Chapter

Promoting Cardiorespiratory Fitness in Young People: The Importance of the School Context

Miguel Peralta, Sandra Martins, Duarte Henriques-Neto, Riki Tesler and Adilson Marques

Abstract

The ability to deliver oxygen to the skeletal muscles and use it to generate energy to support muscle activity is known as cardiorespiratory fitness (CRF). Because of its importance to health, young people's declining CRF is a cause of concern. Therefore, promoting CRF through physical activity (PA) participation is needed. Among young people, the school setting has been proposed as a privileged context to promote PA and CRF, and school-based PA interventions are known to improve PA and CRF. Nevertheless, school-based PA interventions are not universal and may not be sustainable over long periods if the mobilized resources are not sustained. There is a need to promote sustainable health promotion actions to maintain their benefits beyond the initial stage of implementation and deliver within the limits of the available resources. One way of doing so is through physical education (PE). PE is part of the curriculum in most countries, allows children and adolescents to engage in PA, and is supervised by trained PE teachers. The school is a privileged context for health promotion actions through its regular implementation across most education years. This chapter advocates PE as a privileged setting for promoting PA and CRF.

Keywords: adolescent, children, health, physical activity, physical education

1. Introduction

The terms physical activity (PA), exercise and physical fitness are often used interchangeably since they are closely related. However, they do not represent the same construct. This distinction is of importance as throughout the text, these terms will be used often. Thus, it is perhaps best to start by defining each one. PA can be defined as any body movement produced by the skeletal muscle that results in energy expenditure [1]. PA represents a full range of intensities, including light intensity PA (<3 metabolic equivalents of task), moderate-intensity PA (≥3 and < 6 metabolic equivalents of task) and vigorous-intensity PA (≥6 metabolic equivalents of task) [2]. On the other hand, exercise is a normally planned and structured subcategory of PA.

It requires repetitive body movements to maintain or improve one or more components of physical fitness [1]. Lastly, physical fitness is a multi-component construct that can be understood as a set of attributes an individual has or can achieve. From a broader perspective, physical fitness is a physiologic attribute representing an individual's capacity to perform muscle-powered activities [3]. Physical fitness can be divided into health-related and skill-related components. Health-related physical fitness includes cardiorespiratory fitness (CRF), muscular strength, muscular endurance, muscular flexibility, and body composition [1]. Independently of physical activity, health-related physical fitness is linked to a lower prevalence of chronic disease and has a strong relationship with health and wellness [3].

The most studied health-related component of physical fitness is the CRF. CRF relates to the capacity of the circulatory and respiratory systems to supply oxygen to muscles during a sustained physical effort, that is, reflects the capacity of the respiratory and cardiovascular systems to bear prolonged exercise [4]. Even though a large part of the variability of CRF, up to half, is biologically and genetically determined [5], hereditability is not the only determinant of CRF. Socio-environmental factors and PA, particularly exercise, also influence CRF to a large extent [6].

Childhood and adolescence are crucial periods of life marked by several morphological, physiological, psychological, and behavioural changes. Sex and maturity are two determinants of CRF that shape its improvement at these ages. It is widely known that boys' CRF is higher than girls', from late childhood onward. This difference increases throughout adolescence, reaching about a 40% gap in post-pubertal 18-year-old boys. This difference is greatly explained by boys' marked increase in fat-free mass (about 90% increase between 11 and 16 years old, compared to a 40% increase in girls) driven by maturation [7]. Besides sex, maturity status is also an important determinant of CRF, as the growth and development processes are not linear and do not happen simultaneously in young people, between and within each sex.

