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ARTICLE

A Systematic Review of School-based Physical Activity Programs on Physical Fitness, Cognition, and Affective Outcomes in Early Childhood

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ABSTRACT

The purpose of this study was to review intervention studies on school-based physical activity programs in early childhood to identify the gaps and future trends in this topic. Forty-one quantitative experimental studies were identified from nine electronic databases using predefined inclusion and exclusion criteria. All identified studies were coded using a coding template. The interrater reliability between the two coders was 96.5%. The frequencies and percentages for each coded category were reported descriptively. The randomized controlled trial with a control group was the most used research design (70.7%), and 41.5% of the studies were guided by a theoretical/conceptual framework. The intervention length ranged from four days to three years, and 41.5% of the studies reported an intervention fidelity check in various forms. Different dependent variables were measured, and about half of the studies were focused on physical activity and anthropometry outcomes. A trend of the positive impact of school-based physical activity programs on children in early childhood was found. However, the rigor of studies needs significant improvements in multiple areas. Future intervention programs are suggested to include different elements in the design to develop children's cognition, physical fitness, and affective outcomes.

1. Introduction

Physical inactivity has been identified as the fourth leading risk factor for global mortality, leading to various health-related diseases (World Health Organization [WHO], 2020). To prevent people from physical inactivity, WHO (2018) released the Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World, highlighting the role of regular physical activity in people's health and well-being for a quality life. Given the powerful impact of physical activity on children and adults, WHO also developed some global physical activity recommendations for specific age groups. The Guidelines on Physical Activity, Sedentary Behavior, and Sleep for Children under 5 Years of Age is one document that provides suggestions on how much time children in early childhood should spend being physically active. For example, children aged 3-4 should participate in at least 180-minute physical activity throughout the day, at least

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60 minutes of moderate to vigorous intensity.

Many research studies have indicated the positive effect of physical activity on reduced adiposity among children (Davis et al., 2016; Nyberg et al., 2015; Waters et al., 2011). With the growth of the rates for overweight and obesity, childhood obesity is one of the serious public health challenges of the 21st century (WHO, 2012). For instance, the rates of overweight and obesity have tripled over the past three decades in the United States (U.S.) (Ogden et al., 2012). More specifically, the prevalence of childhood obesity was 12.7% among 2- to 5-year-olds, 20.7% among 6- to 11-year-olds, and 22.2% among 12- to 19-year-olds between 2017-2020 (Centers for Disease Control and Prevention [CDC], 2022). Childhood obesity has led to high blood pressure, high cholesterol, type 2 diabetes, breathing problems, and joint problems (CDC, 2022). It has been suggested that children participate in regular physical activity to reduce and prevent overweight and obesity (Lambourne & Donnelly, 2011; Nowicka & Flodmark, 2007; Steinbeck, 2001).

In addition, engagement in physical activity provides significant benefits for health among children, such as increased physical fitness, bone health, and mental health (WHO, 2022). As a result, a solid and healthy body helps a child have more energy and live a longer life. The release of endorphins due to activities helps to reduce the risk of anxiety and depression (U.S. Department of Health and Human Services [USDHHS, 2021). Physical activity participation can also enhance children's psychosocial outcomes, such as confidence and self-efficacy, which might be retained as they become adults (Spruit et al., 2016). Evidence also shows that physical activity improves cognitive outcomes, positively affecting children's memory and concentration in class (Donnelly et al., 2016; Strong et al., 2005). Given those benefits, CDC (2022) has recommended that children aged 3 to 5 should be active throughout their day, and children aged 6 to 17 should have at least 60-minute moderate to vigorous physical activity daily.

Schools have been identified as critical sites for children as they spend the majority of their daytime in school. The Comprehensive School Physical Activity Program (CSPAP) indicates that schools can provide many opportunities for students to be physically active through physical activity after/before school, physical activity during school, physical education, family and community engagement, and staff involvement (CDC, 2018). The opportunities such as movement breaks in the classroom, after-school sports clubs, activities/games in physical education, recess, and other school activities can potentially facilitate children's physical activity levels. Thus, a school-based physical activity program is essential in improving children's physical activity and developing them as a whole person, not only for their health and well-being but also for their academic achievement. Researchers have conducted various studies to examine the impact of school-based physical activity interventions on children. For example, the study conducted by Martínez-Vizcaíno and colleagues (2020) tested a physical activity intervention on obesity indicators, physical fitness, and blood pressure in children, and the study of Podnar and colleagues (2018) explored the effectiveness of a 5-minute classroom-based physical activity on children's on-task behavior and physical activity levels.

