumed as a disadvantage. Regarding the "appraisal of the poster," they were seen as a useful way to draw attention to the project and its measures. It was highlighted that these should be used more intensively.

"Design of the media" comprised the sub-categories "generating attention," "design of the poster," "design of the website," and "design of the logo." In the sub-category "generating attention" (extent to which the design of the media attracts the attention of the interviewees), both positive and negative statements were given, whereby the majority of stakeholders expressed positive statements. The sub-category of "design of the poster" (statements concerning the appearance of the poster) showed the two characteristics of picture material (e.g., lack of expressiveness, good image variety) and color selection (e.g., too dismal, fresh). Besides, the stakeholders made suggestions for improvements, such as making reference to specific measures on the posters. Concerning the sub-category "design of the website" (statements about the processing of the information platform), stakeholders made reference to the amount of information represented (e.g., too much information, good overview) and the visual

TABLE 4 Coding system: appraisal of the communication strategy.

Main category (definition)	Sub-categories	Characteristics
Communication paths (Forwarding of information about the project and its measures *via* company representatives to their employees; distribution list of the participating companies and the operator)	Advantages	• Established communication paths • Wide range • Low costs • Concrete contact persons
	Disadvantages	• Interface problem • Information flooding • Unclear accessibility of employees
	Improvement Suggestions	
Communication Channels (Media used to convey the messages and the information about the measures to the employees in the cross-company network; newsletter, website, posters)	General appraisal	
	Appraisal of the newsletter	• Advantages • Disadvantages
	Appraisal of the website	• Advantages • Disadvantages
	Appraisal of the posters	• General appraisal
Design of the media (Style of the communication channels and the logo)	Generating attention	• Positive appraisal • Negative appraisal
	Design of the poster	• Picture material • Color selection • Suggestions for improvement
	Design of the website	• Amount of information • Visual effect
	Design of the logo	• Physical activity is reflected in design • Draws interest • High memorability • Expressive • Too text-heavy • Missing expressiveness • Design unimportant
Messages (Key statements about the KomRueBer project)	Message 1	• Effect • Improvement suggestion • Information content
	Message 2	• Effect • Information content • Improvement suggestion
	Slogan	• Effect • Improvement suggestion
Overall communication strategy (Overall concept of the communication strategy)	Contribution to promoting physical activity on site	• Can contribute • Cannot contribute • No assessment possible
	Amount of information	
	General appraisal	

effects (e.g., too confusing, underlines topic of physical activity). Feedback concerning the "design of the logo" (composition of the project logo) showed a wide range of characteristics. However, in the majority of cases, it became clear that the design of the logo reflects the topic of physical activity well. Overall, it was noticeable that the

feedback on media design covered a broad spectrum with various opinions.

Within the main category *"messages,"* three sub-categories were identified. Concerning the sub-categories of "message 1" and "message 2" (statements that related to the evaluation of the respective formulations), a considerable diversity of opinions was registered which could be classified into the characteristics of "effect," "information content," and "improvement suggestion." The stakeholders mentioned a wide range of effects (e.g., underlining that physical activity is good, clarifying that everyone is welcome) from which no uniform propensity could be derived. Opinions also differed regarding the information content of the messages (e.g., sufficient, too much text). Some improvement suggestions (e.g., simpler language, addressing the target group more specifically) were stated. The sub-category of "message 3/slogan" (text passages in which the interviewees expressed their opinion about the slogan) identified comments on the effect and suggestions for improvement. Overall, it became apparent that the majority considered the slogan to be appealing and motivating. Suggestions for improvement were related to giving the slogan a different name.

Under the main category *"overall communication strategy,"* three sub-categories could be formed. "Contribution to promote physical activity on site" (statements on how the overall communication strategy helps to put the employees into motion) showed the characteristics of "can contribute," "cannot contribute," and "no assessment possible." In terms of "can contribute," stakeholders gave the estimation that the communication strategy can create initial access to physical activity. Nevertheless, they also expressed skepticism concerning this or could not give an estimation. Concerning the "amount of information" (feedback on the quantity of information provided in the project), stakeholders stated that it was suitable. Concerning the "general appraisal" (statements concerning the overall impression of the communication strategy), stakeholders reported that the communication strategy was essentially well done.

> *"Yes. Well, I think it could be a part of this. It could never, I think never, would it be sufficient on its own, but it could contribute to somehow to pick-up people. Because this page is trying to appeal to people and to send the message: It doesn't matter what you do. What is important is to keep moving. To do your body some good. And yes, that a variety of components dealing with movement are addressed. And there it can make a contribution. It can be a small part of something bigger." (network partner, female)*

Facilitating factors for and barriers to successful communication of physical activity measures in the cross-company network

Regarding research question (3), two main categories were defined: *(f) facilitating factors and (g) barriers*. In addition, the overarching category *(h) coronavirus* was identified. Table 5 illustrates the main categories, their definitions as well as the sub-categories, and characteristics.

Within the main category *"facilitating factors,"* six sub-categories were defined: "alternative use of media," "creation of personal contact possibilities," "communication management," "public relations activities," "participation of stakeholders," and "exhaustion of existing access paths."

The sub-category of "alternative media use" describes channels that were seen as promotive for the communication and the announcement of physical activity measures that extend beyond the channels used to date within the project. Thereby, digital and analogous media were mentioned. In the context of digital media, stakeholders advocated for creating a cross-company digital platform, which facilitates the communication between the employees and not only presents information about the measures. Furthermore, they indicated that the use of social media, apps, blogs, intranet, and QR-codes could be beneficial. Concerning analogous media, stakeholders suggested fliers combined with giveaways, an intensified use of posters, and the creation of a project newspaper as well as the use of information boards.

The "creation of personal contact opportunities" meant opportunities for personal exchange with employees on site. Most stakeholders proposed carrying out low-threshold measures (e.g., inaugural event, action days) to engage in conversation with the employees. On the other hand, the implementation of an e-mail distribution list for all interested employees, the establishment of info spots on site where people can seek information about the project, and company visits could be the opportunities to promote communication.

The aspects of "communication management" (aspects that should be taken into account in the context of communication planning) covered a broad spectrum, within which the regularity of information about measures was identified as one essential factor. Stakeholders also felt that it was beneficial to take employees and companies by the hand and provide individual support. Likewise, regular cross-company exchange was recommended. In addition, the use of a variety of communication channels, taking into account the different prerequisites in the companies, was mentioned. Finally, it was highlighted how important it is to live the messages communicated.

TABLE 5 Coding system: facilitation factors and barriers.

Main category (definition)	Sub-categories	Characteristics
Facilitating Factors (Factors that can promote the communication about physical activity measures in a cross-company network)	Alternative use of media	• Digital • Analogous
	Creation of personal contact possibilities	• Low-threshold measures on site • Establishment of an e-mail distribution list with employees • Info points • Company visits
	Communication management	• Regular information • Individual support • Variety of channels • To live the messages communicated • Cross-company exchange
	Public relation activities	• Visibility • Highlights • Moving images • Talking about the positive actions undertaken • Use of the press
	Participation of stakeholders	• Multipliers • Employees • Management • Direct supervisors • Exercise providers
	Exhaustion of existing access paths	• High-traffic locations • Established information systems
Barriers (Factors that can hinder the communication and awareness of physical activity measures in a cross-company network)	People Lack of information transfer Priority of other topics Time	
Coronavirus (Communicable disease; the impact of the coronavirus pandemic on the project and the communication of physical activity measures on site)		

In the sub-category "public relation activities" (what can be done to be perceived by employees), stakeholders reported that initiators/actors of such a project should be consistently visible for the employees; for example, in person on site or *via* video. Besides, it was proposed to set unusual, accompanying highlights such as coffee rounds or early bird actions. In order to arouse the curiosity of the employees, the use of moving images was also suggested. Further recommendations related to using the press and regularly talking about the positive actions undertaken.

In the sub-category of "participation of various stakeholders" (individuals who can be beneficial for communicating physical activity measures in a cross-company network), most stakeholders indicated that multipliers in the companies play an important role for promoting the topic internally. When interviewees named more specific actors, they mentioned the increased involvement of employees, management, or direct supervisors. The exercise providers themselves could potentially publicize the measures during their courses and thus increase their awareness.

