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A Review of the Literature for a Call for Action to Improve Muscular Fitness in School-aged Students in Physical Education

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ABSTRACT

Muscular fitness (i.e., power, strength and endurance) is reported to be beneficial for children's physical, mental, and social development, encompassing a holistic approach to student wellbeing. However, modern sedentary lifestyles have led to declines in student muscular fitness and motor skills, highlighting the need to prioritize physical activities that promote muscular fitness. Education authorities often claim that their physical education curricula are contemporary and based on recent research; however, is the prescribed curricula truly reflecting this, especially in terms of reflecting the importance of student engagement in activities that promote muscular fitness and neuromuscular development? Too often, these critical aspects are overlooked or underemphasized. This paper examines the role of physical activities that enhance muscular fitness, improving neuromuscular performance, motor skills, and physical competence in school-aged students. When performed with proper technique and supervision, muscular fitness training is safe and beneficial, improving power, strength, balance, coordination, and mental wellbeing, while boosting academic focus and fostering resilience. The paper argues for integrating activities focused on muscular fitness into physical education programs, ensuring stronger, healthier school-aged students. By addressing muscular fitness and neuromuscular development as part of the physical education curriculum, schools can better support students' long-term health and wellbeing, supporting both physical health and mental wellbeing.

Key words: Pediatric Science, Learning, Plyometrics, Calisthenics, Health

INTRODUCTION

The prevalence of physical inactivity among both children and adolescents globally is a critical public health concern, with less than 20% meeting the recommended physical activity levels (Guthold et al., 2020) and according to the World Health Organization, nearly three-quarters of adolescents worldwide do not meet the recommended physical activity guidelines (i.e., 60 minutes of moderate to vigorous intensity physical activity each day) (Bull et al., 2020; Shilton et al., 2024). In Australia, children experience

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high levels of sedentary behaviour; for example, pre-teens aged 11–12 years spend an average of 11 hours per day in sedentary activities (e.g., increased screen time) (Fraysse et al., 2019). In the United States, only 21.6% of American youths meet physical activity guidelines, and more boys (26.0%) than girls (16.9%) report being physically active (Katzmarzyk et al., 2016). Furthermore, in the U.S., a large proportion (42.5%) of children aged 6 to 11 meet physical activity guidelines, but only 7.5% and 5.1% of young people aged 12 to 15 and 16 to 19, respectively (Farooq et al., 2018; Katzmarzyk et al., 2016; Troiano et al., 2008). This increase in sedentary behaviour is linked to health risks (Souilla et al., 2024), including (but not limited to) obesity and diabetes, poor mental health (Shawon et al., 2025) and hampers the development of essential motor competence for engaging in sports, outdoor activities, and general physical expression, such as jumping, throwing, climbing, and crawling (Sortwell et al., 2022). Unfortunately, advancements in technology in the last few decades, in combination with modern lifestyles characterized by excessive screen time and reliance on motorized transportation (e.g., e-scooter, e-bikes), have resulted in declining physical fitness among children and adolescents (Dahlgren et al., 2021). In contrast, previous generations maintained higher levels of physical activity and fitness due to the high physical demands of daily life (Woessner et al., 2021). Moreover, the shift from active recreation activities (e.g., active play) to sedentary recreation activities, such as video games and social media, further reduces opportunities for active play and structured exercise, probably exacerbating reported trends.

THE BENEFITS OF PHYSICAL ACTIVITY FOR K-12 STUDENTS

Engaging in sports, exercise, and active play offers numerous benefits, often described as 'sport and exercise medicine' for preventing chronic hypokinetic diseases (i.e., coronary heart disease, diabetes, obesity, and lower back pain) (Armstrong & Van Mechelen, 2023). Hence, positive attitudes towards sport, exercise and active play are fostered in the Health and Physical Education curriculum to support lifelong engagement in physical activity (Cale, 2023; Usher et al., 2016; Wallhead & Buckworth, 2004). Of note, involvement in adequate levels of physical activity during childhood and adolescence may increase the likelihood of individuals engaging in physical activity into adulthood (Alvarez-Pitti et al., 2020). Additionally, regular physical activity reduces the risk of cardiovascular conditions, improves physical fitness, and supports joint health, along with many other benefits (see Figure 1).

