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Sport and Fitness in Children and Adolescents

A Multidimensional View

Edited by Lucy-Joy Wachira

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Published in London, United Kingdom

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http://dx.doi.org/10.5772/intechopen.98108
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First published in London, United Kingdom, 2023 by IntechOpen
IntechOpen is the global imprint of INTECHOPEN LIMITED, registered in England and Wales, registration number: 11086078, 5 Princes Gate Court, London, SW7 2QJ, United Kingdom

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

Additional hard and PDF copies can be obtained from orders@intechopen.com

Sport and Fitness in Children and Adolescents - A Multidimensional View
Edited by Lucy-Joy Wachira
p. cm.
Print ISBN 978-1-80356-062-5
Online ISBN 978-1-80356-063-2
eBook (PDF) ISBN 978-1-80356-064-9

Meet the editor

Dr. Lucy-Joy Wachira is a scholar of physical activity and exercise science and a full-time faculty in the Department of Physical Education, Exercise and Sports Science, Kenyatta University, Kenya. She has more than 12 years of university teaching experience. She has been a Fulbright Visiting Scholar-In-Residence in the Department of Kinesiology, Temple University, Philadelphia, USA. Dr. Wachira's research interests include physical activity among children and the prevention of obesity-related noncommunicable Diseases. She has participated in several international collaborative research projects. She is an author of book chapters, an editorial board member of the *Journal of Physical Activity and Health*, a guest editor for *Frontiers in Public Health*, and a peer reviewer for several refereed journals.

Contents

Preface

Regardless of gender, social class, cultural orientation, environmental influence, or ability, children have an innate need to play, irrespective of whether it is a formal or an informal mode. As professionals in this area, it is our responsibility to ensure the availability and provision of enjoyable conducive opportunities and environments that not only promote fitness but also nurture, develop, and perfect skills for optimal sports performance. Many books have presented and described basic concepts and general literature concerning physical activity, physical fitness, and sports among children and youth. However, current evidence and reviews targeting specialized programmes and interventions reveal a need for additional literature on topical issues which could provide important new information to support practitioners, future programmes, and possibly be applied in other settings. This book presents a rich mix of topics linked to physical activity and fitness among children and youth that augments existing literature.

Chapter 1 is a chapter on physical activity, fitness, and cognitive function in children and adolescents seeks to clarify the less understood influences of participation in physical activity on cognitive function at different stages of development. The authors note that specific effects of physical activity vary by intensity, mode, volume, and domain. They also summarize the relevant literature by linking empirical research to school and community settings. The chapter concludes that comprehensive approaches across multiple settings, offering opportunities to participate in physical activity, have the most significant potential for enhancing cognitive health among children and adolescents.

Studies have increasingly focused on the role of motor skill development on performance and the well-being of children with disabilities. Chapter 2 is a review chapter comparing the motor proficiency between children with typical development and children with autism spectrum disorder focuses on typical and atypical motor development. The chapter authors present proposals for improving the motor development of children and young people with autism.

Chapter 3 reminds us that over the last few decades, decreasing physical activity and increasing sedentary lifestyles have been associated with the progressive decline in physical fitness in children and adolescents. The authors investigate the evolution of fitness in adolescents by comparing the status of both muscular strength and body mass index (BMI) in 1990 with that of 2020. The study concludes that there is a need to assess and monitor physical fitness, as a health status indicator, in adolescents.

In cognizance of the global increase in vitamin D3 Deficiency associated with several health challenges likely to compromise performance in physical activity and sports, a chapter in this book highlights the role of vitamin D and its deficiency and implications on physical activity and sports performance. Chapter 4 focuses on children and adolescents, who are at a prime age for foundational development of motor function,

skills, and performance. It recommends sun exposure as the primary source of vitamin D with additional attention to vitamin D supplementation to support health and sports performance.

The final chapter seeks to examine the role and status of school sports. Although the literature supports the importance of quality physical education and school sports for different aspects of learners' development, school sports face various implementation challenges. The chapter authors express concerns that without meaningful motivation, continuous reform, or revision of policy, the desired delivery of physical education and school sports will remain unachievable.

I thank all the authors who contributed to the writing and successful completion of this book. I also express my heartfelt gratitude to Dr. Yasmin Goodwin for her encouragement and support in the editorial process.

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Chapter 1

Physical Activity, Fitness, and Cognitive Function in Children and Adolescents

Darla M. Castelli

Abstract

From the playground to youth sports, the benefits of physical activity for children and adolescents are primarily known. Less understood is how participation influences cognitive function at different stages of development. This chapter aims to summarize the literature on child and adolescent physical activity, fitness, and cognitive performance by translating empirical research to school and community settings. The specific effects of physical activity vary by intensity, mode, volume, and domain. This review suggested that physical activity and fitness were positively associated with higher cognitive function. Children who are aerobically fit and regularly physically activite are faster, more accurate responders and tend to do better in school. Participation in light to vigorous intensity physical activity cognitively benefits children. Additional benefits come from cognitively demanding (e.g., team sports) and vigorously intense (e.g., jumping rope) activities. Because benefit varies by physical fitness component and physical activity type, it is recommended that preschool children participate in an assortment of movements for 3 h a day, working up to 60 min of moderate-to-vigorous physical activity by age 6. Comprehensive approaches across multiple settings, offering opportunities to participate in physical activity, have the most significant potential for enhancing cognitive health among children and adolescents.

Keywords: development, cognitive performance, executive function, maturation, physical fitness, academic achievement

1. Introduction

Across the lifespan, childhood is the time when the rate of physical activity participation is highest. From a child running on the playground to a teen on the basketball court in the high school playoffs—human movement has many benefits, including disease prevention and improved physical, emotional, mental, and cognitive health [1–3]. Because physical activity is a health-protective factor, participation is essential. Human movement profoundly impacts cognitive development, beginning with the maternal physical activity during pregnancy in the first 1000 days of life and evolving to habitual participation in physical activity as an emerging adult. Behaviors of speaking, smiling (a facial expression of emotion), kicking, and transitioning from one place to another require sensorimotor integration; however, we often dismiss

these learned behaviors as reflexive and unassociated with physical activity across the lifespan. Early life physical activity experiences like this shape a child's cognitive developmental trajectory and provide opportunities for sustained participation in later life. The purpose of this chapter is to summarize the literature on child and adolescent physical activity, fitness, and cognitive performance by translating rigorous empirical research to school and community settings.

2. Physical activity behavior and recommendations for youth

How physical activity is defined has evolved. The initial definition differentiated between the term exercise from physical activity. As goal-oriented energy expenditure, exercise was associated with targeted training to increase physical fitness and workouts organized within a given competitive activity or sport (e.g., personal best in running the mile, playing a competitive game of tennis). *Physical activity* was broadly defined as "any bodily movement produced by skeletal muscles that result in energy expenditure". This seminal position paper by Caspersen et al. [4] framed how we classify forms of human movement. Sports, occupations with physical demands, and household tasks are considered physical activities. Today we still think of physical activity as behavior and fitness as a state of being, but its application is more nuanced and contextually grounded, reflecting physiological, metabolic, and psychological specific demands of participation within a given context and activity.

Regardless of the stage of development, human movement is classified using a continuum from sedentary to high levels of physical activity. The first physical activity continuum (**Figure 1**) [5] was based on data published in the 1996 Surgeon's General's Report [6] and intended to outline motivational behavior management strategies to increase adult participation. It is worth noting that the report did not contain specific recommendations for children's physical activity but did highlight behavior research studies like Child and Adolescent Trial for Cardiovascular Health (CATCH) and Sports, Play, and Active Recreation for Kids (SPARK) that transpired in schools to encourage that educational policy focus on offering physical activity and physical education within schools. Across the highlighted studies, physical activity

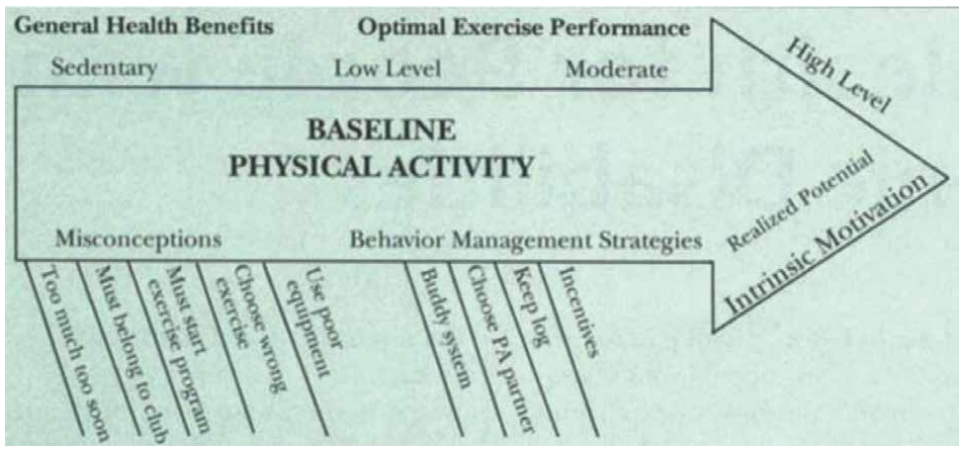

Figure 1.
Physical activity continuum [5].

programs as treatment increased participation and health markers, but there was little evidence that the effects were sustained during follow-up studies.

A 2021 report shows that adults in the United States (US) are more physically active than they were 20 years ago [7], but adults and adolescents continue to be insufficiently active, given the high prevalence of sedentary behaviors [8]. To promote physical activity in early life, the 2018 Physical Activity Guidelines for Americans targeted two distinct population groups of preschool (ages 3–5 years) and children and adolescents (ages 6–17). The US guidelines recommend that children under the age of 6 be physically active throughout the day. In contrast, the Canadian Physical Activity Guidelines have specified recommendations from birth to 5, with 3–4 year olds accumulating 180 minutes of physical activity at any intensity throughout the day [9]. Physical activity should engage a variety of movement skills in different environments. Life experiencing movement should progress toward a daily accumulation of 1 h of moderate to vigorous physical activity (MVPA) by age 5, which should be sustained throughout childhood.

A contemporary version of the physical activity continuum (**Figure 2**) [10] identifies multiple movement forms across a 24-h day. The visual representation suggests that participation in physical activity, as both daily living and planned behaviors, may mitigate health risk, especially when long periods of sedentary behaviors are disrupted. Although predominantly driven by data on chronic disease in later life, the physical activity continuum is applicable across the lifespan. Physical activity should be part of every child's day, from tummy time in infants to riding balance bikes in preschool. Among children ages 0–4, the Canadian Physical Activity Guidelines endorse more time moving and sleeping with less time sitting [11]. For school-aged children, the emphasis is placed on sweating (MVPA), stepping (light physical activity), uninterrupted sleep, and less time sitting [12]. The only similar designation in the US is the National Academies of Science, Engineering, and Medicine (NASEM) Consensus Report focused on US physical activity surveillance [13], with two of the four areas focusing on children and community support for physical activity. The report provides evidence-based strategies that will be presented later in the chapter.

2.1 Physical activity: why is promotion important?

Evidence demonstrating the health benefits of physical activity has grown substantially over the last 20 years [14]. Children globally and specifically benefit from

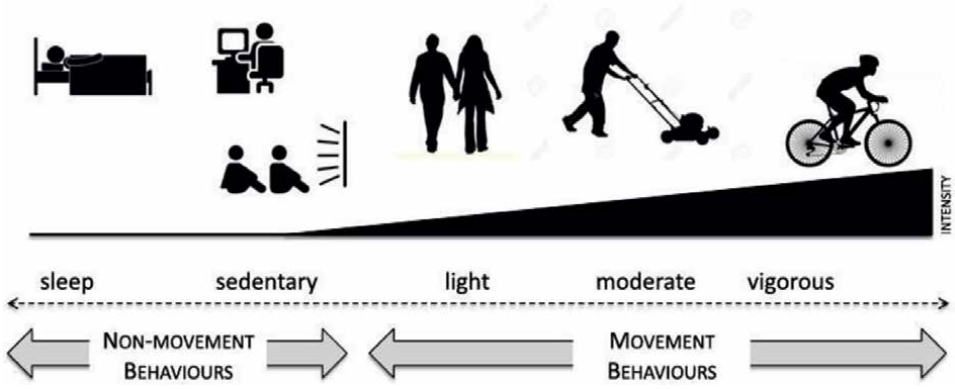

Figure 2.
Range of movement and nonmovement behaviours over a 24 h day.

physical activity, as regular participation decreases the risk of cardiovascular disease, especially when physical activity participation leads to increases in cardiorespiratory fitness [15]. Habitual participation in MVPA increases aerobic fitness and bone mass during childhood and reduces obesity, hypertension, and diabetes.

Independent of physical activity, sedentary behaviors continue to rise. Since the turn of the century, lifestyle has dramatically changed with technology manifesting sedentary behaviors because there is no longer a need for physical exertion in our contemporary lives. We most often think of this as accurate for adults, but the idea is also applicable to the lives of children. On average, children spend 41–51% of their time after school engaged in sedentary behaviors [16], with National Health and Nutrition Examination Survey (NHANES) accelerometer-assessed data demonstrating that sedentary behaviors ranged from 5.5 h/day among 6–11 year olds to 8.5 h among 6–19 year olds [17].

2.2 Racial and ethnic differences in rates of participation in physical activity and sedentary behaviors

It is recommended that school-aged children participate in 60 or more minutes of MVPA each day. Despite these recommendations, only 42% of children aged 6–11 years and 8% of adolescents meet this standard [18]. The Behavioral Risk Factor Surveillance System (BRFSS), a Centers for Disease Control and Prevention sponsored phone survey, collected data from 49 states by asking people how physically active they have been in the last month (https://www.cdc.gov/physicalactivity/data/inactivity-prevalence-maps/index.html). Data from 2017 to 2020 identified an overall prevalence of physical inactivity of 25.3%. Among Hispanic and non-Hispanic youth, 31.7% and 23.4% reported no physical activity participation in the last month. The prevalence of sedentary behavior such as prolonged sitting is on the rise.

The amount of time spent engaging in physical activity decreases continuously from childhood to older adults, and both physical activity and obesity during childhood track into adulthood [19]. In view of the numerous health benefits of physical activity, sedentary behaviors in America have become a public health concern and need to be addressed in research and practice.

3. Physical fitness among children and adolescents

Physical fitness is different from physical activity because it is not a behavior but is considered a state of being. Fitness is made up of 11 different elements and can be thought of as both health and skill-related, representing the capacity of body systems to work together to effectively perform the activities of daily living [20, 21]. Cardiorespiratory, muscular endurance, body composition, flexibility, power, and strength are health-promoting and are therefore called components of health-related fitness. Agility, balance, coordination, reaction time, and speed, are associated with better motor and sport performance and are therefore called skill-related fitness. There is a reciprocal interaction between physical activity, physical fitness, and health. If someone is regularly physically active, they will improve fitness and reduce their risk for disease, thus improving health. Likewise, if someone is physically fit, they are more likely to be physically active and healthy. Once thought of as the absence of disease, we now think of a child's well-being as the interaction between physical, mental, social-emotional, and cognitive health.

3.1 Physical fitness and development

Physical fitness is easily achieved and maintained in early life as functional movement throughout daily living, and natural growth and maturation will increase physical fitness, especially cardiorespiratory and muscular fitness. During pubescent and adolescent stages of development, there will be a slowing down of the natural benefits from any movement. More intense and specified types of physical activity are needed to improve fitness. Adolescents will need to add resistance to their physical activity, like lifting weights, to maximize their potential for strength and power. Greater attention needs to be given to the type of physical activity than the amount of weight being added. Resistance or weight training should improve both upper and lower body muscular fitness, and the program should encourage muscular balance and monitor fitness by component through standardized measurement in 3rd through 12th grade where there are established standardized cutpoints [22].

Physical fitness is a crucial state of being that should be sustained across the lifespan. Unfortunately, policymakers sometimes narrowly consider fitness from a competitive sport perspective only, particularly when deciding about physical education and physical activity opportunities in and around schools. Types of fitness that impact cognitive health and function should be integrated into all settings in which children spend significant amounts of time (e.g., home, school, child care, recreational and community programs) given its causal relationship with multiple types of health.

3.2 Effects of physical fitness and cognitive health

The examination of the effects of physical fitness on children's cognitive health ranges from big data analysis and cross-sectional studies in specified contexts to randomized controlled trials. The cognitive outcome variables of interest are commonly related to executive function, a set of higher-order cognitive processes that leads to goal-directed behaviors [23]. There are three primary mental processes: (a) cognitive flexibility, (b) inhibitory control, and (c) working memory. Since humans are not multi-taskers, cognitive flexibility is essential because it shifts one's attention from one thing to another, while inhibitory control blocks or resists the temptation to attend to irrelevant information sources (e.g., a ventilation system humming in the distant background). Working memory is the active process of retaining information.

Cross-sectional data evidencing a positive association between physical fitness and academic achievement are plentiful [24–26]. Research revealed more consistent effects with girls over boys [27] and significant effects in math and language arts versus other academic subject matters [28]. A year long study of Estonian children with a beginning average age of 6.6 years revealed that objectively measured physical activity predicted cardiorespiratory fitness, related to higher perceptual skills [29]. Another cross-sectional study called Cogni-Action Project assessed cardiorespiratory and muscular fitness and a range of executive functions in 1171 Chilean schoolchildren aged 10–14 in fifth to eighth grade. Positive associations were found between both types of fitness and five of the seven cognitive tests. Notably, speed and agility were not significantly related to cognitive function. The favorable association suggests that we should continue to encourage 60 min of MVPA per day, given the physical and cognitive benefits, with further examination of the effects of sleep, nutrition, and duration of sedentary behaviors as potential contributing factors.

The most robust data emerged from clinical trials with children. Randomized controlled trials named FITKids1 and FITKids2 ran for more than 10 years and produced a large body of empirical evidence surrounding habitual physical activity and aerobic fitness effects on several cognitive outcomes ranging from academic achievement to neural activation [25, 30, 31]. The trials focused on providing a physical activity-focused afterschool program for third and fourth grade students, who were randomly assigned to the program or a wait-list. Among the findings from the series of studies was that physical fitness can be significantly increased through an afterschool program [32]. Further, this series of studies suggested that aerobic fitness enhances brain function and changes brain structure [31, 33–35].

A 6-week study of 10–12 year olds randomized into team games, aerobic exercise, and control conditions suggests that both physical activity conditions improved aerobic fitness, but only the team games condition was positively related to inhibitory control and cognitive flexibility [36]. The researchers concluded that team games were superior to aerobic physical activity and recommended that children participate in the cognitively demanding sport over aerobic activities like running. The length of the fitness intervention, the type of cognitive function assessments, and an inability to control physical activity intensity for all players in a team sport suggest that we cautiously interpret these results. Moreover, a ceiling effect may influence the relationship between physical fitness and academic achievement [37]. Another caution is that trials involving adolescents may suffer from a lack of treatment fidelity (e.g., participating at a lower intensity required for the research) [38].

4. Effects of physical activity on cognitive health

As presented, there is compelling evidence supporting the protective role of physical activity against obesity and other chronic diseases. When safe, all types of physical activities have potential benefits for mental, physical, cognitive, and brain health for children and adolescents and, when there is continued adherence, can offer both short- and long-term positive cognitive outcomes [1]. Specifically, there is robust evidence of a causal association between regular physical activity and cognitive function in children [39]. The greatest substantiation has been produced among school-aged, preadolescent children.

4.1 Chronic or habitual physical activity participation effects on cognitive health

The reciprocal relationship between physical activity, fitness, and academic achievement has received much attention because of the increasing prevalence of overweight and unfit children and the inescapable pressure on schools to produce students who meet academic standards [24]. A seminal study examined 259 public school students in third and fifth grades and found that physical activity during physical education class, measured as field physical fitness tests, was positively related to academic achievement [25]. Specifically, aerobic capacity was positively associated with achievement, whereas body mass index (BMI) was negatively related. Associations were demonstrated in total academic, mathematics, and reading. Findings from this cross-sectional study led to the development of school-based physical activity programs and the more refined examination of the effects on children's cognitive function and academic achievement.

Among the findings from the FITKids program regarding executive function was that participants produced significantly faster and more accurate responders than children in the control group [40]. The treatment group had better neural conflict management as information processing [41] as well as enhanced relational memory [42]. The children who participated in the physical activity-oriented afterschool program for the 9-months used more complex mental processing strategies to move information from working memory to long-term memory, while children who went home after school regressed from their baseline performance-related processing speed and working memory capacity.

Beyond the neurobiological and cognitive influences of physical activity, there has also been a focus on better understanding the characteristics of physical activity interventions [43] and investigating the effects of the cognitive demands of the activity. Evidence that complex motor movements requiring higher cognitive demands produce higher cognitive benefits than rote physical activity is currently being gathered [44]. A meta-analytic review evaluating the cognitive function effects of physical activity interventions for children ages 3–7 years determined that in addition to MVPA, the programs offered activities that required combinations of motor skills (e.g., dribble and pass a ball) likely produce more significant cognitive gains [45]. The positive, moderate gains in executive functions suggest that children should engage in physical activity with varying motor demands.

A 2-year exploratory, non-controlled study of one hundred and sixteen 8–9 year old children that examined hot- (emotion associated actions) and cold-related (emotionless actions) executive functions suggested that there may be dispositional and emotional health benefits (self-control) from participation in physical education. The cognitive engagement required to execute combinations of complex motor movements likely produces even more significant cognitive benefits; however, further study is warranted, as the existing evidence is correlational. It is unclear whether an underlying mechanism like neurotrophic factors such as brain-derived neurotrophic factor (BDNF) and cerebral blood flow increases during complex tasks and enhances cognitive function. BDNF is a growth factor that promotes cell repair and activity-dependent plasticity, facilitating behavior adaptations due to environmental changes [46].

In sum, there is proof of causality and positive associations among chronic physical activity, fitness, cognitive function, and academic achievement. However, the findings vary in strength, and the effects of numerous elements of physical activity on cognition need to be explored, such as how much, how often, how hard, and when to offer physical activity.

4.2 Acute or immediate effects of participation in a single session of physical activity

Although high doses of chronic physical activity are associated with superior life expectancy, primarily when habits were formed in early life, low doses of physical activity that disrupt sedentary behaviors may also have health benefits [14]. Specifically, an acute bout of physical activity is one session lasting less than 60 min and typically represents the most substantial participation during a given day [47]. The single bout varies in intensity from light (e.g., walking to school) to vigorous (e.g., sports competition). Most research in this area has been completed in a laboratory setting, where the physical activity intensity and duration can be held constant and compared to control groups.

There is evidence that even a single bout of physical activity, such as a short bout of light to moderate physical activity, improves response accuracy and reaction time within laboratory experiments [24]; however, not all studies in educational settings have produced the same results [48]. Despite the mixed findings, no known studies have identified adverse cognitive effects resulting from physical activity participation when examining the effects of a single session of or regular participation in physical activity.

One study conducted in schools examined the timing of the physical activity break and the intensity among 123, 10–11 year olds and measured selective attention before and after the physical activity [45]. The results showed a positive increase in selective attention after the physical activity break compared to the baseline. Using different measures related to academic success, a randomized controlled trial investigating the effects of physically active academic lessons in the classroom [49] demonstrated that time on task was higher among active lessons than those that covered the same content but were delivered in a sedentary (seated) format [50].

Results from investigations of acute bouts of physical activity vary. For example, 156 fifth and sixth grade students were randomized into two of four physical activity conditions classified by intensity (sedentary, light, moderate and vigorous), concluding that 10-min bouts of physical activity did not significantly differ from one another [48]. Similarly, in a study of 465 children in 40 different classrooms across 6 different school districts, classrooms were assigned to high-intensity physical activity breaks or low-intensity physical activity breaks. Children participated in pre/post cognitive assessments related to math facts, memory, and the executive function of inhibitory control. There are were no significant differences between the different intensities of physical activity. Although the study was limited by not having a sedentary comparison group, it increased our understanding that the duration of the acute bout may impact the potential effects on cognitive function. Less than 10 min did not produce immediate cognitive benefits regardless of intensity. It is important to note that there were no adverse effects of participation (e.g., the decline in overall academic performance).

Acute bouts of physical activity disrupt prolonged periods of sedentary behaviors. The effects of sedentary behaviors on children in school have been understudied. Further, the mode or type of physical activity is related to the unique benefits. The effects of play, which can be unstructured (e.g., walking and talking with a friend) or structured (e.g., intense exercise for elite performance), need to be examined in authentic contexts, like schools and community physical activity programs like youth sports and clubs.

4.3 Dose-response effects of physical activity on cognitive function

Identifying a potential dose-response relationship between physical activity that can improve cognitive function in children has implications for education and the offering of opportunities for physical activity in and around schools. Although there is believed to be a dose-response relationship between physical activity on cognitive function, there is only limited empirical evidence of direct effects of physical activity volume, duration, frequency, intensity, and domain.

The cognitive assessment deployed to measure cognitive function influences study results and the generalizability of the findings. Neuroscientists have been using electroencephalogram (EEG) neuroimaging and executive function tasks, like Flanker's task, to assess the accuracy and reaction time of responses. Standardized test scores such as the Woodcock-Johnson and systematic observational scales of time on task have also been

used. The variability of how cognitive function is measured, from academic success in schools to concentration and attention and neural activation, hinders the development of standardized recommendations for children at specific developmental stages.

Cross-sectional accelerometer and EEG data collected during the multiple waves of the FITKids trials were examined to determine a dose-response relationship between physical activity and neurocognitive function among 8–10 year old children [35]. It was concluded that vigorous physical activity is strongly associated with inhibitory control and other neuroelectric indices related to processing speed. The researchers recommended that short bouts of physical activity be vigorous, like jumping rope, hiking/walking up stairs, playing soccer, and fast bicycling, be included in children's daily routines.

As previously detailed, the trait of aerobic fitness is associated with better academic performance [25], while the effects of specific physical activity like dancing have only been studied in older adults and have not comprehensively been explored among preschool children [51]. Further, the effects of elite training are understudied, as complex motor skills like playing soccer are associated with a better concentration than their matched control participants, peers who participated in non-motor demanding physical activity [52]. The general and specific effects of the volume of physical activity should be investigated, particularly in early childhood educational contexts. Overall, there is believed to be a dose-response relationship between physical activity and cognitive function; however, the lack of study replication across multiple samples and developmental stages of children limits the recommendations that can be made at this time.

5. Physical activity recommendations for healthy cognitive development

Meeting or exceeding the physical activity guidelines for daily physical activity duration and intensity will enhance cognitive function. These benefits vary by the total volume of physical activity, achievement of aerobic fitness, and the type of cognitive assessment measure used. Despite the variability in outcomes, there are no known detrimental effects to adhering to the guidelines. Health disparities include the lack of equitable access to physical activity opportunities, rise in sedentary behaviors related to screen time and use of technology, and various psychological factors, like a lack of perceived skill, that prohibit most children from meeting these guidelines. Therefore one overarching recommendation is to provide inclusive, equitably accessible physical activity programs for all children. What we currently understand to be true about such effects is outlined next [1].

5.1 Children who are ages 3–5 years

We know the least about preschool-aged children since there is a paucity of research focused on this developmental stage. However, new investigations that leverage wearable technologies and mobile neuroimaging devices to collect data are currently underway. A meta-analysis of seven studies enrolling 414 participants from 5 countries demonstrated that higher physical activity produced cognitive benefits in 67% of the studies [53]. A cross-sectional study of 552, 3 and 4 year olds investigated the interaction and codependence of sleep, physical activity, and body composition (measured as BMI and adiposity). Not surprisingly, healthier children moved more, thus revealing additional home and community-level health disparities, as children with access to fruits and vegetables are more likely to have a healthy BMI [54].