The final sub-category identified was "exhaustion of existing access paths" (usage of channels or locations that are already established on site). In this context, the stakeholders recommended a connection to platforms that are already used for communication in the companies. Besides, high-traffic locations such as cafeterias, parking facilities, meeting rooms, or main entrances could be specifically used to place information.

> *"So, I have to repeat myself there because, at the end of the day, you have to tap into various channels. Because, as I said, the companies differ so much, you know. They are from different branches, they have different employees, office jobs, and then some are on the machines. It is very, very, very different. And in such cases, you have to try and use all channels." (network partner, male)*
>
> *"What comes to mind quite clearly for me is to have an impetus which really supports the issue." (network partner, female)*

In the main category *"barriers,"* a total of four sub-categories could be categorized: "people," "lack of information transfer," "priority of other topics," and "time."

The first sub-category of "people" was defined as the dependence on various actors in making measures known. Thus, both the recipient him/herself and the commitment of the person responsible for communication in the companies can represent a barrier from the stakeholders' perspective. Besides, stakeholders reported that the "lack of information dissemination" can also be a barrier for making measures known on site. It described the fact that information is not passed on in the companies. Stakeholders also cited "priority of other topics" and "time" as additional barriers. Thus, they mentioned that other issues may have higher priority for project partners than the communication of physical activity measures, while a lack of time during the workday may also influence the communication of physical activity measures in this setting.

> *"And then there is another difference. Do I just pass this on without a comment. Or do I at least write something about it, or do I use other paths of communication internally, inside the company. By saying: I will address several executives, so that they take it up. Or, let's say, draw attention to it in other ways in my company. Well, it depends so very, very much on the individual people. And that is, I just see the difficulty there." (network partner, female)*

"Coronavirus" could be identified as another main category. Overall, it became clear that the pandemic situation was an overarching factor influencing the communication and awareness of physical activity measures within the cross-company network. The stakeholders mentioned that due to the pandemic situation many measures and project management activities had to be implemented digitally, personal contact on site was restricted and many companies also had to struggle with the new pandemic situation.

> *"And if Corona is already a difficult situation. And a lot is being restructured in the company. Then there is the possibility that someone might not deal with it quickly enough, or be able to deal with it, that creates problems too. And then maybe the employees are not on site regularly. Then it will get really difficult." (exercise provider, female)*

Discussion

The present study aimed to evaluate a communication strategy for promoting physical activity in a cross-company network. Furthermore, it was aimed to derive findings for a successful communication of measures promoting physical activity. Our results show that a variety of factors must be considered when communicating physical activity measures in a cross-company network, and that it is important to engage in an appropriate communication management. It is noticeable that reaching the target group depends on more than simply welldesigned media or messages; rather, factors like an interpersonal communication should be explicitly taken into account. Beyond this, the major influence of organizational circumstances on the successful communication of measures becomes clear.

As shown in Figures 2, 3, the usage of the digital communication channels within the project was subjected to major fluctuations. Given the high number of employees on site (about 2000), potentially many more visitors could have used the website or newsletter subscription. Therewith, the usage of the digital communication channels fell short of expectations. Comparing Figure 2, Table 3, it was noticeable that an increase in the number of users was mostly associated with the announcement of new measures *via* the distribution list of the participating companies and the dispatch of newsletters. The same applies to the distribution list of the operator, albeit to a much lesser extent. The fact that the e-mail distribution list of the participating companies had a better effect than the distribution list of the operator could indicate that distribution to a broad unknown mass is not automatically more adjuvant. Nevertheless, it also opened the chance to reach other companies. Essentially, this procedure seemed to have achieved the goal of calling attention to new measures presented on the website. In times when no communication activities were carried out (e.g., weeks 58–61, 64–67), the number of users remained at a low level. Vacation periods also seemed to have an impact on website usage, with hardly any users over the turn of the year and the first summer vacations during the project (weeks 13–18, 38–40). However, it should be noted that fewer measures for the cross-company network were usually implemented at

these times. A very closely timed mailing of newsletters—as was done in the second year of the project (starting from week 46)—caused the number of users to repeatedly increase but did not seem to lead to more frequent use of the website over time. Why the number of users was extraordinarily high—especially in week 47—leaves room for discussion. During this time, there was a partial lockdown to control the epidemic in Germany and fitness studios were closed. The project was offering a digital back pain prevention course at this time and based on the registration number information seemed to get around in one company in particular. Likewise, one measure was promoted by a fitness studio *via* Instagram. It cannot be explained by a reliable cause–effect relationship. Comparing Figure 3, Table 3, the number of newsletter subscribers could also be linked to the dispatch of new information *via* the distribution lists of the participating companies. Why there was a sharp drop in subscribers in week 42 remains questionable. During this period, students were involved in the project who possibly enrolled and quickly disenrolled for the newsletter.

Considering the website users, parallels may be drawn to the use of web-based interventions. As mentioned above, low usage data and high attrition rates are a common problem (27, 28). To counteract this problem, blended interventions—i.e., interventions that combine digital and analog approaches—seem to be more effective (58, 59). A number of studies (60, 61) have also reported that regular reminders and personal contact provided can also have a positive impact. Comparable to the importance of blended approaches in the context of web-based interventions, such serration may also play a decisive role in the context of publicizing and using digital information platforms or newsletters, as applied in the present project. Prospective regular visitation or registration could be promoted during (kick-off) events on site. This recommendation could be supported by Stassen et al. (62), who have shown that initial face-to-face contact can be helpful to log on to a web-based platform. As mentioned in the literature (25), the strength of one-on-one conversation is a very high target group specificity and interactivity. Furthermore, one-on-one conversation can achieve a very high depth of information, credibility, and clarity, which underlines the importance of their usage (25). Combined with regular reminders *via* company representatives and repetitive personal contacts on site, the existence of such information channels could be advertised on a regular basis. To avoid ignorance, information should be sent out regularly but not too closely timed. This would be in line with Geraghty (63), who reported that multiple e-mails can also be counter-productive. Drawing on earlier work by Budde (64), it is also important to maintain such information platforms continuously and create incentives for visits. Finally, the problem of media disruption that Bonfadelli and Friemel (39) mention should be highlighted. According to the researchers (39), the use of websites always requires other channels in a campaign that draw attention to the website.

The fact that an increase in website users and newsletter subscriptions was closely related to the chosen communication paths showed that they can be a useful way to draw attention to measures in a cross-company network. This can also be supported by the qualitative results of our study in which stakeholders considered these communication paths as a useful way to spread information. In the literature, too, the possibility of reaching a specific target group *via* mailings is rated high (25). Generally, emails seem to be a good way to communicate information about physical activity (26). Nevertheless, it became clear how important it is to keep one's eyes on possible interface problems with this type of communication paths and avoid information flooding. The latter notion corresponds with previous findings (49) where circulars were critically considered in times of information overload. Besides, the potential of mailings to increase the perceived relevance of the topic is low (25). However, coupled with our various communication channels, good requirements were created for informing employees about measures in a cross-company network. Thereby, each channel implicated its own advantages and disadvantages, which should be considered in advance and in the context of the framework conditions in the company (e.g., what work is performed and how can the employee's best be reached). Baumann et al. (25) also recommend to compile an individual media mix for each communication project, as the potentials of the individual channels differ significantly from one another and the content, objectives, and target group in projects can vary. Further literature (39) also highlights that no general recommendations can be made about the selection of channels. It must also be pointed out that the effort and costs of channels differ greatly (25). While costs and effort for websites tend to be high, mailings are significantly cheaper (25), so that decisions must also be made based on budget within the framework of communication projects.

