ORIGINAL SCIENTIFIC PAPER

The influence of a specific high intensity circuit training during physical education classes in children's physical activity and body composition markers

Daniel A Marinho[1,2], Henrique P Neiva[1,2], Luis Marques[1], Vitor P Lopes[2,3], Jorge E Morais[2,3]

Affiliations: [1]University of Beira Interior, Covilhã, Portugal, [2]Research Centre in Sports, Health and Human Development (CIDESD), Covilhã, Portugal, [3]Instituto Politécnico de Bragança, Bragança, Portugal

Correspondence: Jorge E Morais, Department of Sport Sciences, Instituto Politécnico de Bragança, Campus Sta. Apolónia, Apartado 1101, 5301-856, Bragança, Portugal. Email: morais.jorgestrela@gmail.com

Abstract

Physical activity plays a paramount role on children growth and schools emerged as a key setting for promoting physical activity during childhood. The aim of this study was to verify the effects of a high intensity circuit training performed during regular physical education classes at schools. One hundred and five children aged 11–14 years (71 boys and 34 girls) were evaluated. The participants were split into a control group (boys: N = 47; girls: N = 16) and an experimental group (boys: N = 24; girls: N = 18). Besides the normal physical education classes, the experimental group also performed a high intensity circuit training for eight weeks, twice a week, at the beginning of the lesson. A pre- post-test was performed. Cardiorespiratory (20 m shuttle run test) and a set of strength variables were evaluated. Percentage of fat mass was used as a somatic indicator. The 20 m shuttle run test presented a significant time effect, but not a time X sex, time X group, and time X weight status interactions. Conversely, the strength variables presented a significant time X group interaction (significant differences between groups). Percentage of fat mass presented a significant time effect, but not a significant time X group interaction. Data showed that adding a high intensity circuit training to physical education classes would result in a significant increase in muscular fitness performance in children, but cardiorespiratory fitness may not present the same magnitude of improvement. High intensity circuit training programs (performed during regular physical education classes at schools) seem to present a positive and significant effect in physical fitness parameters as well as reducing the percentage of fat mass.

Keywords: *children, physical activity, extra-school programs, strength, fitness*

@MJSSMontenegro
HIGH INTENSTY TRAINING IN PHYSICAL EDUCATION CLASSES
http://mjssm.me/?sekcija=article&artid=239

Cite this article: Marinho D.A., Neiva H.P., Marques L., Lopes V.P., & Morais J.E. (2022). The influence of a specific high intensity circuit training during physical education classes in children's physical activity and body composition markers. *Montenegrin Journal of Sports Science and Medicine*, 11 (2), 29–36. https://doi.org/10.26773/mjssm.220904

Received: 02 April 2022 | Accepted after revision: 06 June 2022 | Early access publication date: 01 July 2022 | Final publication date: 1 September 2022

Conflict of interest: None declared.

Introduction

It is worldwide known that physical activity plays a paramount role on children growth (García-Hermoso et al., 2020). The level of physical activity presents a strong relationship with the development of motor skills (Loprinzi et al., 2015). Literature has suggested that increased motor stimulation during childhood would lead to children's development of fundamental motor skills acquisition (Balaban, 2018; Loprinzi et al., 2015). Indeed, the regular physical stimulation would provide new opportunities for enhancement of motor, perceptual, cognitive, and social skills (Adolph, 2019). Moreover, physical activity during childhood contributes to health and quality of life status (Larsen et al., 2018a). For instance, it was reported that children who perform physical activity are more likely to achieve musculoskeletal changes getting beneficial consequences for long-term osteogenic health (Larsen et al., 2018a,b). Therefore, it is recognized that physical activity in children plays a key-role on promoting long-term healthy lifestyle habits and preventing diseases (Donnelly et al., 2016).