Although CRF is mostly dependent on genetics, sex, and maturation, other environmental and behavioural factors are also important for aerobic capacities, such as weight status, sleep, nutrition or PA levels. Among those factors, PA has the greatest impact on CRF. Engaging in PA and exercise activates almost all biological systems to support the muscle contraction and energy production [8]. In response to PA, the cardiovascular and respiratory systems increase oxygen availability for energy production in the muscle; when regularly stimulated, muscles improve their ability to function optimally. Therefore, PA is considered the primary means of promoting CRF [6]. Within PA, exercise seems to contribute the most to improvements in CRF, mainly because of the higher activity intensity and regularity of practice. Engaging in regular moderate-to-vigorous, especially vigorous, PA is most beneficial for improving CRF [9]. Also, previous investigations have demonstrated that children and adolescents participating in organised sports have better CRF than their non-participating peers and that appropriate exercise training is known to increase CRF levels in youth, irrespective of sex, age or maturity [10, 11]. More specifically, programmes to benefit CRF usually involve 20–45-minute sessions of continuous moderate-to-vigorous or vigorous-intensity training or high-intensity interval training over at least 2 to 3 months [10, 12].

PA, exercise and physical fitness are the related concepts that warrant differential interpretations. Furthermore, PA, especially higher intensity, exercise and CRF are positively associated. Because of that, better CRF performances can be seen as a marker of PA levels, total amount or volume essentially of higher intensities, with evidence highlighting vigorous activities. Therefore, from a monitoring perspective,

CRF provides a robust measure and stable reflection of recent and past PA levels and indicates biological system functioning [6].

2. Cardiorespiratory fitness and health

The health benefit evidence of PA and fitness, namely CRF, in children and adolescents is undisputable. For that reason, promoting PA and healthy lifestyles has become a priority for education and health authorities worldwide [13]. Among young people, engaging in PA and having better physical fitness are beneficial for several health outcomes, such as obesity, cardiometabolic health, bone health and mental health, as well as for pro-social behaviour, sleep, and cognitive outcomes [2]. Promoting PA has been consistently shown to be an effective strategy to improve health in general and is considered as a 'best buy' in health promotion [14].

In youth, regular PA is positively associated with beneficial cardiometabolic health outcomes, including improved blood pressure, lipid profile, glucose control, insulin sensitivity and bone health, while being inversely associated with overweight and obesity [2]. Furthermore, the benefits of PA seem to be greater with increasing intensity. For example, children and adolescents who engage in higher levels of PA have lower resting blood pressure and triglyceride concentration [15] and more favourable indicators of arterial stiffness [16]. Also, recent evidence reinforces the idea that PA, especially when participating in 30–60 minutes of moderate-to-vigorous PA for three or more days per week, improves CRF and musculoskeletal fitness in children and adolescents [3]. Besides physical health, the promotion of mental health and the development and maintenance of cognitive function are essential across the entire lifespan. Scientific evidence has shown that PA has positive effects on overall mental health and health-related quality of life [3, 17], and the prevention or treatment of depression and anxiety [18]. Furthermore, PA has positive effects on cognitive function and academic outcomes [19, 20].

Several hypotheses have been proposed regarding the underlying mechanisms responsible for the effects of PA on mental health. On a physiological level, PA may promote mental health by releasing endorphins and neurogenesis [21, 22]. On a psychological level, PA is associated with several aspects related to mental health, such as positive relationships with others, social learning, making new friends and self-esteem [22, 23].

Independently of PA, CRF is a well-known indicator of young peoples' current and future health [24], which is associated with cardiovascular health, cholesterol and blood lipids levels, obesity and mental health [25, 26]. **Figure 1** summarises the associations between CRF and health in youth.

Children and adolescents with greater CRF levels have healthier cardiovascular and metabolic profiles [25]. Furthermore, CRF is inversely associated with total adiposity, and having high levels of CRF can counteract the harmful consequences attributed to having a higher inflammatory profile [25, 26]. Therefore, CRF is related to the clustering of cardiometabolic risk factors and is an important marker of health [27]. CRF is also associated with mental health in youth. CRF is related to greater global grey and white matter, brain volume and anterior hippocampal functional connectivity [28]. This is of importance and may explain why, among adolescents, higher CRF is related to better academic performance [20].