However, for media design and message conception, no general recommendations could be derived from our findings. Following McGuire's first three steps in the model of persuasion (54), we cannot say conclusively whether our messages were well designed to persuade. The possibility of exposing employees to the messages was severely limited by the pandemic and there was a variety of different opinions by the stakeholders about the message's attention generation and understanding. The significance of coherent messages—especially in the context of mass media campaigns—has been highlighted in the literature (65). Williamson et al. (66) recommend that physical activity messages for adults should be brief and framed positively (e.g., addressing the benefits). In WHP projects and especially in such cross-company networks, one should possibly ascribe more attention to the strategic approach of information brokerage than the development of the design and messages. As Budde (64) has noted, a positive public image and advertising are insufficient for the success of WHP and their disclosure. In this context, the author emphasizes the importance of a systematic and strategic

approach of communication (64), which is also mentioned by further researchers (44, 67). Nevertheless, the design aspect should not be completely disregarded. As Nöhämmer (68) showed in an earlier qualitative study, information in the context of health promotion should show appreciation for the employees, which is also achieved through an appealing design. In this context, Bergeron et al. (26) also emphasize the importance of a high quality of information transmitted.

Our identified facilitating factors and barriers toward successful communication also showed parallels with previous research. The use of alternative communication channels beyond newsletters, websites, and posters was cited as a key factor in terms of a successful communication within a cross-company network. This is also described as a success factor in literature (39, 64, 69).[2] According to Bergeron et al. (26), various modalities and different channels that convey the messages can enhance the impact of a campaign. Furthermore, our findings indicate that face-to-face contact should be ensured. Several studies have emphasized that conversational communication holds strong significance (21, 64, 68, 70). As Walter et al. (21) and Baumann et al. (25) have highlighted, there is a higher probability of reaching addressees. Our results indicate that in this context, low-threshold events and activities that enable personal conversation with employees provide an opportunity. A study by Stummer et al. (49) also identified such symbolic events as being conducive to successful communication. Thereby, our results suggest that the exchange should also be made possible within the target group. This could potentially be realized by providing a corresponding function within the information platforms, which was a recommendation by the stakeholders. According to the literature (25), the strength of such online forums can be seen in a very high target group specificity and interactivity, which in turn could have a beneficial effect on the communication process.

Moreover, our results suggest considering existing access paths and good public relations. As also described in the literature (6), public relations' activities are one central plank in the context of WHP. Overall, the entire communication procedure should be integrated into a management, as already mentioned above. Among others, this takes into account the regularity of information, which is also recommended by the literature (68, 69). Thereby, communication of WHP measures should always consider the organizational context. As Stummer et al. (49) have noted, organizational conditions can have a significant influence on the success of communication and the timing of communication is essential. Thus, in the context of health marketing, the literature (46) also refers to the appraisal of organizational prerequisites within the planning process. In a cross-company context—as in our study—this cannot always be realized but should be considered as a possible influencing factor. Basically, some disadvantages can be mentioned regarding communication processes in cross-company networks (compared to communication in single companies). First of all, a higher planning effort for the communication strategy can be assumed. Companies from a wide range of sectors can be represented in cross-company networks. Often—depending on the sector—the everyday work differs greatly. Besides, the target group can be very heterogeneous. In addition, it is more difficult to involve the target group in the conception, since there are significantly more employees to deal with. There is also a challenge in specifically adapting the communication process to the needs of the individual company. However, if reliable contact persons are available in the companies and good internal structures for passing on information have already been created, cross-company networks also offer the opportunity to address health messages to a broad mass.

Our findings also support previous research concerning the importance of different stakeholders in the communication of WHP measures. In particular, engaged multipliers represent an important facilitating factor. Several studies (21, 44, 64) have reported the importance of a timely involvement of various multipliers, whereby managers and work councils in particular are mentioned in this context. As we have seen in our study, the focus was not so strongly placed on the profession of the multiplier in the company, but rather the importance of the personal commitment and the willingness and motivation to address the issue, particularly when it comes to promoting behavioral change and accessing difficult-to-reach target groups. Wäsche (44) emphasizes the important role of informal actors in the company (e.g., respected colleagues) to transmit health-related information.

In many cases, stakeholders reported that people could also act as a barrier in the communication of measures. Baumann and Hastall (71) also highlight the influence of people regarding the success of health communication. As it is also known from the literature (72, 73), successful WHP is related to the support of the management level. Furthermore, it should not be forgotten that measures are still voluntary and people cannot be forced to participate (6). Finally, a lack of time and the priority of other topics—which are known challenges in the context of WHP, especially in smaller companies (6, 74, 75)—were named as barriers for successful communication.

Overall, the implementation of the communication strategy was strongly influenced by the coronavirus pandemic. This may also be one reason for the low usage data of the website and the newsletter. Throughout the course of the project, the pandemic situation made it almost impossible to get in personal contact with the employees. Among others, a major inaugural event on site during which the project was due to be widely publicized had to be canceled. Since no on-site events could be conducted, the banner and business cards were not used. Additionally, the posters were distributed much less frequently, partly due to the

2 https://www.cdc.gov/workplacehealthpromotion/planning/communications.html

fact that the technology park was less frequently visited due to the pandemic. As the literature points out (25, 76), posters offer a high degree of clarity and can again help to increase the perceived relevance of the topic. Communication options were therefore also limited by the fact that many employees worked in their home offices. The qualitative data support these statements, as stakeholders also saw the pandemic as a strong influencing factor. Besides, current research (77) confirms that there were difficulties in reaching target groups due to the pandemic circumstances. As Bonfadelli (33) has noted, insufficient time to reach the target group is one factor that can limit the success of communication campaigns. This may have also been true for the present project.

Home office working will most likely continue to play a major role in the future (77). This is attached to new challenges for WHP measures and their communication. Therefore, hybrid approaches will continue to be relevant in the next years, which once again requires effective communication management and close exchange with the companies. However, the literature (78) indicates that e-health tools can be supportive in WHP, including when it is about information and communication. Finally, our results support the assumption that the cross-linked use of instruments with a dialog-oriented focus is significant for communication as Walter et al. (21) postulated in their model for the systematization of communication tools for WHP. Nevertheless, additional research is necessary to confirm these results, especially in the context of cross-company networks.

Strengths and limitations

The results of our study offer insights into the design of communication strategies to promote physical activity in cross-company networks and allow drawing conclusions for the general WHP praxis. Thus, this study makes an important contribution to the transfer of science and practice as it captures relevant questions from praxis. Thereby, the serration of qualitative and quantitative data enabled a comprehensive evaluation of the communication strategy implemented. The monitoring of the usage data provided an initial insight into the applied communication strategy at the output level. Afterward, the results of the monitoring contributed to the development of the interview guide. The interviews themselves enabled a deeper insight into the communication strategy. Overall, serration of data thus made it possible to develop a better overall interpretation of the communication strategy.

However, it is necessary to acknowledge some limitations. Regarding the planning conception and development of the communication strategy, it could be critically noted that no employees or project partners were involved, although this is recommended in the literature (25, 39, 79) (e.g., *via* participatory measures as survey or workshop). A lack of time at the beginning of the project did not allow for this. Second, the evaluation and interpretation of the qualitative results are based on a weak empirical foundation with only 14 participants with heterogeneous backgrounds. There could also have been a response bias in the evaluation of the communication strategy since the interviewees were all part of the project and there is a barely assessable extent to which the results of the interviews may appear to be socially desirable. Further research is required to generalize the qualitative findings concerning the facilitators and barriers. As with all interventions in WHP, the present study was a complex intervention in a complex setting, and it was strongly influenced by the coronavirus pandemic. Therefore, the results should be interpreted conservatively. Besides, the limits of the meaningfulness of the usage data must be pointed out. The number of users does not provide evidence about the real number of users. It is also possible that people visited the website more than once (e.g., from different devices), which would be associated with an even lower number of total users. Also, we did not distinguish between the number of users and the number of views and there is also no socio-demographic data available to gain more insights concerning the usage data. Finally, reference must be made to the general depth of our analysis. The KomRueBer project was a model project that did not allow to contribute to an evaluation of effectiveness. The overall study focused a descriptive approach. Therefore, it was not the aim of the present study to conduct an evaluation of effectiveness concerning the communication strategy. Rather, the present paper must be seen as part of a clear process evaluation, which is a strength at the same time. It provides valuable information in terms of quality development in the context of communication processes in WHP and contributes to the output level in the overall context of the impact model-based evaluation of the KomRueBer study.