Unlike some pharmaceutical interventions, muscular fitness training (e.g., jump rope training) has little or no adverse side effects when performed correctly by children (even during the maturation process) (Legerlotz, 2020; Ramirez-Campillo et al., 2020). Beyond improving physical health and fitness, involvement in muscular fitness training (e.g., active play or group training activities) fosters social connections, enhances perceived energy levels, supports the development of positive self-perception (social and scholastic) and improves concentration in the classroom learning environment, contributing to better academic as well as emotional outcomes (Sortwell, O'Brien, et al., 2024). In line with the overarching rationale for Health and Physical Education in schools (Aira et al., 2021; Huotari et al., 2011; Telama et al., 2006), adherence to physical activity is crucial, as regular exercise supports physical and cognitive health, which is at risk of declining with age. However, inadequate muscle fitness (i.e., strength, power and endurance) during childhood increases the risk of insufficient neuromuscular capacity for the effective development of fundamental movement skills or motor performance skill, increasing the risk of injuries and may diminish future participation in physical activities, underscoring the importance of early intervention (Behringer et al., 2011; Park et al., 2024; Sortwell et al., 2022).

RELATIONSHIP BETWEEN PHYSICAL FITNESS, PHYSICAL ACTIVITY AND HEALTH OF K-12 STUDENTS

Currently, the importance of physical activity and exercise for improving the health and fitness of the general population is well known (American College of Sports Medicine et al., 2022). Indeed, in children and adolescents, there is a relationship between strength (evaluated in different tests) and variables that are important for physical health. For example, direct, moderate and significant relationships have been shown ($r = 0.43$ - 0.71, $p < 0.001$) between hand grip strength and bone mineral density and content in boys and girls aged 10 to 14 years (Hyde et al., 2020; Pelegrini et al., 2022). Furthermore, direct and significant relationships ($p < 0.01$) have been observed between peak knee extension and flexion torque and bone mineral content of the leg ($r = 0.80$ and 0.72, respectively), femoral neck ($r = 0.61$ and 0.56, respectively), total body ($r = 0.73$), bone cross-sectional area ($r = 0.53$ and 0.45, respectively), bone diameter ($r = 0.39$ and 0.35, respectively), lean mass ($r = 0.88$), and fat mass ($r = 0.84$) of pre-pubertal girls (Daly et al., 2008; van Langendonck et al., 2004). Likewise, quadriceps strength (knee extension), hip abduction and flexion strength have been shown to have direct, low-moderate and significant correlations ($r = 0.18$ - 0.41, $p < 0.02$) with bone mineral density and content in girls and boys (Hyde et al., 2020). Similarly, horizontal jump and medicine ball throwing have been shown to have a direct, moderate-high and significant relationship with bone mineral density ($r = 0.73$ and 0.87, respectively) in child baseball players (Barreto et al., 2021).

Relatedly, other studies have evidenced the strong benefits of physical activity on bone health. For example, a systematic review with meta-analysis, which included 22 interventions in children aged 3-18 years (Specker et al., 2015), an annual increase in bone accrual of 0.6% - 1.7% due to physical activity or an exercise intervention was identified. A systematic review of 22 studies (Mello et al., 2022) that applied physical education interventions to $n = 2{,}556$ students reported a significant increase in whole-body bone mineral content (standardized mean difference [SMD] = 1.348, confidence interval at 95% [CI95%] = 1.053 - 1.643), and density (SMD = 0.640, CI95% = 0.417 - 0.862), femoral neck content