Curiously, and despite all motor skills and health benefits, it seems that physical activity among children and adolescents have been declining or considered insufficient worldwide (Guthold et al., 2020). Moreover, it has been estimated that most of school-aged children and youth worldwide do not reach recommendations, specifically regarding the minimum of 60 minutes of moderate to vigorous physical activity per day (Sallis et al., 2016). This decline in physical activity values were believed to happen mostly during adolescence, however, studies found that it starts in early ages (Basterfield et al., 2011). The most known causes that could explain this phenomenon may be related to environmental context and resources and social influences (Sember et al., 2018). For instance, there are evidence suggesting that parental encouragement may affect the patterns of physical activity in children (Bradley et al., 2011). Moreover, it seems that transition into adolescence seems especially relevant among rural children, girls and those who are overweight or obese (Corder et al., 2015). In this context, schools (specifically physical education classes) emerged as a key setting for promoting physical activity during childhood (García-Hermoso et al., 2020; Sember et al., 2018).

Indeed, children are exposed to vigorous physical activity mainly in school-based classes (Drummy et al., 2016). Therefore, physical education classes at school can be seen and used to promote health-related and an active lifestyle by ensuring moderate to vigorous activities or exercises (Delgado-Floody et al., 2019). A wide range of interventions have been developed to increase quality and quantity of physical activity interventions in children at school (Larsen et al., 2018a,b). For instance, different cardiorespiratory and/or resistance training strategies (e.g., bodyweight exercises, suspension training, plyometric training, small-sided games, circuit training) implemented during physical education classes in children aged 8–10 years caused favorable training responses on muscular fitness, cardiorespiratory fitness, body composition, motor performance skills, mental health, well-being, and even motivation for physical activity (Larsen et al., 2018a,b). Specifically, it was shown that high intensity training programs (with low volume intervention) promoted meaningful improvements in variables related to cardiometabolic risk, namely triglycerides and waist circumference, in 14 years children (Weston et al., 2016). Moreover, restrictions or the impossibility of attending school (such as the COVID-19 pandemic), promote a meaningful decline on children's physical activity (Yomoda & Kurita, 2021). Thus, it seems that school environment may be considered of paramount importance for maintaining children's levels of physical activity.

However, most of the times, the requirements of the school curriculum do not allow increasing frequency or duration of physical educations classes. Thus, additional strategies should be studied to understand the most effective way to increase youths' levels of physical activity in children. Although several high intensity interval trainings were assessed before (Larsen et al., 2018a,b), it is not known if this type of activity can be effective to improve children and youth health and physical fitness, implemented in short sessions, during physical education classes. Therefore, the aim of this study was to verify the effects of a high intensity circuit training (HICT) performed during regular physical education classes at schools. It was hypothesized that the HICT would promote positive and significant effects in physical fitness parameters (i.e., cardiorespiratory fitness and strength) as well as in reducing health-related parameters (i.e., % of fat mass).

Methods

Participants

One hundred and five children aged 11–14 years old (71 boys: 11.63 ± 0.90 years; and 34 girls: 11.50 ± 0.61 years) were evaluated. The participants were split into two groups: (1) control group (CG: 47 boys and 16 girls with 11.64 ± 0.87 and 11.69 ± 0.70 years, respectively); (2) experimental group (EG: 24 boys and 18 girls with 11.63 ± 0.97 and 11.33 ± 0.49 years, respectively). Parents or guardians signed an informed consent form. All procedures were in accordance with the Declaration of Helsinki regarding human research, and the University Ethics Board approved the research design.

Design and Procedures

Based on the school's guidelines, a typical physical education class was lectured twice per week with a 60 minute duration. Within this physical education class, the EG also performed a HICT during the initial 20 minutes of the class for eight weeks. Thus, the EG performed the HICT during 20 minutes and the typical physical education class in the remaining 40 minutes. The CG performed a typical physical education class during 60 minutes. The HICT program's are commonly used by teachers in their physical education classes and coaches in many sports (Alves et al., 2021; Klika & Jordan, 2013). This typically includes exercises using body weight which are executed in a circuit fashion-way aiming to enhance neuromuscular structure and function (Engel et al., 2019). Table 1 shows the exercises included in the additional HICT program (EG), purpose, time of exercise and time of rest between drills. Ten exercises were included and performed twice by each participant, making a total of 20 minutes of exercise. Participants (both CG and EG groups) were instructed not to participate in any other physical activity besides the ones implemented in their school.