Conclusion

Communication is an important factor that should always be taken into account when planning WHP projects. This mixed-methods study revealed which factors may have an influence on the successful communication of physical activity measures in the context of WHP in cross-company networks. Thereby, the importance of active management of the communication process became clear. Our results provide initial suggestions for successful campaign management in future cross-company networks. As part of the project, we primarily focused on developing professional messages and design during the development of the communication strategy. However, the results also show the strong importance that should be attached to the strategic planning of the entire communication process. Reaching the target group requires a systematic approach, not only in individual companies but also in cross-company networks featuring companies from different

sectors and with different sizes and requirements. In any case, media should be appealing and messages appreciative. Nevertheless, we recommend not investing excessive time in this regard, but rather trying to create spaces for personal contact opportunities with people on site. We also recommend involving the target group in the planning process from beginning. In addition, the structural conditions in the companies should be recorded promptly, for example, as part of introductory working groups. From our perspective, a communication strategy should be included into every WHP project as it creates initial access to the topic. To sum up, the results of our study provide valuable information on how communication strategies for physical activity in cross-company networks can be designed. Thus, the study addresses a relevant problem from practice—namely, reaching the target group for health promotion measures. The evaluation approach with focus on the output level is a valuable basis for subsequent effectiveness studies and takes on an important role concerning quality development in the context of WHP.

Data availability statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of the German Sport University Cologne (Reference Number: 068/2020). The patients/participants provided their written informed consent to participate in this study.

Author contributions

CH and AS: conceptualization and methodology. CH: analysis, visualization, and writing—original draft. AS: resources, project administration, funding acquisition, and writing—review and editing. Both authors have read and approved the final manuscript.

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Conflict of interest

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

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Barriers and facilitators to the adoption of physical activity policies in elementary schools from the perspective of principals: An application of the consolidated framework for implementation research–A cross-sectional study

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Background: Studies have shown that policies to promote physical activity in schools can have a positive impact on children's physical activity behavior. However, a large research gap exists as to what determinants may influence the adoption of such policies. Applying the Consolidated Framework for Implementation Research (CFIR), we investigated barriers and facilitators to the adoption of physical activity policies in elementary schools in Baden-Wuerttemberg, Germany, from the perspective of school principals.

Methods: A cross-sectional study was conducted between May and June 2021. School principals from elementary and special needs schools ($n = 2,838$) were invited to participate in the study. The online questionnaire used was developed based on the CFIR and included questions on school characteristics and constructs of the CFIR domains inner setting, characteristics of individuals, and process. Logistic regression analyses were performed to examine associations between policy adoption and school characteristics as well as CFIR determinants.

Results: In total, 121 schools (4%) participated in the survey, of which 49 (40.5%) reported having adopted a policy to promote physical activity. Positive associations with policy adoption were found for general willingness among teaching staff [odds ratio (OR): 5.37, 95% confidence interval (CI): 1.92–15.05], available resources (OR: 2.15, 95% CI: 1.18–3.91), access to knowledge and information (OR: 2.11, 95% CI: 1.09–4.09), and stakeholder engagement (OR: 3.47, 95% CI: 1.24–9.75).

Conclusions: This study provides a first insight into potential barriers and facilitators at the organizational level of schools that may be relevant to the adoption of physical activity policies, from the perspective of school principals. However, due to a low

response rate, the results must be interpreted with caution. A strength of this study includes theoretical foundation through the use of the CFIR. The CFIR could be well-adapted to the school setting and provided valuable support for developing the questionnaire and interpreting the study results.

KEYWORDS

implementation outcome, implementation determinants, health promotion, schoolchildren, implementation framework

Introduction

Physical activity can have a positive impact on children's health and academic achievement (1–3). According to the World Health Organization's (WHO) recommendations on physical activity, children and adolescents aged 5–17 years should do at least an average of 60 min of moderate-to-vigorous intensity of physical activity per day (4). However, the recent Global Matrix 3.0 Physical Activity Report Card analysis showed that only 20–26% of children and adolescents in high- and very high-income countries meet this recommendation (5). To counteract physical inactivity, the WHO recommends different evidence-based policy actions (including school-based concepts) to create active societies, environments, people, and systems (6).

Schools are an important setting for implementing health programs, as they can reach children across various sociodemographic backgrounds and over a relatively long period of time (7–9). Countries such as the United States and Canada have already developed and introduced school-based policies aimed at increasing children's daily physical activity levels (10–12), and the current evidence base underpins the effectiveness of such policies (13, 14). In general, however, the effectiveness of a policy depends not only on the policy itself, but also on the way it is implemented in practice (15).

Implementation can be described as the process of putting to use or integrating innovations within a setting (16). In addition to the setting itself, actors, strategies, the target group, and the characteristics of the policy, may influence this process. In turn, they all interact with an active and dynamic cultural, social, economic, and political context (17, 18). Consequently, the implementation process can be influenced positively (facilitators) and negatively (barriers) in many ways (19).

If organizations such as schools have an intention, make an initial decision or take actions to try or employ an innovation, this is referred to as the implementation outcome "adoption" (20). Adoption occurs at an early to mid-stage of the implementation process and is assessed from the organization's or provider's perspective (20). Either adoption leads to implementation activities or adoption is rescinded (21).

To understand the underlying mechanisms relevant to policy actions, the use of implementation science theories, models, and frameworks can be supportive. Thus, determinant frameworks–in contrast to process and evaluation frameworks–show basically conceptual constructs that can have a potential impact on implementation outcomes (19). One determinant framework that provides a systematic guide for assessing potential barriers and facilitators is the Consolidated Framework for Implementation Research (CFIR) (22). The framework lists 26 key determinants, which are grouped into the following five domains: intervention characteristics, outer setting, inner setting, characteristics of individuals, and process (22).

Previous studies on programs promoting physical activity have examined the processes or underlying determinants of implementation, with some studies focusing on interventions (23, 24) and others on policies (25–28). Compared to interventions, policies are not only individual measures or actions, but provide a framework within which interventions are tendered, developed, financed or implemented (13). Regarding school-based interventions, there is already some evidence on processes and barriers and facilitators that might influence adoption (24, 29–32). In a systematic review by Cassar et al. (24), studies were evaluated for determinants associated with the adoption of school-based physical activity or sedentary behavior interventions. The identified factors were categorized according to Durlak and DuPre's determinant framework (15), whereby most of the facilitators ($n = 15$) and barriers ($n = 9$) related to adoption (e.g., characteristics of the school) could be assigned to the domain "prevention delivery system" (24), which is a domain reflecting organizational capacity. However, research on this topic in relation to policies is rather scarce (11, 29, 33, 34). Furthermore, the research team is not aware of any cross-national, Germany-wide, or south-west Germany-wide studies on barriers and facilitators to the adoption of physical activity policies in elementary schools. So far, there is also little information on what might influence the adoption of a policy from the perspective of school-level decision-makers (11).

Previous studies that have investigated possible determinants to the adoption of physical activity policies in schools have–if at all–used evaluation frameworks [e.g., RE-AIM Framework (35)] which, due to their focus on the evaluation of implementation, are suboptimal for assessing determinants that might impact implementation processes (19). Although numerous frameworks exist for evaluating determinants for policies promoting physical activity (36), we chose the CFIR as it is one of the most widely used frameworks (37, 38), provides a detailed description of constructs (22), and has also been found to be applicable and appropriate for the school setting (39, 40).

The aim of this study, therefore, is to exploratively examine, which barriers and facilitators at the organizational level are associated with the adoption of physical activity policies in elementary schools in Baden-Wuerttemberg (south-west Germany) from the perspective of school principals by using the determinant framework CFIR.

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval; CFIR, Consolidated Framework for Implementation Research; WHO, World Health Organization.