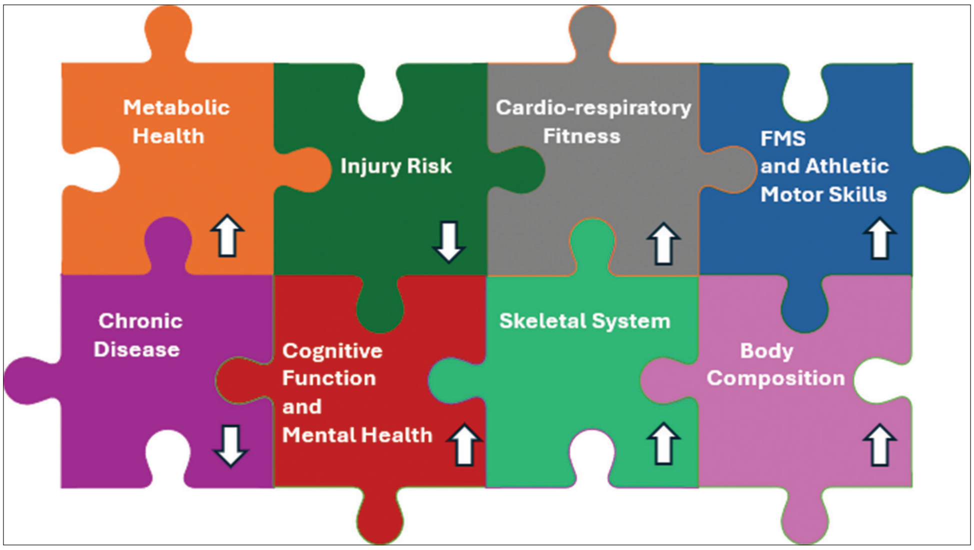

Figure 1. Piecing together benefits of muscular fitness training among school students
The upward arrow means increase, and the downward arrow means decrease; FMS = fundamental movement skills

for boys (SMD = 1.527, CI95% = 0.990 - 2.065) and girls (SMD = 1.27, CI95% = 0.782 - 1.767), femoral neck density for boys (SMD = 0.518, CI95% = 0.064 - 0.972) and girls (SMD = 0.817, 95% CI = 0.349 - 1.284), and lumbar spine content for boys (SMD = 1.860, CI95% = 1.018 - 2.700) and girls (SMD = 1.275, CI95% = 0.782 - 1.767).

Additionally, a systematic review found that minor quality-based modifications of the typical physical education program can improve the students' health-related physical fitness outcomes and fundamental motor skills, including adiposity indicators (García-Hermoso et al., 2020). This finding was recently corroborated in 12-18 years boys and girls (g = - 0.11 [CI95% = - 0.22, - 0.01], $p < 0.04$, = 32.49%), including meaningful reductions in body fat percentage (g = - 0.28 [CI95% = - 0.49, - 0.06], $p < 0.01$), particularly in programs involving ≥ 4 days per week of physical education (Rocliffe et al., 2024). Likewise, in a recent publication that attempted to describe the effects of chronic physical activity at school on the cognitive performance of children and adolescents (Mello et al., 2025), examining different types of intervention in the school environment, a significant relationship was shown between physical activity at school and changes in cognitive flexibility (g = 0.244, CI95% = 0.116 – 0.373, $p < 0.001$, = 0%); in working memory (g = 0.123, 95% CI = 0.028 – 0.219, p = 0.012, = 14%); in inhibitory control (g = 0.122, CI95% = 0.062 – 0.182, $p < 0.001$; = 3%); and in attention (g = 0.100, CI95% = 0.040 – 0.161; $p < 0.001$, = 0%). Finally, these findings are consistent with other studies where it has been shown that better measures of physical fitness related to physical activity is a good predictor of executive functions (β = 0.472; t = −6.075, $p < 0.001$), visuospatial working memory (β = 0.159, p = 0.014), information processing and control (β = 0.238, $p < 0.001$) and interference control (β = 0.156, p = 0.039), connectivity in specific directions within the cingulo-opercular network (d = 0.72), cognitive flexibility (β = 0.30 - 0.25, $p \leq 0.009$) among other variables (Fernandes et al., 2024; Haverkamp et al., 2021; Ligeza et al., 2024; Mora-Gonzalez et al., 2019).