Fat mass (FAT, in %) was measured by bioimpedance with body composition digital scale (Omron BF511, Japan). The same instrument was also used to measure body mass (BM, in kg). The height (H, in cm) was measured as the distance be-

 DOI 10.26773/mjssm.220904

Table 1. Exercises included in the high intensity circuit training (HICT) program, purpose, time of execution and rest.

		Exercise and rest time		
Exercise description	Purpose	Week 1 – 2	Week 3 – 5	Week 6 – 8
Jump to box	Lower-limbs strength			
Chest press	Upper-limbs strength			
Squat clean press	Lower-limbs and abdominal strength			
Jefferson curls	Lower-limbs flexibility			
Jumping jacks	Aerobic	30 s drill – 30 s rest	40 s drill – 20 s rest	45 s drill – 15 s rest
In and out squat	Lower-limbs strength			
Mountain climbers	Upper-limbs and abdominal strength			
Sit ups	Abdominal strength			
Shoulder rotation	Upper-limbs flexibility			
Side shuffle	Aerobic			

tween the vertex to the floor with a digital stadiometer (SECA, 213, Germany). The body mass index (BMI, in $kg \cdot m^{-2}$) was calculated as BMI = body mass / height^2. Age- and sex-specific cut-offs suggested by the International Obesity Task Force (IOTF) were used to classify weight status (Cole et al., 2007).

Physical fitness was assessed with two main components from the Fitnessgram test battery (Plowman & Meredith, 2013), specifically cardiorespiratory fitness and strength. The 20 m shuttle run test (20 m SRT, in number of laps) was used to assess the cardiorespiratory fitness. This is a non-invasive test that presents a strong relationship with maximal oxygen uptake ($VO_{2máx}$) and it can be applied in children with different weight status (Nevill et al., 2020). It is characterized by running between two lines set 20 m apart at a pace dictated by a sound beep emitting tones at appropriate intervals. Velocity was 8.5 $km \cdot h^{-1}$ for the first minute, and it was increased by 0.5 $km \cdot h^{-1}$ every minute thereafter as reported elsewhere (Nevill et al., 2020). The test scores achieved by the participant was the number of shuttles (20 m) completed before the subject either withdrew voluntarily from the test or failed to be within 3 meters of the end lines on two consecutive tones (Paradisis et al., 2014).

Strength assessment included: (i) curl-up (CU, in number of repetitions); ii) push-up (PU, in number of repetitions); (iii) standing long jump (SLJ, in cm), and; (iv) vertical jump (VJ, in cm). For the CU, the participants were instructed to lay on their back, knees bent at approximately 140 degrees, feet flat on the floor, legs slightly apart, arms straight and parallel to the trunk with palms of hands resting on the mat. With the heels in contact with the mat, he/she curls up, then curls back down until their head touches the mat. Movement was controlled by a sound system at the cadence of 20 curl-ups per minute (1 curl-up every 3 seconds). The test finishes until he/she reached exhaustion or 75 curls (Plowman & Meredith, 2013). For the PU, participants were asked to touch with hands and toes on the floor, the body and legs in a straight line, feet slightly apart, the arms at shoulder width apart, extended and at a right angle to the body (Plowman & Meredith, 2013). Boys performed the PU by keeping the back and knees straight, he/she lowers the body until there is a 90º angle at the elbows, with the upper arms parallel to the floor. Girls performed the PU as boys but with knees standing on the ground. The push-up movement was controlled as described previously (cadence of 20 reps per minute). The test finishes until he/she can do no more in such rhythm, has not done the last three in rhythm, or has reached the target number of push-ups (Plowman & Meredith, 2013).