Early childhood is when children experience rapid physical and cognitive development, and their lifestyle habits are open to changes and adaptations. Helping children develop a physically active lifestyle is critical, and school plays an essential role in developing their habits. To date, while the majority of the systematic reviews on school-based physical activity programs have focused on K-12 students (i.e., elementary school students, middle school students, and high school students) and emphasized one or some of the following variables: physical activity, health, cognition, and/or motor skills (Mehdizadeh et al., 2020; Woodforde et al., 2022), few reviews are about the overall impacts on early childhood aged 0-8 years. This systematic review aimed to comprehensively review the impact of school-based physical activity programs in early childhood. By analyzing previous studies, this study attempted to provide insights into how physical activity programs were designed and implemented for early childhood and their impact on different outcomes.

2. Materials and Methods

This study reviewed research on school-based physical activity programs in early childhood to understand the status, identify the gaps and future trends, and make recommendations for future research studies.

2.1 Data Source and Literature Search

Before searching for research articles, two authors conducted three discussions to narrow down the scope of the review and inclusion and exclusion criteria. As a result of the discussions, nine electronic databases highly used in the field were emphasized for literature research, including Education FullText, Eric, SportDiscus, Medline, PsycINFO, EBSCO Host, JSTOR, PubMed, and Proquest. In addition, the authors also examined Google Scholar, reference lists, and other literature review papers on the

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relevant topic as supplements. The following key terms were used to search: physical activity program, physical activity intervention, school-based physical activity program, before-school physical activity program, after-school physical activity program, early childhood, classroom physical activity, classroom movement, and brain breaks. In addition, all types of dependent variables were included.

2.2 Inclusion and Exclusion Criteria

Seven inclusive criteria were used: (1) intervention study, (2) quantitative study, (3) early childhood (0-8 years old); (4) school-based physical activity program; (5) published after 2000, (6) English article, and (7) peer-reviewed academic paper. Studies were excluded if they only employed a qualitative method, included mixed age groups of participants, focused on motor skill programs/intervention rather than physical activity, or the study was a proposal, not an actual study. Intervention studies in a physical education setting were also excluded from this review. The first two authors manually examined the articles in the databases using the key terms and inclusion and exclusion criteria. When examining, the authors investigated the titles, abstracts, methods, and age groups. Through this search round, 56 articles were identified by the first two authors as the first review pool. Next, the first two authors independently examined the pool and highlighted the articles that did not meet the criteria and should be removed from the pool. Then the two authors met and discussed the highlighted articles. As a result, 15 articles were removed from the first pool, with a 100% consensus between the two authors. In the end, 41 articles that met inclusion and exclusion criteria were included as the final review pool for further analyses in the present study. Each article was given a specific I.D. number for organization and future use.

2.3 Data Extraction Procedure

To extract data from the articles, the first author developed an initial coding template with an operational definition for each variable in a coding book. Then the first two authors met to discuss the initial template, and revisions were made based on suggestions and comments. The details of the coding template are described below.

Coding Template

The coding template consisted of twelve columns, including I.D., citation, year, region, the purpose of the study, theoretical/conceptual framework, participants (i.e., sample size, age, and other characteristics as identified), research design, length of intervention/treatment, intervention/treatment program, fidelity check of implementation, and dependent variables. The first two columns (i.e., I.D. and citation) were provided based on the final review pool. The citation format followed the American Psychology Association (APA) guideline. The coders coded the rest ten columns for each identified article using the same template. Specifically, the operational definition for each variable is described below.

Year and Region. The year the paper was published was coded based on the citation as this information helps identify the time patterns of the experimental studies on this topic. In this region column, the authors focused on identifying the country where the study was conducted to examine whether research interests on this topic varied in different geographical zones. This information has the potential to provide backgrounds and contexts for school-based physical activity programs.