As globally stated in both the US and Canadian Guidelines for physical activity at this developmental stage, children should be physically active throughout the day across multiple environments engaged in differing physical and cognitive demands. Whether in the home or school environment, adult caregivers should conscientiously seek out such opportunities for the child. The total daily participation should equal or exceed 3 h of movement, whether light or moderate in intensity. Movement should involve multiple motor skills and transpire in structured (e.g., circle time dancing, clapping, singing) and unstructured settings (e.g., the playground, sandbox, and water play). Finally, researchers and policymakers alike should develop methods for surveillance of physical activity participation and locations where participation transpires (e.g., home, green space, preschool).

5.2 Children ages 6–17 years

At this developmental stage, we have causal evidence that physical activity moderately enhances cognitive health and is essential for academic success in later school years. A single bout of physical activity should be considered one session and contributory to the accumulated physical activity across the day. The daily 60-min of MVPA should include at least 3 days of the week dedicated to aerobic type of activities (e.g., running, jumping), and 3 days to muscle-strengthening, which can likely happen in conjunction with the aerobic activities or as separate sessions (e.g., gymnastics taking weight on hands, or by adding resistance to the body, climbing, pushing/pulling). Bone-strengthening physical activity should be part of the 60 daily minutes for at least 3 days. For school-aged children, bone-strengthening activities may include hopping, jumping rope, or sports involving rapid direction changes. The activities become more complex for adolescents, as someone may be a goalkeeper, ride horseback, and/or visit a local skate park. Adolescence is also a time to increase resistance training by moving away from using one's own body weight as resistance and begin weight training with machines or free weights. The last stage of "childhood" should also be a time to participate in active recreation leading into adulthood. Activities like kayaking, hiking, adult recreational leagues outside of high school, and forms of yoga, pilates, and dynamic stretching should also be integrated into planned physical activity. The book *Fitness for Life* comprehensively outlines the specificity and progression of such engagement for adolescents [21].

It is reasonable to believe that adherence to these prescribed guidelines will improve cognitive health among children and adolescents. How cognitive health will be enhanced depends on the outcome measure and the timing, type, duration, and intensity of physical activity. There is no "one size fits all" prescription for physical activity participation. Instead, such participation should be based on the child's interests, likes, motives, and developmental readiness. When activities are enjoyable, we tend to adhere and come back for more.

5.3 Physical activity by place and context (domain)

There should be opportunities to participate in physical activity from the moment they awake to when a child's head hits the pillow. Since adults are responsible for building regulatory systems, making policy, securing resources, providing inclusive and equitable access to physical activity opportunities, we all must share the burden

of children's physical activity. **Table 1** outlines the recommended strategies for enhancing physical activity surveillance and how this information could be used to inform our current practice [55].

If children are to engage in physical activity over sedentary behavior, we must continue to engage policymakers to monitor where, when, and how children are active. Knowing who the children are within the activity space (e.g., parents, teachers, friends, classmates, community leaders) also adds value to our understanding of such contexts. Understanding the facilitators and barriers of participation will help inform policy and practice within formal child care and educational settings, but moreover, may also shed light on mechanisms for enhancing population health. Cognitively and physically healthy individuals have a more positive impact on the economy.

5.3.1 Physical activity in school for improving cognitive function

Every child attends school; some do so in a building, others do so from home. A meta-analytic review confirmed that curriculum derived physical education interventions designed to increase daily physical activity were most effective [56]. Having physical activity surveillance systems associated with such educational experiences is paramount. Schools that take a health-first approach to policy and implement Comprehensive School Physical Activity Programs (CSPAPs) are well-position to have children reap the benefits associated with physical activity [57]. The cornerstone of the CSPAP is physical education, with physical activity also offered across the curriculum through before/after school programs and active transportation, staff involvement by modeling healthy behaviors, during the school day physical activity (e.g., recess, classroom breaks), and community engagement where physical activity includes youth sport and community venues (e.g., skate parks, bike trails, disc golf courses, swimming pools).

Quality physical education is where surveillance is already and could continue to be advanced. The use of fitness testing and reporting the results to parents as a proxy measure of health risks is a practice that should continue to be undertaken as part of

Children
Strategy 1: Develop and implement state- and national-level systems for monitoring physical activity policies and practices in early child care and early childhood education settings. Estimated costs: high.
Strategy 2: Enhance existing surveillance systems for monitoring elementary through high school-based physical activity policies and programs. Estimated costs: medium.
Strategy 3: Develop a protocol that leverages ongoing administration of physical fitness tests, such as FitnessGram, for the purpose of monitoring fitness levels of children and youth. Estimated costs: low.
Strategy 4: Expand objective monitoring of physical activity in children (ages 3–18 years) by incorporating validated wearable technologies into the existing surveillance systems. Estimated costs: medium.
Strategy 5: Develop a system for monitoring community-level availability of organized sports and other physical activity programs for children. Estimated costs: medium.
Strategy 6: Identify features of the built environment that are most likely to influence physical activity in children and embed an assessment of perceived ability and use of these features into existing surveillance systems. Estimated costs: low.

Table 1.
Recommended strategies to enhance physical activity surveillance and estimated relative costs for implementation [55].

the CSPAP. Fitness testing must be implemented in ways that do not disenfranchise students. Such data should be collected with a student's perceived ability. Do they feel capable of participating in the physical activities offered? Fitness testing should never be associated with grades. The fitness assessment can be used for personalizing physical activity participation by drawing on the individual's strengths and used for goal setting to increase perceived abilities. The cost and investment for physical activity programs in and around schools are minimal and embedded in our societal norms. We should continue supporting and providing school-based physical activity programs like physical education, athletics, and clubs.

5.3.2 Physical activity in the home and community to enhance cognitive function

Wearable technologies and sensors of physical activity are ubiquitous. Watches, cell phones, and other devices contain accelerometers and applications that can interpret human movement. Sharing such data in aggregate and cyber secure ways can help us understand who has mobility, the energy expenditure related to mobility, and if persons are alone or with others when engaging in physical activity. Although further research is needed to define what devices are best for whom, there is great potential for advancing our understanding of the role of place and context in physical activity participation across the lifespan.

Developing community and home level monitoring systems can aid in joint land use and sharing potentially scarce resources. Identifying what youth sports programs and activities may be popular can augment the value of the community [58]. In Australia, only 27% of adolescents surveyed used the park nearest to them because it lacked the most desired features (the presence of a skate park) [59]. The universal tracking of the usage of community venues is a form of surveillance that should be expanded.

If you build it, they will come and be active. The built environment influences our decision to participate in physical activity. We need to understand the subcultures that emerge in specific venues. For example, a female may be anxious in one weight room but feels comfortable in another. No one ever feels good about themselves when they are cut from a team. Even though such psychological outcomes may be seen as beyond the scope of this chapter, it should be noted there are mental and emotional benefits also stem from physical activity participation. Appreciating what features of the built environment facilitate and those that inhibit participation are sometimes far less obvious than one might observe. Embedded surveillance systems would help us understand how best to financially invest in a healthy, active community.

6. Conclusions and implications

There are numerous benefits related to daily participation in physical activity ranging from short bouts like riding a bike to school to more formal, sport-specific exercise in adolescence. Our work begins with **Figure 2** and identifying and participating in health-enhancing behaviors each day. Schools, community, and home environments are situated to contribute to a child's total accumulated physical activity. Models like the CSPAP provide the framework for organizing and providing opportunities for physical activity. However, because the behavior of physical activity is a socially constructed norm, we must consider the intersectionality of time, type, intensity, volume, and domain of physical activity and how these impact ethnicity, race, culture, and community initiatives.

The seminal research in 2007 [25] was the first modern-day empirical publication associating academic achievement with aerobic fitness among elementary school children. Since then, hundreds of studies have been published, and our understanding has exponentially evolved. There may be many more research questions about preschoolers and place and context, but we now know that children and adolescents who meet the national daily physical activity guidelines will benefit cognitively. Given the dose-response relationship between physical activity and cognitive function, participation for 60 min of movement in the home, school, and community settings in activities requiring various motor skills has the most significant potential to maximize children's cognitive function. This recommendation sets the stage for habitual engagement across the lifespan.

Conflict of interest

The authors declare no conflict of interest.

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References

[1] Erickson KI, Hillman C, Stillman CM, Ballard RM, Bloodgood B, Conroy DE, et al. Physical activity, cognition, and brain outcomes: A review of the 2018 physical activity guidelines. Medicine and Science in Sports and Exercise. 2019;**51**(6):1242-1251

[2] Loprinzi PD, Cardinal BJ, Loprinzi KL, Lee H. Benefits and environmental determinants of physical activity in children and adolescents. Obesity Facts. 2012;**5**(4):597-610

[3] Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. International Journal of Behavioral Nutrition and Physical Activity. 2010;**7**(1):1-16

[4] Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. Public Health Reports. 1985;**100**(2):126

[5] Hooper JM, Leoni E. A physical activity continuum and the surgeon general's report. Journal of Physical Education, Recreation & Dance. 1996;**67**(9):62-63

[6] United States Public Health Service Office of the Surgeon General, National Center for Chronic Disease Prevention and Health Promotion, President's Council on Physical Fitness and Sports. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA: U.S. Dept. of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996. p. xvii+278

[7] Whitfield GP, Ussery EN, Saint-Maurice PF, Carlson SA. Trends in aerobic physical activity participation across multiple domains among US adults, National Health and Nutrition Examination Survey 2007/2008 to 2017/2018. Journal of Physical Activity & Health. 2021;**18**(S1):S64-S73

[8] The Physical Activity Guidelines for Americans | Geriatrics | JAMA | JAMA Network [Internet]. 2022. Available from: https://jamanetwork-com.ezproxy.lib.utexas.edu/journals/jama/fullarticle/2712935

[9] Tremblay MS, Leblanc AG, Carson V, Choquette L, Connor Gorber S, Dillman C, et al. Canadian physical activity guidelines for the early years (aged 0-4 years). Applied Physiology, Nutrition, and Metabolism/Physiologie Appliquée, Nutrition et Métabolisme. 2012;**37**(2):345-369

[10] Rao DP, Orpana H, Krewski D. Physical activity and non-movement behaviours: Their independent and combined associations with metabolic syndrome. International Journal of Behavioral Nutrition and Physical Activity. 2016;**13**(1):1

[11] Tremblay MS, Chaput J-P, Adamo KB, Aubert S, Barnes JD, Choquette L, et al. Canadian 24-hour movement guidelines for the early years (0-4 years): An integration of physical activity, sedentary behaviour, and sleep. BMC Public Health. 2017;**17**(Suppl 5): 874-874

[12] Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: An Integration of physical activity,

sedentary behaviour, and sleep. Applied Physiology, Nutrition, and Metabolism. 2016;**41**(6 Suppl. 3):S311-S327

[13] National Academies of Sciences Engineering, Medicine. Implementing Strategies to Enhance Public Health Surveillance of Physical Activity in the United States [Internet]. Washington, DC: The National Academies Press; 2019. Available from: https://www.nap.edu/catalog/25444/implementing-strategies-to-enhance-public-health-surveillance-of-physical-activity-in-the-united-states

[14] Eijsvogels TMH, George KP, Thompson PD. Cardiovascular benefits and risks across the physical activity continuum. Current Opinion in Cardiology. 2016;**31**(5):566-571

[15] Bailey DP, Boddy LM, Savory LA, Denton SJ, Kerr CJ. Associations between cardiorespiratory fitness, physical activity and clustered cardiometabolic risk in children and adolescents: The HAPPY study. European Journal of Pediatrics. 2012;**171**(9):1317-1323

[16] Arundell L, Fletcher E, Salmon J, Veitch J, Hinkley T. A systematic review of the prevalence of sedentary behavior during the after-school period among children aged 5-18 years. International Journal of Behavioral Nutrition and Physical Activity. 2016;**13**(1):93-93

[17] Whitt-Glover MC, Taylor WC, Floyd MF, Yore MM, Yancey AK, Matthews CE. Disparities in physical activity and sedentary behaviors among US children and adolescents: Prevalence, correlates, and intervention implications. Journal of Public Health Policy. 2009;**30**(S1):S309-S334

[18] Troiano RP, Berrigan D, Dodd KW, Msse LC, Tilert T, Mcdowell M. Physical activity in the united states measured by accelerometer. Medicine and Science in Sports and Exercise. 2008;**40**(1):181-188

[19] Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: A systematic review. Maturitas. 2011;**70**(3):266-284

[20] Pate R, Oria M, Pillsbury L, Committee on Fitness Measures and Health Outcomes in Youth, Food and Nutrition Board, Institute of Medicine. Fitness Measures and Health Outcomes in Youth [Internet]. Washington, DC: National Academies Press (US); 2012. Available from: https://www-ncbi-nlm-nih-gov.ezproxy.lib.utexas.edu/books/NBK241311/

[21] Corbin C, Castelli DM, Sibley BA, Le Masurier GC. Fitness for Life [Internet]. 7th ed. Champaign, IL: Human Kinetics; 2021. Available from: https://us.humankinetics.com/products/fitness-for-life-7th-edition-paper-with-web-resource

[22] Pate R, Oria M, Pillsbury L, Committee on Fitness Measures and Health Outcomes in Youth; Food and Nutrition Board; Institute of Medicine. Measuring Fitness in Youth [Internet]. Fitness Measures and Health Outcomes in Youth. Washington, DC: National Academies Press; 2012 [cited 2022 Mar 7]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK241311/

[23] Norman DA, Shallice T. Attention to action: Willed and automatic control of behavior. In: Davidson RJ, Schwartz GE, Shapiro D, editors. Consciousness and Self-Regulation: Advances in Research and Theory. NY: Plenum; 1986. pp. 1-18

[24] Donnelly JEED, Hillman CH, Castelli D, Etnier JL, Lee S, Tomporowski P, et al. Physical activity, fitness, cognitive function, and academic

achievement in children: A systematic review. Medicine and Science in Sports and Exercise. 2016;**48**(6):1197-1222

[25] Castelli DM, Hillman CH, Buck SM, Erwin HE. Physical fitness and academic achievement in third- and fifth-grade students. Journal of Sport & Exercise Psychology. 2007;**29**(2):239-252

[26] van der Niet AG, Hartman E, Smith J, Visscher C. Modeling relationships between physical fitness, executive functioning, and academic achievement in primary school children. Psychology of Sport and Exercise. 2014;**15**(4):319-325

[27] Eveland-Sayers BM, Farley RS, Fuller DK, Morgan DW, Caputo JL. Physical fitness and academic achievement in elementary school children. Journal of Physical Activity & Health. 2009;**6**(1):99-104

[28] Lambourne K, Hansen DM, Szabo AN, Lee J, Herrmann SD, Donnelly JE. Indirect and direct relations between aerobic fitness, physical activity, and academic achievement in elementary school students. Mental Health and Physical Activity. 2013;**6**(3):165-171

[29] Reisberg K, Riso E-M, Jürimäe J. Physical activity, fitness, and cognitive performance of estonian first-grade schoolchildren according their MVPA level in kindergarten: A longitudinal study. International Journal of Environmental Research and Public Health. 2021;**18**(14):7576

[30] Castelli DM, Hillman CH, Raine LB, Drollette ES. Ten years later: What we learned about after-school programming from the Fitness Improves Thinking in Kids (FITKids) Clinical Trial. In: Marttinen R, Centeio EE, Quarmby T, editors. Before- and After-School Physical Activity Programs: Frameworks, Critical Issues, and Underserved Populations. 1st ed. London: Routledge; 2020. pp. 83-96. ISBN: 9780367509361. https://doi-org.ezproxy.lib.utexas.edu/10.4324/9781003051909

[31] Chaddock-Heyman L, Weng TB, Loui P, Kienzler C, Weisshappel R, Drollette ES, et al. Brain network modularity predicts changes in cortical thickness in children involved in a physical activity intervention. Psychophysiology. 2021;**58**(10):e13890

[32] Castelli DM, Hillman CH, Hirsch J, Hirsch A, Drollette E. FIT Kids: Time in target heart zone and cognitive performance. Preventive Medicine. 2011;**52**:S55-S59

[33] Khan NA, Hillman CH. The relation of childhood physical activity and aerobic fitness to brain function and cognition: A review. Pediatric Exercise Science. 2014;**26**(2):138-146

[34] Chaddock L, Pontifex MB, Hillman CH, Kramer AF. A review of the relation of aerobic fitness and physical activity to brain structure and function in children. Journal of the International Neuropsychological Society. 2011;**17**(6):975-985

[35] Pindus DM, Drollette ES, Raine LB, Kao S-C, Khan N, Westfall DR, et al. Moving fast, thinking fast: The relations of physical activity levels and bouts to neuroelectric indices of inhibitory control in preadolescents. Journal of Sport and Health Science. 2019;**8**(4):301-314

[36] Schmidt M, Egger F, Benzing V, Jäger K, Conzelmann A, Roebers CM, et al. Disentangling the relationship between children's motor ability, executive function and academic

achievement. PLoS One. 2017;**12**(8):e018 2845-e0182845

[37] Aadland KN, Ommundsen Y, Anderssen SA, Brønnick KS, Moe VF, Resaland GK, et al. Effects of the active smarter kids (ASK) physical activity school-based intervention on executive functions: A Cluster-Randomized Controlled Trial. Scandinavian Journal of Educational Research. 2019;**63**(2):214-228

[38] Wassenaar TM, Wheatley CM, Beale N, Nichols T, Salvan P, Meaney A, et al. The effect of a one-year vigorous physical activity intervention on fitness, cognitive performance and mental health in young adolescents: The Fit to Study Cluster Randomised Controlled Trial. International Journal of Behavioral Nutrition and Physical Activity. 2021;**18**(1):47-47

[39] Biddle SJ, Ciaccioni S, Thomas G, Vergeer I. Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. Psychology of Sport and Exercise. 2019;**42**:146-155

[40] Hillman CH, Pontifex MB, Castelli DM, Khan NA, Raine LB, Scudder MR, et al. Effects of the FITKids randomized controlled trial on executive control and brain function. Pediatrics. 2014;**134**(4):e1063-e1071

[41] Drollette ES, Pontifex MB, Raine LB, Scudder MR, Moore RD, Kao S-C, et al. Effects of the FITKids physical activity randomized controlled trial on conflict monitoring in youth. Psychophysiology. 2018;**55**(3)

[42] Monti JM, Hillman CH, Cohen NJ. Aerobic fitness enhances relational memory in preadolescent children: The FITKids randomized control trial. Hippocampus. 2012;**22**(9):1876-1882

[43] Vazou S, Pesce C, Lakes K, Smiley-Oyen A. More than one road leads to Rome: A narrative review and meta-analysis of physical activity intervention effects on cognition in youth. International Journal of Sport and Exercise Psychology. 2019;**17**(2):153-178

[44] Pesce C, Lakes KD, Stodden DF, Marchetti R. Fostering self-control development with a designed intervention in physical education: A Two-Year Class-Randomized Trial. Child Development. 2021;**92**(3):937-958

[45] Li L, Zhang J, Cao M, Hu W, Zhou T, Huang T, et al. The effects of chronic physical activity interventions on executive functions in children aged 3-7 years: A meta-analysis. Journal of Science and Medicine in Sport. 2020;**23**(10):949-954

[46] Duarte CB, Tongiorgi E. Brain-derived neurotrophic factor (BDNF). In: Duarte CB, Tongiorgi E, editors. 1st ed. New York, NY: Springer New York; 2019. p. xii+258 (Neuromethods, 143). ISBN: 1-4939-8970-7; OCLC: (OCoLC)1122910830; ISBN: 1-4939-8969-3

[47] Janssen M, Chinapaw MJM, Rauh SP, Toussaint HM, van Mechelen W, Verhagen E. A short physical activity break from cognitive tasks increases selective attention in primary school children aged 10-11. Mental Health and Physical Activity. 2014;**7**(3):129-134

[48] Calvert HG, Barcelona JM, Melville D, Turner L. Effects of acute physical activity on NIH toolbox-measured cognitive functions among children in authentic education settings. Mental Health and Physical Activity. 2019;**17**:100293

[49] Bartholomew JB, Jowers EM. Physically active academic lessons

in elementary children. Preventive Medicine. 2011;**52**(Suppl):S51-S54

[50] Grieco LA, Jowers EM, Bartholomew JB. Physically active academic lessons and time on task: The moderating effect of body mass index. Medicine and Science in Sports and Exercise. 2009;**41**(10):1921-1926

[51] Beddoes Z, Castelli DM, Barcelona JM. Acute Physical Activity and Cognitive Performance Among Elementary Schoolchildren. Translational Journal of the ACSM. 1 February 2020;**5**(3):21-28. DOI: 10.1249/TJX.0000000000000117

[52] Budde H, Voelcker-Rehage C, Pietraßyk-Kendziorra S, Ribeiro P, Tidow G. Acute coordinative exercise improves attentional performance in adolescents. Neuroscience Letters. 2008;**441**(2):219-223

[53] Carson RL, Castelli DM, Beighle A, Erwin H. School-based physical activity promotion: A conceptual framework for research and practice. Childhood Obesity. 2014;**10**(2):100-106

[54] Alber JM, Green SH, Glanz K. Perceived and observed food environments, eating behaviors, and BMI. American Journal of Preventive Medicine. 2018;**54**(3):423-429

[55] Sallis JF, Pate RR. Creating the future of physical activity surveillance in the United States: Better data for better health. Journal of Physical Activity & Health. 2021;**18**(S1):S1-S5

[56] Álvarez-Bueno C, Pesce C, Cavero-Redondo I, Sánchez-López M, Martínez-Hortelano JA, Martínez-Vizcaíno V. The effect of physical activity interventions on children's cognition and metacognition: A systematic review and meta-analysis. Journal of the American Academy of Child and Adolescent Psychiatry. 2017;**56**(9):729-738

[57] Webster CA, Rink JE, Carson RL, Moon J, Gaudreault KL. The comprehensive school physical activity program model: A proposed illustrative supplement to help move the needle on youth physical activity. Kinesiol Review (Champaign, Ill.). 2020;**9**(2):112-121

[58] Turcott R. Moving boarders: Skateboarding and the changing landscape of Urban Youth Sports: by Atencio M, Beal B, Wright EM, McClain Z, Fayetteville AR. The University of Arkansas Press; 2018. 342pp+ xvi, 30/75, ISBN: 978-1-68226-079-1 (paper back), ISBN: 978-1-68226-078-4

[59] Edwards N, Hooper P, Knuiman M, Foster S, Giles-Corti B. Associations between park features and adolescent park use for physical activity. International Journal of Behavioral Nutrition and Physical Activity. 2015;**12**(1):21-21

Chapter 2

Motor Proficiency of Children with Typically Developing Children and Children with Autism Spectrum Disorder

Carla Lourenço, Dulce Esteves and Mariana Pinheiro

Abstract

Children with autism spectrum disorder (ASD) frequently present difficulties in communication, social interaction, and motor abilities. Physical activity presents several major benefits for children with and can be considered a non-pharmacological therapy to improve both motor and social skills. This chapter aims to compare motor proficiency of children with ASD and neurotypical children. Twenty Portuguese children participated in this study, half diagnosed with ASD (6.9 ± 1.97 years) and half typically developed (7 ± 1.83 years). Children's age ranged from 4 to 10 years (6.95 ± 1.85 years), with a prevalence of males (60%). Motor proficiency was evaluated using the Bruininks-Oseretsky test of motor proficiency (BOT-2). Children with ASD scored significantly lower on different items of motor proficiency (fine manual precision, manual dexterity, coordination of the upper limbs, balance, and motor proficiency profile). We conclude that, due to the deficits found, supervised physical exercise preferentially in small groups combining children with and without ASD is highly recommended.

Keywords: children with autism Spectrum disorder, motor proficiency, physical exercise

1. Introduction

Autism spectrum disorder (ASD) consists of neurological disorders affecting children's communication, social, and language development [1]. Diagnostic and statistical manual of mental disorders (5th ed.) and is typically characterized by core impairments in social communication functioning and rigid repetitive behavior styles [2]. Seven decades have passed since Leo Kanner's classic description of the syndrome early infantile autism [3], and over time, the concept has undergone several changes, namely those introduced by Volkmar & McPartland [4], that suggested an alternative classification system of ASD that incorporates both etiological factors (e.g. neurobiological and genetic) and clinical symptoms.

1.1 Motor impairments in children with ASD

Currently, ASD refers to neurodevelopmental disorders that generate deficits in communication and socialization, restricted interests, and repetitive behaviors [5]. Children with ASD usually present a dysfunctional sensory profile [6, 7] that might create difficulty attending to and processing sensory stimuli [8, 9] and consequently to motor impairments. In fact, the motor functioning in individuals with ASD and detected a pronounced motor impairment among those subjects [10]. Several other authors [2, 11–14] also confirm the existence of motor deficits in children with the condition. That motor deficits can be divided into two categories: the basic motor control (coordination, gait, posture and muscle tone) and motor performance deficits [15]. However, the specific motor deficits associated with ASD cannot be generalized nor simplified and are more evident in the most demanding activities [16]. Also, children on the spectrum demonstrate poor motor performance, and this becomes more persistent with an increase in age [17].

The motor impairments in ASD affect a variety of domains [12], such as balance [18], movement planning [19], gait and postural stability [20], and fine and gross motor coordination [2, 21].

1.2 Motor development in children with ASD

Face to this evidence, it is important to consider interventions to help improve motor skill in children with ASD.

Motor development is defined as the acquisition of fundamental motor skills, allowing different postures, locomotion, and manipulation of objects [22]. Researchers suggest that motor skill acquisition accompanies intellectual development and physical fitness which may be linked to a positive effect in the cognitive development in children [23]. When a child's development occurs according to the established developmental stages, it is considered typical development. However, when there are changes in the developmental trajectory, we have to consider them as early warning signs/red flags for different pathologies [24].

Although this topic has been persistent in different investigations, an approach focusing on the motor proficiency profile in children with ASD has not been sufficiently developed [25]. Understanding motor proficiency in children with the condition is necessary in order to assess their onset of motor skill development and acquisition. Motor proficiency profile is described as the "index or sum of the best performance or performance observed in a wide variety of situations or motor tasks and which tends to increase with age" ([26], p. 10). It is positively linked with physical activity participation and inversely to the children's sedentary lifestyle [27]. Evaluating the motor proficiency profile allows us to better understand each child's motor capacity, as well as to analyze different motor aspects in an isolated approach and a better evaluation of the fundamental fine and gross motor skills [28].

1.3 Exercise interventions in children with ASD

In addition to motor deficits, children with ASD tend to be physically inactive and to have sedentary behaviors [29], which has serious consequences for their health status and sustainable lifestyle.

One of the approaches to improve motor deficits is the use of physical activity-based intervention. In fact, it was reported that physical activity programs may provide benefits for children with ASD [30–32] and can be an excellent non-pharmacological therapy to reduce the challenges they face. The effects of physical activity interventions such as swimming [33, 34], walking/hiking [35, 36], running [37–39], and hippotherapy [40–42] have been supported by previous research and suggested that an improvement of motor proficiency in children on the spectrum branches from the participation in physical activity intervention [27]. Therefore, the engagement in physical activity interventions is a key modifiable factor in ensuring an active live across the lifespan. Creating an active routine during early years may lead autistic subjects to continue certain physical activities into adulthood, improving not only many health-related outcomes but also their quality of life [43]. Additionally, physical activity engagement has been shown to have some positive effects on the social functioning of young individuals on the autism spectrum, as well as a significant impact on their muscular strength and endurance [44]. Besides, motor skill development through exercise interventions is a critical step toward ensuring continued engagement in physical activity [45] as well as in leading positive trajectories for health outcomes [46].

Regarding the type of motor intervention, there is currently a wide variety of treatments and therapies targeted at autistic populations [47, 48]. Nevertheless, many of those current intervention models have only been designed to focus on the core characteristics of autism. Apart from modifying present intervention models for the physical activity setting [49], few interventions have been designed to target the motor domain [50]. Even fewer still are interventions targeting motor skill development for autistic populations [51].

Yet, evidence suggests there are countless benefits of physical activity for autistic individuals [44, 52]. Physical activity has been shown to be beneficial in improving an autistic individual's motor proficiency [31], social skills [53], functional, cognitive and behavioral [52], among others. In the case of group physical activities, they can be an important contribution to the increase of mental health of these individuals [54].