The SLJ test consists of reaching the maximum distance in length, aiming to assess the explosive strength of the lower limbs. The students were asked to stand behind a line that marks the starting point with both feet shoulder-width apart. Starting from standing position, in continuous movement, the students were instructed to flex the knees, pull the arms back and jump in length as far as possible, landing with both feet parallel. The evaluator should be placed across the jump zone and record distance (measuring tape, RossCraft, Canada). Distances are measured from the starting point to the heel. Two trials were attempted, and the best value was recorded (Plowman & Meredith, 2013). The VJ was analyzed as the highest distance in height. Students were instructed to stand on a contact mat (Ergojump Digitime 1000, Digitest, Jyvaskyla, Finland), with both feet shoulder-width apart, knee angle between 90º to 120º, both hands on the waist throughout the exercise, and afterwards to perform an explosive extension of the legs (without any countermovement) (Acero et al., 2011). Two repetitions were performed, and the best trial was selected for further analysis.

Statistical analyses

Normality, and homoscedasticity assumptions were tested beforehand with the Kolmogorov-Smirnov, and Levene tests, respectively. The mean plus one standard deviation, and the relative difference (Δ, in %) were calculated as descriptive statistics. Cohen's d was selected as standardized effect size, and interpreted as: (i) small effect size $0 \leq |d| \leq 0.2$; (ii) medium effect size if $0.2 < |d| \leq 0.5$ and; (iii) large effect size if $|d| > 0.5$ (Cohen, 1988).

Hierarchical linear modeling (HLM) was used to test when there was significant changes between pre and post-test and when these changes were significant different between boys and girls and between experimental and control group Maximum likelihood estimation was calculated with HLM7 software.

Results

Figure 1 and Table 2 present the descriptive data and the relative difference and effect size comparison for each group (i.e., control – CG, and experimental – EG) by sex, respectively. Overall, the participants in the EG (boys and girls) showed an improvement in all variables related to physical fitness. Boys presented the highest improvement in the CU test, and girls in the PU test. The % FAT and BMI presented a large decrease in both sexes (i.e., improvement) (Table 2).

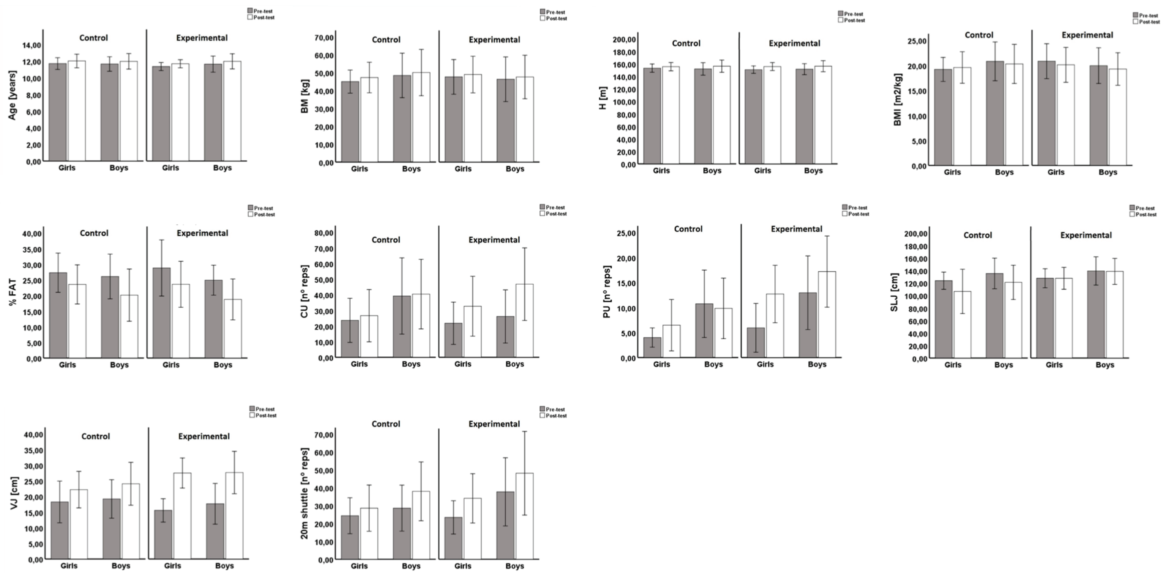

Figure 1. Descriptive statistics (mean ± one standard deviation) for the control and experimental group by sex.