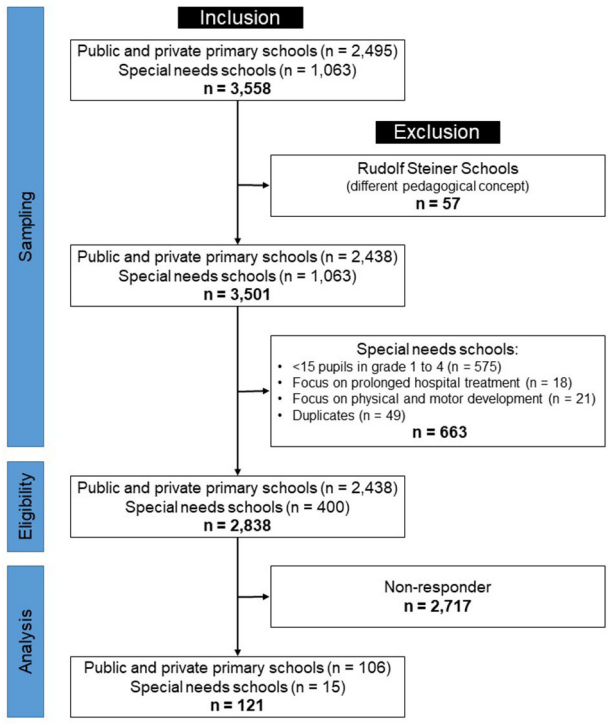

FIGURE 1
Data sampling flow diagram.

Materials and methods

Study design, sample and recruitment

A cross-sectional study of elementary schools and schools for children with special needs was conducted between May and June 2021 in Baden-Wuerttemberg, south-west Germany. In Baden-Wuerttemberg, elementary schools range from first to fourth grade. Without taking early or deferred enrollment and possible repetitions of a grade into account, the age range of students in grades one to four is generally from six to ten years.

The sample of schools was taken from a database provided by the Federal Statistical Office Baden-Wuerttemberg. All public and private elementary schools (n = 2,495) as well as special needs schools (n = 1,063) were eligible for participation, with the following exceptions: Rudolf Steiner Schools (n = 57) were excluded as they practice a different pedagogical concept. Given that special needs schools usually contain grades five and higher, those with fewer than 15 students in grades one to four were considered to be secondary schools and thus excluded (n = 575). Moreover, special needs schools with a focus on students undergoing prolonged hospital treatment (n = 18) and physical and motor development (n = 21) were excluded, as the promotion of physical activity only plays a subordinate role due to students' physical conditions or is based on special concepts. Furthermore, duplicates among special needs schools (n = 49) were removed. Finally, 2,838 schools [elementary schools: n = 2,438 (86%); special needs schools: n = 400 (14%)] were invited to participate. The data sampling strategy is outlined in Figure 1.

An invitation letter was sent to each school asking all principals and deputy principals to participate in an online survey. The letter contained a brief description of the purpose of the study, all necessary information on the conditions of participation, confidentiality practices, and data protection measures, as well as the contact information of the study office. In addition, the letter included a QR code and URL to access the online questionnaire, as well as an individual study code for each school. To enhance recruitment, two postcards containing key information about study participation and the QR code were enclosed with the invitation letter. In addition, a short video was presented on the front page of the online questionnaire to motivate school principals and provide completion instructions. A reminder letter was sent on June 1, 2021 to increase participation rates. The survey period ran for a total of six and a half weeks between May and June 2021. The study was approved by the ethics committee of Ulm University (Application Number 252/20) as well as the Ministry of Education, Youth and Sports of Baden-Wuerttemberg.

Questionnaire and measures

The development of the questionnaire is based on the CFIR and existing survey instruments for evaluating physical activity policies or interventions in schools. Individual items of the School Physical Activity Policy Assessment (S-PAPA) (41), School Health Policies and Practices Study (SHPPS) (42), COMPASS school programs and policies (SPP) (43) and "Join the Healthy Boat" (German version) (44) questionnaires were included. The questionnaire was pre-tested by members of the research team, external colleagues, an elementary school principal, and a special education teacher to assess question comprehension, skip patterns, flow and completion time. The final version was transferred to the online survey software Unipark EFS (Enterprise Feedback Suite) (45) and comprised the following sections: (1) personal details, (2) school characteristics, (3) physical activity policies, (4) implementation determinants/attitudes toward policies, (5) physical education, (6) students with disabilities, (7) recess, (8) health promotion, (9) school environment, (10) active way to school, (11) resources and funds, and (12) final questions. The variables used in the present study are described in more detail in the following sections.

Outcome variable: Policy adoption

Policies can be defined as "*purposeful decisions, plans and actions made by voluntary or authoritative actors in a system designed to create system-level change to directly or indirectly achieve specific societal goals.*" [derived from PEN Consensus with adaptions from Lakerveld et al. (46)]. Based on this definition, policies aiming to promote physical activity at elementary schools in Baden-Wuerttemberg were identified through an internet search and subsequent consultation with the Ministry of Education, Youth and Sports of Baden-Wuerttemberg. Accordingly, there is one mandatory policy (physical education curriculum) and three voluntary policies. The following three voluntary policies, which were focused on, are: (1) National Recommendations for Physical Activity and Physical Activity Promotion, (2) Elementary school with a focus on sport and physical education, (3) Sports and activity-friendly schoolyard.

Through the question "Does your school implement one or more of the following physical activity policies?" and the possible response categories yes/no, the adoption of each individual policy was ascertained. In addition, the participants had the opportunity to name other policies that exist on district/municipal level through an open-ended question. Schools that had reported implementing at least one policy were classified as "adopters," while schools that had reported not implementing any policies were classified as "non-adopters."

Respondents who indicated adopting a policy were asked additional questions about the duration of policy adoption, requirements and decision making-process, as well as reasons and requirements for adoption.

Predictor variables: CFIR determinants

Due to the lack of evidence on potential determinants associated with the adoption of physical activity policies in elementary schools, the selection of CFIR determinants was based on a meta-review that applied the CFIR to examine implementation determinants of school-based physical activity, diet, and sedentary behavior policies (27). In this regard, those CFIR constructs were included in the present study that were indicated as occurring in implementation processes in at least 80% of reviews/stakeholder documents analyzed in the meta-review. Subsequently, the constructs "structural characteristics," "implementation climate," "readiness for implementation" (domain inner setting), and "knowledge and beliefs about the intervention" (domain characteristics of individuals) as well as "engaging" (domain process) were included.

To best reflect the CFIR construct structural characteristics, individual items of the aforementioned questionnaires (41–44) were adapted. Participants were asked about the number of students and staff, type of school, care concept, information about the schools surroundings and facilities as well as the minutes of daily recess. Furthermore, the CFIR Interview Guide Tool (https://cfirguide.org/guide/app/#/) was used to formulate questions on CFIR determinants regarding the (sub-)constructs "implementation climate" and "readiness for implementation" as well as on the constructs "knowledge and beliefs about the intervention" and "engaging stakeholders." A total of 21 questions were asked to reflect the CFIR constructs. All predictor variables, the corresponding questions asked and their respective coding categories are described in Table 1.

Data analysis

Descriptive statistics such as frequencies and percentages and medians and 25^{th}-75^{th} percentiles were computed to summarize categorical and continuous variables, respectively. Normality of data was tested by Kolmogorov-Smirnov test. The chi-square test (categorical variables) and the Mann-Whitney U-test (continuous variables) were used to analyze differences between policy "non-adopters" and "adopters."

Multiple logistic regression analysis, using the enter method, were performed to examine the association between the outcome variable policy adoption and CFIR determinants on structural characteristics of the school (model 1) and the (sub-) constructs implementation climate, readiness for implementation, knowledge and beliefs about the intervention and engaging stakeholders (model 2). In both models, a complete case analysis (CCA) restricted to schools with no missing values on both the outcome variable policy adoption and predictor variables were performed. Associations are reported as odds ratios (OR) and the respective ninety-five percent confidence intervals (95% CI). A two-sided $p \leq 0.05$ was considered to be statistically significant. Because of the explorative nature of this study, all results from statistical tests must be interpreted as hypothesis-generating and not as confirmatory. An adjustment for multiple testing was not made. Data were analyzed using IBM SPSS Statistics version 28.0.1.0 (47).