Despite the demonstrated beneficial impacts of physical activity on the factors of quality of life for autistic individuals, this population remains more sedentary than the general population [55] and they face numerous obstacles to physical activity from early childhood through adolescence [56, 57] into adulthood [58–61]. In fact, a physical education class can be really challenging for these children, who may have difficulties in accessing instruction, meeting with stringent rules, in learning abstract content, as well as in collective games due to the speed and exchange of functions (defense and attack) [62].

Due to motor and/or social difficulties, the actors in the teaching process (parents and teachers) would sometimes reveal some difficulties in promoting motor activities, as well as difficulties in understanding how to evaluate children with ASD.

1.4 Motor proficiency of children with ASD and typically developing children

Perhaps more important than evaluating motor proficiency of children with ASD is to compare motor proficiency of children with ASD and neurotypical children, to quantify the differences found.

Previous research revealed that children with ASD performed poorer when compared to their typically developing peers [63, 64] in many areas, such as coordination of the upper and lower limbs in manual dexterity, balance, agility, and speed [65–67].

Lourenço, et al. [68] compared the motor proficiency profiles between children with ASD and their typically developing peers in Portugal, using the Bruininks-Oseretsky test of motor proficiency (BOT-2) [69]. Twenty Portuguese children participated in this study, half diagnosed with ASD (6.9 ± 1.97 years) and half typically developed (7 ± 1.83 years). Children's age ranged from 4 to 10 years (6.95 ± 1.85 years), with a prevalence of males (60%). Children with ASD scored significantly lower on fine manual precision ($p < 0.05$) and large effect sizes were found ($d > 0.8$). Children with ASD also performed poorer in item 1—drawing line through path (1.90 ± 0.87) and item 2—fold paper (4.00 ± 2.30).

No statistically significant difference was found between the two groups in fine motor integration subtests ($p > 0.05$). However, effect sizes showed moderate effect ($d > .5$) indicated children with ASD were less proficient, suggesting a trend for delays in motor integration tasks.

A significant difference was found between children with ASD and the typically developing children on manual dexterity ($p = 0.024$), and a large effect size was found ($d = 4.467$) with ASD children scoring significantly lower, revealing that children with ASD were delayed on manual dexterity.

Regarding coordination of the upper limbs (items 10 and 11), the first one did not present significantly differences between the two groups whereas item 11 registered significant differences ($p = 0.044$) and a large effect size ($d = 1.664$). Portuguese children with ASD scored lower mean values in both items when compared to their typical developing peers.

No statistically significant differences were found regarding bilateral coordination, but typical developing displayed higher mean values than the children with ASD. They showed better results in item 6 than the other item in bilateral coordination subtest.

To what concerns balance, children with typical developing presented significantly higher mean values ($p = 0.028$) and a large effect size was found ($d = 4.221$). Similar results were found in speed and agility ($p = 0.043$; $d = 2.496$).

It is noteworthy that Portuguese children with ASD registered lower values of motor proficiency profile, translating into statistically significant differences (**Figure 1**).

Portuguese children with ASD (80%) were classified in well below the average or below average and only two children were in the average motor proficiency category. On the other hand, 90% typical developing children's motor proficiency was in the average or above average category.

The results revealed significant differences in fine motor proficiency on manual dexterity, showing the children with ASD had lower indices, similar to the results presented by Pan [63], that concluded that Adolescents with ASD demonstrated less proficient motor skills than adolescents without ASD.

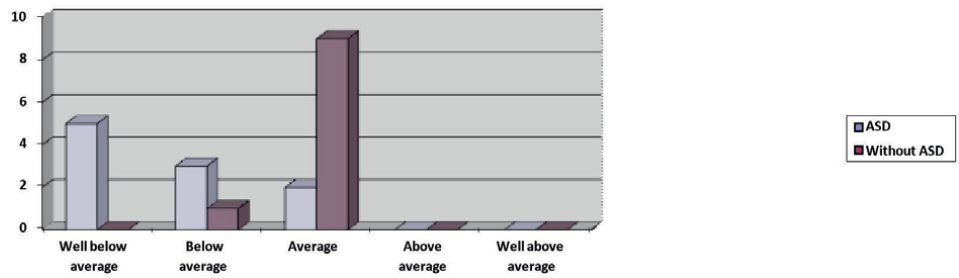

Figure 1.
Classification of the motor proficiency profile of children with and without ASD.

The significant differences found in the coordination of the upper limbs may impair an object-control proficiency, such as kicking, catching, and overhand throwing, which are requirements to most sport activities and is a predictor of physical inactivity/no participation in sports activities.

As referred by Pan [63], "the lower level of motor proficiency and physical fitness in adolescents with ASD requires increased attention and immediate intervention," suggesting the participation of typically developing peers as intervention agents, such as in-peer tutoring and peer-assisted learning, to teach students with ASD motor skills to encourage inclusion and increase enjoyment. Furthermore, group activities involving both students and their families, such as swimming, biking, and walking, are strongly recommended because of the limited duration of physical education in schools and the lack of active recess times in secondary schools [63].

Acknowledgements

This work is funded by National Funds through the FCT - Foundation for Science and Technology, I.P., within the scope of the project Refª UIDB/05507/2020. Furthermore, we would like to thank the Centre for Studies in Education and Innovation (CI&DEI) and the Polytechnic of Viseu for their support.

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References

[1] American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 5th ed. 2013

[2] Grace N, Enticott PG, Johnson BP, Rinehart NJ. Do handwriting difficulties correlate with core symptomology, motor proficiency and attentional behaviors? Journal of autism and developmental disorders. 2017;**47**(4):1006-1017

[3] Kanner L. Autistic disturbances of affective contact. Nervous Child. 1943;**2**(3):217-250

[4] Volkmar FR, McPartland JC. "From Kanner to DSM-5: Autism as an evolving diagnostic concept." Annual Review of Clinical Psychology. 2014;**10**:193-212

[5] Worley JA, Matson JL. Comparing symptoms of autism spectrum disorders using the current DSM-IV-TR diagnostic criteria and the proposed DSM-V diagnostic criteria. Research in Autism Spectrum Disorders. 2012;**6**(2):965-970. DOI: 10.1016/j.rasd.2011.12.012

[6] Posar A, Visconti P. Sensory abnormalities in children with autism spectrum disorder. Jornal de Pediatria. 2018;**94**:342-350. DOI: 10.1016/j.jpedp.2017.11.009

[7] Tomcheck SD, Dunn W. Sensory processing in children with and without autism: A comparative study using the short sensory profile. American Journal of Occupational Therapy. 2007;**61**:190-200. DOI: 10.5014/ajot.61.2.190

[8] Kern JK, Trivedi MH, Garver CR, Grannemann BD, Andrews AA, Savla JS, et al. The pattern of sensory processing abnormalities in autism. Autism. 2006;**10**(5):480-494. DOI: 10.1177/1362361306066564

[9] Piek JP, Dyck MJ. Sensory-motor deficits in children with developmental coordination disorder, attention deficit hyperactivity disorder and autistic disorders. Human Movement Science. 2004;**23**:475-488

[10] Fournier K a, Hass CJ, Naik SK, Lodha N, Cauraugh JH. Motor coordination in autism spectrum disorders: A synthesis and meta-analysis. Journal of Autism and Developmental Disorders. 2010;**40**(10):1227-1240. DOI: 10.1007/s10803-010-0981-3

[11] Dziuk MA, Gidley Larson JC, Apostu A, Mahone EM, Denckla MB, Mostofsky SH. Dyspraxia in autism: Association with motor, social, and communicative deficits. Developmental Medicine & Child Neurology. 2007;**49**(10):734-739. DOI: 10.1111/j.1469-8749.2007.00734.x. PMID: 17880641

[12] Hocking DR, Ardalan A, Abu-Rayya HM, Farhat H, Andoni A, Lenroot R, et al. Feasibility of a virtual reality-based exercise intervention and low-cost motion tracking method for estimation of motor proficiency in youth with autism spectrum disorder. Journal of NeuroEngineering and Rehabilitation. 2022;**19**(1):1-13

[13] Hogan DP, Rogers ML, Msall ME. Functional limitations and key indicators of well-being in children with disability. Archives of Pediatrics & Adolescent Medicine. 2000;**154**(10):1042-1048

[14] McPhillips M, FinlayJ, Bejerot S, Hanley M. Motor deficits in children with autism spectrum disorder: A cross-syndrome study. Autism Research: Official Journal of the International Society for Autism Research. 2014;**7**(6):664-676. DOI: 10.1002/aur.1408

[15] Gizzonio V, Avanzini P, Campi C, Orivoli S, Piccolo B, Cantalupo G, et al. Failure in pantomime action execution correlates with the severity of social behavior deficits in children with autism: A praxis study. Journal of Autism and Developmental Disorders. 2015;**45**:3085-3097. DOI: 10.1007/s10803-015-2461-2

[16] Whyatt CP, Craig CM. Motor skills in children aged 7-10 years, diagnosed with autism spectrum disorder. Journal of Autism and Developmental Disorders. 2012;**42**(9):1799-1809. DOI: 10.1007/s10803-011-1421-8

[17] Staples K, MacDonald M, Zimmer C. Assessment of motor behavior among children and adolescents with autism spectrum disorder. International Review of Research in Developmental Disabiliteis. 2012;**42**:179-214. DOI: 10.1016/B978-0-12-394,284-5.00007-3

[18] Lim YH, Partridge K, Girdler S, Morris SL. Standing postural control in individuals with autism spectrum disorder: Systematic review and meta-analysis. Journal of Autism Development and Disorders. 2017;**46**(7):2238-2253

[19] Dowd AM, McGinley JL, Taffe JR, Rinehart NJ. Do planning and visual integration difficulties underpin motor dysfunction in autism? A kinematic study of young children with autism. Journal of Autism and Developmental Disorders. 2012;**42**(8):1539-1548

[20] Rinehart NJ, Tonge BJ, Iansek R, McGinley J, Brereton AV, Enticott PG, et al. Gait function in newly diagnosed children with autism: Cerebellar and basal ganglia related motor disorder. Developmental Medicine and Child Neurology. 2016;**48**(10):819-824

[21] Cook JL, Blakemore SJ, Press C. Atypical basic movement kinematics in autism spectrum conditions. Brain: A journal of neurology. 2013;**136**(9):2816-2824

[22] Santos S, Dantas L, Oliveira JA. Motor development of children, the elderly and people with coordination disorders. Revista Paulista Physical Education. 2004;**18**:33-44

[23] Abdelkarima A, Ammar A, Chtourou H, Wagner M, Knisel E, Hökelmann A, et al. Relationship between motor and cognitive learning abilities among primary school-aged children. Alexandria Journal of Medicine. 2017;**53**(4):325-331

[24] Illingworth RS. The Development of the Infant and the Young Child: Normal and Abnormal. Haryana, India: Elsevier Health Sciences; 2013

[25] Pan CY. Motor proficiency and physical fitness in adolescent males with and without autism spectrum disorders. Autism. 2014;**18**(2):156-165. DOI: 10.1177/1362361312458597

[26] Morato P, Rodrigues A. Avaliação da Proficiência Motora nas Perturbações do Desenvolvimento. Lisboa: Edições FMH; 2014

[27] Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. Pediatrics. 2006;**118**:1758-1765

[28] Deitz JC, Kartin D, Kopp K. Review of the Bruininks-Oseretsky test of motor proficiency, (BOT-2). Physical & Occupational Therapy in Pediatrics. 2007;**27**(4):87-102. DOI: 10.1080/J006v27n04_06

[29] Jones RA, Downing K, Rinehart NJ, Barnett LM, MayT, McGillivray JA, et al. Physical activity, sedentary behavior and their correlates in children with

autism spectrum disorder: A systematic review. PLoS One. 2017;**12**(2):e0172482. DOI: 10.1371/journal.pone.0172482

[30] Lang R, Koegel LK, Ashbaugh K, Regester A, Ence W, Smith W. Physical exercise and individuals with autism spectrum disorders: A systematic review. Research in Autism Spectrum Disorders. 2010;**4**:565-576. DOI: 10.1016/j.rasd.2010.01.006

[31] Lourenço C, Esteves D, Corredeira R, Seabra A. Avaliação dos efeitos de programas de intervenção de atividade física em indivíduos com transtorno do espectro do autismo. Revista Brasileira de Educação Especial. 2015;**21**(2):319-328

[32] Sowa M, Meulenbroek R. Effects of physical exercise on autism spectrum disorders: A meta-analysis. Research in Autism Spectrum Disorders. 2012;**6**: 46-57. DOI: 10.1016/j.rasd.2011.09.001

[33] Pan C, Frey G. Physical activity patterns in youth with autism spectrum disorders. Journal of Autism and Developmental Disorders. 2006;**36**(5):597-606. DOI: 1007/s10803-006-0101-6

[34] Pan CY, Tsai CL, Chu CH. Fundamental movement skills in children diagnosed with autism spectrum disorders and attention deficit hyperactivity disorder. Journal of Autism and Developmental Disorders. 2009;**39**(12):1694-1705. DOI: 10.1007/s10803-009-0813-5

[35] Petetti IKH et al. The efficacy of a 9-month treadmill walking program on the exercise capacity and weight reduction for adolescents with severe autism. Journal of Autism and Developmental Disorders. 2007;**37**(6):997-1006

[36] Todd T, Reid G. Increasing physical activity in individuals with autism. Focus Autism Other Developmental Disabilities. 2006;**21**(3):167-176

[37] Fragala-Pinkham M, Haley SM, e O'Neil ME. Group aquatic aerobic exercise for children with disabilities. Developmental Medicine and Child Neurology. 2008;**50**(11):822-827

[38] Petrus C, Adamson SR, Block L, Einarson SJ, Sharifnejad M, Harris SR. Effects of exercise interventions on stereotypic behaviours in children with autism spectrum disorder. Physiotherapy Canada. Physiotherapie Canada. 2008;**60**(2):134-145. DOI: 10.3138/physio.60.2.134

[39] Rosenthal-Malek A, Mitchell S. Brief report: The effects of exercise on the self-stimulatory behaviors and positive responding of adolescents with autism. Journal of Autism and Developmental Disorders. 1997;**27**(2):193-202. DOI: 10.1023/a:1025848009248

[40] Bass MM, Duchowny CA, Llabre MM. The effect of therapeutic horseback riding on social functioning in children with autism. Journal of Autism and Developmental Disorders. 2009;**39**(9):1261-1267. DOI: 10.1007/s10803-009-0734-3

[41] Ajzenman HF, Standeven JW, Shurtleff TL. Effect of hippotherapy on motor control, adaptive behaviors, and participation in children with autism spectrum disorder: A pilot study. The American Journal of Occupational Therapy: Official Publication of the American Occupational Therapy Association. 2013;**67**(6):653-663. DOI: 10.5014/ajot.2013.008383

[42] Gabriels RL, Agnew JA, Beresford C, Morrow MA, Mesibov G, Wamboldt M. Improving psychiatric hospital care for pediatric patients with autism spectrum disorders and intellectual disabilities. Autism Research and Treatment. 2012;**2012**:685053. DOI: 10.1155/2012/685053

[43] Bishop-Fitzpatrick L, Kind AJH. A scoping review of health disparities in autism spectrum disorder. Journal of Autism and Developmental Disorders. 2017;**47**(11):3380-3391. DOI: 10.1007/s10803-017-3251-9

[44] Healy S, Nacario A, Braithwaite R, Hopper C. The effect of physical activity interventions on youth with autism spectrum disorder: A meta-analysis. Autism Research. 2018b;**11**(6):818-833. DOI: 10.1002/aur.1955

[45] Jones EK, Hanley M, Riby DM. Distraction, distress and diversity: Exploring the impact of sensory processing differences on learning and school life for pupils with autism spectrum disorders. Res. Autism Spectrum Disorders. 2020;**72**:101515. DOI: 10.1016/j.rasd.2020.101515

[46] Robinson L, Stodden D, Barnett L, Lopes V, Logan S, Rodrigues L, et al. Motor competence and its effect on positive developmental. Trajectories of Health Sports Medicine. 2015;**45**(9). DOI: 10.1007/s40279-015-0351-6

[47] Peña J. Autism and Asperger's Syndrome, Guiding for Family, Friends and Professionals. Salamanca: Amarú Ediciones; 2004

[48] Wong C, Odom SL, Hume K, Cox AW, Fettig A, Kucharczyk S, et al. Evidence-based practices for children, youth, and young adults with autism spectrum disorder. Journal of Autism and Developmental Disorders. 2015;**45**(7):1951-1966. DOI: 10.1007/s10803-014- 2351-z

[49] Colombo-Dougovito AM. Successful intervention strategies for autism spectrum disorder and their use for the development of motor skills in physical education. Palaestra. 2015;**29**(2):34-41

[50] Benevides T, Shore S, Andresen M, Caplan R, Cook B, Gassner D, et al. Interventions to address health outcomes among autistic adults: A systematic review. Autism. 2020. DOI: 10.1177/1362361320913664.

[51] Colombo-Dougovito AM, Block ME. Fundamental motor skill interventions for individuals with autism spectrum disorder: A literature review. Review Journal of Autism and Developmental Disabilities. 2019;**6**(2):159-171. DOI: 10.1007/s40489-019-00161-2

[52] Sorensen C, Zarrett N. Benefits of physical activity for adolescents with autism spectrum disorders : A comprehensive review. Review Journal of Autism and Developmental Disorders. 2014;**1**:344-353. DOI: 10.1007/s40489-014-0027-4

[53] Reinders NJ, Branco A, Wright K, Fletcher PC, Bryden PJ. Scoping review: Physical activity and social functioning in young people with autism spectrum disorder. Frontiers in Psychology. 2019;**10**:120. DOI: 10.3389/fpsyg.2019.00120

[54] Howells K, Sivaratnam C, May T, Lindor E, McGillivray J, Rinehart N. Efficacy of group-based organised physical activity participation for social outcomes in children with autism spectrum disorder: A systematic review and meta-analysis. Journal of Autism and Developmental Disorders. 2019;**49**(8):3290-3308. DOI: 10.1007/s10803-019-04050-9

[55] Gehricke JG, Chan J, Farmer JG, Fenning RM, Steinberg-Epstein R, Misra M, et al. Physical activity rates in children and adolescents with autism spectrum disorder compared to the general population. Research in Autism Spectrum Disorders. 2020;**70**:101490. DOI: 10.1016/j.rasd.2019.101490

[56] Blagrave A, Colombo-Dougovito A. Experiences participating in community

physical activity by families with a child on the autism spectrum: A phenomenological inquiry. Advances in Neurodevelopmental Disorders. 2019;**3**(1):72-84. DOI: 10.1007/s41252-018-0094-0

[57] Stanish H, Curtin C, Must A, Phillips S, Maslin M, Bandini L. Enjoyment, barriers, and beliefs about physical activity in adolescents with and without autism spectrum disorder. Adapted Physical Activity Quarterly. 2015;**32**(4):302-317. DOI: 10.1123/apaq.2015-0038

[58] Colombo-Dougovito AM, Blagrave AJ, Healy S. A grounded theory of adoption and maintenance of physical activity among autistic adults. Autism: The International Journal of Research and Practice. 2021;**25**(3):627-641. DOI: 10.1177/13623613209324442 0932444

[59] Buchanan A, Miedema B, Frey G. Parents' perspectives of physical activity in their adult children with autism spectrum disorder: A social-ecological approach. Adapted Physical Activity. 2017;**34**(4):401-420. DOI: 10.1123/apaq.2016-0099

[60] Hillier A, Buckingham A, Schena D. Physical activity among adults with autism: Participation, attitudes, and barriers. Perceptual and Motor Skills. 2020. DOI: 10.1177/003151252 0927560

[61] Nichols C, Block M, Bishop J, McIntire B. Physical activity in young adults with autism spectrum disorder: Parental perceptions of barriers and facilitators. Autism. 2019;**23**(6):1398-1407. DOI: 10.1177/1362361318810221

[62] Menear KS, Neumeier WH. Promoting physical activity for students with autism spectrum disorder: Barriers, benefits, and strategies for success. Journal of Physical Education, Recreation & Dance. 2015;**86**(3):43-48. DOI: 10.1080/07303084.2014.998395

[63] Pan CY. Effects of water exercise swimming program on aquatic skills and social behaviors in children with autism spectrum disorders. Autism: the International Journal of Research and Practice. 2010;**14**(1):9-28. DOI: 10.1177/1362361309339496

[64] Bhat AN, Landa RJ, Galloway JC. Current perspectives on motor functioning in infants, children, and adults with autism spectrum disorders. Physical Therapy. 2011;**91**(7):1116-1129. DOI: 10.2522/ptj.20100294

[65] Brás G, Correia N, Silva A. Study of the motor profile of children with autism spectrum disorders. In: Rodrigues LP, Saraiva L, Barreiros J, Vasconcelos O, editors. Studies in Child Motor Development II. Viana do Castelo: School of Education Polytechnic Institute of Viana do Castelo; 2009. pp. 139-146

[66] Borremans E, Rintala P, McCubbin J. Motor skills of young adults with Asperger Syndrome: A comparative study. EuroASDn Federation of Adapted Physical Activity. 2009;**2**:21-33. DOI: 10.1080/15368370701380843

[67] Fontes ACM. Psychomotor Development in Children with Autism Spectrum Disorders and Development. Lisbon: University of Lisbon; 2013

[68] Lourenço C, Esteves D, Nunes C, Liu T. Motor proficiency of children with autism spectrum disorder and typically developing children in Portugal. Journal of Physical Education and Sport. 2020;**20**(3):1491-1496. DOI: 10.7752/jpes.2020.03205

[69] Bruinninks RH, Bruininks BD. Bruininks-Oseretsky Test of Motor Proficiency. 2nd ed. Minnesapolis, MN: ASDrson Assessment; 2005

Chapter 3

Increase in BMI and Negative Muscular Strength Trends in Adolescents in 1990 and 2020: Results from the Regional Observatory of Motor Development in Southern Italy

Domenico Monacis and Dario Colella

Abstract

In the last decades, low levels of physical activity and sedentary lifestyles were associated with the progressive decline in physical fitness in children and adolescents. The present cross-sectional study aims to assess the evolution of muscular strength in adolescents in an Apulia province (Italy), comparing motor performance in 1990 and 2020. The sample consists of 107 adolescents attending secondary school in Lecce in 1990, and 118 attending the same school in 2020 (11–12 years old). After dividing the sample according to gender and BMI, muscular strength was assessed with Standing Long Jump (SLJ) and Medicine Ball Throw 2 kg (MBT). Statistical analysis included ANOVA to highlight significant differences in motor performances in 1990 and 2020 according to gender and BMI, and linear regression to investigate the variance explained by BMI on SLJ and MBT. The results showed (a) lower motor performance in 2020 compared to 1990, (b) the increase in the percentage of overweight-obese from 1990 to 2020, and (c) a negative association between BMI and the SLJ in 2020. Findings suggest the need to assess and monitor physical fitness—as a health status indicator—in adolescents, and promote further opportunities to encourage and expand the time spent in physical activity in Apulia.

Keywords: healthy lifestyles, cross-sectional study, obesity, muscular strength, regional observatory

1. Introduction

Overweight and obesity are both specific causes of premature death in adulthood [1]. The progressive reduction of physical activity levels (PAL) in children and adolescents, together with the increase of sedentary habits, promote the development of non-communicable and chronic—cardiovascular, respiratory and metabolic—degenerative

diseases [2, 3], bone demineralization and osteoporosis [4], but also sarcopenia, loss of strength and muscle tone [5].

The international guidelines and recommendations of the World Health Organization (WHO) provide for children and adolescents—aged between 5 and 17 years old—the daily practice of at least 60 minutes of moderate to vigorous physical activity (MVPA), together with muscular strength activities [5].

However, several studies showed that a large percentage of children and adolescents do not respect these guidelines and recommendations, preferring sedentary activities. According to a recent report—including 298 schools from 146 countries around the world—about 81% of students aged 11–17 years old did not regularly engage in physical activity in 2016 [6]. Furthermore, the socio-economic status was not a determining variable in predicting PAL: in low-income countries and high-income countries, the percentage of inactive children and adolescents was about 85 and 79%, respectively [6].

Sedentary habits during childhood and adolescence can generate a non-virtuous circular process, in which reduced levels of physical activity contribute to further reducing opportunities for motor practice (i.e., sports activities, recreational activities, group games, unstructured physical activity, free play, etc.), with consequent negative effects on physical literacy and motor development [7].

The latest data of the HBSC study—Health Behavior in School-aged Children—Health-related behaviors in school-age children [8]—aimed at monitoring the health and related factors of children in about 50 countries in Europe and North America, highlighted that (data referred to 2018):

- since 2014 there has been a global progressive decline in levels of moderate to vigorous physical activity (MVPA) in children and adolescents;
- only 20% of children and adolescents practiced daily physical activity;
- the percentage of children/adolescents who regularly practice physical activity decrease progressively as age increase;
- a high proportion of young people regularly consume alcoholic beverages;
- one in five teenagers is overweight/obese.

In Italy, the results of the HBSC report showed low levels of daily consumption of fruit and vegetables (about 27% of young people), low levels of daily moderate to vigorous physical activity (similar results were found in Portugal and France) and high levels of digital communication (smartphones, tablets, notebooks, etc.), especially in girls aged 15 years old (about 63%).

These results are supported by the latest ISTAT (Istituto Nazionale di Statistica) report referred to 2017–2018, according to which more than 2 million children and adolescents in Italy are overweight (25.5% of children aged 3–17), with a significant prevalence in boys (27.8%) than in girls (22.4%) [9]. Despite the slight decrease in the percentage of overweight/obese children and adolescents—28.5% in 2010–2011 and 25.2% in 2017–2018—the percentage of inactive and sedentary young people still remains very high: 1 million 925 thousand children and adolescents, equal to about 23% of the Italian population aged 3–17 years [9]. Italy together with Cyprus, Spain, Greece and Malta is the country with the highest proportion of overweight/obese children in the 7–8 years range [9].

Furthermore, the latest Okkio alla SALUTE report—the Italian national surveillance system on overweight, obesity and related risk factors in primary school children (6–10 years)—coordinated by the National Center for Disease Prevention and Health Promotion showed that the percentage of overweight and obese children was 20.4 and 9.4%, respectively (data referred to 2019) [10].

What effects on physical fitness and health status?

Healthy lifestyles promote better body composition preventing overweight and obesity [11], improving muscle strength development and a better functionality of the cardiovascular and lymphatic system [12, 13]. Regarding the psychological and cognitive domain, physical activity in childhood and adolescence involves personal well-being [14], and a better cognitive and emotional development [15, 16].

Recent findings revealed changes in body size, body circumferences and the percentage of body fat in adolescents aged 16–17 years [17].

A recent systematic review analyzed the evolution of motor skills in children aged 6–18 years from 1972 to 2015, highlighted a progressive decline in aerobic fitness and muscle power between 1986 and 2010–2012, and a moderate development of muscle strength and speed in the same period [18]. Other studies associated the increasing BMI (Body Mass Index) to decline in physical fitness related to 20 m shuttle run test [19], standing long jump test, sit-and-reach test, 50 m sprint and aerobic fitness [20]. Low physical activity and higher levels of BMI were also associated with reduced motor performance more significant in boys than girls [21–23] and especially in the 13–14 years group [24].

Previous studies, based on the monitoring of physical fitness in Apulia Region (Southern Italy), showed lower motor performance (strength, speed and aerobic fitness) in overweight/obese children aged 9–10 years, associated with lower levels of self-perception and enjoyment compared to normal weight peers [25, 26].

The assessment of physical fitness in adolescents allows the acquisition of transversal and longitudinal information on the development and evolution of motor skills as health indicators. Furthermore, it is possible to infer the evolution of the educational process during adolescence by combining anthropometric and physical fitness data (BMI, strength, speed, aerobic fitness) with psychological factors related to physical activity (e.g., intrinsic motivation, physical self-efficacy, enjoyment).