TRENDS IN PHYSICAL FITNESS AMONG SCHOOL-AGED CHILDREN

Research indicates that contemporary children and adolescents exhibit lower physical fitness and, more specifically, muscular fitness levels than previous generations (Chaabene et al., 2024; García-Hermoso et al., 2022; Hardy et al., 2018). For example, today's youth demonstrate reduced performance in movement assessments such as pull-ups and standing long jump compared to students 30 years ago (Fraser et al., 2019). Prolonged sedentary behaviour has contributed to conditions such as exercise-deficit disorder (i.e., reduced levels of moderate-to-vigorous physical activity), inconsistent with public health recommendations among children, resulting from failing to meet the recommended 60 minutes of moderate-to-vigorous physical activity daily (Tremblay et al., 2011). Insufficient physical activity also leads to pediatric dynapenia, characterized by reduced muscular fitness and associated physical limitations (Ruas et al., 2024). This condition is particularly concerning as many children today possess weaker cardiovascular, muscular, and skeletal systems, adversely affecting their ability to perform basic movements and participate in sports. The implications of these trends are profound, as they not only hinder physical development but also contribute to long-term health issues, including obesity and cardiovascular diseases. Consequently, many children today have weaker cardiovascular, muscular, and skeletal systems, which affects their ability to perform basic movements and participate in sports.

STRATEGIES TO INCREASE MUSCULAR FITNESS

Despite these concerns in the school-aged population, it is crucial to recognize that it is never too late to introduce muscular fitness training-type activities to improve muscular fitness among primary and secondary school children. Scientific evidence supports the benefits of initiating exercise at any age (Izquierdo et al., 2021). Aiming for at least one hour of daily physical activity can yield significant improvements in health and wellbeing (Janssen & LeBlanc, 2010). Exercise encompasses more than traditional sports practice; activities like cycling, dancing, walking, and playful games such as hopscotch and climbing are equally beneficial. These activities target the neuromuscular system and thus improve power, strength, balance, and coordination in a fun and engaging manner. As reinforced by the World Health Organization's physical activity guidelines, strength-building exercises, performed two to three times per week, are advantageous for developing stronger muscles and improving overall neuromuscular performance, contributing to overall health (World Health Organization, 2020). In school physical education classes or Cognitive Activation Physical Activity Sessions (i.e., brain breaks), equipment is not a prerequisite for muscular fitness training; calisthenics, plyometric training and integrative neuromuscular training can be incorporated with movements such as push-ups, pull-ups, squats, and sit-ups, offer a versatile and effective means of improving muscular and physical fitness (Sortwell, Ramirez-Campillo, et al., 2024).

DISPELLING MYTHS ABOUT STRENGTH TRAINING FOR MUSCULAR FITNESS FOR STUDENTS AND PARENTS

Strength training (or resistance training) is one of the effective methods to improve muscular fitness, and concerns about potential harm to growing bones (i.e., stunted growth) and the risk of muscle bulk have been debunked by scientific research long time ago (Sadres et al., 2001). Indeed, strength training or activities that improve muscular fitness are safe and beneficial for children and adolescents when performed with proper technique and supervision (Dahab & McCambridge, 2009). Moreover, the American College of Sports Medicine recommends that children and adolescents performing resistance training ≥3 weekly sessions, with intensities using body weight or 8-15 submaximal repetitions, with moderate fatigue with good mechanical form, as part of ≥ 60 min of exercise per day (American College of Sports Medicine et al., 2022). Strength training enhances motor and sports performance skills and builds a foundation of strength and neuromuscular architecture that supports lifelong physical activity (Akbar et al., 2022; Grainger et al., 2020). Importantly, children as young as seven years old experience rapid development of their neuromuscular systems (Casamento-Moran et al., 2018; Tumkur Anil Kumar et al., 2021; Viru et al., 1998). This period presents a crucial opportunity to introduce activities that aim at improving muscular fitness, which in turn can also enhance fundamental movement skills—such as running, jumping, and throwing—and improve motor performance and support athletic development (see Figure 2). These activities performed at a young age lay a strong foundation for future competence in physical activities and sport-specific skills performance, fostering greater confidence and participation in physical activities throughout life (Suchomel et al., 2016).

Students in schools who are given the opportunity to engage in well-structured muscular fitness programs (e.g., resistance training, calisthenics, integrative neuromuscular development, jump training), supervised by a teacher with appropriate training are less likely to sustain injuries and get maximal benefits compared to unsupervised activities (Faigenbaum & Myer, 2010). Muscular fitness training (e.g., using jump exercises – jumping, hopping, bounding) also provides valuable skill development for activities requiring physical competence, such as gymnastics, climbing, and skating (Akbar et al., 2022) and helps children build a robust physical framework and strength reserve that supports overall health, resilience, and sport performance and contributes to long-term fitness (Lloyd & Oliver, 2012). This structured approach is crucial, as it mitigates the risks associated with unsupervised exercise, ensuring that children learn proper techniques and safety measures. Furthermore, muscular fitness training aids in developing discipline, focus, and a positive attitude toward exercise (Vasudevan & Ford, 2022). These factors can contribute to sustained engagement in physical activity and improved health outcomes into adulthood.