Although the adverse effects of non-communicable diseases are mainly manifested in adults and older adults, it is evident that the development of these conditions

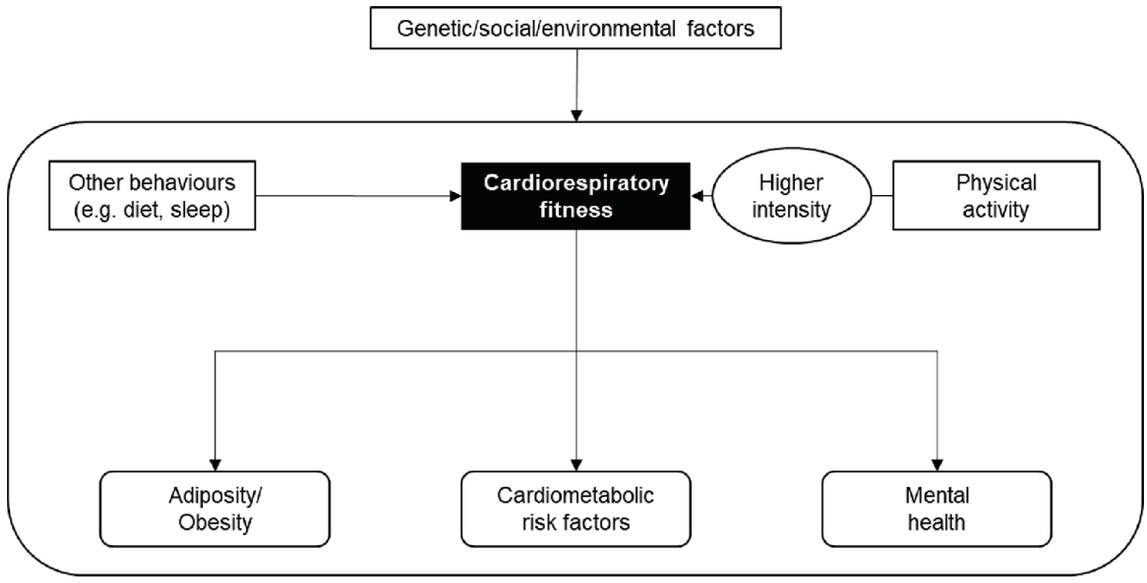

Figure 1.
Associations between cardiorespiratory fitness and several health outcomes in children and adolescents (adapted from [25]).

may start much earlier in life. Additionally, it is known that CRF moderately tracks from childhood to adolescence and from adolescence to adulthood [29]. Therefore, it seems reasonable to conclude that promoting PA and physical fitness, including CRF, in young people is essential to nurture healthy lifestyles that may help to prevent present and future non-communicable diseases and take the right steps to a healthier population.

PA is an important health behaviour [2], and CRF is a powerful marker of health [25], so PA should be part of our daily routine. Considering this evidence, the World Health Organization (WHO) recommends children and adolescents aged 5–17 years old engage in at least 60 minutes of daily moderate-to-vigorous PA to achieve the health benefits [2]. It is further recommended that most of the daily PA be aerobic and that muscle-strengthening activities should be performed at least three times per week [2]. Also, considering the health benefit of greater CRF, several specialists have stressed the importance of improving and promoting CRF in children and adolescents [6, 25, 26].

3. What are the current cardiorespiratory fitness levels?

Despite the health benefits summarised previously, PA and CRF levels among young people are low and declining globally. Using a pooled analysis of cross-sectional survey data from 146 countries, recent evidence suggests that 81% of children and adolescents aged 11–17 do not meet the current recommendations for daily PA [30]. It was further observed that more girls than boys were insufficiently active in 2016, respectively 84.7% and 77.6%. Similarly, the global matrix 3.0 PA report card project, which graded evidence to harmonise available data from 49 countries worldwide, has suggested that children and adolescents have low compliance with the WHO PA guidelines, and only 27–33% (grade D) met the PA recommendations [31].