Table 2. Effect size comparison for the control and experimental group by sex.

	Control group		Experimental group	
	Boys (N = 47)	Girls (N = 16)	Boys (N = 24)	Girls (N = 18)
	Δ (d)	Δ (d)	Δ (d)	Δ (d)
Age [years]	2.75 (0.36)	2.65 (0.41)	2.84 (0.35)	3.00 (0.69)
BM [kg]	3.32 (0.13)	5.11 (0.30)	2.65 (0.10)	2.79 (0.13)
% FAT [%]	-22.66 (0.76)	-13.57 (0.59)	-24.96 (1.09)	-18.15 (0.64)
H [cm]	2.88 (0.44)	1.51 (0.35)	3.16 (0.54)	3.24 (0.79)
BMI [kg·m^{-1}]	-2.50 (0.13)	1.93 (0.13)	-3.41 (0.20)	-3.54 (0.21)
CU [nº of reps]	3.03 (0.05)	12.70 (0.19)	79.07 (1.01)	50.00 (0.66)
PU [nº of reps]	-8.47 (0.14)	61.60 (0.58)	32.58 (0.48)	118.89 (1.23)
SLJ [cm]	-8.40 (0.47)	-9.35 (0.58)	-0.54 (0.03)	-0.08 (0.01)
VJ [cm]	25.25 (0.74)	21.59 (0.63)	56.59 (1.50)	76.74 (2.76)
20 m shuttle [nº of reps]	32.77 (0.63)	17.43 (0.37)	27.60 (0.49)	45.52 (0.91)

BM – body mass; % FAT – percentage of fat mass; H – height; BMI – body mass index; CU – curl up's; PU – push-up's; SLJ – standing long jump; VJ – vertical jump; Δ – relative difference in %; d – Cohen's d (effect size index).

Participants in the CG presented mixed findings. For boys, the highest improvement was observed in the 20 m shuttle. However, a small decrease was observed in the PU, and a large decrease in the SLJ. Girls presented the highest and large improvement in the PU. As well boys, girls also presented a large decrease in the SLJ. Both sexes presented a large decrease (i.e., improvement) in the % FAT, and BMI (Table 2).

Table 3 presents the variation of each physical fitness variable modelled with HLM. The 20 m shuttle run test presented a significant sex effect and weight status at baseline (pre-training). A significant time effect was also observed. A non-significant time X sex, time X group, and time X weight status interactions were observed. Conversely, the variables related to strength assessments presented a significant time X group interaction (i.e., significant differences between the CG and EG). The % FAT presented a significant time effect, but not a significant time X group interaction. (Table 3).

Table 3. Parameters estimates for fixed effects of the final model computed for each variable with standard errors (SE) and 95% confidence intervals (95CI).

Parameter	Estimate (SE)	95CI	p-value
20 m shuttle run test (nº of reps)			
Intercept (pretest)	25.72 (2.32)	21.17 to 30.27	<0.001
Sex (girls)	8.98 (2.40)	4.28 to 13.68	<0.001
Group (experimental)	6.18 (2.73)	0.83 to 11.53	0.026
Weight status (O/Ob)	-13.35 (2.33)	-17.92 to -8.78	<0.001
Time	7.12 (1.70)	3.79 to 10.45	<0.001

(continued on next page)

DOI 10.26773/mjssm.220904

(continued from previous page)