These data can be used to carry out surveillance studies necessary and unavoidable to program and to put into practice multi-component and interdisciplinary interventions, allowing dialog and synergies between the professionals dealing with health promotion.

In Southern Italy, a large percentage of children and adolescents are overweight-obese (about 32.7%) children and adolescents are very high [9]. In Apulia only 10% of children and adolescents carry out daily physical activity for 1 hour, with 1 out of 5 teenagers overweight or obese; at the same time, there are high levels of consumption of soda and sugars and low consumption of fruits and vegetables (lower than the recommendation of at least 5 servings per day) [8]. Moreover, in addition to the analysis of nutritional status highlighting alarming levels of overweight-obesity, there is a growing feeling of malaise that teenagers live in the relationship with their body image [8].

Health status of children and adolescents were behind the development of the Regional Observatory of Motor Development and Health Prevention in Apulia (Italy), a regional project—included in the Triennial Apulia Guidelines 2019/2021 on Sport [27]—for secondary schools of first and second grade and coordinated by the University of Foggia, afferent to the Laboratory of Didactics Motor Activities, aiming at: (a) assess health status and physical fitness in children and adolescents;

(b) create a regional database on motor development and levels of physical activity accessible and shared by different health professionals; (c) create and achieve regional reference values about physical fitness and PAL; (d) compare PAL and motor development of pupils in different ages; (e) disseminate results in different contexts (school, university, healthcare system, sport, local administrators) by orienting institutional resources and educational interventions; (f) develop and collect good practices, didactic guidelines and methodological implications in physical education (PE) for the promotion of healthy lifestyles. In addition, it allows to acquire and periodically compare quanti-qualitative data on the evolution of physical fitness and motor abilities in different geographical areas, evaluating the effectiveness of school, institutional and sports interventions for health promotion.

In the light of this evidence, this study aims to assess the evolution (development or decline) of strength levels in young adolescents aged 11–12 years, comparing motor performance in 1990 and in 2020 in the same Apulia province (Lecce).

2. Materials and methods

2.1 Sample and study design

The present study used cross-sectional data from the "Regional Observatory of Motor Development and Health Prevention" project in Apulia Region, coordinated by the University of Foggia—Laboratory of Didactics of Motor Activities—aimed at assessing levels of physical fitness and health in young children and adolescents. The sample consisted of 107 and 118 children aged 11–12 years (first grade of the secondary school) attending the same school in Lecce, respectively in 1990 and in 2020.

The data from the 1990 sample were retrieved from physical education teacher's assessment during the monitoring carried out by the University of Foggia in the '90s, while data from 2020 sample were collected as part of the Motor Development and Health Prevention project. Written informed consent was obtained from all children's parents/guardians, both in 1990 and 2020 and stored at school institute.

2.2 Assessment tools

The assessment in 2020 involved anthropometric characteristics and a physical fitness test. Standing height and body weight were measured using a calibrated stadiometer and a balance scale (nearest 0.1 cm), respectively. BMI was obtained by dividing the body weight (kg) by the body height squared (m^2) [28].

After collecting and analyzing the sample's anthropometric characteristics (weight, height and BMI), participants were classified as normal weight (Nw) or overweight-obese (Ow-Ob) according to Cole's standard definition for child overweight and obesity [29].

Starting from BMI, Cole's Scale used cutoff points—based on centiles BMI curves adjusted by age and sex—to define child's normal weight, overweight or obese status [29].

The motor assessment involved the standing long jump—as a part of the Eurofit Fitness Testing Battery [30]—and the medicine ball throw test [31] to evaluate the strength and explosive power of the lower and upper limbs, respectively.

The assessment protocol was the same in 1990 and in 2020, as follows:

- Standing long jump (SLJ) [30]:

- student behind the starting line, previously traced in the gym;
- from here—with the lower limbs slightly apart on the front plane—perform a long jump with a semi-bend on the lower limbs, slandering the arms forward, falling back on the mattress on equal feet;
- measure jump distance in meters, from the starting line to the nearest sign left by the feet or from the other part of the body on the mattress;
- Medicine ball throw 2 kg (MBT) [31]:
- student positioned with his feet slightly apart on the front plane behind a line drawn on the floor—frontal to the throw direction—with his arms high and grabbing a 2 kg medical ball;
- from this position, after performing a semi-bending on the lower limbs, the throws the medical ball forward-up as far as possible;
- measure throw distance in meters.

For both physical fitness test, three trials were carried out. Only the best result was considered.

2.3 Data collection procedure

After recovering data from the PE teachers monitoring in 1990, a group of Graduates in Preventive and Adapted Motor Sciences conducted the assessment in the same school in Lecce (Apulia) in 2020. For better reliability of the results, five secondary school classes were randomly recruited and involved in the study, together with their respective physical education teachers (n = 2).

Sample characteristics—in terms of age and educational attainment—were the same in 1990 and 2020, while PE teacher's characteristics were not considered relevant variables in this study.

The monitoring activities were carried out by agreement with the school manager and the physical education teachers involved.

Three Graduates in Preventive and Adapted Motor Sciences were recruited by the Laboratory of Didactics of Motor Activities and trained to standardize the assessment protocol.

The assessment was conducted during curricular physical education lessons in January 2020 by Graduates in Preventive and Adapted Motor Sciences and PE teachers.

2.4 Statistical analysis

After verifying the normal distribution of data with the Saphiro-Wilk test (abnormal and minimum/maximum values were excluded), the results of the descriptive analyses were reported in terms of mean and standard deviation (M ± SD). After verifying the homoscedasticity condition (Levene test), variance analysis (ANOVA) was performed to compare motor performance in 1990 and 2020 (a) based on gender and BMI, and (b) based on total sample

according to BMI. The effect size (ES; ηp^2) was reported to estimate the size of the detected differences, interpreting the values as follows: $\eta p^2 \sim 0.020$ = low ES, $\eta p^2 \sim 0.50$ = medium ES and $\eta p^2 \sim 0.80$ = high ES [32]. The chi-square test was used to highlight any differences in the distribution of normal weight and overweight-obese adolescents in 1990 and 2020. Linear regression analysis was performed to investigate variance in physical fitness test explained by BMI in 1990 and 2020. Data analysis was conducted using SPSS ver.25 software. All levels of significance were set at $p < 0.05$.

3. Results

Table 1 summarizes the anthropometric characteristics (age, weight, height and BMI) according to gender and BMI (normal weight and overweight-obese).

The analysis related to the prevalence of overweight-obesity (**Table 2**) showed that:

a. the proportion of overweight adolescents increased significantly from 5.3 (1990) to 20.6% (2020) in boys ($X^2 = 6.250$, $p = 0.012$), and from 4.0 (1990) to 34.5% (2020) in girls ($X^2 = 13.762$, $p = 0.000$);

b. the percentage of the normal weight on total sample decreased significantly from 92.5 to 60.2% ($X^2 = 4.612$, $p = 0.032$), while the percentage of overweight and obese children increased from 4.7 to 27.1% ($X^2 = 19.703$, $p = 0.000$) and from 2.8 to 12.7% ($X^2 = 8.000$, $p = 0.005$), respectively.

Table 3 and **Figures 1** and **2** summarize the results of the physical fitness tests according to gender and BMI (Male/Female and Nw/Ow-Ob). Results showed better motor performance in the SLJ test in 1990 compared to 2020, regardless of gender and/or BMI (male normal weight $p = 0.016$; male overweight-obese $p = 0.049$; female normal weight $p = 0.000$; female overweight/obese $p = 0.049$; total normal weight

Sample						
		N	**Age**	**Weight**	**Height**	**BMI**
1990						
Male	Nw	54	11.17 ± 0.50	40.38 ± 7.32	1.50 ± 0.07	17.69 ± 2.17
	Ow-Ob	3	11.67 ± 1.15	54.33 ± 1.52	1.52 ± 0.07	23.57 ± 1.49
Female	Nw	45	11.02 ± 0.33	40.60 ± 7.46	1.49 ± 0.05	17.96 ± 2.55
	Ow-Ob	5	11.20 ± 0.45	60.20 ± 9.98	1.51 ± 0.05	26.28 ± 3.04
2020						
Male	Nw	42	11.60 ± 0.49	40.32 ± 7.84	1.50 ± 0.08	17.73 ± 2.14
	Ow-Ob	21	11.62 ± 0.49	58.54 ± 10.47	1.52 ± 0.06	24.98 ± 3.29
Female	Nw	29	11.24 ± 0.43	40.64 ± 7.75	1.51 ± 0.08	17.45 ± 1.89
	Ow-Ob	26	11.62 ± 0.50	59.38 ± 8.19	1.53 ± 0.05	25.04 ± 2.90

Nw = normal weight, Ow-Ob = overweight-obese.

Table 1.
Anthropometric characteristics of the sample.

Percentage of normal weight and overweight-obese adolescents								
		1990		**2020**		X^2	***df***	***p***
		n	**%**	***n***	**%**			
Male	Nw	54	94.7	42	66.7	1.500	1	0.221
	Ow	3	5.3	13	20.6	6.250	1	0.012
	Ob			8	12.7	/	/	/
Female	Nw	45	90	29	52.7	3.459	1	0.063
	Ow	2	4.0	19	34.5	13.762	1	0.000
	Ob	3	6.0	7	12.7	1.600	1	0.206
Total	Nw	99	92.5	71	60.2	4.612	1	0.032
	Ow	5	4.7	32	27.1	19.703	1	0.000
	Ob	3	2.8	15	12.7	8.000	1	0.005

Table 2.
Sample distribution about BMI.

Physical fitness test								
			1990	**2020**				
			***M* ± SD**	***M* ± SD**	***F***	***df***	***p***	ηp^2
Male	SLJ	Nw	1.57 ± 0.23	1.46 ± 0.24	6.015	1	0.016	0.060
		Ow-Ob	1.23 ± 0.22	1.20 ± 0.20	4.253	0.1	0.049	0.162
	MBT	Nw	4.88 ± 0.87	4.24 ± 1.05	10.591	1	0.002	0.101
		Ow-Ob	4.70 ± 1.15	4.10 ± 0.76	1.408	1	0.248	0.060
Female	SLJ	Nw	1.43 ± 0.18	1.21 ± 0.18	24.828	1	0.000	0.256
		Ow-Ob	1.38 ± 0.24	1.10 ± 0.22	4.171	1	0.049	0.134
	MBT	Nw	4.31 ± 0.72	3.64 ± 0.48	18.737	1	0.000	0.206
		Ow-Ob	5.01 ± 0.75	3.83 ± 0.63	13.560	1	0.001	0.319
Total	SLJ	Nw	1.51 ± 0.21	1.36 ± 0.25	17.699	1	0.000	0.095
		Ow-Ob	1.42 ± 0.22	1.15 ± 0.21	8.599	1	0.005	0.144
	MBT	Nw	4.62 ± 0.85	4.00 ± 0.91	20.792	1	0.001	0.110
		Ow-Ob	4.89 ± 0.85	3.95 ± 0.70	11.439	1	0.001	0.178

Table 3.
Motor performance about gender and BMI.

$p = 0.000$; total overweight/obese $p = 0.005$). The effect size values were relatively low; higher levels were reported in the normal weight female group ($\eta p^2 = 0.256$).

The same results were obtained in the MBT test: all groups showed higher motor performances in 1990 compared to 2020 (male normal weight $p = 0.002$; female normal weight $p = 0.000$; female overweight/obese $p = 0.001$; total normal weight $p = 0.001$; total overweight/obese $p = 0.001$), except in male overweight/obese.

Data analysis revealed better results in the 1990 sample, suggesting a decline in lower and upper limb strength levels. The effect size values were relatively low, except in female overweight/obese group ($\eta p^2 = 0.319$).

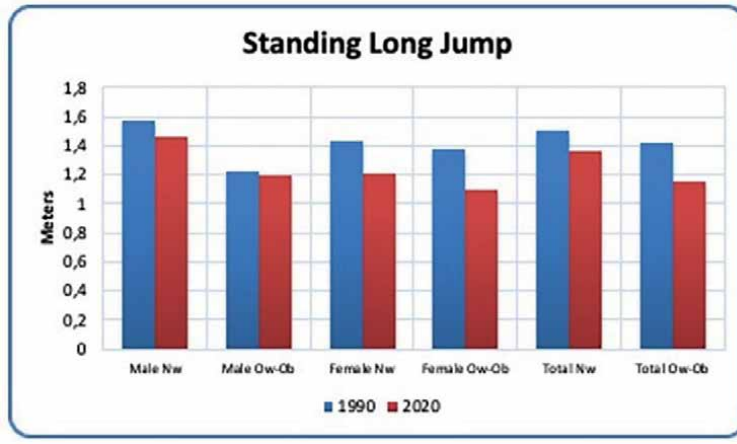

Figure 1.
Performance in SLJ:1990 vs 2020.

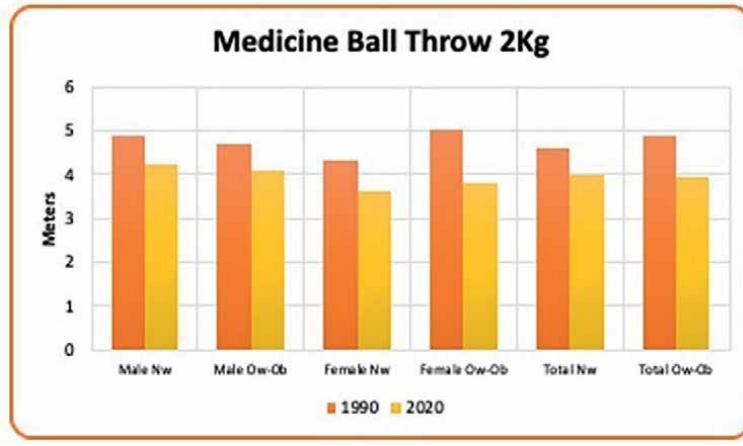

Figure 2.
Performance in MBT: 1990 vs 2020.

Linear regression between BMI and physical fitness test										
	BMI in 1990					**BMI in 2020**				
	b	***R*²**	***F***	***df***	***p***	***b***	***R*²**	***F***	***df***	***p***
SLJ	−0.190	0.036	3.971	1	0.052	**−0.329**	0.108	14.092	1	**0.000**
MBT	**0.213**	0.046	5.006	1	**0.027**	0.118	0.014	1.141	1	0.202

Table 4.
Relationship between BMI and motor performance.

Regression analysis (**Table 4**) highlighted the relation between BMI and motor performance: in 1990 BMI was significantly related to MBT (b = 0.213. p = 0.027) explaining only 4.6% of total variance, and in 2020 BMI was inversely related to SLJ (b = −0.329, p = 0.000, with the 10.8% of the total variance explained).

4. Discussion

This study aimed to assess and compare the evolution of physical fitness in adolescents attending the first year of secondary school in 1990 and in 2020.

The first statistically significant (and alarming) data was related to the sample's distribution: the percentage of overweight and obese male adolescents increased from 5.3% in 1990 to 33.3% in 2020, and from 10.0 to 47.2% in females. This data, in addition to soliciting the interest of coaches, PE teachers, parents and institutional policies (*something has changed?*), reflected the decline and involution of physical fitness over the last 30 years.

Results showed a reduction and decline in motor performance from 1990 to 2020, both in boys and girls regardless of the BMI. In addition, this study showed more significant differences in girls than boys. The interpretation of the physical fitness test underlined a key concept: adolescents in 1990 were stronger than those in 2020, and this result cannot be considered separately from the increase in the percentage of overweight-obesity.

BMI was related to MBT in 1990 and no relation was found SLJ in the same year. In 2020 BMI was negatively associated with the SLJ, without significant effects on MBT. These results lead to the following (possible) considerations:

- in 1990 the low percentage of overweight-obese children did not allow to define the BMI a variable significantly associated with the strength of the lower limbs (SLJ). At the same time, overweight-obese children in 1990 had higher upper limb strength (MBT). The BMI helped to explain only 4.6% of variance of MBT in 1990: a small percentage, although statistically significant, that put the BMI in second plane in explaining these differences, considering that the sample was almost exclusively normal weight (92.5%);

- in 2020 the BMI was inversely related to SLJ, so as the BMI increases, the motor performance in the SLJ progressively reduced. Only BMI explains about 11% of the total variance in the SLJ.

Contrary to findings evidenced by other studies [24, 33], according to which the BMI increase it corresponds an increase of the upper limbs strength in the MBT, this study did not provide a significant relation between BMI and MBT. This could imply a flattening of motor performance and upper limb strength levels, regardless of BMI levels. BMI did not determine, in this case, a greater strength expression in tasks that require moving and/or moving an object (e.g., throwing), but it influences significantly the SLJ, that is, a task requiring the horizontal movement of the entire body, stressing the need to define physical fitness sex-specific and age-specific normative values for children and adolescents [34].

The results of this study were partly confirmed by previous studies. A recent systematic review, analyzed the evolution of motor abilities (strength, speed, flexibility and coordination) from 2006 to 2019 in children and adolescents aged 4–18 years, showing the decline in physical fitness over the past decade, especially in terms of aerobic fitness, strength and flexibility [35].

A further review analyzed the evolution of motor performance in children and adolescents (6–18 years) from 1972 to 2015, considering aerobic fitness, strength, muscle power and speed as health indicators [18]. The results of the 22 studies included in the systematic review can be summarized as follows:

- development of aerobic fitness from 1972 to 1986, and a subsequent decline until 2010–2012, then stabilized until 2015;
- slight increase in muscle strength (stable since 2006);
- progressive reduction and loss of muscle power (expression of strength in the shortest time possible) with a slight increase in speed (especially in the 3 years 2012–2015).

Contrary to the trends highlighted so far, positive trends of improvement of motor abilities (from 1989 to 2019) were reported in Slovenian children aged 7–10 years, especially in girls [36].

A further Slovenian study showed, however, a negative trend between the increase in anthropometric factors (especially BMI) and the decline in motor abilities, emphasizing a significant reduction in lower and upper limb strength levels, with peaks (in terms of involution) observed in the years 1993/1994–2003/2004 [37].

What has been highlighted so far is even more worrying and is an important wake-up call considering that the development of physical fitness—especially the standing long jump—is an important health indicator in children and adolescents [38].

These results suggest that the progressive reduction of health-related components and physical fitness was more oriented towards overweight-obese children showing worse motor performances in aerobic fitness, muscular endurance and explosive muscular power [39].

The strength development also has important effects and implications for the prevention of numerous non-communicable diseases and premature death. A recent study analyzed the evolution of the muscular strength of the American population—assessed through Hand Grip (grip strength)—in the years 2011–2012 and 2013–2014 on 12295 participants aged 6–85 years. Although, the results did not reveal significant differences over the years (based on age, gender, and ethnicity), they stressed and reiterated the importance of assessing and monitoring the strength development of the entire population, as an important indicator of the general health status [40].

Other studies, in addition to highlighting significant lower physical fitness measures (grip strength, standing long jump, 20-meter shuttle run) and motor competence (throwing and catching skills) in schoolchildren aged 13–14 years from 2014 to 2019, reported the reduction of the 16% of the hours spent in physical education between 2010 and 2019 [40]. Data revealed that the normal-weight group has highlighted the most important decline in fitness levels and motor competence compared to the overweight-obese peers [41].

Furthermore, a recent systematic review and meta-analysis examined the effects of physical education interventions carried out on curricular time, based on quanti-qualitative intervention protocols, in terms of motor development and motor skills learning [42]. Results suggest that quanti-qualitative interventions are associated with an increase in aerobic fitness, strength and, at the same time, allows to enhance end improve motor learning [42].

The learning of motor skills is guaranteed by the interaction of the child with the environments, spaces, tools, objects, classmates, and is mediated by the circular relation between the executive variants (spatial-temporal-qualitative-quantitative) applied to one or more fundamental motor skills (e.g., jump + long-forward), and

sense-perceptual, coordinative and conditional abilities functional to a specific motor task (e.g., jump long-forward = rapid strength of lower limbs).

This study captured BMI and physical fitness in two-time points highlighting moderate changes in physical strength in children in Apulia.

Despite the randomization of the sample in the same school in 1990 and the involvement of the same protocols in performing SLJ and MBT, some limitations of the study that would have increased the magnitude and the generalization of the results emerged.

Socio-economic status, levels of motor competence, behaviors, diet, eating habits and maturation, as well as factors related to the practice of physical activity (e.g., enjoyment, self-perception, intrinsic motivation, etc.), were not available at both time points (1990 and 2020), so the conclusions are based only on objective measures (BMI and muscular strength).

5. Conclusions

The present study provides several considerations regarding the decline in muscular strength in adolescents according to (a) the increase in BMI and sedentary lifestyles, (b) general lower health status and (c) motor learning processes. The progressive decline in motor performance and the corresponding increase in BMI, therefore, affects not only physical education teachers, graduates in motor science, coaches, etc. but the entire public health system, requiring a convergence of intentions and interventions by educational, political, cultural, social and health Apulia institutions. The analysis and interpretation of the data show the need to monitor and, consequently, intervene through the implementation of good practices in the younger populations.

Despite the undoubted positive effects linked to a physical education based on quanti-qualitative interventions, further opportunities are also needed to encourage and expand the time spent in physical activity (e.g., through active breaks, active lessons and active transport).

Future research should be oriented at monitoring health status, anthropometric characteristics and physical fitness (in terms of strength, speed, aerobic fitness and flexibility) in children and adolescents involving more factors, such as socio-economic status, ethnic group, urban or rural environment, etc. to obtain results that are as representative as possible of a specific target sample.

Acknowledgements

We gratefully acknowledge the contribution of PE teachers, Experts in Sciences of Preventive and Adapted Motor Activities, and the Laboratory of Didactics Motor Activities staff.

Conflict of interest

The authors declare no conflict of interest.

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References

[1] Bhaskaran K, Santos-Silva I, Leon DA, Douglas IJ, Smeeth L. Association of BMI with overall and cause-specific mortality: A population-based cohort study of 3·6 million adults in the UK. The Lancet Diabetes and Endocrinology. 2018;**6**(12):944-953

[2] Zhang T, Xu J, Li S, Bazzano LA, He J, Whelton PK, et al. Trajectories of childhood BMI and adult diabetes: The Bogalusa Heart Study. Diabetologia. 2019;**62**(1):70-77

[3] Umer A, Kelley GA, Cottrell LE, Giacobbi PJ, Innes KE, Lilly CL. Childhood obesity and adult cardiovascular disease risk factors: a systematic review with meta-analysis. BMC Public Health. 2017;**17**(1):683

[4] Pinheiro MB, Oliveira J, Bauman A, Fairhall N, Kwok W, Sherrington C. Evidence on physical activity and osteoporosis prevention for people aged 65+ years: a systematic review to inform the WHO guidelines on physical activity and sedentary behaviour. International Journal of Behaviour Nutrition and Physical Act. 2020;**17**(1):150

[5] Rosique-Esteban N, Babio N, Díaz-López A, Romaguera D, Alfredo Martínez J, Sanchez VM, et al. Leisure-time physical activity at moderate and high intensity is associated with parameters of body composition, muscle strength and sarcopenia in aged adults with obesity and metabolic syndrome from the PREDIMED-Plus study. Clinical Nutrition. 2019;**38**(3):1324-1331

[6] Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 16 million participants. The Lancet Child & Adolescent Health. 2020;**4**(1):23-35

[7] Faigenbaum AD, Rebullido TR, MacDonald JP. Pediatric Inactivity Triad: A Risky PIT. Current Sports Medicine Reports. 2018;**17**(2):45-47

[8] Cavallo F, Dalmasso P, Vieno A, Lazzeri G, Galeone D. La Sorveglianza HBSC 2018.

[9] Stili di vita di bambini e ragazzi. Anni 2017-2018 [Internet]. 2019. Available from: https://www.istat.it/it/files/2019/10/Report_Stili_di_vita_minori.pdf [Accessed: January 11, 2022]

[10] Indagine nazionale 2019: i dati nazionali. Available from: https://www.epicentro.iss.it/okkioallasalute/indagine-2019-dati [Accessed: January 11, 2022]

[11] Al-Khudairy L, Loveman E, Colquitt JL, Mead E, Johnson RE, Fraser H, et al. Diet, physical activity and behavioural interventions for the treatment of overweight or obese adolescents aged 12 to 17 years. Cochrane Database of Systematic Reviews. 2017;**6**(6):CD012691

[12] Abrignani MG, Lucà F, Favilli S, Benvenuto M, Rao CM, Di Fusco SA, et al. Lifestyles and cardiovascular prevention in childhood and adolescence. Pediatric Cardiology. 2019;**40**(6):1113-1125

[13] Alves JGB, Alves GV. Effects of physical activity on children's growth. Journal of Pediatrics. 2019;**95**(Suppl. 1):72-78

[14] Hosker DK, Elkins RM, Potter MP. Promoting mental health and wellness in youth through physical activity, nutrition, and sleep. Child and Adolescent Psychiatric Clinics of North America. 2019;**28**(2):171-193

[15] Singh AS, Saliasi E, van den Berg V, Uijtdewilligen L, de Groot RHM, Jolles J, et al. Effects of physical activity interventions on cognitive and academic performance in children and adolescents: a novel combination of a systematic review and recommendations from an expert panel. British Journal of Sports Medicine. 2019;**53**(10):640-647

[16] Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. Sports Medicine. 2019;**49**(9):1383-1410

[17] Godina EZ, Lhagvasuren G, Shagdar B-E, Zadorozhnaya LV, Permiakova EY, Khomiakova IA. Secular changes in Mongolia: Shift in Tempos of growth. Collegium Antropologicum. 2019;**43**:11-20

[18] Fühner T, Kliegl R, Arntz F, Kriemler S, Granacher U. An update on secular trends in physical fitness of children and adolescents from 1972 to 2015: A systematic review. Sports Mediicne. 2021;**51**:303-320

[19] Tomkinson GR, Léger LA, Olds TS, Cazorla G. Secular trends in the performance of children and adolescents (1980-2000): An analysis of 55 studies of the 20m shuttle run test in 11 countries. Sports Medicine. 2003;**33**(4):285-300

[20] Bi C, Zhang F, Gu Y, Song Y, Cai X. Secular trend in the physical fitness of Xinjiang children and adolescents between 1985 and 2014. International Journal of Environmental Research and Public Health. 2020;**17**:2195

[21] Colley RC, Clarke J, Doyon CY, Janssen I, Lang JJ, Timmons BW, et al. Trends in physical fitness among Canadian children and youth. Health Reports. 2019;**30**(10):3-13

[22] Dong Y, Lau PWC, Dong B, Zou Z, Yang Y, Wen B, et al. Trends in physical fitness, growth, and nutritional status of Chinese children and adolescents: a retrospective analysis of 1·5 million students from six successive national surveys between 1985 and 2014. The Lancet Child & Adolescent Health. 2019;**3**(12):871-880

[23] Milanovic I, Radisavljevic-Janic S, Zivkovic MZ, Mirkov DM. Health-related physical fitness levels and prevalence of obesity in Serbian elementary schoolchildren. Nutrición Hospitalaria. 2019;**36**:253-260

[24] Pate RR, Schenkelberg MA, Dowda M, McIver KL. Group-based physical activity trajectories in children transitioning from elementary to high school. BMC Public Health. 2019;**19**(1):323

[25] Colella D, Monacis D, d'Arando C. Motor performances in relation to perceived physical self-efficacy, enojoyment and BMI in primary school children. European Journal of Physical Education and Sports Science. 2020;**6**(3):27-46

[26] Colella D, Bellantonio S, D'Arando C, Monacis D. Interventions for the promotion of motor activities in primary school. Assessment of motor performance in relation to perceived self-efficacy and enjoyment. Italian Journal of Educational Research. 2020;**25**:49-62

[27] Bozza Linee Guida Triennali 2019/2021 in materia di Sport [Internet]. Available from: http://www.pugliasportiva.it/visualizzazione?p_p_id=visualizzazionedettagliocontenuti_WAR_visualizzazionefrontendportlet01&_visualizzazionedettagliocontenuti_WAR_visualizzazionefrontendportlet01_myaction=visualizzaDettaglioElemento&idElemento=43782&tipoElemento=Contenuto web [Accessed: February 16, 2022]

[28] Khosla T, Lowe CR. Indices of obesity derived from body weight and height. British Journal of Preventive & Social Medicine. 1967;**21**(3):122-128

[29] Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. BMJ. 2000;**320**(7244):1240

[30] Sport C of EC for the D of. Eurofit: Handbook for the Eurofit Tests of Physical Fitness [Internet]. Council of Europe; 1993.