In adults, insufficient PA has been identified as one of the leading risk factors for premature mortality and disease burden [32]. Thus, the low PA levels in children and

adolescents are alarming as they are associated with lower physical activity levels later in life [33] and might be one of the causes for the declining trend observed in CRF worldwide in this population [34]. In a trend analysis from 1981 to 2014, Tomkinson et al. [34] verified a moderate decline in young people's CRF living in 19 high-income and upper-middle-income countries between these years (−7.3% change). Furthermore, a substantial decline since 1981 was observed, which has slowed and stabilised internationally since 2000.

Given the health benefits of being physically active and fit worldwide, there is a concerning declining trend in both PA and CRF. Exactly because of that, the WHO has declared that one of their global health initiatives is to increase the populations' PA levels and reduce by 10% the prevalence of insufficient PA by 2025 [35]. Therefore, there is an imperative need to develop strategies for the promotion of PA and CRF at the population level that are effective and sustainable.

4. The role of school in promoting cardiorespiratory fitness

Promoting PA and healthy lifestyles has become a priority for public health authorities worldwide [13]. There are several contexts to consider when developing PA and fitness promotion strategies among children and adolescents, including organised sports participation, active commuting, unstructured leisure time and school [13, 36].

School is considered an important setting for health promotion among children and adolescents, and PA and CRF are no exception [36]. It is recognised that the single most important channel to address physical inactivity in youth is through school [35, 37]. Comprehensive whole-of-school approaches represent an effective strategy to address young people's physical inactivity levels [38]. The role of the school extends to encouraging children and adolescents to continue engaging in PA by providing coordinated opportunities for all young people and developing partnerships with the wider community, in the both health and sports sectors, to extend and improve the opportunities available for students to remain physically active [39].

Several reasons contribute to the proclamation of schools as a priority setting for promoting PA and fitness. In the first place, schools provide opportunities for children and adolescents to engage in PA during discrete periods of the day, including PE, recess, school sports programmes and other extra-curricular programmes. This is especially important when considering youth from disadvantaged settings who have less access to PA [40]. Secondly, many children and adolescents spend a great part of the day at school. School-based interventions are the most universally applicable and effective way to counteract low PA and fitness since children and adolescents spend at least half of their waking hours in this setting [39]. Lastly, school is mandatory for children and adolescents in most countries worldwide. Thus, its programmes reach many young people [40].

There is considerable evidence from middle- and high-income countries that school-based health interventions moderately promote PA and CRF [41]. Thus, from a health promotion perspective, the school has been proposed as an important setting to promote PA and CRF. However, there is a gap between demonstrating the effectiveness of such PA interventions and understanding the wide-scale implementation and/or dissemination of these interventions [39]. Furthermore, these interventions are not universal and may not be sustainable over long periods if senior leaders and staff that are knowledgeable, skilled and motivated to continue delivering health promotion

through ever-changing circumstances are not retained [42]. The implementation of effective school-based models into the real world setting is complex. It demands a multi-partner investment over the long term. Ecological approaches that integrate existing resources and institutions in the community are likely key to successful and sustained implementation [39]. Therefore, there is a need to promote sustainable health promotion actions that can maintain their benefits for communities and populations beyond their initial implementation stage and deliver within the limits of finances. One possibility for such action is through PE, which is already within the scope and budget of schools.

5. Physical education as an important setting to promote cardiorespiratory fitness

The importance of PE to promote health is widely recognised, as PE is by far the most common method of promoting PA during the school day [40]. PE, part of the school curriculum in most countries, allows children and adolescents to engage in structured, specialist-led, and appropriate PA. Particularly through PE, the school provides an opportunity for youth to be physically active and promote healthy lifestyles. In line with promoting health-enhancing PA, schools and PE are also important for promoting physical fitness. When performed appropriately and incorporated as one component of a broad and holistic health education programme, fitness monitoring in PE is a valuable part of the curriculum. It supports healthy lifestyles and PA [43].

One of the reasons why PE comprises a primacy setting for health promotion is throughout formative development, which can influence positive attitudes and behaviours of young people during compulsory school attendance years [39]. PE makes a unique contribution to health education through the development of physical and health literacy, where students are prompt to develop the necessary skills to make healthy choices, but also through providing opportunities to engage in PA and promote fitness [37, 39]. Additionally, PE is, for the most of school curricula worldwide, the subject focused on the body's movement and physical development, helping young people to learn, respect and value their bodies and abilities [39].