Parameter	Estimate (SE)	95CI	p-value
Time*Sex (girls)		N.S.	
Time*Group (experimental)		N.S.	
Time*Weight status (O/Ob)		N.S.	
Curl Up			
Intercept (pretest)	29.13 (3.50)	22.27 to 35.99	<0.001
Sex (girls)	10.36 (3.45)	3.60 to 17.12	0.003
Group (experimental)	-4.58 (3.80)	-12.03 to 2.87	0.015
Weight status (O/Ob)		N.S.	
Time		N.S.	
Time*Sex (girls)		N.S.	
Time*Group (experimental)	15.56 (3.06)	9.56 to 21.56	<0.001
Time*Weight status (O/Ob)		N.S.	
Push Up			
Intercept (pretest)	4.41 (0.90)	2.65 to 6.17	<0.001
Sex (girls)	6.85 (1.05)	4.79 to 8.91	<0.001
Group (experimental)		N.S.	
Weight status (O/Ob)		N.S.	
Time	3.10 (1.04)	1.06 to 5.14	0.004
Time*Sex (girls)	-3.03 (1.07)	-5.13 to -0.93	0.006
Time*Group (experimental)	4.81 (1.16)	2.54 to 7.08	<0.001
Time*Weight status (O/Ob)	-2.41 (1.07)	-4.51 to -0.31	0.027
Standing long jump			
Intercept (pretest)	128.68 (3.58)	121.66 to 135.70	<0.001
Sex (girls)	10.50 (3.68)	3.29 to 17.71	0.005
Group (experimental)		N.S.	
Weight status (O/Ob)	-12.28 (3.83)	-19.79 to -4.77	0.002
Time	-11.17 (3.79)	-18.60 to -3.74	0.004
Time*Sex (girls)		N.S.	
Time*Group (experimental)	10.89 (4.16)	2.74 to 19.04	0.010
Time*Weight status (O/Ob)		N.S.	
Vertical jump			
Intercept (pretest)	19.01 (1.27)	16.52 to 21.50	<0.001
Sex (girls)		N.S.	
Group (experimental)		N.S.	
Weight status (O/Ob)	-3.21 (1.18)	-5.52 to -0.90	0.007
Time	5.70 (1.13)	3.49 to 7.91	<0.001
Time*Sex (girls)		N.S.	
Time*Group (experimental)	6.23 (1.07)	4.13 to 8.33	<0.001
Time*Weight status (O/Ob)		N.S.	
% Fat mass			
Intercept (pretest)	24.71 (1.01)	22.73 to 26.69	<0.001
Sex (girls)	-2.54 (1.04)	-4.58 to -0.50	0.016
Group (experimental)		N.S.	
Weight status (O/Ob)	9.68 (1.04)	7.64 to 11.72	<0.001
Time	-4.40 (0.78)	-5.93 to -2.87	<0.001
Time*Sex (girls)		N.S.	
Time*Group (experimental)		N.S.	
Time*Weight status (O/Ob)		N.S.	

Notes: O/Ob = overweight/obese. N.S. – non-significant.

Discussion

The purpose of this study was to verify the effects of including a short duration HICT (for eight weeks) into the regular physical education classes at schools. A significant sex effect was verified for all variables (except for the VJ), i.e., boys presented better scores than girls. Overall, the results showed significant improvements in cardiorespiratory fitness in both groups (i.e., CG and EG). Muscular fitness (except the curl-up), and fat mass presented a similar trend. However, our hypothesis was only partially confirmed because the HICT caused significant gains (i.e., a time X group interaction) in the muscular fitness variables (curl-up, push-up, standing long jump and vertical jump) by the EG, but not in the cardiorespiratory fitness and fat mass (somatic feature).

Previous studies aimed to understand the effects of implementing high-intensity training programs in children, trying to achieve the health benefits of physical activity but in a shorter time than traditional training methods (Larsen et al., 2018a,b). The use of circuit training as a strategy for implementing high-intensity training has shown to be effective. It was found that 10 months of intense exercise, 3 x 40 min per week of small-sided ball games or circuit training decreased diastolic blood pressure and elicited cardiac adaptations, bone mineralization, jump performance and postural balance, suggesting improving cardiovascular and musculoskeletal health in 8–10 year-old children (Larsen et al., 2018a,b). Still, these training programs were time-consuming and shorter duration sessions could be implemented instead. A pioneering study examining 8–10 min of high-intensity interval training embedded within physical education class (3 times per week) for eight weeks was found to improved cardiorespiratory fitness and body composition in adolescents boys and girls aged between 15 to 16 years (Costigan et al., 2015).