Results

A total of 121 schools (4% of those eligible) took part in the survey. The questionnaire was completed by 102 principals (84%) and 19 deputy principals. About half of them (56%) had more than 5 years of experience in their position and the majority were women (61%). The distributions of school structural characteristics and the individual CFIR determinants are shown in Tables 2, 3, respectively.

Overall, 49 schools (40.5% of participating schools) reported implementing one or more physical activity policies at their school. "Elementary school with a focus on sport and physical education" was the policy adopted most frequently ($n = 38$), followed by "Sports and activity-friendly schoolyard" ($n = 19$). In contrast, the "National Recommendations for Physical Activity and Physical Activity Promotion" were adopted by one school. Overall, there were nine schools that implemented two policies. The mean year of policy adoption for "Elementary school with a focus on sport and physical education" and "Sports and activity-friendly schoolyard" was 2011 (earliest: 2000; latest: 2019; missing $n = 9$) and 2007 (earliest: 1995; latest: 2020; missing = 5), respectively.

According to participants, the policies were implemented "completely" at four schools (8%), "mostly" at 27 schools (55%), and "more or less" at nine schools (18%), whereas six participants (12%) indicated that they "don't know" if the policy was implemented as intended (missing: $n = 3$, 6%). One or more of the following reasons were indicated as being crucial for the adoption: decision of school management/principal ($n = 23$, 47%), decision of teaching staff ($n = 22$, 45%), evidence-based policy ($n = 9$, 22%), low costs and high benefits ($n = 7$, 14%), recommendation of another school ($n = 3$, 6%), and recommendation of an authority ($n = 2$, 4%).

Proportionally, the following persons were involved in the decision-making process to adopt a policy: principal ($n = 42$, 86%), teachers ($n = 40$, 82%), deputy principal ($n = 16$, 33%), specialist coordinators, ($n = 8$, 16%), school social workers ($n = 4$, 8%), students' parliament ($n = 4$, 8%), and supervisors ($n = 3$, 6%).

Based on bivariate associations, the data show no differences on school structural characteristics between policy non-adopters and adopters, except for the type of school ($p = 0.03$) and size of schoolyard ($p = 0.03$) (Table 2). Group differences were also found for the CFIR determinants general climate ($p < 0.01$), available resources ($p < 0.01$) and, access to knowledge and information ($p < 0.01$) (Table 3).

For logistic regression analyses, the data of six schools had to be excluded in both models due to incomplete data. Model 1 revealed

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TABLE 1 Description of CFIR predictor variables.

Predictor variable	Survey question and response categories	Coding categories
CFIR domain: Inner setting; Construct: Structural characteristics		
Number of students[a]	How many children in grades 1 to 4 attend your school?	n/a
Number of students with migration background[a]	How many children at your school have a migration background?	n/a
Numbers of employees[b]	How many personnel in the following positions do you have at your school? *(1) Teachers; (2) Integration assistants; (3) Social education workers; (4) All-day staff*	n/a
Type of school[c]	Please select the school type: *1 = Elementary school, 2 = Special needs school, 3 = Elementary school in combination with a comprehensive school, 4 = Other type of school, 5 = I don't know*	• Elementary school/Elementary and comprehensive school *(ref.)* • Special needs school
Care concept[c]	What is the care concept at your school? *1 = Half-day school; 2 = Open all-day school; 3 = All-day school; 4 = Another care concept; 5 = I don't know*	• Half-day school *(ref.)* • Open all-day school/all-day school
Location of school[d]	What is your school's zip code?	• Rural area *(ref.)* • Urban area
Size of schoolyard[c]	What is the size of the schoolyard at your school? *1 = up to 500 m²; 2 = 501–1,000 m²; 3 = 1,001–1,500 m²; 4 = 1,501–2,000 m²; 5 = 2,001 or more m²*	• ≤1,500 m² *(ref.)* • ≥1,501 m²
Number of sport facilities[e]	Which of the following sports facilities are available at your school? *(1) Sports hall; (2) Basketball court; (3) Football pitch; (4) Athletics facility; (5) Swimming pool; (6) None; (7) Other*	• Up to 3 facilities *(ref.)* • 4 or more facilities
Recess minutes[f]	On average, how many total minutes per day does a student receive recess? (during regular instruction time (without afternoon care); recesses when students can be physically active, without breakfast and lunch recesses)	• ≤ 34 min *(ref.)* • ≥ 35 min
CFIR domain: Inner setting; Construct: Implementation climate		
General climate[g]	There is a general willingness within the teaching staff to adopt or implement physical activity policies.	n/a
Tension for change[g]	At our school, lack of exercise or physical inactivity among students is a problem.	n/a
Compatibility[g]	The adoption or implementation of a physical activity policy can be well-integrated into existing workflows at our school.	n/a
Relative priority[g]	At our school, health promotion measures already exist (e.g., prevention programs on mental health or nutrition). The adoption or implementation of a physical activity policy tends to take a back seat compared to these.	n/a
Organizational incentives and rewards[g]	Those who are involved in the adoption or implementation of a policy at our school generally receive special recognition for it.	n/a
Goals and feedback[g]	The goals of existing or planned policies are generally clearly formulated and communicated to all persons involved (staff, parents, students).	n/a
Learning climate[g]	At our school, a working climate exists in which principals and/or teachers can express their own fallibility and need for support.	n/a
CFIR domain: Inner setting; Construct: Readiness for implementation		
Leadership engagement[g]	At our school, it can be expected that the principal or the person responsible for the project will provide support when introducing or implementing policies.	n/a
Available resources[g]	At our school, we have sufficient resources (time, staff, financial) to adopt or implement PA policies.	n/a
Access to knowledge and information[g]	At our school, we receive or it is planned to receive sufficient information and materials to adopt or implement physical activity policies.	n/a
CFIR domain: Individual characteristics		
Knowledge and beliefs about the intervention[g]	Research-based policies cannot be implemented in daily practice.	n/a
CFIR domain: Implementation process		
Engaging stakeholders[g]	It is important to involve all possible stakeholders (e.g., teachers, school management, parents, students, researchers, politicians) in the development of policies.	n/a

[a]The variable was assessed through an open-ended question. For analysis, it was treated as a continuous variable.
[b]The variables were assessed through an open-ended question. For analysis, responses were summed and treated as a continuous variable.
[c]The variable was assessed through a single-answer multiple-choice question. For analysis, it was dichotomized.
[d]Based on the 2002 State Development Plan of the Ministry of Economics Baden-Wuerttemberg, zip codes were assigned to the categories 1 = densely populated areas, 2 = peripheral areas around densely populated areas, 3 = central places and service areas, and 4 = rural areas. 1–3 were categorized as "urban area" and 4 as "rural area."
[e]The variables were assessed through closed-ended dichotomous questions (0 = "no"; 1 = "yes"). For analysis, responses were summed and dichotomized based on the median.
[f]The variable was assessed through an open-ended question. For logistic regression analysis, it was dichotomized based on the median.
[g]Responses to the corresponding survey question were measured on a five-point Likert scale ranging from 1 = "Do not agree at all" to 5 = "Totally agree." For the analysis, it was treated as a continuous variable.

TABLE 2 Descriptive and bivariate analyses of CFIR determinants of the construct structural characteristics with policy adoption (n = 121 schools).