[31] Morrow JJR, Mood D, Disch J, Kang M. Measurement and Evaluation in Human Performance, 5E [Internet]. Human Kinetics; 2015. Available from: https://books.google.it/books?id=xN5rCgAAQBAJ

[32] Cohen P, West SG, Aiken LS. Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences. Psychology Press; 2014

[33] Colella D, Monacis D, Massari FE. Assessment of motor performances in Italian Primary School Children: Results of SBAM Project. Advances in Physical Education. 2019;**9**(2):117-128

[34] Tomkinson GR, Carver KD, Atkinson F, Daniell ND, Lewis LK, Fitzgerald JS, et al. European normative values for physical fitness in children and adolescents aged 9-17 years: results from 2 779 165 Eurofit performances representing 30 countries. British Journal of Sports Medicine. 2018;**52**(22):1445-14563

[35] Eberhardt T, Niessner C, Oriwol D, Buchal L, Worth A, Bös K. Secular trends in physical fitness of children and adolescents: A review of large-scale epidemiological studies published after 2006. International Journal of Environmental Research and Public Health. 2020;**17**

[36] Potočnik ŽL, Jurak G, Starc G. Secular trends of physical fitness in twenty-five birth Cohorts of Slovenian Children: A Population-Based Study. Frontiers in Public Health. 2020;**8**:616

[37] Đurić S, Sember V, Starc G, Sorić M, Kovač M, Jurak G. Secular trends in muscular fitness from 1983 to 2014 among Slovenian children and adolescents. Scandinavian Journal of Medicine & Science in Sports. 2021

[38] Pinoniemi BK, Tomkinson GR, Walch TJ, Roemmich JN, Fitzgerald JS. Temporal trends in the standing broad jump performance of United States Children and Adolescents. Research Quarterly for Exercise and Sport. 2021;**92**(1):71-81

[39] Albon HM, Hamlin MJ, Ross JJ. Secular trends and distributional changes in health and fitness performance variables of 10-14-year-old children in New Zealand between 1991 and 2003. British Journal of Sports Medicine. 2010;**44**(4):263-269

[40] Loprinzi PD. An initial assessment of secular trends in muscular strength among children, adolescents, and adults across the lifespan: National Sample of Americans. American Journal of Health Promotion. 2016;**32**(3):705-707

[41] Weedon BD, Liu F, Mahmoud W, Burden SJ, Whaymand L, Esser P, et al. Declining fitness and physical education lessons in UK adolescents. BMJ Open Sport & Exercise Medicine. 2022;**8**(1):e001165

[42] García-Hermoso A, Alonso-Martínez AM, Ramírez-Vélez R, Pérez-Sousa MÁ, Ramírez-Campillo R, Izquierdo M. Association of physical education with improvement of health-related physical fitness outcomes and fundamental motor skills among youths: A systematic review and meta-analysis. JAMA Pediatrics. 2020;**174**(6):e200223

Chapter 4

Vitamin D3 Deficiency: The Missing Component in the Physical Activity and Lifelong Health of Children and Adolescents in Sub-Sahara Africa?

Gitahi Theuri and Lucy-Joy Wachira

Abstract

Urbanization in Africa has led to lifestyles changes that undermine physical activity. These behavioral changes are also linked to spending less time in the Sun. Vitamin D is primarily synthesized dermally when sun rays directly strikes exposed skin. Vitamin D deficiency and insufficiency is now recognized as a global issue impairing the health of more than 1 billion people Worldwide. Serum Vitamin D levels in children in Sub-Sahara Africa (SSA) has been linked to inadequate exposure to sunlight, despite it straddling the equator that affords almost yearlong overhead sunshine. Vitamin D deficiency is associated with several health challenges, which in turn undermines normal growth, development, and potential physical and mental function likely to compromise performance of physical activity and sports. This chapter highlights the role of Vitamin D, its deficiency and implications on physical activity and sports performance with particular focus on children and adolescents, who are at a prime age for foundational development of motor function, skills and performance. While parents, healthcare professionals, coaches and caregivers of children in SSA need to promote sun exposure as the primary source of vitamin D, this perhaps also calls for further attention on Vitamin D supplementation, to support health and sports performance.

Keywords: vitamin D, deficiency, physical activity, sports, fitness, health, children, Sub-Sahara Africa

1. Introduction

Sub-Sahara Africa (SSA) is an expansive area about 23,852,823 square kilometers in size that lies between latitudes 16 ° N and 35° S. Its population was estimated at 1.1 billion in 2019 by the United Nations Department of Economic and Social Affairs [1], with more than 40% of this population estimated to be below the age of 15 years.

The World Bank in 2020 estimated urbanization in this region to be above 45% with the highest rate at 90% in Gabon and 17% in Malawi [1]. Urbanization is known to offer numerous conveniences that tend to improve the standard of living in general. However, it is also associated with lifestyles that undermine engagement in sports and physical activity in children and adolescents due to numerous factors; motorized transportation, a built environment devoid of parks or social amenities for exercising, air pollution, and long hours in traffic while commuting to and from school. In general, children living in such an environment spend less time in the Sun resulting in impaired dermal Vitamin D synthesis: a key component of not only bone metabolism but also for maintaining immune homeostasis, activation of genes influencing muscle growth and differentiation, all critical factors in physical activity and sports performance.

This chapter seeks to highlight the role of Vitamin D, its deficiency and implications on physical activity and sports performance. We appreciate that effects of Vitamin D deficiency cut across all athletes but we choose to focus on children and adolescents, who are at a prime age for foundational development of motor function, skills and performance. Surprisingly, evidence on children in SSA may suggest that Africa could be the continent with one of the highest frequency of severe vitamin D deficiency [2]. This chapter appreciates that while Sun exposure is the main source for Vitamin D, it should be the primary focus for advocacy compared to prescription of supplements among athletes especially in economic-resource deprived settings such as those in Sub-Saharan Africa.

2. Sports and fitness activities among children and youth in SSA

There is a perception that children are `naturally' active [3], and as previously witnessed in Africa, they would take advantage of every opportunity and space to play, given adequate time and an enabling environment regardless of availability of equipment or the ideal facility. Sports, active play and fitness activities among children and youth in SSA usually take place in the school settings (during PE classes, school sports programmes and recess time activities), home environment (active play at home and in the neighborhood with siblings and friends) and at the leisure and recreation centres (organized club activities and outdoor pursuits programmes). Activities among children and adolescents range from organized/formal sports activities (such as ball games, racket and batting sports, athletics, swimming and martial arts) and fitness programmes to informal active play characterized with fun, less stringent rules and improvisation of equipment and facilities. These are excellent opportunities to develop and nurture motor abilities and skills linked to enhanced fitness, necessary for health and performance. There is also evidence that such physical activity behavior and resulting active lifestyles tracks from childhood through adolescence and into adulthood [4].

Notably, most of these activities (especially in SSA) are designed to take place in the outdoors where participants not only interact with the built and social environment but also engage in nature-based learning, survival and experiential learning, characterized by physical engagement and active transportation. In the process, participants gained the much needed direct exposure to sunshine for Vitamin D. We are now witnessing an increase in indoor-based programmes with rapid digitization of education materials, an influx of motorized and digitized equipment and play gadgets, leading to minimized energy expenditure, overdependence on screen-based sedentary activities [5] and less sun exposure.

3. Vitamin D

While Vitamin D is widely known for its role in bone metabolism, the past two decades have seen a plethora of research pointing to its endocrine effects such as regulating calcium and phosphorous in the body i.e. its skeletal role. However, Vitamin D is increasingly being appreciated for its paracrine, autocrine and exocrine functions in the body as it directly affects a broad range of cells in the body, in addition to this, it regulates expression of genes involved in cell growth, protein synthesis and immune function [6].

3.1 Vitamin D metabolism

Vitamin D is primarily synthesized dermally by the action of UVB radiation of between 250 and 300 nm wavelengths when it directly strikes the exposed skin. This is then picked up by 7-dehydrocholesterol and transported in the blood to the liver where it is hydroxylated by the enzyme CYP2R1 into 25 hydroxycholecalciferol before it's transportation in the blood to the kidneys for further hydroxylation with the help of CYP27B1, where it is converted into the active metabolite 1,25 dihydroxycholelaciferol (Calcitriol), a potent steroid hormone. Calcitriol then enters the different target cells bound to Vitamin D Receptors (VDR) [7] found widely in the human body.

Cutaneous synthesis of Vitamin D via UVB solar radiation is however not possible on a year round basis for individuals living at latitudes further away from the Equator due to seasonal changes that result from the shifting of the Earth on its axis. Secondly, even in regions enjoying overhead UVB radiation on a year round basis, failure to expose oneself to the Sun's rays in a state of near or total undress when the UV index is above 3, anything below this predisposes one to Vitamin D deficiency. Thirdly, darker skinned people have less cutaneous vitamin D synthesis as a results of higher levels of melanin which absorbs UVB and therefore require three to five times longer duration of skin exposure to sunlight [8], this is particularly important given that 50–90% of Vitamin D is synthesized through the skin [9]. Extenuating circumstances such as these require supplementation with vitamin D to optimize serum levels of Vitamin D.

Vitamin D (Vitamin D3/Cholecalciferol) can be derived from foods of animal origin: animal fat, oily fish, liver and pastured eggs, while foods from plant sources such as mushrooms and fortified cereals provide ergocalciferol/ vitamin D2, however this form of vitamin D has been found to be less effective at raising serum 25(OH)D levels [10].

3.2 Vitamin D status

Vitamin D status is determined by measuring serum levels of circulating 25(OH)D, on account of its half-life of about 2–3 weeks [11]. Classification of vitamin D status is not universally agreed upon; the Institute of Medicine (IOM) classifies a serum level of 20 ng/mL as adequate [12] while the Endocrine Society suggests a serum concentration of at ≥30 ng/mL as sufficient [13]. The difference arising from the former's recommendations were exclusively based on skeletal integrity while the latter's was based on a broader range of studies examining associations between vitamin D deficiency with immune dysfunction, pregnancy and cancers alongside a decline in serum parathyroid hormone (PTH) reaching its nadir asymptomatically with 25(OH)D levels in adults at 30-40 ng/mL [12].

3.3 Vitamin D deficiency

The ubiquity of Vitamin D Receptors (VDR) in numerous tissues in the human body points to the body's widespread need for 25(OH)D, where it therefore follows that deficiency or insufficiency of the same is associated with several diseases. Vitamin D deficiency and insufficiency is now recognized as a global issue impairing the health of more than 1 billion children and adults in the World [13].

3.3.1 Vitamin D3 deficiency in SSA

A study on vitamin D deficiency in 3880 African children aged 0–8 years drawn from four African countries: Kenya, Burkina Faso, Uganda and South Africa, found a relatively low prevalence of Vitamin D deficiency at 0.7% when using cut-off of less than 30 nmol/L and 7.4% prevalence when using a cut-off of less than 50 nmol/L [14]. This was in stark contrast to a meta-analysis by the same investigators on the Vitamin D status of 21,474 individuals living in 23 African countries that concluded that about 18% of these had severe vitamin D deficiency using a cut-off of <30 nmol/l, "suggesting that Africa could be the continent with the highest frequency of severe vitamin D deficiency" [2]. Perhaps, the noted low prevalence of vitamin D deficiency among the children was due to the use of IOM cut-offs focused on skeletal integrity rather than the Endocrine Society's cut-offs. Ironically, the vitamin D deficiency study on young African children found that 35.4% of these children had serum concentrations between 50 and 70 nmol/L(20-28 ng/mL) clearly pointing to a 35.5% prevalence of Vitamin D3 deficiency when evaluated using the Endocrine Society's cut-off of at least 70 nmol/L(30 ng/mL) linked with better health outcomes [12].

4. Risk factors for vitamin D deficiency in children and adolescents

Risks associated with Vitamin D deficiency can be traced all the way from fetal development and at birth. Children born of Vitamin D deficient mothers tend to: be born prematurely, have low birth-weight, be at risk of allergies, develop asthma and impaired neurodevelopment. Achievement of a serum vitamin D concentration of greater than 100 nmol/L (40 ng/ml) by gravid mothers has been linked with prevention of some of these health risks [15]. Maternal serum vitamin D levels have been associated with fetal femur length, femur volume, cross -sectional area of the distal metaphysis and the ratio between the former and latter in offspring as measured using ultrasound exacerbating the risk of skeletal dysplasia and shorter stature at birth [15]. Such risks likely disadvantage physical development and lead to physiological limitations in sports performance in children and adolescents years later.

Serum Vitamin D levels in children and adolescents in SSA have been linked to inadequate exposure to sunlight, despite it straddling the equator as this affords almost yearlong overhead sunshine: a UVB wavelength advantage suitable for dermal Vitamin D synthesis. In two studies focusing on Vitamin D deficiency and rickets in low income informal settlements in Nairobi, Kenya, reported both low serum Vitamin D during pregnancy and in breast milk at delivery further raising the risk of rickets in their offspring. Similarly lengthy hours indoors during infancy in daycare facilities, as mothers work during the day, further compounded the risk of rickets. In addition to this finding, about 1% of the infants had as little as 3 hours of Sunshine exposure weekly [16–18].

In the southern most region of SSA; South Africa, seasonal variation and latitude have been identified as factors influencing Vitamin D status [17, 18]. Other non-pathological factors affecting Vitamin-D status in this region have been identified as: urban lifestyles, obesity, skin pigmentation and age demographics [18], while afebrile malaria has been associated with low serum vitamin D in SSA Children and adolescents.

5. Implications of vitamin D3 deficiency on health, physical activity and sports performance

Vitamin D deficiency in children and adolescents is associated with several health and metabolic challenges, which in turn undermine normal growth, development and potential physical and mental function. Negative effects of Vitamin D deficiency that are likely to compromise the performance of physical activity and sports are noted in the following functions:

5.1 Cardiac function

VDR are abundant in the myocardium, vasculature, myocytes and cardiac fibroblasts, suggesting the importance of Vitamin D in myocardial function. Calcitriol, the active form of Vitamin D, has been shown to participate in structural remodeling of cardiac muscle and vascular tissue, activates myocyte contractility and in turn up-regulating myocardial force [19]. This highlights the role of Vitamin D deficiency as a negative myocardial inotrope leading to poorer contractility, the result of which is reduced cardiac output. This negative effect on myocardial function is further compounded by an increase in cardiac collagen content resulting from Vitamin D deficiency.

Abnormal electrocardiographic and echocardiographic findings suggestive of dilated cardiomyopathy, heart failure and left ventricular dysfunction, have all been found present in vitamin D deficient infants diagnosed with rickets, and such findings have returned to normal upon treatment of rickets, [20, 21].

Scientific literature indicates that Vitamin D deficiency up-regulates production of Parathyroid hormone (PTH) and that this can in turn lead to pathological enlargement of the left ventricle (LVH) and subsequently modifies the filling capacity of the left ventricle and ejections fraction, the sequela of this being hypoxic muscle tissue posing a physiological limitation to physical activity or sports performance [22–24]. Vitamin D deficiency is also associated with atherogenesis, arterial stiffness and endothelial dysfunction, and these changes in vascular function undermine vascular competence. Optimal performance in sports and physical activity is not feasible with pathological structural or functional changes in the myocardium, thus the importance of optimal serum vitamin D in children and adolescents is therefore a key component of sports and physical activity performance.

5.2 Muscular function

The importance of Vitamin D in muscle growth and function can be understood when viewed from the perspective that Vitamin D receptors are located in both the cytoplasm and the nucleus of muscle fibers to regulate their genomic or non-genomic actions [25]. In addition to this, muscle cell proliferation, differentiation and the

interaction between myosin and actin filaments in the sarcomere of muscle cells are all dependent on adequate serum Vitamin D which serves to improve the concentration of adenosine triphosphate (ATP), the energy fuel reserve in the cell [26–29].

Low vitamin D is associated with atrophy of muscle fibers, fatty infiltration and fibrotic factors that all slow peak muscle contraction subsequently impeding generation of force [30, 31]. Vitamin D is one of several hormones known to influence the structure and function of striated muscles during all stages of life [32]. Vitamin D deficiency in children and adolescents may present as muscular pain, weakness or heaviness in the legs, these are important symptoms that parents, pediatric clinicians, sports coaches and caregivers would do well to keep in mind as they interact with this population. In this regard, Vitamin D deficiency is therefore antithetical to optimal physical activity and sports performance.

5.3 Lung function

Vitamin D deficiency is associated with lower lung function, altered lung structure, wheezing, increased asthma exacerbations and use of corticosteroids [33, 34] due to deprivation of oxygen to tissues in the lung as a results of inflammation of the alveolar, damaged epithelia and impaired regeneration of endothelial barriers [35, 36], with this easily progressing to and exacerbating asthma and respiratory infections. Vitamin D deficiency is therefore at the heart of all stages of respiratory infections and severity, however, adequate vitamin D lowers susceptibility to these types of respiratory infections via production of antimicrobial cathelicidins and defensins both of which are antibacterial and antiviral in their expression [36].

Given that optimal lung function is a primary factor in extraction of oxygen from inhaled air, for delivery to the lungs and then transportation via blood to the myocardium for onward delivery to muscles during physical activity and sports performance, Vitamin D deficiency in children and adolescence would likely have an adverse effect engendering sedentary lifestyles and an increased risk of chronic obstructive pulmonary disease over the long haul.

5.4 Skeletal effects of vitamin D

Vitamin D is thought to facilitate bone metabolism through its effects in promoting calcium and phosphate absorption, both of which are critical factors for both bone development and maintenance. A second pathway by which vitamin D maintains bone Calcium levels occurs by its regulation of serum Parathyroid hormone (PTH) to prevent hypocalcemia and hypophosphatemia [37] which would otherwise result in bone loss and fracture, manifesting in bone diseases such as osteomalacia and osteoporosis in old age, however among children and adolescents, a low serum Vitamin D levels manifest in rickets.

Rickets is a bone disease marked by deformities of wrists, legs, delayed closure of the soft membranous gaps between the cranial bones in infants, as well as fraying, metaphyseal cupping and widening of the growth plate as a result of vitamin D deficiency [38], while rickets can also be caused by calcium deficiency. A case control study on rickets in children in a slum in Nairobi, comparing rickets cases to controls (children without rickets or acute malnutrition) determined biochemically and phenotypically that the pathogenesis of rickets in this cohort was a result of vitamin D deficiency and not Calcium deficiency [39]. With an estimated 18% of the population in Sub-Saharan Africa having a severely deficient serum Vitamin D level of less than

30 nmol/L (12 ng/mL) [18]. The implication of this has significant negative ramifications on bone development, structural stability, bone length in children and adolescence but also in their ability to engage in physical activity and sports performance at all levels even in future.

6. Conclusion

The purpose of our review was to relate the relevance of vitamin D to physical activity and sports performance. We reviewed recent advances in this field and novel insights about vitamin D: its deficiency and implications on physical activity and sports performance.

Low vitamin D status could negatively impact the health and training efficiency of athletes regardless of their age and developmental level. Research to date suggests that certain athletes are at risk for suboptimal vitamin D status, which may increase risks for stress fractures, acute illness, and suboptimal muscle function.

The emerging evidence about vitamin D and sports performance suggests the need to determine vitamin D concentration in athletes but further research is necessary to characterize the true vitamin D status by simply measuring free vitamin D rather than total 25-OHVITD.

In relation to the prevention of vitamin D deficiency, parents, healthcare professionals, coaches, caregivers of children and adolescents need to be aware that Sun exposure is the primary means of vitamin D synthesis, unfortunately, this may not be feasible for all demographics on account of distance from the Equator, pollution or skin pigmentation, however, this demographic can benefit from Vitamin D supplementation alongside minerals and vitamins that aid its absorption, activation or metabolism such as Magnesium and Vitamin K2. The importance of optimal vitamin D in myocardial, skeletal, pulmonary and immune functions is a critical component in physical activity and lifelong health of children and adolescents in Sub-Saharan Africa. This perhaps also calls for further investigation of the efficacy of Vitamin D supplementation in this demographic on health, physical activity and sports performance outcomes.

Conflict of interest

The authors declare no conflict of interest.

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References

[1] United Nations Population Division. Urban population (% of total population) - Sub-Saharan Africa. World Urbanization Prospects. 2018. Available from: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=ZG [Accessed: February 15, 2022]

[2] Larqué E, Morales E, Leis R, Blanco-Carnero JE. Maternal and foetal health implications of vitamin D status during pregnancy. Annals of Nutrition and Metabolism. 2018;**72**(3):179-192

[3] Livingstone MB, Robson PJ, Wallace JM, McKinley MC. How active are we? Levels of routine physical activity in children and adults. Proceedings of the Nutrition Society. 2003;**62**(3):681-701

[4] Tammelin R, Yang X, Leskinen E, Kankaanpaa A, Hirvensalo M, Tammelin T, et al. Tracking of physical activity from early childhood through youth into adulthood. Medicine and Science in Sports and Exercise. 2014;**46**(5):955-962

[5] Wachira LJ. Lifestyle Transition towards Sedentary Behavior among Children and Youth in Sub-Saharan Africa: A Narrative Review.

[6] Weydert JA. Vitamin D in children's health. Children. 2014;**1**(2):208-226

[7] Kamen DL, Tangpricha V. Vitamin D and molecular actions on the immune system: Modulation of innate and autoimmunity. Journal of Molecular Medicine. 2010;**88**(5):441-450

[8] Clemens TL, Henderson SL, Adams JS, Holick MF. Increased skin pigment reduces the capacity of skin to synthesise vitamin D3. The Lancet. 1982;**319**(8263):74-76

[9] Sizar O, Khare S, Goyal A, Bansal P, Givler A. Vitamin D deficiency. StatPearls [Internet]. 2021

[10] Balachandar R, Pullakhandam R, Kulkarni B, Sachdev HS. Relative efficacy of vitamin D2 and vitamin D3 in improving vitamin D status: Systematic review and meta-analysis. Nutrients. 2021;**13**(10):3328

[11] Hollis BW, Wagner CL, Howard CR, Ebeling M, Shary JR, Smith PG, et al. Maternal versus infant vitamin D supplementation during lactation: A randomized controlled trial. Pediatrics. 2015;**136**(4):625-634

[12] Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al. Evaluation, treatment, and prevention of vitamin D deficiency: An Endocrine Society clinical practice guideline. The Journal of Clinical Endocrinology & Metabolism. 2011;**96**(7):1911-1930

[13] Holick MF. Vitamin D deficiency. New England Journal of Medicine. 2007;**357**(3):266-281

[14] Mogire RM, Morovat A, Muriuki JM, Mentzer AJ, Webb EL, Kimita W, et al. Prevalence and predictors of vitamin D deficiency in young African children. BMC Medicine. 2021;**19**(1):1-4

[15] Larqué E, Morales E, Leis R, Blanco-Carnero JE. Maternal and foetal health implications of vitamin D status during pregnancy. Annals of Nutrition and Metabolism. 2018;**72**(3):179-192

[16] Arabi A, El Rassi R, Fuleihan GE. Hypovitaminosis D in developing countries—Prevalence, risk factors and outcomes. Nature Reviews Endocrinology. 2010;**6**(10):550-561

[17] Jones KD, Hachmeister CU, Khasira M, Cox L, Schoenmakers I, Munyi C, et al. Vitamin D deficiency causes rickets in an urban informal settlement in Kenya and is associated with malnutrition. Maternal & Child Nutrition. 2018;**14**(1):e12452

[18] Bouillon R. Vitamin D status in Africa is worse than in other continents. The Lancet Global Health. 2020;**8**(1):e20-1

[19] Uysal S, Kalayci AG, Baysal K. Cardiac functions in children with vitamin D deficiency rickets. Pediatric Cardiology. 1999;**20**(4):283-286

[20] Verma S, Khadwal A, Chopra K, Rohit M, Singhi S. Hypocalcemia nutritional rickets: A curable cause of dilated cardiomyopathy. Journal of Tropical Pediatrics. 2011;**57**(2):126-128

[21] Misra M, Pacaud D, Petryk A, Collett-Solberg PF, Kappy M. Drug and therapeutics Committee of the Lawson Wilkins Pediatric Endocrine Society. Vitamin D deficiency in children and its management: Review of current knowledge and recommendations. Pediatrics. 2008;**122**(2):398-417

[22] Wang TJ, Pencina MJ, Booth SL, Jacques PF, Ingelsson E, Lanier K, et al. Vitamin D deficiency and risk of cardiovascular disease. Circulation. 2008;**117**(4):503-511

[23] Lavie CJ, Dinicolantonio JJ, Milani RV, O'Keefe JH. Vitamin D and cardiovascular health. Circulation. 2013;**128**(22):2404-2406. DOI: 10.1161/CIRCULATIONAHA.113.002902

[24] Willis KS, Smith DT, Broughton KS, Larson-Meyer DE. Vitamin D status and biomarkers of inflammation in runners. Open Access Journal of Sports Medicine. 2012;**3**:35

[25] Haussler MR, Jurutka PW, Mizwicki M, Norman AW. Vitamin D receptor (VDR)-mediated actions of 1α, 25 (OH) 2vitamin D3: Genomic and non-genomic mechanisms. Best Practice & Research Clinical Endocrinology & Metabolism. 2011;**25**(4):543-559

[26] Goltzman D. Functions of vitamin D in bone. Histochemistry and Cell Biology. 2018;**149**(4):305-312

[27] Caruso TJ, Fuzaylov G. Severe vitamin D deficiency—Rickets. New England Journal of Medicine. 2013;**369**(9):e11

[28] Koundourakis NE, Avgoustinaki PD, Malliaraki N, Margioris AN. Muscular effects of vitamin D in young athletes and non-athletes and in the elderly. Hormones. 2016;**15**(4):471-488

[29] Norman AW. From vitamin D to hormone D: Fundamentals of the vitamin D endocrine system essential for good health. The American Journal of Clinical Nutrition. 2008;**88**(2):491S-499S

[30] Holick MF. Vitamin D: Extraskeletal health. Rheumatic Disease Clinics. 2012;**38**(1):141-160

[31] Cannell JJ, Hollis BW, Sorenson MB, Taft TN, Anderson JJ. Athletic performance and vitamin D. Medicine & Science in Sports & Exercise. 2009;**41**(5):1102-1110

[32] Greising SM, Gransee HM, Mantilla CB, Sieck GC. Systems biology of skeletal muscle: Fiber type as an organizing principle. Wiley Interdisciplinary Reviews: Systems Biology and Medicine. 2012;**4**(5): 457-473

[33] Gupta A, Sjoukes A, Richards D, Banya W, Hawrylowicz C, Bush A, et al. Relationship between serum vitamin D, disease severity, and airway remodeling in children with asthma. American Journal of Respiratory and Critical Care Medicine. 2011;**184**(12):1342-1349

[34] Brehm JM, Schuemann B, Fuhlbrigge AL, Hollis BW, Strunk RC, Zeiger RS, et al. Childhood Asthma Management Program Research Group. Serum vitamin D levels and severe asthma exacerbations in the Childhood Asthma Management Program study. Journal of Allergy and Clinical Immunology. 2010;**126**(1):52-58

[35] Foong RE, Zosky GR. Vitamin D deficiency and the lung: Disease initiator or disease modifier? Nutrients. 2013;**5**(8):2880-2900

[36] Hiemstra PS. The role of epithelial β-defensins and cathelicidins in host defense of the lung. Experimental Lung Research. 2007;**33**(10):537-542

[37] Zosky GR, Berry LJ, Elliot JG, James AL, Gorman S, Hart PH. Vitamin D deficiency causes deficits in lung function and alters lung structure. American Journal of Respiratory and Critical Care Medicine. 2011;**183**(10):1336-1343

[38] Misra M, Pacaud D, Petryk A, Collett-Solberg PF, Kappy M. Vitamin D deficiency in children and its management: Review of current knowledge and recommendations. Pediatrics. 2008;**122**(2):398-417

[39] Jones KD, Hachmeister CU, Khasira M, Cox L, Schoenmakers I, Munyi C, et al. Vitamin D deficiency causes rickets in an urban informal settlement in Kenya and is associated with malnutrition. Maternal & Child Nutrition. 2018;**14**(1):e12452

Chapter 5

Sports Participation in South African Schools. Have We Lost the Plot?