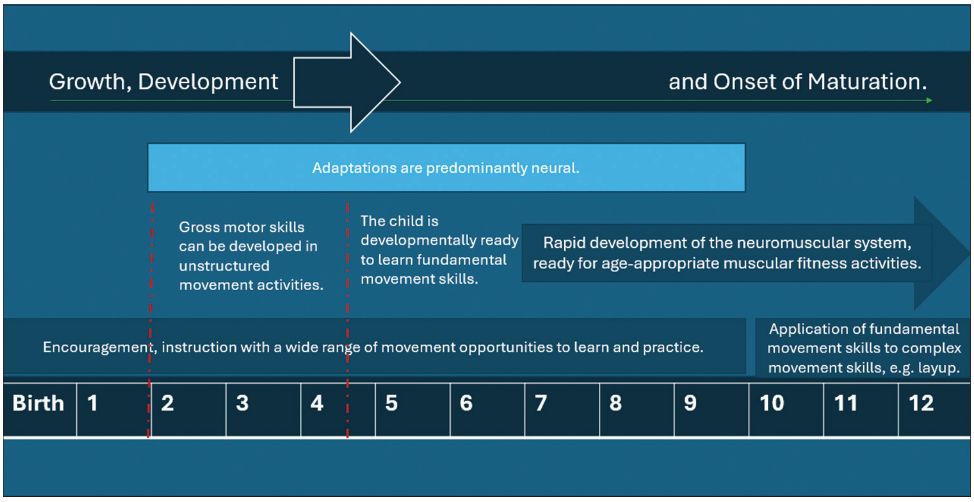

Figure 2. Biological maturation, optimal development of movement skills

CONCLUSION

Physical activity is indispensable for maintaining healthy bodies and minds, especially during the developmental stages of childhood and adolescence. A lack of regular movement and even correctly prescribed physical activities, such as a lack of muscular fitness-building activities, poses significant risks to health and wellbeing. Developing muscular fitness in schools should be a priority, given the physical, cognitive, and emotional benefits associated with these practices. Including structured muscle-strengthening activities in physical education curricula can play a crucial role in promoting health and improving students' motor performance. Incorporating various forms of exercise, including training focused on improving muscular fitness, can mitigate these risks and establish habits that promote lifelong fitness. Despite the growing recognition of the importance of physical activity, many programs still predominantly emphasize aerobic exercise, neglecting the development of strength and motor coordination. Implementing well-structured programs can provide significant benefits, such as increased strength, endurance, and coordination, in addition to contributing to the formation of lifelong healthy habits. These programs are also essential for the development of fundamental motor skills and participation in sports and everyday physical activities. Moreover, these activities support physical development and enhance social, emotional, and cognitive outcomes. However, education authorities need to explore the robust research evidence surrounding the benefits of activities promoting muscular fitness and carefully consider how these align with curriculum outcomes. While physical education programs are often designed to be contemporary, many still overlook the crucial role of muscular fitness in promoting overall health and development. By incorporating evidence-based practices into school curricula, educators can ensure that students engage in well-rounded physical activity, including those targeting muscular fitness, supporting immediate and long-term health benefits. As such, providing students with and encouraging them to engage in regular, diverse forms of physical activity is crucial.

Children and young people can develop their muscular capacities safely when guided by trained professionals, reducing the likelihood of injuries and encouraging the adoption of a more active and healthier lifestyle. In this context, it is essential that educational policies encourage a balanced approach to physical education, including structured resistance and neuromuscular training. To this end, schools must ensure that their teachers are prepared to implement such activities safely and effectively, promoting an environment conducive to the integral physical development of students. Therefore, muscular fitness must be recognized as an essential component of student education. To ensure that children and adolescents develop a solid physical foundation, it is necessary that muscular training programs are integrated consistently and safely into school physical education curricula. This change will help combat the increasing rates of sedentary lifestyles and strengthen students' physical and mental wellbeing, preparing them for a healthier and more active life.

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