Our data indicated that children of both sexes tended to significantly improve muscular fitness over time. However, those who underwent a HICT (i.e., EG) presented higher and significant improvements. This specific HICT was composed by a set of muscular, flexibility, and aerobic drills. However, most of the drills (60%) were muscular based. Literature reports that HICT's are prone to improve muscular strength in children aged 11.6 ± 0.2 years on average (Engel et al., 2019). The authors indicated that power and strength training (with similar drills as the one used by us) have a positive impact on functional strength as well as on jumping and sprinting performance in children (Engel et al., 2019). Moreover, in children aged between 10 and 12 years, Mayorga-Vega et al. (2013) also verified significant improvements in muscular strength parameters (and different drills were used) after a HICT performed for eight weeks (twice per week). Indeed, it was claimed that adaptations in neuromuscular structure and function, and improvements in intra- and inter-muscular coordination are responsible for the sharp increases in functional strength after high-intensity training (Granacher et al., 2011). In the present study, a HICT performed for eight weeks (twice per week) was enough to elicit such improvements in most of the muscular fitness variables. The exception was found in SLJ, which was maintained from pre to post-intervention in EG. Nonetheless, it should be highlighted that EG prevented SLJ values from being decreased as happened in CG.

Studies indicated that HICT can be prone on improving the cardiorespiratory fitness of children (Seo et al., 2021; Weiss et al., 2015). Indeed, our data indicate that the 20 m shuttle run test significantly improved over time for boys and girls. However, non-significant time X group interaction was observed. That is, the EG group did not improve largely over time than the CG. As aforementioned, most studies about this topic indicated that HICT (or other similar training programs) elicit cardiorespiratory fitness in children (Cvetković et al., 2018; Seo et al., 2021). Nonetheless, such studies employed the training program for more than eight weeks (i.e., this study's timeframe). For instance, Cvetković et al. (2018) employed a high intensity interval training that lasted 12 weeks, two times per week, and it was complemantary to the physical education classes. Others, employed a training program during eight months, two times per week during 45 minutes per session in addition to regular physical educations classes (Weiss et al., 2015). S Thus, one can argue that the duration of the program can be determinant to achieve positive and significant results on cardiorespiratory fitness variables. Like our results, Engel et al. (2019) also noted that cardiorespiratory fitness was not significantly enhanced after a HICT with an intervention period of four weeks. The authors claimed that the short duration of the HICT (6.0 ± 1.5min) combined with the short intervention period were the main reasoning for not eliciting sufficient stimulus to enhance cardiorespiratory fitness. On the other hand, Mayorga-Vega et al. (2013) observed a significant improvement in the cardiorespiratory fitness variable over an eight-week training but with 50-minute sessions. Therefore, one can argue that HICT's that include drills more related to functional strength are more prone to elicit muscular strength rather than cardiorespiratory fitness.

The percentage of fat mass (as a somatic marker) showed a similar trend to the 20 m shuttle run test. That is, a significant improvement over time was observed in boys and girls but not a significant time X group interaction (i.e., it was not verified larger effects by the EG in comparison to the CG). Studies that used the % of fat mass as a body composition marker based on HICT (Seo et al., 2021), high-intensity interval training or even moderate-intensity continuous training (Dias et al., 2018) indicated that all types of training programs were effective on decreasing the % of fat mass in children. Nonetheless, it was claimed that the effect of exercise training on body fat was larger whenever the amount of time performing such programs was higher (Atlantis et al., 2006). Despite non-significant differences over time between groups (i.e., EG and CG) the EG did show larger improvements in the % of fat mass (i.e., decrease over time) in comparison to CG. Additionally, the weight status indicated a significant difference in most of the variables assessed (except for the curl- and push-up). This highlights that children who are most likely to be overweighted or obese present more difficulties in performing such physical fitness drills. This can be extrapolated for daily basis tasks. Thus, extra training programs to the normal school program can play a positive and meaningful key role in schoolchildren physical fitness and overall life quality (Larsen et al., 2018a,b).