Jacques J. Vosloo and Dorita du Toit

Abstract

In view of global health concerns about elevated levels of inactivity and related disease patterns of citizens, policy reform in physical education and school sport (PESS) is seen as a basic human right and tool for societal transformation. Although literature supports the importance of quality PESS for different aspects of learners' development, various implementation challenges facing school sports in South Africa have been reported. Drawing on a nationwide research project, this paper seeks to provide empirical insights into the role and status of school sport. Addressing the question, *Sport participation in South African schools. Have we lost the plot?* This study adopted a blend of self-determination theory (SDT) and social justice theoretical frameworks to understand how educators' livid experiences impact their personal and social responsibility to teach, enhance, and facilitate PESS to a diverse group of learners in a diversity of schools. Results indicated that school sport is exceptionally varied, multifaceted, and complex, with different pressures and imperatives. It is exacerbated by educators who are required to assume the dual role in schools within a pressurized school environment, which results in overload, emotional rollercoaster rides, and a lack of motivation. Without meaningful motivation, continuous reform, or the revision of policy, the delivery of PESS will remain unachievable.

Keywords: school sport, role-players, perceptions, school sport management, social justice, self-determination theory (SDT), diversity

1. Introduction

Sport has become an international focus as it transcends language, social, cultural, religious, financial, and political barriers [1]. Equally important, sport is also an integral part of human being and relating with others, and being physically active [2, 3]. It has the potential to be a positive force in the life of all children, but if the context and benefits thereof, amongst others, are not understood, it can contribute to poor choices and health risks. Research investigating children's commitment to and involvement in physical activity (PA) reveals a tangled web of personal and social factors that influence participation levels, quality of experience, and in some cases drop-out [4, 5]. Scholars in general agree that a great deal of human health

and health behaviors are formed during childhood and adolescence [6, 7]. More specifically, based on numerous data sets from countries across the globe, Gaetano [8], D'Isanto, Manna and Altavilla [9], Draper et al. [10], as well as Van Woudenberg et al. [11], amongst others, further argue that there is no articulacy that over many decades, school children's health has gradually deteriorated. Hence, considering that physical inactivity is currently seen as the fourth leading risk factor for global mortality [12], the researcher concurs with Di Palma, Raiola, and Tafuri [13] together with Francesco, Coco, Frattini, Vago, and Andrea [14] who reaffirmed the importance of quality physical education (QPE) and school sports programs and their role in the health and well-being of children. It is thus imminent now more than ever, that the time has come to implement effective high-quality school sports and QPE programs.

In order to promote and enhance sports participation, it is necessary to get a deeper understanding of why children participate in sports. Moreover, converging interests and the role of significant others have strengthened the alliance between influential institutes and persons in sport, physical education (PE), and the government [15, 16]. Samek, Elkins, Keyes, Iacono and McGue [17], Jacobs, Claringbould and Knoppers [18], and Kavassanu Al-Yaaribi [19] averred that the coach in particular is seen as the catalyst for promoting the positive effects of sport participation, which are linked to a greater school attachment and sense of belonging, higher academic aspirations, and less risky behaviors, such as alcohol and drug abuse. Similarly, Blomfield and Barber [20], Boyes, O'Sullivan, Linden, McIsaac, and Pickett [21] observed that time spent in sport and related activities is related to better peer relationships, autonomy, identity development, sense of belonging, and emotional adjustments at school, while Vella, Oades, and Crowe [22] advocated that coaches as transformational leaders are seen as role models, which together with a good relationship with learners are important tools for life skill development of learners participating in sport. However, while it is assumed that school sport is a site for pleasure and participation, as well as a positive development, Jacobs, Smits, and Knoppers [23] explicitly warn about the emotionally abusive coaching behavior in elite (competitive) school sport.

Significant others, such as educators, umpires, referees, coaches (educators and external), officials, voluntary workers, sports medical assistants, emergency services, team managers, and parents, all have a vital pedagogical function in co-creating the educational practice of competitive games in school sport, and thus, influencing learners' (participants) behavior, learning, and socializing within the game [18, 23–26]. A specialist school sports manager is a central figure and plays a pivotal and crucial role not only in the learner's sports experience and well-being [23] but also in the success and the management of school sports as a whole [27–29]. Eksteen, Willemse, Malan, and Ellis [27] extend their thinking, noting that the school sports manager is seen as the leader who regulates, facilitates, promotes, or organizes any sport-related activity in school, and utilizing resources (people, finances, facilities, and information) to achieve the goals and objectives of the school. Additionally, school sport managers plan, exercise control, give direction, and evaluate all sport and related activities and has a dual role, that is, of an educator and coach, manager, facilitator, interpreter, and enforcer, etc. [30–33]. Taken together, the role of the school sport manager thus implies [34] to dispose of background knowledge regarding the theoretical aspects of PA, exercise, and movement (play, games, sport, dance, and swimming), as well as management of sport and sport-related activities in school. Evidence indicates, however, that educators neither receive training related to content-context specific training for school sports globally [35–38] and in South

Africa [27], nor training related to cultural awareness during their initial training as educators, specifically PE teacher education [39]. Within the preceding context, the next section outlines the theoretical framework applied in this chapter.

1.1 Theoretical framework

Social justice can be viewed as both a process and a goal as educators (current and pre-service) are empowered to engage in learning, understand how power dynamics apply to their own lives, and reflect on ways to pursue a more socially just society [40, 41]. Proponents of the social justice theoretical framework like Gray [42] advocate the belief that this framework allows for critical questioning of "*currently held values and assumptions.*" Bell [43] denotes that social justice in education can be seen as the full and equal participation of all groups in a society that is mutually shaped to meet their needs. She goes on to state that the process for attaining the goal of social justice needs to be "*participatory, inclusive and affirming of human agency and human capacities for working collaboratively to create change*" [43]. Embracing the views of Angrosino [44] and Shiver, Andrew, Richards, and Hemphill [41], the researcher was able to directly connect to the poor and marginalized in society and used his sociological imagination to "get under the skin of daily life and an understanding of what passes as 'routine' in the context of the broader issues of power, control, and resistance to domination," [45, 46] as they are reflected in school sport.

Central to how one conceptualizes school sport, is the notion of motivation, which is underpinned by health promotional actions and development. To understand the motivational factors underpinning health promotional actions, development of children, both physically and emotionally, benefitting cognitive and social systems, the self-determination theory (SDT) of Deci and Ryan [47], has gained ground and is increasingly used by a vast amount of researchers, academics, and like as theoretical framework [48, 49]. Authors, such as Haerens et al. [50], Aelterman, Vansteenkiste, and Haerens [51], as well as Vansteenkiste, Ryan, and Soenens [52] all resolved to the use of SDT.

Deci and Ryan [53] posit that according to the tenets of SDT, the basic psychological needs of autonomy, competence, and relatedness differ in the degree to which they are supportive of the needs of a person to be satisfied in order for them to be intrinsically motivated to persevere with a specific activity. *Autonomy* is typified by the need to employ a sense of choice and personal endorsement in one's actions and is perceived by Gorozidis and Papaioannou [54] as a vital ingredient for optimal functioning and professional growth of educators. *Competence* is seen as the need to be equipped with the knowledge and skills, in addition to concerns to feel optimally challenged and capable of effectively mastering and achieving goals. *Relatedness* refers specifically to the need to feel close to and accepted by others, and to internalize the value of an activity which connected, denoting an experience of warmth, kind-heartedness, and attention [52, 55]. Van den Berghe, Vansteenkiste, Cardon, Kirk, and Haerens [56] argue that SDT suggests that a relationship exists between the extent to which these three needs are satisfied and the optimization of the intrinsic motivation of an individual. Within this framework, these psychological needs of learners should be met in sport in order to reap the health benefits and other benefits offered by PA and presented in PE [57] and sport [58, 59]. Coupled with the psychological needs of learners, other significant role-players, such as educators, principals, members of the school governing body (SGB), and sport organizers' psychological needs should also be met for them to be motivated to teach and promote QPE and sport in their school.

In seeking to provide empirical insights into the role and status of school sports in three South African provinces, by addressing the question, *Sport participation in South African schools. Have we lost the plot?* this study adopted a blend of the SDT and the social justice theoretical frameworks to understand how educators' livid experiences impact their learning and understanding of culturally relevant practices related to their personal and social responsibility to teach, enhance, and facilitate physical education and school sport (PESS) to a diverse group of learners in a diversity of schools. Based on these theories referred to previously, the experiences of prospective and current educators may further influence their future teaching styles and confidence. Subsequently, inferences made from a blended version of the two aforementioned theories should cast some light on some of the main problems encountered in contemporary South Africa, namely, motivation in a social world culturally derived and historically situated amidst rife injustice. Considering the urgency of the necessity to reduce obesity amongst South African citizens and the need for PA for school children, it is critical to know what can improve the importance and usefulness of school sports as experienced by different role-players in a diversity of South African schools with a view to increasing school practice of PA.

With such a plethora of influences and practices and the current congested space, some burning questions remain. In the light of the preceding discussion, one can justifiably ask: What does school sport look like in the South African public school system, and what type of activities or models feature in the school sport? Such questions inform the comprehensive national research project mandated by the UNICEF-DBE partnership where 25 researchers from seven South African public universities participated as a key driver from the South African University Physical Education Association (SAUPEA) [60]. Drawing on the national research, this paper reports on the perception of different role-players, main activities, importance, and role and status of school sport that constitute the current school sports space' and dimensions associated with school sport and QPE across a spectrum of diverse school types. For clarity, one, therefore, has to scrutinize and examine existing practices.

2. Materials and methods

2.1 Research design

The mixed method case-study approach employing an interpretative approach was adopted for the complex national and in-depth explorative study to which the research in this study contributed [61–63]. The school as a unit of analysis across different geographical settings (rural and urban), types of schools based on a socio-economic status (SES) categorization (quintile 1 to 5), and type of learners (primary and secondary school learners, as well as learners with special educational needs), used in this study, informed the investigation of the social world of participants. As a result, hereof, the researcher and participants were allowed to actively "*participate in dialogue about multiple ways of seeing and hearing; making sense of the social world and standpoints of what is important and to be valued and cherished*" [64]. Such an approach enabled multi-layered interpretations of how programs are delivered in the PESS "space" and how they are experienced, understood, and connected to the wider school curriculum [65–67]. Furthermore, the described, adopted approach

also allowed for the triangulation of results and concurrent theme integration of idiosyncratic circumstances, approaches, opinions, and practices of different respondents from the combination of both qualitative (individual and focus group interviews and observation) and quantitative methods (questionnaires) to reveal the complex reality of multiple understandings where data intersect, and to attain trustworthiness [68].

Informed by earlier research for a global priority and the need to measure and evaluate the impact of sports development relating to the management and delivery of a program and the impact on human and social development, Burnett and Hollander [69] developed the Sport for Development Impact Assessment Tool (S•DIAT). The S•DIAT gained global attraction and has subsequently been utilized for other national sport-related assessments [70–72]. In fact, Haudenhuyse, Theeboom, and Nols [73] believe that the S•DIAT offers a solution to prejudice and biased views of intervention required when involved with children in PESS. Consequently, based on Haudenhuyse et al.'s [73] advice *"to find a balance between the contextual-realistic sport and PE viewed interventions and at times seen more valuable and intellectually sound evaluation practices,"* it allowed for an adapted and open-minded approach during interviews with learners by the researcher, thus refraining to stereotype and a biased approach.

The research methodology used during the study to collect the data ensured that all relevant stakeholders and significant others that play a role in the "PESS space" provided relevant information by applying various research methods.

2.2 Study setting, sampling, and instruments

The current study, which dovetailed with a larger study informed and driven by the SAUPEA (REC-01-131-2016), in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO), which provided the impetus for nationwide research under the leadership of the United Nations International Children's Emergency Fund (UNICEF), the DBE and Higher Education Institutions (HEI), three provinces, namely, Free State, North West, and Northern Cape were chosen. Schools included in the sample were within a radius of 150 kilometers from the university, (University of the Free State, Free State province and North West University, Potchefstroom campus, North West province) or the airport where there was no participating local university (Northern Cape). Non-probability sampling as proposed by Leedy and Ormrod [74] to afford clustered comparison across all school types who often are not only externally homogeneous, but internally heterogeneous on the one hand, but on the other hand, share associated contextual realities, in the form of purposive and convenience (availability) were applied [75, 76]. Within the clustered sampling of school and participant types, specific schools were selected with a specific purpose in mind. A specific selection of schools were subsequently combined with the convenience (availability) of schools. Schools selected for this research included six former (ex) Model C [1], of which one was technically inclined (quantile four and five) and six rural schools (quantile one

[1] *Former (Ex) Model C schools* refer to former state-aided public schools, which formerly constituted mainly white learners in which the school governing body (SGB) may determine their own admission policy within the legal bounds of the South African Schools Act and the Constitution of South Africa.

to three)[2], five township schools (quantile one to three)[3] as well as four schools for learners with special educational needs (LSEN). In the South African school context, all public schools are categorized based on the socioeconomic status of the school. All schools are thus benchmarked against three poverty indicators: income, unemployment rate, and the level of education of the community it serves. A poverty score is given to the community and school which is then assigned a "quintile" – categories defined at the national level [77, 78]. Schools in this study included one school each of quantile one and three, four schools of quantile two, six from quantile three, and five from quantile five. Were used[4]. The four LSEN schools are not awarded a quantile ranking and represent a combined model for primary and secondary learners.

Data in the form of semi-structured interviews with principals or deputy principals (n = 21), heads of sport (n = 21), focus group interviews with heads of departments (HOD's), educators as well as learners [(Grade 10 and/or 11 (Secondary schools) and Grade 6 and/or 7 (Primary schools)] (n = 48), in total 198 focus group participants, were collected, while questionnaires were completed by sport directors (n = 21), and educators who have not participated in the focus group interviews (n = 46). All 21 schools were co-educational schools across three provinces (Free State, North West, and Northern Cape), inclusive of two sport-focus schools as determined by the DBE.

2.2.1 Collection procedures

During research visits to schools, an observation protocol was followed to identify and visually capture the quality of physical resources (facilities and equipment), infrastructure, surroundings, environment (context), and branding, as well as signage. All relevant documentation regarding school-based statistical information contributing to the profile of the school, networking, and partnerships relating to school sport and PE-related practices were captured for description and analysis. On-site procedures followed the same pattern at each school, inclusive of the following: an introduction to the research with each research cohort, completion of questionnaires by educators and HODs, separate focus group interviews with learners,

[2] Rural schools are schools found in farms, villages, semi-urban areas, remote areas, and mainly infrastructurally underdeveloped.

[3] Township schools refer to schools in residential areas of South Africa, which originated as racially segregated, low cost-housing developments for black learners, that is, Africans, Coloreds, and Indians. Hence, in relation to this study, township schools would refer to any school built on the periphery of towns and cities, often characterized by poverty, crime, and violence.

[4] In the South African school's context the National Norms and Standards for School Funding (NNSSF) aimed to improve equity in funding of education by ranking each school into quantiles from one [1] to five [5]. The schools in the most economically disadvantaged (poor/impoverished) geographical areas are categorized as quantile one [1] schools and those in the most economically advantaged geographical areas (wealthiest/affluent) as quantile five [5]. Quantile one, two and three schools are no fee schools, while quantile four and five schools are fee-paying schools. The assumption was that parents from the latter can afford to pay school fees, and therefore, these schools require less governmental support, while no fee schools should receive more support from government than schools serving wealthier communities. It was expected that this decision should result in equal and fair distribution of funds between impoverished and affluent schools. In general, it is assumed that across all provinces that schools across the same quantile ranking should be of comparable socioeconomic status and standard. The implementation of the quantile system has not, however, proved to be as effective as originally envisaged.

educators, HODs, and an individual interview with the school principal and head of sport. Each participant, except learners, also completed a questionnaire to provide some background information about the participants.

The exploratory questionnaires, completed by a total of 46 educators/HODs, served to establish the current demographic data of educators involved in school sports. Section two of the questionnaires focused on school-related experiences, perceptions, and opinions regarding the status, availability, and use of resources and implementation practices of school sports in their respective schools. The last section required Likert-scale and categorical responses to strategic information regarding challenges and recommendations, followed by an open category of actionable recommendations to prioritize views and identify real needs.

A questionnaire distributed to sport directors was completed by the purposive sample of 21 sport directors (one per school, $n = 21$) and captured the values, perceptions, and interests of the respondents [70] within a pre-determined scaffold. Respondents were thus required to provide information in terms of demographic data about themselves and the school (section one), physical resources (section two), and sport competitions (section three), followed by information with regards to financial resources. In conclusion information about different stakeholders and parents' involvement was captured.

Focus group interviews followed the same design as the questionnaires but enabled the collection of narrative data so as to offer contextual explanations of empirical data and to allow for thematic integration for case data analysis [79, 80]. The interview schedule fixated on in-context implementation of PESS within a school setting, followed by the detection of good practices, challenges, and recommendations for improving the quality of PESS against the background of what globally constitutes QPE [81] and innovative teaching and learning through sport for well-rounded and developed learners [82–85]. In an endeavor to ensure a holistic approach, the researcher also took down notes during focus group interviews to record nuances, cues, and nonverbal expressions. In addition, during research visits at each of the 21 participating schools, an observation checklist was used by the researchers to capture their observations of the quality of physical resources (facilities and equipment), surroundings (SES), billboards and/or advertisements relating to partnerships (branding), as well as the teaching/implementation of PESS and learner participation, by keeping field notes.

The aims of the research were clearly communicated to the participants, and they were informed that their participation was voluntary. Ethical clearance (REC 01–35-2019) was obtained from the DBE and the ethics research committee in the Faculty of Health Sciences of the University of Johannesburg (UJ) where the national project is located.

Consistent with the ethical requirements of the researcher to uphold the duty scholars have to society to conduct their studies in the most conscientious and responsible manner possible, all research participants gave signed consent for taking part in the research (in the case of the learners, parental consent was obtained) and audio recording of interviews. All audio recordings were on password devices designated for the research, while pseudonyms were used to protect the anonymity of the participants and the schools they represent; all devices were deleted after transcription. The researcher abided by high standards of ethical conduct and considerations at all times regarding the right to privacy, confidentiality, and anonymity, respecting basic human rights, as enshrined in the Constitution, and protecting participants against possible harm and abuse [86].

2.2.2 Data analysis

An inductive qualitative content analysis process integrating the guidelines of Graneheim and Lundman [87], Creswell and Poth [79], as well as Mikaelson, Rutberg, Lindqvist, and Michaelson [88], aided by a computer software program, Atlas.ti™ Version 8, was utilized to analyze all interviews after the interviews were recorded and transcribed verbatim. Each interview was read several times to obtain a sense of the content. Next, the data from participant responses to questions in the interviews were encoded and patterns were identified in accordance with the aims of the study. Patterns resulted in identified categories and sub-categories, which were condensed (refined) further through selective coding to identify core categories or main themes with semantically related sub-themes.

Quantitative data were interpreted using the statistical package of the social sciences (IBM SPSS 21). This computer program analyzed data collected from closed questions and generated descriptive statistics, including means, standard deviations, and frequencies. To identify inter-group comparisons, such as respondents from different school types (quintiles) and comparing HOD and educator data, geographical location (province or urban vs. rural), or gender-related differences, a cluster analysis was applied and cross-tabulation to determine statistical significance levels (Pearson chi-square values, $p = <0.05$ and $p = <0.0001$), as well as Cramer's V to determine effect size ranges [89]. For the purposes of this study, Cronbach's alpha (χ) coefficient was employed to determine the internal reliability of the measurement instrument (in this case, the questionnaire). Responses to the questionnaires were scrutinized for patterns, inconsistencies, contradictions, and consequences. This line-to-line coding (open coding) identified emerging themes [90, 91].

2.2.3 Validity, reliability, and trustworthiness

A pilot study was done prior to the data collection with non-related research participants in Gauteng and North West, in order to ensure a uniform understanding of the types of questions to be asked. Following the pilot, research questions were adapted according to feedback, which included providing more clarification as to what the question was asking or to add more instructions for easier understanding of the children's questionnaire. Standardized procedures and protocols were followed but were adapted in accordance with circumstances.

Trustworthiness was attained through triangulating multiple methods of data collection [92–94] in order to establish credibility through constant comparative analysis of transcribed interviews and focus groups, which in this study addressed different methods and sets of data, settings, and clustered samples, times, space, and levels. Validity in data analysis was ensured by giving transcribed data to participants to validate and recordings were presented to an independent researcher to validate the transcriptions [95].

All participants completed consent forms in addition to learners who also completed assent forms. The current paper draws on descriptions and visual recordings (observations) of the types of activities in which learners participate in sport as a source of triangulation and thematic saturation. The results of the research are under discussion next.

3. Results

From the analysis of all data sets, with regard to school sport, and consistent with the aims of this study, different approaches of implementation emerged, which points to a typology highly associated with quintile-ranked clustering. The sample schools were clustered according to their quintile ranking showing a bias toward quintiles two and five for primary schools and quantiles one, three, and five for secondary schools. For analysis and discussion purposes, the lower (one to three) and higher (four and five) are grouped together as they share similar features and school practices. Results obtained from the adapted S- DIAT questionnaire in synthesis with the semi-structured interviews, document analysis, and observations are now presented according to each school context and discussed, as previously stated using a blended theoretical framework of SDT and social justice.

3.1 Former model C schools

The results show that all the former Model C school learners in the study have access to sport that is facilitated by trained coaches, which is supported by a sport-focused approach to PE along a continuum of sport-for-all (inclusive participation) or mass participation [60]. In most cases, the former Model C schools who applied this approach, chose sports activities that related to the main sport, codes the school participated in during a particular term, citing the purpose hereof as preparation for the upcoming season. In all of the former Model C schools, outsourced specialists, in addition to educators are employed, offering a wide range of sporting activities. Four of the former Model C schools are well-resourced and endowed with a swimming pool, although two are no longer in use due to high cost of maintenance and repairs, more than one rugby and/or soccer field and hockey fields, as well as an Astroturf hockey field (or are within walking distance of an adjacent school who has one), tennis and netball courts, indoor cricket facilities. One secondary school also disposes of a soccer complex and clubhouse, and two secondary schools also have an indoor cricket center and a well-equipped gymnasium. Special sports academies for specific sports are established on the school premises, which allow for superior quality, needs-specific individual coaching, and improved quality. All schools have sufficient ablution facilities and change rooms. Equipment for different sporting codes offered by the school is available, although the majority of learners provide their own equipment.

The majority of schools have a sports policy, and in the former Model C schools, participation is compulsory, with learners required to participate in at least one activity per term. For athletics and swimming mass participation is encouraged, but to be competitive only the best available, participating learners are selected for teams. Based on personal sporting backgrounds and having received sports coach training, some educators or external coaches assist in talent identification (not necessarily talent development). Most of them engage in sports coaching at school.

Perceptions and realities within schools were disjointed with regard to school sport. Experiences and perceptions varied from positive to negative. Principals and learners, in general, were perceived to be more positive than the HOD's and educators, not only about life kills (LS) or life orientation (LO) but also PESS. The positive experiences and perceptions were clear from the principals' points of view as they

indicated that sport together with PE specifically contributes to the holistic development and health of learners. Subsequently, PE is seen as an important means to identify and develop sporting talent. For this reason, some schools employ outside coaches, specially trained fitness consultants, medical (biokinetics, physiotherapists, and sports psychologists), or sports scientists to invest in the development of learners, infrastructure, and marketing. Similar views are expressed by the deputy principal of one of the secondary schools, an experienced coach of more than 30 years himself, who firmly believes that sport has a place in school, but due to circumstances, sport is slowly, but surely disappearing from schools. He echoes the belief that government is not serious about the sport and does not provide enough support.

> *"They (government) are not worried about the sport, they are just there and happy there is sport, I am involved with rugby, there is no money."*

Generally speaking, involvement as an educator also affords one the opportunity to develop a holistic approach to view a learner not only from involvement in sports but also academically; the ultimate result is a well-equipped coach who develops learners as sportsperson, which has value to the community: "*A well-rounded learner that stays of the street and mischief, because a child in a sport, is a child out of court.*" Educators are also cognizant of the real value of school sport and what it means to the learners and the school. Ultimately, educators believe that "sport builds team spirit, character, and helps one become a better person" who is awarded amongst others by going on camps, receives certificates and awards, such as trophies and possible bursaries. One educator, though, was quick to highlight the downside of sport, in particular during sports days, where sport becomes "a festive point of alcohol and substance abuse, violence and verbal abuse of players and officials." With reference to sport, learners from the former Model C schools, in particular, welcomed the fact they were able to compete amongst others in a variety of sports and were not forced to choose between different sports, in addition to receiving a lot of support and encouragement from their educators and school. *"I think it is particularly good because we can choose what we want to do. We can do more than one thing. You can do everything that you like to do."*

3.2 Township schools

Sport in township schools is mostly facilitated by an untrained, unqualified, inexperienced educator who is an enthusiast of some kind of sport, mostly soccer. At the root of the life skill value approach, which forms the basis of sport in the township schools, is an endeavor by peer-educators for the correction and/or rehabilitation tailored to the prevention or countering of socially deviant behaviors through PESS. In this regard, a deputy principal from a primary township school recognizes the importance of school sport to reduce behavioral problems, such as discipline in school, and believes that sport can thus bring tremendous relief to minimize discipline problems, because a *"child in a sport, is a child out of court."*

The results from the study also clearly pointed to a correlation between the SES of the school and resources. A common comment from all role-players in township schools was that they lack sufficient resources (physical, financial, human, and information). The premises of all the primary schools were neglected, the grass uncut and there was a lot of rubbish on the school grounds. All three primary schools also had a courtyard between classrooms, which was paved and neat, but needed care,

as that was the area mostly used for PE classes, and sports. All the primary schools were surrounded by squatter camps, while there was a community sports complex, which catered for amongst others, soccer and cricket, basketball, netball, and athletics either across the road or within walking distance. The neighborhoods were not regarded as safe and there was a high incidence of gangsterism and substance abuse. A HOD of one of the primary schools clearly states that "*We (they) have no equipment whatsoever, only a few portable, collapsible poles which can be used for soccer and netball.*" The premises of all the secondary schools were clearly not taken care of and they mostly made use of local community sports centers or clubs to facilitate sports, such as rugby, cricket, soccer, basketball, netball, and athletics. The grass is not cut, and the available space used mostly for soccer is unkempt. Secondary township schools to a large extent also relied on donations or sponsors to assist with apparatus/equipment. Ablution facilities in all township schools were inadequate with toilets that were frequently blocked, and there were insufficient toilets to provide for the needs of learners in the respective schools. There were no change rooms which presented a challenge of its own.

In contrast to the former Model C schools, none of the township schools had a designated sports policy in place. Mass participation is encouraged, although only a selected few, the best of the best are selected to continue participation in leagues and competitions. Only one primary and two secondary schools have an educator who has formal training in PE, while the others are not trained at all. Educators are involved with sport only, sometimes simply because it is seen as part of their job description, and in other instances only if they have to, but have no formal training. Due to a lack of resources (facilities, equipment, and finances) learners hardly train for participation in sport, except maybe just prior to a competition and/or event organized by DBE. Both secondary schools, though, participate at all levels, that is, local, district, regional, provincial, and national representing the school and/or province. Equipment in the secondary schools also does not last long because of wear and tear, or it is often stolen. Parents cannot contribute toward the provision of equipment for their children, although they complain if the school has insufficient equipment and opportunities. The importance of PESS is acknowledged by respondents for the impact on health, mainly because of a dedicated educator and sports coach who is involved with the practical PE periods and chess.