Study Purpose and Theoretical/Conceptual Framework. The study's purpose statement was included descriptively in the template for coders to understand the focus of the study. The coders identified the statement primarily from the paper abstract, and a second round of examination of the purpose statement in the main text was used to ensure consistency throughout the study. Once the coders finished collecting the purpose statement, they moved to identify the theoretical or conceptual framework applied to the studies. While collecting data for this column, the coders aimed to identify whether a theoretical or conceptual framework was applied to guide the study or the intervention design. If the authors employed a theoretical or conceptual model (e.g., Social Cognitive Theory, Achievement Goal Theory, Social-ecological model) to guide their study, it was coded as "1". Otherwise, it was coded as "0". The coders collected this information mainly from the methods section, with some exceptions that information was provided in the introduction section.

Participants. Two data sets were descriptively involved in the participant column: the total number of participants and age groups. Studies with participants aged 0-8 years old were selected (e.g., Pre-schoolers, K-2, etc.) and studies have mixed grade levels (e.g., PreK-5) were excluded from this review. If other characteristics were identified in participants, the coders included additional notes.

Research Design. The research design was coded based on the modified categories presented by Li et al. (2020), which included seven categories: (1) quasi-experimental design: only one intervention group without a repeated measure or with a repeated measure, (2) quasi-experimental design: multiple group comparisons

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without control and with a post measure, (3) quasi-experimental design: multiple group comparisons with a control group and a post measure, (4) quasi-experimental design: multiple group comparisons with a repeated measure without a control, (5) quasi-experimental design: multiple group comparisons with a repeated measure with a control, (6) randomized controlled trials (randomly assigned treatments with a control group: pre- and post-), and (7) single subject design for behavioral research. The research design was coded using the number of the category listed above.

Intervention and Fidelity Check. The length of the intervention was descriptively recorded based on the description by the authors (e.g., number of lessons/sessions, number of weeks, months, or years). If the length of the intervention was less than 12 weeks (about three months), it was coded "1."; if the length was between 12 weeks and 24 weeks long (about three months to six months), it was coded "2." If it was more than six months or 24 weeks, it was coded "3." Fidelity of implementation refers to "the extent to which delivery of an intervention adheres to the protocol or program model originally developed" (Mowbray, Holter, Teague, & Bybee, 2003, p.315). If a fidelity check of intervention implementation was conducted in the study, it was coded as "1". Otherwise, it was coded as "0."

Dependent Variables and Significance of Findings. The dependent variables were coded into seven categories descriptively: (1) physical activity (e.g., moderate physical activity [MPA], vigorous physical activity [VPA], moderate to vigorous physical activity [MVPA]), (2) anthropometry variables (e.g., Body Mass Index [BMI], waist circumstances, heart rate), (3) cognition (e.g., knowledge of the physical activity, school readiness, attention), (4) affective variables (e.g., on-task behaviors, behavior control, motivation, emotion, interest, attitudes), (5) motor skills, and (6) physical fitness (e.g., running time; balance). In the category of others, any variables not listed in categories 1 to 6 were coded as others. One column on the significance of findings was used to examine the effectiveness of the intervention on the dependent variables targeted in the study. The study's key findings were coded descriptively based on the identified dependent variables. The emphasis in coding this category was whether *statistical significance* was found in the specific dependent variables.

Coding and Data Analysis Procedure

The first two authors employed a series of steps to code all the identified articles. First, the two authors used the finalized coding template to practice coding two randomly selected articles from the pool independently; then, they met to compare and discuss the coding results. All questions and clarifications were addressed before moving to the second step. Second, over one-third of the identified articles were selected (n=15) and independently coded by the first two authors. Interobserver agreement (IOA) was calculated following the formula: IOA = (Total of Agreed Coding Items /Total Agreed and Disagreed Coding Items) X 100%. The IOA between the authors was 96.5%. Five disagreed coding items were discussed, and 100% consensus was achieved between the two authors. Lastly, the first two authors equally coded the rest of the articles. Once all articles were coded, all data were merged into one master Microsoft Excel Worksheet for analysis. A descriptive analysis procedure was performed for each variable identified in the coding template. The frequency and percentage for each variable were reported next.