PE is the only setting where all children, especially those from low socio-economic status and girls, have access to moderate-to-vigorous PA and learn important fundamental movement skills that may provide the foundation for a lifetime of PA [40, 43]. It has been shown that PE classes contribute to an increase in daily moderate-to-vigorous PA in children and adolescents [44, 45]. It is estimated that PE lessons increase daily moderate-to-vigorous PA in about 12.8 minutes compared to days without PE lessons [46]. Furthermore, PA opportunities in PE are often regular, mostly two to three times a week, and represent the most of school-based PA [47]. Participation in PE was determined as the single most important determinant of school-based PA recommendations of at least 500 steps per hour, at least 25% of school time spent in PA, and at least 20 minutes of moderate-to-vigorous PA [47]. This is especially important when considering the promotion of fitness as regular higher-intensity PA is critical for improving it [6]. Due to its importance PE guidelines often recommend that at least 50% of class time should be spent in moderate-to-vigorous PA [37, 48].

Another important aspect related to PA offered in PE is the structuring and appropriateness of PA delivered [43, 49]. PE is often delivered by specialists, namely

PE teachers, with adequate training and capable of providing meaningful PA [50]. It is known that PE delivered by well-trained specialists increases PA during school hours in youth [37]. Furthermore, promoting PA and fitness in PE captures more than just the intensity of PA provided during the classes. Young people are more likely to engage in activities both in-class and outside of school, when activities are perceived as inherently meaningful, interesting and enjoyable, or hold personal relevance. Thus, Haerens et al. [51] argue that PE can only promote an active lifestyle if the activities provided have these characteristics. This view is supported by the self-determination theory [52] and reinforces the importance of promoting intrinsic motivation in PE. In this sense, PE teachers also have an important role in encouraging PA and fitness, as well as providing positive feedback which is associated with greater intentions to participate in PA [53].

Besides the important action of PE in promoting PA and CRF in children and adolescents, it also has an important role in monitoring and informing about students' CRF. Therefore, PE teachers have several quality tools to assess the students' CRF. Several field tests allow CRF assessment in the school setting and whole school classes to be assessed in one session. The most commonly used field-based CRF tests in the school setting are the Progressive Aerobic Cardiovascular Endurance Run (PACER), also known as the beep test or the 20-meter shuttle run, the 1-mile test and the Cooper test. Notwithstanding, fitness testing in PE, including CRF tests, should be done within a positive and health-promoting context [54]. For that it is recommended that teachers: a) provide meaningful practice opportunities so students become familiar with and develop value toward the tests, b) work with students to create personal goals toward physical fitness, and c) track individual progress across time.

6. Conclusion

CRF can be defined as the ability of the body to deliver atmosphere oxygen to the skeletal muscles and use it to generate energy to support muscle activity during exercise. CRF is associated with present and future cardiometabolic health, an important health marker [24]. Although up to half of the CRF is hereditable, participation in PA has still been considered the primary means of improving fitness [6]. Despite its associations with health, recent evidence has shown a substantial decline in CRF since 1981 in upper-middle- and high-income countries [34], which is a cause of concern.

The school has been proposed as an important setting to promote PA and CRF. School-based PA interventions are the effective strategies to promote children's and adolescents' PA levels and CRF [36]. However, these interventions are not universal and may not be sustainable over long periods if senior leaders and staff that are knowledgeable, skilled and motivated to continue delivering health promotion through ever-changing circumstances are not retained [42]. Therefore, there is a need to promote sustainable health promotion actions that can maintain their benefits beyond the initial stage of implementation and deliver within the limits of the available resources.

Within the school activities, PE, which is part of the school curriculum in most countries, allows children and adolescents to engage in structured and appropriate PA [43]. Thus, school is a privileged context for health promotion actions through its regular implementation across most education years.

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