Most educators are positive that sport is valuable and plays a role in the school. One HOD from a secondary township school's perception regarding the role and importance of school sport was that it "gives the learners who cannot cope academically some kind of confidence and a need to win." According to her, parents often accuse the educators of schools that were biased toward learners, and that the diverse cultures at the school occasionally led to learners offending one another, sometimes unknowingly and sometimes intentionally. Educators needed support from parents because they had to face many challenges, "*No time for sports, obviously, and learners are not interested and then there are no facilities, nothing anyone wants to partake in, we struggle to develop.*" To honor the vision of effective teaching and learning in an environment conducive to developing the potential of all learners optimally, a HOD from one of the primary schools elucidates that "*we have started appointing qualified educators. I am now bringing on other educators from other races, like we are now appointing white people at this school for them to integrate with us. At present, we are having two white educators at school and I am aiming to have more.*" Several educators from primary schools made a remark that PESS can be significant if it is incorporated into teaching in the classroom. Educators further perceive that there is a relationship between what

they do in the theory in textbooks, in terms of LO and PE and the practical execution thereof in PE. Moreover, they believe there is a positive relationship between sport and academic performance. At one primary school, educators, in general, feel that their attempts to improvise should be recognized, even if the activity is not in the policy because the children were actively busy. A seasoned educator from a primary school observes, *"Teaching before, even during the times of apartheid, the sport was one of the most important things in the school, learners used to participate in athletics, soccer matches, soccer tournaments, softball, basketball, now since now the new government came into place, sports has been relegated to the fringes, whereby everything is knowledge, knowledge, and knowledge."*

Educators from secondary schools agree with their primary school colleagues regarding challenges they encounter as a result of a lack of facilities and add to that a lack of proper training, whilst the lack of adequate, quality space and a sports ground, as well as other facilities and equipment hampers sport participation. "*Challenge, we do not really have facilities, we need to implement sport, we do not have the sporting ground, we do not have the equipment, so we are having difficulties to expose the learners to sport, so they do not have time to practice. We lack resources to enable learners to be involved in sport. Parents want learners to participate in sport.*"

Learners from both primary and secondary schools agreed that sport was necessary and strengthened one's body. They also listed the benefits, such as reduction of stress, better focus, and clear mind. It helps one emotionally and psychologically, with social skills and decision-making. It kept learners off the street away from crime as well as being given the opportunity to "*express their minds and to play because in basketball, we always go outside.*" Some learners were concerned about the safety of the school premises. A learner from a primary school commented that PE could help educators with talent identification, but without PE, talented sportsmen and women would not be recognized.

3.3 Rural schools

Regarding rural schools, results indicated that rural schools in particular face many challenges, which viewed from the blended theoretical frameworks of SDT and social justice, indicated that rural schools are vulnerable, educators lack motivation and learners need to be given the opportunity to participate in school sport. In the rural schools, there are no trained PE educators, and the majority of educators are also in need of training to be able to successfully implement and facilitate sport, while funding for the facilitation of school sports and facilities is often non-existent. Substance abuse and gangsterism are ongoing challenges in all three provinces. The rate of fetal alcohol syndrome (FAS) in the Northern Cape is amongst the highest in the world, with the Galeshewe Township, where part of this study took place, recording rates of 11% per 1000 young people (as compared to global average of 0.1–0.8%) [96, 97]. One primary school has a sports ground attached to it, while another has an all-weather sports ground attached to the school and one school has a soccer field and a space behind the school that is used for netball. Two primary schools also have a tennis and netball court. The third and last primary school has a sub-standard netball court, with no correct painted lines and demarcations. In response to the question about the physical resources, one of the sports coordinators from a primary school responded as follows*: "The problem that we are actually having is equipment, it is the biggest problem we have. Soccer balls, cricket bats, hockey sticks, all of those things and especially the sports grounds."* Another respondent from a primary

school responded that *"facilities are the weakness."* From her response, it was evident that she has lost all faith and was frustrated with a total lack of any resources because she was well aware of the role and importance of school sport. *"Sport will benefit the learners, it will make learners healthy, they will do much better, they will have a fresh mindset, keep them out of trouble, if you have time for sport, you will not have time to do bad things, things outside school."*

In the secondary schools, there are no facilities, except for a large open field, which is not conducive to and adequate for sport. One school at least has two dilapidated multi-purpose courts, although the surfaces of the courts have disintegrated and are not suitable for physical activities and PESS in particular. The deputy principal of a secondary school confirmed that they are faced with challenges to implement school sport, including dropout of school, socioeconomic issues like poverty and malnutrition, high workload, and the precedence of academics over sport, amongst others, "*Only through the grace of the Lord, do learners excel in sport.*"

Similar to the township schools, the majority of the rural schools do not dispose of a designated sport policy, and sport in these schools have a low status. Both school cohorts offer limited sports opportunities, due to a lack of resources (physical, financial, human, and information). Some of the reasons cited by learners and educators for limited opportunities for participation in sports, included amongst other pressure to perform academically and time constraints, especially the Grade 12 learners. Learners in the general train when competitions are forthcoming and participate in competitions and events organized by the DBE. Learners also play for clubs in the community.

Schools, in general, make use of educators as coaches and in the case of soccer, in particular outside coaches, old scholars, and experts with previous and/or experience being involved in sport at this point in time to assist with the facilitation of sport in the school. According to the principal of a primary school *"learners like to play." As a result, our learners encouraged to participate in a wide variety of sports, because "schools who do not have sport, their enrolment goes down." Learners have a lot of energy. This energy must be used somewhere, otherwise, they are gonna be involved in social ills."* Educators feel that there is enough information available for all sports coaches, however, the basic knowledge required to use the information is lacking. Although some of primary school coaches dispose of expertise and knowledge of the sport, the implementation of the sport is curtailed by the negative perception of the equipment and facilities. The concern lies in that the equipment and facilities are unsafe because the educators do not know how to use them. Resources, therefore, are under-utilized due to a lack of awareness, proper training, commitment, and involvement. In the words of a male educator: *"Educators must be more involved and regularly empowered, receive workshops, maybe if they know how the sport work, they will know how to appreciate the sport. In that way, they will obligate and be more involved."*

Although several educators from both the primary and secondary rural schools recognize the value of sport for the development of learners, many of the educators held the opinion that the lack of equipment had a negative effect on their motivation to present PE and coach sports. Most of the learners in the focus group interviews agreed that the lack of equipment demotivated them to participate in PESS. The deputy principal of a secondary school clearly indicated that educators are demoralized to be involved in sports due to the lack of infrastructure. He also believes school sport is important, but because of lack of facilities, it has an impact on learner participation.

The preceding view echoed that of the vast majority of educators from rural schools. In the majority of secondary schools, PE and/or sport is not implemented.

Educators offer the following reasons: "*there is too much administration and paperwork,*" "*inadequate facilities*" (having only an open space, unsafe fields, or a space next to classrooms where it should be quiet), "*lack of equipment*" (in some cases only two soccer and two netball balls for a school of about 400 learners), and "*have no training or interest*." This articulates a low status and educators not appreciating or recognizing the potential educational value of PESS within a broader educational framework. Alarmingly, older, more experienced educators, in general, believe that when new educators come to the school to teach PE and coach sports, they are not fully qualified to teach as they "*do not know the basics, such as stretching and exercises.*" As a result, they rely on a fragmented knowledge and understanding of what sport is to coach a sport. One educator, in particular, insists that coaches should be taken on courses, different courses for different sports codes, with at least two to three trained per sports code. He also believes that "*one should start with PE. Then sport will flourish*." Another educator reports that learners should be educated and taught the correct values, the importance of sport, and how to be fit and healthy, because "*most of the time the children go home and sit and eat in front of the TV, watch TV and become fat,*" whereas *if learners are motivated to stay healthy and fit, the end result will be a healthy mind and body, keeping them away from bad habits.* For some educators, the achievements of the school in sport are seen as key to the market sport through the school and the marketing of the school.

3.4 LSEN schools

At all four LSEN schools the principals, HODs, educators, and learners were all in agreement that PESS played an important role, not only in the general education of learners but also in their holistic development (physical, emotional, cognitive, social, moral, personality, and psychological). Noticeably, PESS were seen as beneficial in particular to physically impaired learners as part of their physical conditioning, rehabilitation therapy, and health improvement. In the LSEN schools, there was thus a strong focus on sport within PE as part of the physical conditioning and health improvement of learners as well as to be competitive in the different categories of disabled sport. Moreover, PE is thus regarded as a platform or vehicle to introduce learners to the various kinds of sports that are available at school or that they can pursue in their own time. This articulates high esteem for sport underpinned by a dominant health-focused approach and educators appreciate the educational value of PE and sport within the broader educational framework. Specialized staff (occupational and speech therapist, physiotherapist, nurses, and psychologist), based upon a thorough assessment of learners and regular follow-ups, mostly assist in the adaptation of activities to ensure inclusive participation and rehabilitation. These activities are facilitated by dedicated educators, who are not necessarily trained to facilitate PE and sports for disabled learners to ensure optimum results in terms of rehabilitation. The underpinning of a corrective, adaptive, and rehabilitative approach underpins the notion of framing PESS as a means for a bio-medical paradigm for preventing or countering bad health. There seems also to be a variety of activities and particularly sports skills that enabled the learners to participate meaningfully and benefit physically according to their rehabilitation profile and physical abilities. These include amongst other cricket, netball, rugby, soccer, cross country, chess, athletics, swimming, softball, and archery. Sports specifically for physically disabled learners include chess, swimming, athletics, cycling, para-cycling, table tennis as well as wheelchair table tennis and boccia (A sport played by learners in wheelchairs and is the

equivalent of grass or lawn bowls). The importance of sport is further supported by the results from the questionnaires, which indicated that 88.2% of all primary school and 81.3% of secondary learners participate in sport.

A socioeconomic picture emerges once more when comparing the physical resources of LSEN school to those of the former Model C schools, rural and township schools. Because one of the LSEN schools used to be considered one of the "state-of-the-art" schools for learners with disabilities, it has a lot of infrastructure and space in place, however, is not at the same standard that it used to be because of high maintenance costs as well as severe droughts and water restrictions. They have a hall that is used for boccia, a well-equipped indoor gymnasium, and two indoor swimming pools, used mainly for therapy. Facilities at the other three LSEN schools include amongst others, a school hall used for Boccia, netball courts, swimming pools, and tennis courts, while two schools have a multisport court sponsored by the National Lottery Fund, and one school in addition to the aforementioned facilities also has an Astroturf Hockey field, an archery range, an outdoor gymnasium, and two rugby fields, which are also used as a cricket and soccer field.

In the LSEN schools, it is paramount to dispose of a specific sports policy, in particular aspects related to liability. For LSEN schools' independence and traveling of learners is challenging, but due to a high number of learners residing in the school's hostel, most learners participate in extramural sports and are in fact given as much opportunities as possible to participate and are encouraged to participate in at least two sports, one summer and one winter sport. The emphasis in sports is on mass participation and encouraging a healthy lifestyle. Educators and volunteers are responsible for the facilitation of sport and for that purpose, a sports period in addition to the normal PE as part of LO is used to specifically coach and train learners for sport. Most of the principals, HOD's and educators alluded to the lack of adequately trained educators to deliver sport and related activities in accordance with the physical and/or mental abilities of learners.

As a whole, principals, HOD's, educators, and learners all avow that school sport has value and benefits to the school, educators, learners as well as the community. In this regard, most of the principals and educators referred to the opportunities sport presents to learners. In the words of a principal: "*sport is an area where learners shine and showcase their talents. We have a number of learners selected for provincial and national teams. It affords one the opportunity to participate even internationally*." Educators supplemented the preceding view by saying that sport affords these learners the opportunity to tour and see places. *"Go on tours. They like it. It is the only way they can get anywhere, to see places like Cape Town and Pretoria."* Similar views were expressed by learners when asked what the value of sport was and emphasized the fact that they were given opportunities and were prepared for life through vocational (practical) training. "*They give us lots of opportunities at our school in a wide variety of sports,*" "*Prepare us for life after school, focus on vocational training.*" "*It is good for your body. It gives me opportunities to be involved and get away from all the bad things, teach me enjoyment and teamwork*."

Other benefits according to educators relate to the fact that learners with learning disabilities can let go, vent their frustrations and feelings, and as such regards sport as an opiate. These educators further believe that sport is beneficial to learners with learning disabilities because sport is a place where they feel they belong and fits in, because they can do things what other can do or even do better, when then withdrawn, all of a sudden, "*the child is frustrated and irritated, they really get mad if they do not get the physical training (PT) and/or sports sessions*."

One of the biggest problems with regard to school sport according to another principal, not only in South Africa but globally is that humans tend to do sport in order to represent a specific team or whatever, and if they do not make it, they start losing and then they stop doing it. He recommends a *"change in perception to see sport as an investment in your own health. In that way, one will participate in sport your whole life."* In conclusion, educators, perceive sport to be a catalyst for those who struggle academically, but excel in sport and ultimately, eventually progress and perform better academically.

4. Discussion

All the sampled schools present or offer school sports to a certain extent to the best of their ability and capabilities. The different typologies (former Model C schools, rural, township, and LSEN) are however not consistent with the implementation of school sports. In general, the approach of those participants to school sports and the implementation challenges they experience as reported in this study, are consistent with those reported in other South African studies [98–100]. Overall, former Model C schools were found to be the most effective at implementing sport due to a variety of factors, such as access to resources and trained staff, as well as internal support within the school structure. In rural and township schools, the implementation of school sports is constrained by numerous factors, which include the lack of specialists, trained sports coaches, and managers (no champions for the different sports), poor or non-existent facilities and sports equipment, and limited internal support. The quality of the sports coaching and the experiences of learners are directly impacted by the availability of facilities, equipment, and opportunity to gain experience and practice new sports skills individually and within a team context. These findings are congruent with a study conducted by Mchunu and Roux [101] who reported a lack of proper, well-maintained, and accessible facilities conducive to sports participation as well as equipment, as the main reasons why learners are discouraged from participation in sport. Kubayi, Toriola, and Monyeki [102], Morar, Coopoo, Shaw and Shaw [103], Du Plessis, and Mestry [104] together with Moloi [105] further supported the preceding finding when they recommended the provision of basic equipment, hiring of qualified coaches and sport coordinators, facilitated access to sports facilities and parental support to motivate and encourage learner participation in sport. Similarly, Nongogo, Kubayi, and Amusa [66] inferred that in South Africa's historically White-only suburbs, where every school has several sports facilities, inclusive of some of which are not being used to full capacity, the low participation rate amongst girls in historically Black townships in South Africa can be attributed to a lack of quality sporting facilities and unqualified, inexperienced coaches. Educators who hold a sports federation level qualification (from level 1 to level 3) are relatively more successful at applying technical information, whereas external specialist sport coaches often focus on the sports skill learning and developing talented players or athletes for competitive sports participation. Disconcertingly, a large number of schools still have older, more experienced educators who question the ability, attitude, and commitment to the teaching of their younger colleagues, but more specifically the facilitation of school sport. Many specialist PE educators qualified in the 1980s or 1990s when universities offered such degree courses but did not necessarily keep track of the subject matter that meets the interests and reflects a more popular youth culture. This resulted in the over-emphasis on competitive sports skills and less didactical flexibility than that of

"compassionate educators" who offer classes in which learners enjoy and experience success despite the diversity in skill level. Similar findings are reported by Burnett [60] in her report on the state and status of PE in public schools in South Africa. She indicates that at the time of the report, only 65.3% of HOD's taught PE. Moreover, she explicitly warns different stakeholders and policymakers of the challenge it would pose to schools and HOD's in particular in being optimally informed of educator performances or being able to provide adequate leadership and mentorship for inexperienced and inadequately trained educators. This is an area that is worthy of further formal inquiry.

In all four school contexts the inclusion of PE in the curriculum to enhance and improve performance in school sport and ultimately sport as a whole is supported for reasons that include the following: helps with cognitive development and self-confidence; helps learners to get fit and healthy; is considered to be very important in helping learners to stay away from smoking, crime, alcohol, and drugs, including glue and *whoonga* (street drug), that is rife in the township in particular; and provides an opportunity for academically weak learners to possibly express themselves on the field. Educators, learners, and other role-players, such as subject advisors, have reported that they value both school sports and PE for their contribution to learners' health in the studies of Nongogo et al. [66], Hollander [106] and Stroebel, Hay and Bloemhoff [107], while Wegner and Struthers [108], as well as Moll and Bester [109] more specifically to learners with disabilities, asserted that it provides social support and is seen as a driver of social inclusion. In their study on the effect of participation in competitive sports on school connectedness of secondary school students, Kamau, Rintaugu, Muniu, and Amusa [110] concede that school type and school status, and lack of resources had a significant impact on participation in sport. Stroebel, Hay, and Bloemhoff [98, 99, 107] add to this when they conclude that the lack of qualified educators, and the lack of facilities and resources to present school sports, still impede the effective implementation of PESS, which naturally impacts participation or lack thereof. This state of not an only school sport, but also PE, is reflected in the healthy active kids South Africa report card (a research report compiled by a working group of more than 30 academics on the PA and health levels of South African children and youth), reporting that 60% of all learners do not participate in organized school sport, while 68% of learners did not participate in weekly PA [10]. Researchers, such as Eksteen et al. [27], Burnett [111], and Draper et al. [10] listed time constraints, the reluctance of educators to become involved in non-compulsory school activities, workload, inadequate resources, lack of knowledge and expertise, and specialization together with educator qualifications as the main reasons for failure to effectively implement sport in schools.

Viewed through the lens of the SDT, not only the perceptions of the sport of both educators and learners but also their motivational levels were impacted negatively by a failure to satisfy their basic psychological needs for autonomy, competence, and relatedness [47]. Educators felt insecure when PESS periods were assigned to them, simply because they had a free period or time, and their allocated package was not full or no one else was available to coach a particular sport; thus, their need for autonomy was not met, learners often felt they had no choice in the type activities or sport they had to, in some cases forced to do, because of the tradition and beliefs of the school. More than half of the educators involved in sports have received no training and/or are qualified to teach the sport, implying that their need to be equipped with knowledge and skills to effectively coach and teach the sport, thus the need for competence was not met. In addition, lack of training further translates into low motivation, and

inadequate mentoring that is exacerbated by "limited time" and a "heavy workload" [60]. Several learners expressed their dissatisfaction, not being able to learn new skills and techniques, due to educators not being properly, trained or being coached and/or taught by the same coach or educator year in and year out. Regardless of the value of both sport and PE, expressed by both the educators and learners, challenges remain with regard to the implementation sports, which means because there was no internalization, implicit therein, thus no satisfaction of the need for relatedness. In relation to the preceding, findings of research conducted on the effect of PESS needs support educator training [112–114] suggest that participants' perceptions of PESS and motivational levels to teach and coach a sport or to participate have indeed improved after the needs-support educator training.

Seen from the perspective of the social justice framework, it was evident that rural and township schools are not adequately resourced and structured to ensure an enabling environment for learners to have access to quality sport. The issue of training for coaches and those involved with school sport to facilitate sport, or the lack thereof seems to be a mutual challenge. The majority of educators in the better-resourced schools are either qualified as PE specialists, or they have extensive background or experience in sport, as opposed to educators in the lesser-resourced schools that lack the know-how and confidence to offer the sport.

There was a real sense of frustration that so many years into the democratic era in South Africa there are still so many disparities with regard to access, equality, and inclusivity. It is interesting to note that the researchers have observed that existing inequalities are in fact widening between lower ranked and higher ranked quintile schools, and even between schools of the same quantile for that matter. Competition between quintile 4 and 5 schools seems to be having the effect of accelerating infrastructural improvements in these schools that are trying to establish more and better facilities as part of their marketing campaigns, that s, marketing of sport and marketing through sport. However, competition between these schools has led to lesser competitive schools and schools that do not have equal resources (physical, financial, and human) and boast the same number of participants to opt not to participate against those schools anymore, which in turn have led schools who have the same number of participants to seek competition elsewhere, mostly outside the borders of their own province and use inter schools as a means of participation in school sport. The quintile 2 and 3 schools on the other hand would seem content only to dispose of sufficient resources, just to participate, let alone the quality thereof. This is an area that is worthy of further formal inquiry.

Based on the results, it can be inferred that a lack of facilities, training, and relevant funding, as well as substance abuse, is not a new phenomenon globally [115], but also in South Africa. Previous studies by Kubayi et al. [102], Kamau et al. [110], and Stroebel et al. [98, 99] reported that learners growing up in South African townships and rural locations (areas) are marginalized, and unable to participate, because of a lack of adequate and proper, high-quality facilities and proper funding amongst other that do not stimulate or enhance well-organized sport participation practices. Nongogo et al. [66] in particular assert, consistent with findings of this study, that it could be due to an inability of the public schools' (Section 21 Government funded schools) incompetence to obtain and/or secure enough funds to build new and/or maintain the often-measly available sporting facilities. This should be of great concern to the parents, schools, and the relevant authorities, as research has shown that learners from schools with sufficient resources are more likely to continue participation.

Unfortunately, various challenges for schools to present quality school sports, still exist. Evidently, discontent toward the DBE is fueled by frustration due to a lack of involvement in resourcing and upgrading facilities as well as human resources. Whilst there are various initiatives directed at the enhancement, emphasis, and importance of the theoretical role and status of school sport, such as personal and social well-being, there is certainly not an equivalent for the practical implementation of PE in support of school sport. To this end, social injustice and inequality are still rife, and as such are the playing fields anything but level when comparing access to trained sports and PE educators, equality of resources (physical, human, and financial), and inclusivity, in this case, in terms of providing for boys and girls with equal ability and opportunity to participate in school sport in particular against those (schools and individuals) with the same ability and strength as theirs. The suburban, former Model C school, quintile 4 and 5 schools employ coaches trained specifically for a particular sport or outsourced specialists, and are well resourced, offering several sporting codes, not only as part of the PE program, but also the sport as part of their extra-mural activities and the infrastructure to support these. It is within the preceding context in which school sport and QPE are offered in the former Model C schools. Due to the inadequacy of all resources (physical, financial, human, and information) sport and QPE cannot take place in township, rural, and LSEN schools.

Valuable and valid recommendations can be drawn from the findings of this study to address the situation of QPE and school sports in the Free State, North West, and Northern Cape province, as well as in South Africa. Multiple levels of recommendations are offered by different research cohorts. Despite an awareness amongst all role-players in schools of the health and other benefits of quality, values-driven school sport, educational, social justified sport and PE, strategies need to be put in place to address the implementation challenges facing educators and learners on grassroots level. It can thus be recommended, as has been proposed already by several researchers like Du Toit et al. [116], Van der Merwe [117], Van Deventer [118, 119], and Stroebel et al. [98] to reinstate PE as a stand-alone subject and to make it an examinable subject; ultimately, improving its academic status. Furthermore, as Bloemhoff [120], Eksteen et al. [27], Van der Merwe, Malan and Willemse [121], and Stroebel, Hay, and Bloemhoff [99], have recommended a specialist-trained school sports manager should be employed in all schools by DBE to manage sport in the school as well as to mentor younger and inexperience educators with teaching and coaching PESS in the school. In addition to that, in-service training of LO educators who have to present P.E together with regular up-to-date sport-specific training in all sports codes in all schools inclusive of (LSEN) and of all educators involved in school sports seems eminent to improve educators' perception of PESS school sport, motivation levels and quality of teaching as well as coaching of and involvement in a school sport [99, 107, 122, 123]. Over and above the preceding, should outsourced specialists who teach PESS as part thereof or are entirely involved in coaching, also receive training in basic, sound educational values, and norms to assist them to deliver quality, values-driven school sport, and QPE. For training, thus to be effective it should include strategies and equipment to present creative, needs specific support programs in PESS within the framework of the SDT and social justice framework to equip all with essential knowledge and skills to teach PE and sport proficiently and scientifically. Ultimately teaching PESS requires an athlete-centered long-term strategy to use neuromuscular training from a young age to ensure a reduction in the risk of injury and sportspeople that are able to perform to their maximum with fun and enjoyment [124].

The call from all research participants was quite clear; the DBE needs to prioritize sports and PE at schools by carefully considering the reasons for the low status and the discrepancies that exist between schools with regard to resources (financial, physical, human, and information). Be that as it may, prioritizing sport and PE in schools needs to filter via a unified, collaboration between DBE, SRSA as well as national and provincial sport bodies to the school management team. The plan and strategies forwarded came from those (principals, educators, parents, and learners) who are directly involved and deal with the challenges on a daily basis. However, the action and support need to come from those who impose the programs, principles, and procedures. The alignment and integration of programs delivered by the mentioned stakeholders have the potential to generate opportunities for children in sport, as well as "*place more South Africans on the podium and support the health and wellness of the nation*" [125]. School sport and PE should therefore be addressed in an integrated way at the policy level to ensure articulation between the different ministries, reflecting on the shared roles and responsibilities of each in an endeavor to ensure equal participation opportunities for all through quality, value-based PE programs. Partnerships could be formed between well-resourced schools and disadvantaged schools with the assistance of the former to the latter. A more hands-on approach by DBE should be visible, where it is seen that PESS is taken seriously, training is conducted of role-players to lend support to schools with the implementation of PESS, regular visits are conducted to monitor and assist schools and responsibility (ownership) is taken for the physical state with regard to basic facilities and infrastructure, such as ablution facilities and change rooms of under-resourced schools and maintenance of the infrastructure and facilities of those well-resourced schools to create a safe environment in which PESS can take place.

5. Conclusion

The current state and status of school sport in the South African public school system shows that school sport is exceptionally varied, multifaceted, complex, with different pressures and imperatives, and shows an absence of educational accountability. It is exacerbated by a society fraud with social injustice and inequality, politicized driven agendas, and educators who are required to assume the dual role of teaching in the classroom and taking on a further role of sports facilitator or coach within a school environment. Educators are susceptible to a number of accumulating pressures, caused by other organizational and administrative tasks, which result in overload, emotional rollercoaster rides, and lack of motivation. Without meaningful motivation, continuous reform, or revision of policy, the delivery of quality PE and values-driven school sports will remain unachievable, because one thing the research conducted confirmed was *that "the more things change, the more they stay the same."* Although the "what" that is offered in terms of sport is more or less the same, the "how" it is delivered and "by whom" reveal that inconsistencies still exist between former Model C schools, LSEN schools (in this particular case) and rural and township schools. It is therefore suggested that DBE takes cognizance of the current limited competencies and training for educators in order to enhance their competencies and skills. Upon implementation of a specialist school sports manager (such as a sports director or an overall sports coordinator) to ease the burden on educators, QPE and values-driven, educationally justified school sport, within the UNESCO conceptualization, where its status is valued and integrated into the sport-and health-related

cultures, supportive of life-long learning, and wellness, is indeed possible. It is sad to say, but currently, this is not the case in most South African schools.

Winning the Rugby World Cup (RWC) in 2019 together with the coronavirus, (COVID-19) pandemic, which is the defining global health crisis of our time and the greatest challenge we have faced since World War II, might just be the catalyst to reunite the "Rainbow Nation." Indeed, this would serve as a reminder to all about the main role of school sport to produce learners who are optimally prepared for a responsible contribution to the development of a multicultural South African society and can develop into independent, young men and women who can contribute to the development of a strong value system, free of corruption, social injustice, and fraud along with excellence in governance, leadership, and management.

In conclusion, as Stuart Frankin said at laying the foundation stone of the Reunie Saal (Reunion Hall) in 1928 at Grey College "*if the past is an inspiration, the future is a challenge,*" [126] every person with an interest in education and the development of our country, should accept the challenge to support the development of sport in South Africa by eradicating poverty, reducing inequalities, and building resilience. Each and every South African citizen is therefore called upon to assist in the endeavors of promoting and developing the sport in the interest of every future South African generation, for a healthy, happy, and fulfilling future. Is the current state of school sport reminiscent of a vision loss or one that is embracing the challenge to reunite a Nation divided, where "one size does not fit all?" Hence, can school sports to come out of the woods to ensure a quality of life for all.