3. Results and Discussion

The purpose of this paper was to review studies conducted on the research topic of school-based physical activity programs in early childhood. Specifically, a variety of categories of each study were examined, including the year of the publication, region of the study being conducted, purpose statement, research design type, theoretical/conceptual framework or model, characteristics of participants, fidelity check of implementation, dependent variables, and significance of the key findings. This section reported the findings in each category, and the interpretation of these findings was discussed afterward. Results of the findings were presented in the following order: year and region of study, study purpose and theoretical/conceptual framework, participants, research design, length of interventions and fidelity check of implementation, dependent variables, and significance of critical findings.

Year and Region of Study

Of the 41 school-based physical activity studies conducted since 2000, five studies (12.2%) were published in 2000-2010, and 36 studies (87.8%) were published since 2010. The data shows that most studies identified in this paper were published after 2010 and only a few were published between 2000 to 2010. The data from studies conducted in different countries are presented in Table 1. Europe and North American countries published significantly more studies on this topic than other continents. As shown in Table 1, almost half (n=20) of the studies were conducted in North America (48.8%). United States has the most studies conducted on this topic, which

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accounts for 43.9% (*n*=18). More than a quarter of studies (*n*=12, 29.3%) were conducted in Europe countries, such as Spain, Switzerland, and Norway. Five studies (12.2%) were conducted in Israel, three (7.3%) were conducted in Australia, and only one study (2.4%) from Asia was identified. The results were not surprising as this review only included the articles published in English that more studies in this paper may come from English-speaking countries.

A couple of reasons may help interpret the findings above. One reason is the prevalence of obesity worldwide, especially in Western countries since 2010. There has been a continuous call to address the obesity issue in prevention at an early stage of child development. In the United States, the obesity prevalence has significantly increased, from 30.5% in 1999-2000 to 41.9% in 2017-2020 (National Health and Nutrition Examination Survey, 2021). The other possible reason is the impact of the national physical activity and health guidelines and documents. Li et al. (2016) identified forty-five national physical activity and health guidelines and documents cited in research on teaching K-12 physical education in the United States since 1996. They found that 41% (108) of 262 articles cited one or more physical activity and health guidelines or documents when rationalizing and contextualizing the study. Thirty-eight guidelines and documents (84.4%) were published after 2000. The most cited documents were Healthy People Documents (USDHHS, 1991; 2000; 2018;), Surgeon General Report (1996), Centers for Disease Control and Prevention documents, National Association of Sport and Physical Education (NASPE) standards, and National Physical Activity Guidelines (USDHHS, 2008). More guidelines and documents have been updated in recent years, such as Healthy People 2030, and the 2018 National Physical Activity Guideline (USDHHS, 2018). A similar pattern could be found in other countries as well. Physical Activity Guidelines and documents provide critical information and statistics on the status of different health indicators for different population groups. Future research should refer to these documents to rationalize and contextualize their study to best serve the population in need and achieve the health objectives recommended in the documents.

Study Purpose and Theoretical/Conceptual Framework

Among the 41 articles, forty studies (97.6%) reported their purposes to examine the effectiveness of the physical activity program on the participants right after the intervention. One study reported that their purpose was to examine the effectiveness of the intervention after 14 weeks of the intervention implementation as a follow-up (Fitzgibbon et al., 2011).

Fifteen of the 41 articles (36.6%) reported the usage of a theoretical or conceptual framework to guide the study or intervention design, while twenty-six studies (63.4%) did not report any usage of the theoretical or conceptual framework. Among the studies with framework guidance, nine studies (60%) reported they applied the social ecological model or social cognitive theory in the study or intervention design. Two studies (13.3%) reported the application of self-determination theory (Riiser et al., 2020; Fitzgibbon et al., 2011). Two articles (13.3%) reported utilizing competence motivation theory in the studies (Gao et al., 2019; Xiong et al., 2019). Achievement goal theory was employed in the study (6.7%) conducted by Robinson et al. (2018), while self-efficacy theory was applied in the study (6.7%) conducted by Annesi, Smith, and Tennant (2013). One study (6.7%) utilized transformational leadership theory in designing their Great Leaders Active StudentS (GLASS) program (Nathan et al., 2017). In addition, two studies reported the usage of more than two theories (Annesi, Smith, & Tennant, 2013; Fitzgibbon et al., 2011).