CFIR inner setting/ structural characteristics	All (*n* = 121)	Policy not adopted (*n* = 72)	Policy adopted (*n* = 49)	Bivariate test statistic (P-value)
Number of students[a]				
Median (P25–P75) Min; Max	111 (57–180) 19; 450	86 (45–168) 19; 280	137 (66–181) 30; 450	2,081.50† (0.07)
Number of students with migration background[b]				
Median (P25–P75) Min; Max	17 (8–56) 0; 360	15 (6–55) 0;198	27 (10–62) 1; 360	1,878.00† (0.13)
Number of employees				
Median (P25–P75) Min; Max	17 (9–30) 4; 100	17 (9–27) 4; 95	17 (9–34) 4; 100	1,854.50† (0.63)
Type of school; *n* (%)				
Elementary school/elementary and comprehensive school	106 (87.6)	59 (81.9)	47 (95.9)	5.23‡*
Special needs school	15 (12.4)	13 (18.1)	2 (4.1)	(0.03)
Care concept; *n* (%)				
Half-day school (Open-) All-day school	63 (52.1) 58 (47.9)	40 (55.6) 32 (44.4)	23 (46.9) 26 (53.1)	0.87‡ (0.35)
Location of school; *n* (%)				
Rural area Urban area	61 (50.4) 60 (49.6)	37 (51.4) 35 (48.6)	24 (49.0) 25 (51.0)	0.07‡ (0.80)
Size of schoolyard; *n* (%)				
≤1,500 m^2 ≥1,501 m^2	71 (58.7) 50 (41.3)	48 (66.7) 24 (33.3)	23 (46.9) 26 (53.1)	4.68‡ (0.03)
Sport facilities; *n* (%)				
Up to 3 facilities 4 or more facilities	71 (58.7) 50 (41.3)	45 (62.5) 27 (37.5)	26 (53.1) 23 (46.9)	1.07‡ (0.30)
Recess minutes				
Median (P25–P75) Min; Max	35 (30–40) 20; 100	30 (26–40) 20; 100	35 (30–40) 20; 100	1,973.50† (0.26)

[a]Missing values n = 6; [b]missing value n = 1.
Values are minimum (min), maximum (max), numbers (n) and percentages (%); †Mann-Whitney-U-test; ‡Chi-square test; *Results are based on Fisher's exact test.

that there were no significant associations between school structural characteristics and the adoption of a physical activity policy.

Model 2 on the associations to CFIR determinants showed that for each higher level of agreement on the question about the general willingness within the teaching staff, the odds for being an adopter school was increased (OR: 5.37, 95% CI: 1.92–15.05). On the other hand, the determinants tension for change (OR: 0.75, 95% CI: 0.46–1.20), compatibility (OR: 0.77, 95% CI: 0.35–1.71), relative priority (OR: 1.07, 95% CI: 0.60–1.89), organizational incentives and rewards (OR: 1.32, 95% CI: 0.68–2.52), goals and feedback (OR: 1.51, 95% CI: 0.75–3.03), learning climate (OR: 0.70, 95% CI: 0.24–2.10), leadership engagement (OR: 0.35, 95% CI: 0.09–1.34), and knowledge and beliefs about the intervention (OR: 1.47, 95% CI: 0.75–2.88) were not found to be associated with the adoption of a policy. However, each higher level of agreement in terms of available resources (OR: 2.15, 95% CI: 1.18–3.91) as well as receiving sufficient information and materials (OR: 2.11, 95% CI: 1.09–4.09) increased the odds of being an adopter school. In addition, the estimated odds of being an adopter school were increased for each higher level of agreement on the importance of stakeholder involvement in policy development (OR: 3.47, 95% CI: 1.24–9.75). All findings from logistic regression analyses on both models are shown in Table 4.

Discussion

This study was the first to examine implementation determinants from the inner setting, individual characteristics, and process domain of the CFIR that were associated with the adoption of a physical activity policy in elementary and special needs schools in Baden-Wuerttemberg, Germany. It is striking that the structural conditions of the schools, such as number of students and staff or schoolyard size and number of sports facilities, were not found to be predictors for the adoption of a policy, whereas the general willingness of the teaching staff, available resources, access to knowledge and information, and involvement of stakeholders were significantly associated with the adoption of a physical activity policy.

Based on information provided by participating principals, the present analysis revealed that a large proportion of the teaching staff were generally willing to adopt and implement a policy to promote physical activity. However, the analysis also indicated that the higher the agreement on the level of willingness, the higher the odds of being an adopter school. The question on general willingness asked in the present study, depicted the construct of implementation climate only in a generic way and could not be further explained by the sub-constructs such as learning climate and compatibility. Since organizational climate is a socially-constructed concept that reflects the perceptions of individuals involved in relation to organizational culture (48), it is conceivable that the general willingness within participating schools could have been more accurately described through other factors of the schools' social context (e.g., cultural factors such as values and norms). However, these constructs were not included in the present study.

In our study, only about 30% of participating principals reported having sufficient financial, personnel, and time resources. Furthermore, slightly more than 30% of principals indicated that they receive sufficient information and materials at their school to adopt or implement policies. Both higher levels of agreement on the availability of resources and access to information and materials were positively associated with the adoption of a policy. This finding reflects previous research documenting factors associated with the adoption of school-based physical activity/nutrition policies (29, 33) or interventions (24). Overall, these findings underscore the need for external (financial) support such as from governments.

Another interesting finding of our study is the perceived importance of stakeholder involvement. Thus, 85% of the participating principals indicated that the involvement of stakeholders such as teachers, school management, parents, students, researchers or politicians is important when developing policies. Here, a higher level of agreement was significantly associated with policy adoption. This is consistent with research indicating that stakeholder engagement is the key to successful implementation (49–51). In addition, non-participation or symbolic participation

TABLE 3 Descriptive and bivariate analyses of CFIR determinants with policy adoption ($n = 121$ schools).

CFIR item		Do not agree at all	Do not agree	Neither agree nor disagree	Agree	Totally agree	Chi-square test (P-value)‡
		n (%)					
Inner setting/ implementation climate	General climate	4 (3.3)	4 (3.3)	26 (21.5)	69 (57.0)	18 (14.9)	29.76 (<0.01)
	Tension for change	10 (8.3)	61 (50.4)	9 (7.4)	32 (26.4)	9 (7.4)	2.47 (0.68)
	Compatibility*	1 (0.8)	14 (11.7)	38 (31.7)	57 (47.5)	10 (8.3)	5.91 (0.18)
	Relative priority	2 (1.7)	18 (14.9)	33 (27.3)	53 (43.8)	15 (12.4)	0.84 (0.98)
	Incentives and rewards*	6 (5.0)	29 (24.2)	52 (43.3)	30 (25.0)	3 (2.5)	5.50 (0.23)
	Goals and feedback*	1 (0.8)	14 (11.7)	37 (30.8)	52 (43.3)	16 (13.3)	5.94 (0.17)
	Learning climate*	–	1 (0.8)	6 (5.0)	74 (61.7)	39 (32.5)	1.03 (0.91)
Inner setting/ readiness for implementation	Leadership engagement*	1 (0.8)	1 (0.8)	4 (3.4)	70 (58.8)	43 (36.1)	3.84 (0.43)
	Available resources	15 (12.4)	47 (38.8)	27 (22.3)	28 (23.1)	4 (3.3)	14.52 (<0.01)
	Access to knowledge and information*	7 (5.9)	31 (26.1)	43 (36.1)	32 (26.9)	6 (5.0)	26.64 (<0.01)
Characteristics of individuals	Knowledge and beliefs about the intervention	5 (4.1)	48 (39.7)	51 (42.1)	17 (14.0)	–	1.56 (0.67)
Process	Engaging stakeholder*	–	4 (3.3)	14 (11.7)	66 (55.0)	36 (30.0)	6.60 (0.07)

*Due to missing values, the numbers varies slightly. ▢ = Median category of five-point Likert scale ranging from 1 = "Do not agree at all" to 5 =" Totally agree"; ‡bivariate association between policy adoption (non-adopter: n = 72, adopter: n = 49) and predictor variable. Results are based on Fisher-Freeman-Halton exact test.

of stakeholders describes a top-down approach (50), which rather hampers successful implementation. Based on responses from the schools that were classified as adopters, our data show that at least 40% of teachers were involved in the decision-making process, which may have facilitated the adoption process. The importance of stakeholder involvement for adoption observed in our study, might be supported by the results of similar research in the school setting (24, 29). However, to better understand the importance of stakeholder engagement on the adoption process of school-based policies, future research should distinguish between individual stakeholder groups.