5.1 Implications for sports policy

The synergy between DBE and SRSA to ensure meaningful policy review and understanding of diverse school contexts, implementation of school sports, and provision of resources (physical, financial, human, and information) are paramount for strategies to enhance school sports performance, whilst quality sport needs-specific training for all educators and employment of a specialist, trained school sports manager, will pave the way to the more effective development of PE and school sport in all provinces of South Africa, in all schools.

Acknowledgements

- The DBE for their support and provision of access to schools in Free State, North West, and Northern Cape province.

- UNICEF South Africa for the sponsorship and support to universities that enabled the structuring of South Africa University Physical Education Association, funding, and support.

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References

[1] Knoetze-Raper J, Myburgh C, Poggenpoel M. Experiences of families with a high-achiever child in sport: Case studies. South African Journal for Research in Sport, Physical Education and Recreation. 2016;**38**(1):75-89

[2] Hanrahan S, Rynne S, Beckman E, Rossi T. Participants' physical activity levels and evaluations of a school sport programme in Papua New Guinea. European Physical Education Review. 2019;**25**(1):3-20

[3] Pot N, Van Hilvoorde I. Generalizing the effects of school sports: Comparing the cultural contexts of school sports in the Netherlands and the USA. Sport in Society. 2013;**16**(9):1164-1175

[4] Kucukibis HF, Gul M. Study on sports high school Students' motivation levels in sports by some variables. Universal Journal of Educational Research. 2019;**7**(3):839-847

[5] Carson V, Rosu A, Janssen I. A cross-sectional study of the environment, physical activity, and screen time among young children and their parents. BMC Public Health. 2014;**14**:61

[6] Ivashchenko O, Khudolii O, Iermakov S, Lochbaum M, Cieslicka M, Zukow W, et al. Methodological approaches to pedagogical control of the functional and motor fitness of the girls from 7-9 grades. Journal of Physical Education and Sport. 2017;**17**(1):254-261

[7] Lucas WC, Titus S, Young MEM. Experiences of gymnasts about health benefits of sport participation. African Journal for Physical Activity and Health Sciences. 2019;**25**(2):216-231

[8] Gaetano A. Relationship between physical inactivity and effects on individual health status. Journal of Physical Education and Sport. 2016;16 Supplement, Issue 2. Art. 170:1069-1074

[9] D'Isanto T, Manna A, Altavilla G. Health and physical activity. Sport Science. 2017;**10**(1):100-105

[10] Draper CE, Tomaz SA, Bassett SH, Harbron J, Kruger HS, Micklesfield LK, et al. Results from the healthy active kids South Africa (HAKSA) 2018 report card. South African Journal of Child Health. 2019;**13**(3):130-136

[11] Van Woudenberg TJ, Bevelander KE, Burk WJ, Smit CR, Buijs L, Buizen M. Testing a social network intervention using vlogs to promote physical activity among adolescents a randomized controlled trial. Frontiers in Psychology. 2020;**10**:2913

[12] World Health Organisation (WHO). Global Recommendations on Physical Activity for Health (Online). Geneva, Swizerland: World Health Organization; 2010. [cited 2018 October]. Available from: https://apps.who.int/iris/handle/10665/44399

[13] Di Palma D, Raiola G, Tafuri D. Disability and sport management: A systematic review of the literature. Journal of Physical Education and Sport. 2016;**16**(3):785-793

[14] Francesco C, Coco D, Frattini G, Vago P, Andrea C. Effective teaching competences in physical education. Journal of Physical Education and Sport. 2019;**19**:1806-1813

[15] Pot N, Verbeek J, Van der Zwan J, Van Hilvoorde I. Socialisation into organised sports of young adolescents with a lower socio-economic

status. Sport, Education and Society. 2016;**21**(3):319-338

[16] Ní Chróinín D, McMullen J. 'The world is a happier place': Celebration in a whole-of-school physical activity initiative. European Physical Education Review. 2020;**26**(2):337-352

[17] Samek DR, Elkins IJ, Keyes MA, Iacono WG, McGue M. High school sports involvement diminishes the association between childhood conduct disorder and adult antisocial behavior. The Journal of Adolescent Health. 2015;**57**(1):107-112

[18] Jacobs F, Claringbould I, Knoppers A. Becoming a 'good coach'. Sport, Education and Society. 2016;**21**(3):411-430

[19] Kavussanu M, Al-Yaaribi A. Prosocial and antisocial behaviour in sport. International Journal of Sport and Exercise Psychology. 2019;**19**(2):179-202

[20] Blomfield C, Barber B. Australian adolescents' extracurricular activity participation and positive development: Is the relationship mediated by peer attributes? Australian Journal of Educational and Developmental Psychology. 2010;**10**:108-122

[21] Boyes R, O'Sullivan DE, Linden B, McIsaac M, Pickett W. Gender-specific associations between involvement in team sport culture and Canadian adolescents' substance-use behavior. SSM - Population Health. 2017;**3**:663-673

[22] Vella SA, Oades LG, Crowe TP. The relationship between coach leadership, the coach–athlete relationship, team success, and the positive developmental experiences of adolescent soccer players. Physical Education and Sport Pedagogy. 2013;**18**(5):549-561

[23] Jacobs F, Smits F, Knoppers A. 'You don't realise what you see!': The institutional context of emotional abuse in elite youth sport. Sport in Society. 2017;**20**(1):126-143

[24] Andersson E. A referee perspective on the educational practice of competitive youth games: Exploring the pedagogical function of parents, coaches and referees in grassroots soccer. Physical Education and Sport Pedagogy. 2019;**24**(6):615-628

[25] Teodor CI, Claudiu M. The role of motivation in education through sport. Procedia-Social and Behavioral Sciences. 2013;**83**:1054-1058

[26] Beaudoin C, Callary B, Trudeau F. Coaches' adoption and implementation of sport Canada's long-term athlete development model. SAGE Open. 2015;**5**(3):2158244015595269

[27] Eksteen E, Willemse Y, Malan DDJ, Ellis S. Competencies and training needs for school sport managers in the North-West Province of South Africa. Journal of Physical Education and Sport Management. 2015;**6**(9):90-96

[28] Trigueros R, Aguilar-Parra JM, Cangas-Díaz AJ, Fernández-Batanero JM, Mañas MA, Arias VB, et al. The influence of the trainer on the motivation and resilience of sportspeople: A study from the perspective of self-determination theory. PLoS One. 2019;**14**(8):e0221461-e

[29] Aoyagi K, Ishii K, Shibata A, Arai H, Oka K. Quantitative assessment of facilitators and barriers to using external coaches in school-based extracurricular sports activities. Journal of Physical Education and Sport Management. 2014;**5**(4):45-53

[30] Dhurup M, Mahomed FE. Role ambiguity, role conflict and work

overload and their influence on job satisfaction of sport facilitators in public schools in the Vaal triangle, South Africa. African Journal for Physical Health Education, Recreation and Dance. 2011;**17**(Supplement 1):172-188

[31] Pule REJ. A Framework for learner's Participation in Sport at Public Township Schools in the City of Tshwane [Thesis – Doctor Technologiae]. Tshwane, Pretoria, South Africa: Tswane University of Technology; 2014

[32] Pule REJ, Drotsky GAP, Toriola AL, Kubayi NA. Children's perceptions of parental involvement in sport at public township schools in Tshwane, South Africa. African Journal for Physical, Health Education, Recreation and Dance. 2014;**20**(4:2):1564-1571

[33] Dhurup M. South African amateur coaches' perceptions of the relationship between employee fit dimensions, organisational commitment and job satisfaction. African Journal for Physical Activity and Health Sciences. 2019;**25**(4):455-471

[34] Du Toit D, Van der Merwe N. Physical education. In: Nel M, editor. Life Orientation for South African Teachers. 2nd ed. Pretoria: Van Schaik; 2018. pp. 243-282

[35] Farias C, Valério C, Mesquita I. Sport education as a curriculum approach to student learning of invasion games: Effects on game performance and game involvement. Journal of Sports Science and Medicine. 2018;**17**(1):56-65

[36] Farias CFG, Harvey S, Hastie PA, Mesquita IMR. Effects of situational constraints on students' game-play development over three consecutive sport education seasons of invasion games. Physical Education and Sport Pedagogy. 2019;**24**(3):267-286

[37] Lambrecht KW, Kraft PM. Opportunities and Challenges in Offering a Sport Management Program in the B-School. North American Society for Sport Management Conference (NASSM); May 27-May 30, 2009. Toronto, Ontario; 2009. NASSM. Retrieved from: www.nassm.com/files_abstracts/2008-341

[38] Opstoel K, Chapelle L, Prins FJ, De Meester A, Haerens L, Van Tartwijk J, et al. Personal and social development in physical education and sports: A review study. European Physical Education Review. 2019;**26**(4):797-813

[39] Walton-Fisette JL, Philpot R, Phillips S, Flory SB, Hill J, Sutherland S, et al. Implicit and explicit pedagogical practices related to sociocultural issues and social justice in physical education teacher education programs. Physical Education and Sport Pedagogy. 2018;**23**(5):497-509

[40] Walton-Fisette JL, Sutherland S. Moving forward with social justice education in physical education teacher education. Physical Education and Sport Pedagogy. 2018;**23**(5):461-468

[41] Shiver VN, Andrew K, Richards R, Hemphill MA. Preservice teachers' learning to implement culturally relevant physical education with the teaching personal and social responsibility model. Physical Education and Sport Pedagogy. 2020;**25**(3):303-315

[42] Gray D. Doing Research in the Real World. 4th ed. London, UK: SAGE; 2017. p. 824

[43] Bell L. Theoretical foundations for social justice education. In: Adams M, Bell L, editors. Teaching for Diversity and Social Justice. 3rd ed. New York, NY: Routledge; 2016. pp. 3-26

[44] Angrosino MV. Ethnography, pedagogy, and the prospects for a progressive political agenda. In: Denzin NK, Lincoln YS, editors. The SAGE Handbook of Qualitative Research. 3rd ed. Thousand Oaks, CA: SAGE; 2005. pp. 729-745

[45] Sugden J, Tomlinson A. Theory and method for a critical sociology of sport. In: Sugden J, Tomlinson A, editors. Power Games: A Critical Sociology of Sport. Abingdon, Oxfordshire, U.K.: Routledge; 2002. pp. 3-21

[46] Coakley J, Burnett C. Sports in Society. Issues and Controversies 1st Southern. African ed. Hatfield, Pretoria: Van Schaik; 2014. p. 384

[47] Deci EL, Ryan RM. Intrinsic Motivation and Self Determination in Human Behavior. New York, NY: Plenum Press; 1985. p. 372

[48] Moral-Garcia JE, Nieto Rodriguez J, Garcia-Canto E, Perez-Soto J, Rosa-Guillamon A, Lopez Garcia S, et al. Perception of adolescents on physical education classes according to the physical activity level, weight status, gender and age. Journal of Physical Education and Sport. 2019;**19**:40-48

[49] Teixera PJ, Carraca EV, Markland D, Silva MN, Ryan RM. Exercise, physical activity, and self-determination theory: A systematic review. International Journal of Behavioral Nutrition and Physical Activity. 2012;**9**:1-30

[50] Haerens L, Vansteenkiste M, De Meester A, Delrue J, Tallir I, Vande Broek G, et al. Different combinations of perceived autonomy support and control: Identifying the most optimal motivating style. Physical Education and Sport Pedagogy. 2018;**23**(1):16-36

[51] Aelterman N, Vansteenkiste M, Haerens L. Correlates of students' internalization and defiance of classroom rules: A self-determination theory perspective. British Journal of Educational Psychology. 2019;**89**(1):22-40

[52] Vansteenkiste M, Ryan RM, Soenens B. Basic psychological need theory: Advancements, critical themes, and future directions. Motivation and Emotion. 2020;**44**(1):1-31

[53] Deci EL, Ryan RM. Motivation, personality, and development within embedded social contexts: An overview of self-determination theory. In: Ryan RM, editor. The Oxford Handbook of Human Motivation. 1st ed. New York, NY: Oxford University Press; 2012. pp. 85-107

[54] Gorozidis G, Papaioannou AG. Teachers' motivation to participate in training and to implement innovations. Teaching and Teacher Education. 2014;**39**:1-11

[55] Ryan RM, Deci EL. Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness. New York, NY: Guilford Press; 2017. p. 756

[56] Van den Berghe L, Vansteenkiste M, Cardon G, Kirk D, Haerens L. Research on self-determination in physical education: Key findings and proposals for future research. Physical Education and Sport Pedagogy. 2014;**19**(1):97-121

[57] Aelterman N, Vansteenkiste M, Soenens B, Haerens L. A dimensional and person-centered perspective on controlled reasons for non-participation in physical education. Psychology of Sport and Exercise. 2016;**23**:142-154

[58] Cuevas R, García-López L, Olivares J. Sport education model

and self-determination theory: An intervention in secondary school children. Kinesiology. 2016;**48**(1):30-38

[59] Bailey R. Sport, physical activity and educational achievement – Towards an explanatory model. Sport in Society. 2017;**20**(7):768-788

[60] Burnett C. National Research: State and Status of Physical Education in Public Schools of South Africa. Report Compiled by Professor Cora Burnett University of Johannesburg. Research Commissioned by UNICEF in Partnership with the Department of Basic Education. Research Conducted by South African University Physical Education Association (SAUPEA). Johannesburg: South African University Physical Education Association (SAUPEA); 2018 10 October; 2018

[61] Burnett C. Qualitative research in search of truth and agency: Challenges and opportunities for qualitative research. In: Smith B, Sparkes AC, editors. Routledge Handbook of Qualitative Research in Sport and Exercise. Abingdon, Oxfordshire, U.K: Routledge; 2017. pp. 462-465

[62] Creswell JW. Qualitative Inquiry and Research Design: Choosing among Five Traditions. 3rd ed. Thousand Oaks, CA: SAGE; 2013. p. 448

[63] Metcalfe SN, Lindsey S. Gendered trends in young people's participation in active lifestyles: The need for a gender-neutral narrative. European Physical Education Review. 2020;**26**(2):535-551

[64] Greene JC. Mixed Methods in Social Inquiry. San Francisco, CA: John Wiley; 2007. p. 216

[65] Hogan A, Stylianou M. School-based sports development and the role of NSOs as 'boundary spanners': Benefits, disbenefits and unintended consequences of the sporting schools policy initiative. Sport, Education and Society. 2018;**23**(4):367-380

[66] Nongogo P, Kubayi NA, Amusa LO. Sport participation in Soweto locations, South Africa: A qualitative study among high school learners. African Journal for Physical, Health Education, Recreation and Dance. 2014;**20**(3:2):1182-1188

[67] Parker A, Morgan H, Farooq S, Moreland B, Pitchford A. Sporting intervention and social change: Football, marginalised youth and citizenship development. Sport, Education and Society. 2019;**24**(3):298-310

[68] Gratton C, Jones I. Research Methods for Sport Studies. 2nd ed. London: Routledge; 2010. p. 304

[69] Burnett C, Hollander WJ. The sport In development impact Assesment tool (S•DIAT). African Journal for Physical Health Education, Recreation and Dance. 2007;**10**(2):123-135

[70] Burnett C. The impact of a sport-for-education programme in the South African context of poverty. Sport in Society. 2014;**17**(6):722-735

[71] Whitley MA, Massey WV, Camiré M, Boutet M, Borbee A. Sport-based youth development interventions in the United States: A systematic review. BMC Public Health. 2019;**19**(1):89

[72] Zipp S. Sport for development with 'at risk' girls in St. Lucia. Sport in Society. 2017;**20**(12):1917-1931

[73] Haudenhuyse R, Theeboom M, Nols Z. Sports-based interventions for socially vulnerable youth: Towards well-defined interventions with

easy- to-follow outcomes? International Review for the Sociology of Sports. 2013;**48**(4):471-484

[74] Leedy PD, Ormrod JE. Practical Research Planning and Design. 12th ed. New York: Pearson Education; 2019. p. 464

[75] Creswell JW, Creswell JD. Research Design: Quantitative, Qualitative, and Mixed-Methods Approaches. 5th ed. Thousand Oaks, CA: SAGE; 2018. p. 278

[76] Creswell JW, Guetterman TC. Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research. 6th ed. New York, NY: Pearson Education; 2019. p. 681

[77] Africa S. National norms and standards for school funding. In: Eaducation DoB, editor. Government Gazette, No. 42445 Vol. 647. 6 May Mei 2019 (NNSSF). Pretoria, South Africa: Government Printers; 2019. p. 8

[78] Statistics South Africa. General Household Survey (GHS). Focus on Schooling 2018 Pretoria. South Africa: Statistics South Africa; 2019. Available from: https://www.education.gov.za/Portals/0/Documents/Reports/20191104_GHS_final.pdf?ver=2019-11-04-111833-313

[79] Creswell JW, Poth CN. Qualitative Inquiry and Research Design: Choosing among Five Approaches. 4th ed. Thousand Oaks, CA: SAGE; 2018. p. 488

[80] Marshall C, Rossman GB. Designing Qualitative Research. 6th ed. Thousand Oaks, CA: SAGE; 2016. p. 323

[81] UNESCO (United Nations Educational Scientific and Cultural Organisation). Quality Physical Education: Guidelines for Policy Makers Paris. France: United Nations Educational Scientific and Cultural Organisation (UNESCO); 2015. Available from: https://en.unesco.org/inclusivepolicylab/sites/default/files/learning/document/2017/1/231101E.pdf

[82] UNESCO (United Nations Educational Scientific and Cultural Organization). The Power of Sport Values Paris. France: UNESCO; 2016. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000244344

[83] UNESCO (United Nations Educational Scientific and Cultural Organization). The Power of Sport Values Poster Paris. France: UNESCO; 2016. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000246351

[84] UNESCO (United Nations Educational Scientific and Cultural Organization). Maximising the Power of Sport-UNESCO Digital Library Paris. France: UNESCO; 2018. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000260817

[85] UNESCO (United Nations Educational Scientific and Cultural Organization). Values Education through Sport 2020. Available from: http://www.unesco.org/new/en/social-and-human-sciences/themes/physical-education-and-sport/values-education-through-sport/

[86] Lindsey I, Zakariah ABT, Owusu-Ansah E, Ndee H, Jeanes R. Researching 'sustainable development in African sport': A case study of a north-South academic collaboration. In: Hayhurst LMC, T. Kay, Chawansky M, editors. Beyond Sport for Development and Peace: Transnational Perspectives on Theory, Policy and Practice. Abington, Oxfordshire: Routledge; 2016. p. 196-209

[87] Graneheim UH, Lundman B. Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. Nurse Education Today. 2004;**24**(2): 105-112

[88] Mikaelsson K, Rutberg S, Lindqvist AK, Michaelson P. Physically inactive adolescents' experiences of engaging in physical activity. European Journal of Physiotherapy [Internet]. 02/07 2020;**20**(4):191-196. DOI: 10.1080/21679169.2019.1567808

[89] Antonius R. Interpreting Quantitative Data with IBM SPSS Statistics. 2nd ed. Thousand Oaks, CA: SAGE; 2013. p. 376

[90] Corbin J, Strauss A. Basics of Qualitative Research. Techniques and Procedures for Developing Grounded Theory. 4th ed. Thousand Oaks, CA: SAGE; 2015. p. 431

[91] Merriam S, Tisdell EJ. Qualitative Research: A Guide to Design and Implementation. 4th ed. San Francisco, CA: John Wiley & Sons; 2016. p. 368

[92] Caillaud S, Doumergue M, Préau M, Haas V, Kalampalikis N. The past and present of triangulation and social representations theory: A crossed history. Qualitative Research in Psychology. 2019;**16**(3):375-391

[93] Denzin NK. The Research Act: A Theoretical Introduction to Sociological Methods. 3rd ed. New York, NY: Prentice Hall; 1989. p. 306

[94] Stavros C, Westberg K. Using triangulation and multiple case studies to advance relationship marketing theory. Qualitative Market Research: An International Journal. 2009;**12**(3):307-320

[95] Farias C, Mesquita IMR, Hastie PA, O'Donovan T. Mediating peer teaching for learning games: An action research intervention across three consecutive sport education seasons. Research Quarterly for Exercise and Sport. 2018;**89**(1):1-12

[96] Health24. Youth Badly Affected by Substance Abuse in Northern Cape 2015 [updated 28 September 2015]. Available from: https://www.health24.com/Lifestyle/Street-drugs/News/Youth-badly-affected-by-substance-abuse-in-Northern-Cape-20150720

[97] Olivier L, Curfs L, Viljoen D. Fetal alcohol spectrum disorders: Prevalence rates in South Africa. South African Medical Journal. 2016;**106**(6): S103-S1S6

[98] Stroebel LCE, Hay J, Bloemhoff HJ. Physical education in South Africa: Have we come the the full circle? South African Journal for Research in Sport, Physical Education and Recreation. 2016;**39**(3):163-177

[99] Stroebel LCE, Hay J, Bloemhoff HJ. An active and winning South African nation: Can the gap between ideal and reality be narrowed? South African Journal for Research in Sport, Physical Education and Recreation. 2019;**41**(3):101-115

[100] Visagie DA. The Professional Development of Non-specialist Physical Education Teachers [Thesis - PhD]. Johannesburg, South Africa: University of Johannesburg; 2016

[101] Mchunu S, Le Roux K. Non-participation in sport by black learners with special reference to gender, grades, family income and home environment. South African Journal for Research in Sport, Physical Education and Recreation. 2010;**32**(1):85-98

[102] Kubayi NA, Toriola AL, Monyeki MA. Barriers to school sport participation: A survey among secondary school students in Pretoria, South Africa. African Journal for Physical, Health Education, Recreation and Dance. 2013;**19**(2):336-344

[103] Morar D, Coopoo Y, Shaw I, Shaw BS. Health and fitness attitudes and lifestyle habits of urban children in South Africa. African Journal for Physical, Health Education, Recreation and Dance. 2014;**20**:102-112

[104] Du Plessis P, Mestry R. Teachers for rural schools – A challenge for South Africa. South African Journal of Education. 2019;**39**:S1-S9

[105] Moloi K. Learners and educators as agents of social transformation in dysfunctional South African schools. South African Journal of Education. 2019;**39**:S1-S8

[106] Hollander W. Delivering physical education in selected schools in Soweto, South Africa: Soweto active schools programme. African Journal for Physical Activity and Health Sciences. 2017;**23**(1:2):204-214

[107] Stroebel LCE, Hay J, Bloemhoff HJ. Challenges facing life skills and life orientation subject advisors in implementation of physical education. South African Journal for Research in Sport, Physical Education and Recreation. 2018;**40**(3):121-136

[108] Wegner L, Struthers P. Sports for learners with physical disabilities in ordinary public primary schools in the Western Cape, South Africa. African Journal for Physical, Health Education, Recreation and Dance 2011;**17**(Supplement 1, June): 103-112

[109] Moll AM, Bester G. Factors that relate to sport participation of adolescents with a mobility impairment. African Journal of Disabilty. 2019;**8**:a614. [Internet] Available from: https://ajod.org/index.php/ajod/article/view/614/1169

[110] Kamau AW, Rintaugu EG, Muniu RK, Amusa LO. The effect of participation in competitive sports on school connectedness of secondary school students. African Journal for Physical, Health Education, Receation and Dance. 2015;**21**(3:1):877-890

[111] Burnett C. Value of sport in post-apartheid South Africa. South African Journal for Research in Sport, Physical Education and Recreation. 2019;**41**(2):11-27

[112] Aelterman N, Vansteenkiste M, Van Keer H, De Meyer J, Van den Berghe L, Haerens L. Development and evaluation of a training on need-supportive teaching in physical education: Qualitative and quantitative findings. Teaching and Teacher Education. 2013;**29**(1):64-75

[113] Kubayi A, Coopoo Y, Morris-Eyton H. Coaches' preferences for continuing coaching education in South Africa. Journal of Human Kinetics. 2016;**50**(1):229-234

[114] Van der Westhuizen SJ. Die Effek Van 'n Indiens-Opleidingsprogram op Onderwysers se Persepsies Van Liggaamlike Opvoeding. (the Effect of an in-Service Training Program on teachers'perceptions of Physical Education) [Dissertation-M.Ed]. Potchefstroom, South Africa: North West University; 2018

[115] De Lima TR, Silva DAS. Association between sports practice and physical education classes and lifestyle among adolescents. Human Movement. 2019;**20**(3):48-55

[116] Du Toit D, Van der Merwe N, Rossouw JP. Return of physical education to the curriculum: Problems and challenges facing schools in South African communities. African Journal for Physical Health Education, Recreation and Dance. 2007;**13**(3):241-253

[117] Van der Merwe N. Evaluering Van Die Herimplementering Van Liggaamlike Opvoeding in Suid-Afrikaanse Skole (Evaluation of re-Implimentation of Physical Education in South African Schools) [Thesis-PhD]. Potchefstroom: North West University (Potchefstroom Campus); 2011

[118] Van Deventer KJ. School physical education in four South African provinces: A survey. South African Journal for Research in Sport, Physical Education and Recreation. 2012;**34**(1):153-166

[119] Van Deventer KJ. Educational worth of physical education and sport participation: A review. South African Journal for Research in Sport, Physical Education and Recreation. 2014;**36**(3):183-200

[120] Bloemhoff HJ. Key principles in primary school sport programmes. African Journal for Physical Health Education, Recreation and Dance. 2008;**14**(3):282-298

[121] Van der Merwe C, Malan D, Willemse Y. The state of teacher-coaches' sport-specific training, participation and coaching experience, mentor interaction and methods of continued education in sport coaching. African Journal for Physical, Health Education, Recreation and Dance. 2015;**21**(3:1):733-743

[122] Stroebel LCE, Hay J, Bloemhoff HJ. Needs and challenges of foundation phase life skills teachers delivering physical education: Jack of all trade and master of none? South African Journal for Research in Sport, Physical Education and Recreation. 2017;**39**(3):163-177

[123] Stroebel LCE, Hay J, Bloemhoff HJ. An approach to re-skilling of in-service teachers in physical education in South African schools. South African Journal of Education. 2019;**39**(2):1-12

[124] Lombard W. Building a robust athlete in the South African high school sports system. South African Journal of Sports Medicine [Internet]. 2018;**30**(1):1-3 Available from: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1015-51632018000100009&nrm=iso

[125] SASCOC (South African Sports Confederation and Olympic Committee). Sport for Life: South African Model for Long Term Participant Development Melrose. South Africa: SASCOC; 2012. Available from: https://sascoc.co.za/wp-content/uploads/files/2011/07/SA-Sport-for-Life-Long-Term-Participant-Development.pdf

[126] Grey College. Home Page. Grey College Beurse en Lenings: Aansoeke Bloemfontein. Grey College; 2019. Bloemfontein, Free State, South Africa. Retrieved from: https://greycollegesecondary.com/beurse-bursaries-2/

Edited by Lucy-Joy Wachira

Participation in fitness and sports activities bestows far-reaching benefits on children's growth, physical and mental development, health, skill acquisition, and physical performance. Besides the typical description of common concepts, subjects, and general literature, this book presents a variety of topics associated with physical activity and fitness among children and youth. Work presented in this book ranges from complex descriptions of the role of vitamin D deficiency on children's physical activity and lifelong health to the analyses of the role of motor proficiency among children with an autism spectrum disorder. Some authors report on the association between physical activity and fitness and cognitive function among children while others describe noted differences in selected physical fitness components among children over a span of 30 years. The book also provides empirical insights into the role and status of school sports. While the feasibility and benefits of designed programmes and organized school activities have been demonstrated, the need for targeted specialized interventions and additional knowledge underpins the need for multidisciplinary and inter-sectoral approaches when working with children.

Published in London, UK

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ISBN 978-1-80356-064-9
9 781803 560649