The crucial finding mentioned above shows that almost two-thirds of the studies reported the usage of a theoretical/conceptual framework or model to guide the design of the study or intervention. The theoretical framework plays a critical role in providing an essential foundation for the researchers and audiences to understand the perspective a study takes. Different frameworks or models have their knowledge base and assumptions to understand how things work or explain different phenomena, which is the foundation for the study design. Therefore, it makes more sense when interpreting the findings from that perspective. The data in this paper showed that the social-ecological model was the most used among all the studies. Considering the complexity of physical activity promotion in early childhood, it may be appropriate to examine the effectiveness of intervention by looking at different factors involved in children's lives, such as parents, school, teachers, community, and policy. Other models or frameworks may also be appropriate depending on the research problems being addressed. Researchers must consider the research problems or questions being answered and employ appropriate theoretical or conceptual frameworks when designing the study.

Participants

The two primary data extracted from participants were

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sample size and age groups. The sample size ranged from 12 to 1,434 participants. One study used the schools as the unit of analysis, and no specific number of participants was reported (Webster, Wadsworth, & Robinson, 2015). Among the 41 articles, the participants ranged from 25 months (about two years old) to 8 years old, from toddlers to second grade. Most studies (*n*=38, 92.7%) focused on 3- 6 years old preschoolers. Three studies (7.3%) covered first- and second-grade participants (7-8 years old) at lower elementary levels. One study focused on children aged 3 to 4 years with autism spectrum disorder.

Research Design

In the category of research design, this study finds that the randomized controlled trial with a control group is the most used design (*n*=29, 70.7%). About 90% of the studies included a control group to compare participants' improvements on different dependent variables between groups. Five studies (12.2%) employed the quasi-experimental design: multiple group comparisons with a repeated measure *with a control*. Four studies (9.8%) reported using the quasi-experimental design: multiple group comparisons with a repeated measure *without a control* (pre-post). Three studies (7.3%) reported using a quasi-experimental design: multiple group comparisons *with a control group (post).* It is suggested that researchers apply rigorous designs when planning for the study, such as randomized controlled trials, group randomized trials, or nested/blocked designs.

Moreover, no mixed methods design was identified in any of the studies. Mixed methods are considered a powerful approach to understanding or examining the effectiveness of the intervention in both quantitative and qualitative ways. Therefore, researchers can include not only a quantitative approach but also a qualitative approach.

Intervention and Fidelity Check of Implementation

The length of treatment ranged from four days to three years of physical activity intervention implementation. Seventeen studies (41.5%) implemented the intervention in less than three months or 12 weeks. About a quarter of the studies (*n*=11, 26.8%) reported that their interventions lasted three months to 6 months or 12 weeks to 24 weeks. One-third of the studies (*n*=13, 31.7%) reported the intervention lasting more than six months or 24 weeks. It is hard for a short-term intervention to be effective, especially on the variables that may require a longer time to demonstrate change, such as BMI. It is recommended that more extended interventions should be designed to see the changes in dependent variables. The intervention arrangement at different periods should appropriately follow the learning curve for children at this age.

Regarding the fidelity check, 17 studies (41.5%) reported that they measured the implementation of the intervention. Twenty-six studies (58.5%) did not report any usage of an intervention fidelity check during their implementation. The measurements used for the fidelity check included checklist, students' responses survey, field observation, and questionnaire. A fidelity check of the intervention implementation is critical to examine whether the intervention is executed as planned, which helps ensure the integrity of implementation and later interprets the data appropriately. As Loffin (2015) argued, the fidelity of program implementation is highly correlated with the intervention outcomes. Without the fidelity check, it will be tough to conclude the effectiveness of one intervention as there may be confounding variables that are not captured by the researchers, regardless of significant findings or not. This study finds that almost 60% of the studies did not report a fidelity check in any form. This should raise research readers' awareness of the findings presented in the study. Future research should always include some forms of fidelity check depending on the complexity of the intervention, such as a checklist, field observations, and questionnaire. Researchers could follow the conceptual framework proposed by O'Donnell (2008) to design the specific forms of fidelity checks, in which five components could be examined during the intervention.