If we contrast our findings to those from reviews on barriers and facilitators to the processes of implementation of physical activity policies in schools, we can find some overlaps regarding the importance of available resources, access to knowledge and information, and general willingness. Using the Theoretical Domains Framework (52), Nathan et al. (25) and Weatherson et al. (26) identified factors such as "lack of time," "lack of funds," "lack of sports facilities," "lack of training" and "teachers' attitudes toward physical activity (intention)" that may hamper implementation success. Although implementation actions and associated challenges may vary depending on the implementation stage (15, 53), it could be assumed that these factors are of particular importance already during the adoption phase, but also during later implementation stages. In order to make a decision to adopt a policy, time and information might be needed up front (e.g., dealing with the content of the policy, writing applications, applying for funds), and if the school has sufficient staff, this workload could be shared among several people. Furthermore, it could be assumed that the general willingness of all individuals involved supports these processes and individual actions in a positive way. The association with sports facilities observed by Nathan et al. (25) and Weatherson et al. (26), however, were not found in our study. One reason for this could be that the presence of sports facilities is not initially relevant for the adoption from the perspective of school principals. However, as shown by Lounsbery et al. (11), the availability of sports facilities might be of greater importance to teachers in terms of the quality of implementation.

Strengths and limitations

By applying the CFIR (22) in developing the questionnaire, this study has a solid theoretical foundation. The CFIR can be considered "meta-theoretical" as it was developed by synthesizing constructs from various existing implementation theories (22). It is widely used in implementation science (37, 38) and has already proven to be useful for assessing the implementation of health programs in schools (39, 40). In order to best reflect the selected constructs

TABLE 4 Multiple logistic regressions: Model 1 and 2 for school structural characteristics and CFIR determinants as predictors of policy adoption (n = 115).

Predictor variable	OR	95% CI	P-value
Model 1 structural characteristics			
Number of students	1.00	0.99–1.01	0.99
Number of students with migration background	1.00	0.99–1.01	0.78
Number of employees	1.00	0.96–1.04	0.96
Type of School; *n* (%)			
Elementary school/elementary and comprehensive school	ref.		
Special needs school	0.23	0.03–1.64	0.14
Care concept; *n* (%)			
Half-day school	ref.		
(Open-) All-day school	1.26	0.50–3.15	0.63
Location of school; *n* (%)			
Rural area	ref.		
Urban area	1.07	0.46–2.49	0.88
Size of schoolyard; *n* (%)			
≤1,500 m^2	ref.		
≥1,501 m^2	1.95	0.85–4.44	0.11
Sport facilities; *n* (%)			
Up to 3 facilities	ref.		
4 or more facilities	1.23	0.53–2.85	0.64
Recess			
≤34 min	ref.		
≥35 min	1.44	0.63–3.29	0.39
Model 2 CFIR determinants			
General climate[a]	5.37	1.92–15.05	<0.01
Tension for change[a]	0.75	0.46–1.20	0.23
Compatibility[a]	0.77	0.35–1.71	0.52
Relative priority[a]	1.07	0.60–1.89	0.83
Organizational incentives and rewards[a]	1.32	0.68–2.53	0.41
Goals and feedback[a]	1.51	0.75–3.03	0.25
Learning climate[a]	0.70	0.24–2.10	0.53
Leadership engagement[a]	0.35	0.09–1.34	0.13
Available resources[a]	2.15	1.18–3.91	0.01
Access to knowledge and information[a]	2.11	1.09–4.09	0.03
Knowledge and beliefs about the intervention[a]	1.47	0.75–2.88	0.26
Engaging stakeholders[a]	3.47	1.24–9.75	0.02

OR, odds ratio; 95% CI, 95% confidence interval; ref., reference category; [a]Five-point Likert scale ranging from 1 = "Do not agree at all" to 5 = "Totally agree".

in a quantitative survey, the CFIR Interview Guide Tool provided sufficient support in formulating corresponding questions. However, whether the respective items actually reflect the constructs adequately is uncertain, as we were not able to conduct validity tests due to limited funding and short study duration. To examine determinants of policy adoption at the organizational level of schools, a variety of constructs from the inner setting, individual characteristics and process domain were included in the analysis. However, possible associations with other domains and their constructs that might better describe, for example, the political and social context in which schools are embedded, were not investigated. Thus, only an incomplete picture could be drawn of the challenges that participating schools faced in adopting a physical activity policy.

Further limitations must be considered when interpreting the present study findings. The overall response rate of schools was low, which limits the generalizability of our results to other schools in Baden-Wuerttemberg. However, the ratio between participating elementary schools and special needs schools was about the same (eligible: 86% and 14%; participated: 88% and 12%). One explanation for the low response rate could be the restrictions imposed to combat the COVID-19 pandemic. Consequently, schools in Baden-Wuerttemberg could still not return to regular operation and principals were facing particular challenges due to organizational overload. Participation in a survey on physical activity among students may therefore not have been a priority. Although measures such as mailing postcards containing the QR-code, a video on the front page of the questionnaire, and a reminder letter were used to increase participation rates, an incentive could not be provided.

It is possible that schools that did not promote physical activity among their students were more likely not to have participated, thus non-response bias may have occurred. As a result, findings may be overestimated in terms of policy adoption. Some questions on the CFIR constructs related to the adoption *or* implementation of policies. Therefore, compared to schools that had not yet adopted a policy, the responses of schools that had already adopted physical activity policies may have been more related to the current situation of implementation rather than the previous circumstances at the time when the policy was adopted. For some schools, the date of implementation was several years ago. Consequently, our study is vulnerable to recall bias. In addition, the complexity of logistic regression models may limit generalizability. Furthermore, no adjustments were made for multiple testing as the research questions were addressed in an exploratory manner.

Conclusion

The present study provides a first insight into possible barriers and facilitators at school level that might be of importance for decision-makers when adopting physical activity policies. It can be hypothesized that the decision of elementary school principals to adopt a physical activity policy would be facilitated if there is a general willingness within the teaching staff, relevant stakeholders are involved, implementers have access to information and sufficient personnel, financial, and time resources are available. Overall, our experience has been that the CFIR can provide good guidance to assess determinants associated with the adoption of physical activity policies. It could be well-adapted to the school setting and was helpful in designing the study and interpreting the results. Future studies could attempt to explain how the characteristics of the individuals

involved affect the adoption of a policy and what importance external influences, such as the political context, may have.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of Ulm University (Application Number 252/20) as well as the Ministry of Education, Youth and Sports of Baden-Wuerttemberg in March 2021. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

The study was designed by JW, DAS, MFM, and JMS. JW and DAS developed the questionnaire with expert advice from MFM, BM, NL, and JMS. JW conducted the data analysis and interpretation, wrote the draft of the manuscript and integrated author comments, and revisions into the final version. DAS, MFM, AL, NL, and JMS critically revised the subject-specific content of the draft manuscript. BM, SF, AB, and KL contributed substantially to the preparation of the draft manuscript. All authors read and approved the final version of the manuscript.

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Conflict of interest

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

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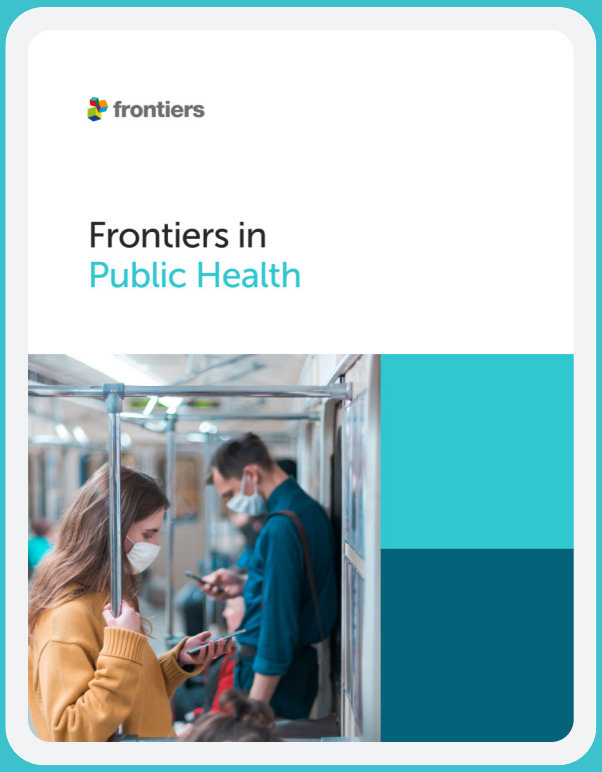

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