Dependent Variables and Significance of Key Findings

Among all 41 studies, 23 studies (56.1%) measured children's physical activity to examine the effectiveness of the intervention (e.g., steps; MVPA; VPA), with 15 studies (65.2%) reporting statistical significance in increasing participants' physical activity levels within the intervention group. Nineteen studies (46.3%) measured anthropometry variables (e.g., body weight, height, BMI, and waist circumstances), with ten studies (52.6%) reporting significant improvement within the intervention group. Twelve studies (29.3%) reported physical fitness as the dependent variable, and eleven studies (91.7%) found significant improvement in the intervention group. Similar findings were observed in the cognition category: twelve studies (29.3%) reported their measurements of cognition-related variables and eleven (91.7%) reported a significant increase in participants' cognition. Additionally, eleven studies (26.8%) in the review pool reported their assessment of affective-related variables, and nine of

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the eleven studies (81.8%) reported significant findings. Lastly, seven studies (17.1%) examined the effectiveness of the interventions on participants' motor skills, and five (71.4%) reported significant improvement in participants' gross motor skills and/or objective control skills.

These findings show that the dependent variables reported focused on physical activity and anthropometry-related variables, with less stress on children's physical fitness, cognition, and affective outcomes. Studies to examine the effects of physical activity programs on these three domain outcomes are critical. Physical fitness levels provide essential data on children's condition and potential to participate in physical activities. They are primary indicators of one individual's physical ability and can be applied to any physical activity. Cognitive levels show how well the children know or understand physical activity. Regardless of age, understanding how physical activity works and what it does to the body and life is vital to develop an active lifestyle. Individuals' attitudes, emotions, or habits in participating in physical activity should not be ignored. Research has shown how valuable physical activity is in regulating people's emotions, values, and motivation to participate in physical activity and social benefits. More future research should be conducted to examine the effectiveness of the intervention on these variables. Moreover, the interventions should also consider integrating elements in developing children's physical fitness, cognition, and affective outcomes into the design rather than physical activity or anthropometry variables only.

The findings of the significance of interventions on different outcomes show that higher percentages of statistically significant findings were presented in variables in physical fitness, cognition, and affective outcomes. In comparison, relatively lower percentages of statistical significance were observed in physical activity and anthropometry-related variables. Different reasons may help interpret this finding. First, different measurements were used to assess physical activity and anthropometry data. Some studies used different tools to assess physical activity, such as accelerometers, pedometers, or parents' reported children's play time. This may result in the variances detected and the significance levels. The same pattern applies to anthropometry measurements. Second, the length of the intervention. As only 30% of the interventions are longer than six months, it may create challenges to see significant positive changes in physical activity and anthropometry outcomes. Especially for anthropometry outcomes, it may take much longer to detect significant changes in children's weight, height, BMI, and waist circumstances, compared to other outcomes. Third, external factors. Most studies did not report any control of other factors, such as nutrition or other physical activity programs in which children participated. How these factors impact children's participation during the intervention must be clarified.

4. Conclusion

This study examined the experimental research on the effectiveness of school-based physical activity programs in early childhood. Overall, the descriptive analysis of the impact of physical activity on children's outcomes in different domains showed a positive pattern. However, improvements in study rigor were identified in the following areas in the present study: theoretical framework utilization, rigorous research design, the longer length of intervention, fidelity check of implementation, and reliable and validated measurements. Appropriate physical activity programs that reflect the development levels in this age group should be designed following the theoretical framework. It is suggested that more in-depth analysis should be conducted to examine further the quality of the intervention and the appropriateness of methodology utilized in the study. Moreover, gaps should be addressed in examining intervention effectiveness in cognition, physical fitness, and affective outcomes in early childhood.

Furthermore, fidelity checks of intervention implementation should be from different components, such as the participants' responses and other stakeholders' observations, rather than only on the execution by personnel providing the treatments. Lastly, it is recommended that researchers should contextualize the research problems in a variety of populations that are in need. This study provides essential information and can contribute to future research design on school-based physical activity programs.

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Table 1

Descriptive Statistics for Region of Studies Being Conducted

Country	Frequency	Percentage
United States	18	43.9%
Israel	5	7.8%
Spain	4	6.8%
Switzerland	4	7.3%
Australia	3	5.9%
Canada	2	4.2%
Denmark	1	2.2%
Scotland	1	2.2%
China	1	2.3%
England	1	2.3%
Norway	1	2.4%
Total	41	100.0%

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