The school environment is suggested to be fundamental for interventions that support children in meeting the recommended level of physical activity (García-Hermoso et al., 2020; Sember et al., 2018). This would lead to a better quality of life regarding social, psychological, and nutritional factors (Seo et al., 2021). Therefore, the investigation tried to further understand the effects of different resistance and/or cardiorespiratory training programs to boost activity levels and reduce sedentary behavior during childhood (Larsen et al., 2018a,b).

DOI 10.26773/mjssm.220904

Most of the times, physical education classes are not enough to meet the needed quantity/intensity of physical activity. Thus, time-efficient methods must be developed as an alternative or even as complementary programs that should be applied at the school context. As suggested, our findings support this by using a short-duration 20 min HICT as a complement of physical education classes. These results showed that adding this kind of HICT to physical education classes would result in a significant increase in muscular fitness performance in children aged 11–14 years old, but not in cardiorespiratory fitness. Nonetheless, it should be highlighted that increasing the amount of time performing the HICT with the same drills could be enough to also improve cardiorespiratory fitness. As main limitation it can be considered the control of the extra physical activitiy besides the one implemented in their school. Nonetheless, parents and teachers were instructed to control and monitor this absence.

Conclusion

Main findings indicate that a HICT program performed during regular physical education classes at schools presented a positive and significant effect in physical fitness parameters, as well as reducing the % of fat mass which is a quality-of-life marker. Implementing this kind of high intensity programs complementary to the school-based program is a must for enhancing children physical fitness and hence their life quality. Future studies should rely on comparing high intensity training programs based on different drills to understand the kind of effect that each type of program/drill has on each pre-established outcome.

Acknowledgments

This work is supported by national funds (FCT - Portuguese Foundation for Science and Technology) under the project UIDB/DTP/04045/2020.

References

Acero, R. M., Fernández-del Olmo, M., Sánchez, J. A., Otero, X. L., Aguado, X., & Rodríguez, F. A. (2011). Reliability of squat and countermovement jump tests in children 6 to 8 years of age. *Pediatric Exercise Science*, 23(1), 151-160. doi: 10.1123/pes.23.1.151.

Adolph, K. E. (2019). An ecological approach to learning in (not and) development. *Human Development*, 63(3-4), 180-201. doi.org/10.1159/000503823.

Alves, A. R., Dias, R., Neiva, H. P., Marinho, D. A., Marques, M. C., Sousa, A. C., Loureiro, V., & Loureiro, N. (2021). High-Intensity interval training upon cognitive and psychological outcomes in youth: A systematic review. *International Journal of Environmental Research and Public Health*, 18(10), 5344. doi: 10.3390/ijerph18105344.

Atlantis, E., Barnes, E. H., & Singh, M. A. (2006). Efficacy of exercise for treating overweight in children and adolescents: a systematic review. *International Journal of Obesity*, 30(7), 1027-1040. doi: 10.1038/sj.ijo.0803286.

Balaban, V. (2018). The relationship between objectively measured physical activity and fundamental motor skills in 8 to 11 years old children from the Czech Republic. *Montenegrin Journal of Sports Science and Medicine*, 7(2), 11-16. doi: 10.26773/mjssm.180902.

Basterfield, L., Adamson, A. J., Frary, J. K., Parkinson, K. N., Pearce, M. S., Reilly, J. J., & Gateshead Millennium Study Core Team. (2011). Longitudinal study of physical activity and sedentary behavior in children. *Pediatrics*, 127(1), 24-30. doi: 10.1542/peds.2010-1935.

Bradley, R. H., McRitchie, S., Houts, R. M., Nader, P., & O'brien, M. (2011). Parenting and the decline of physical activity from age 9 to 15. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 1-10. doi.org/10.1186/1479-5868-8-33.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Lawrence Earlbaum Associates.

Cole, T. J., Flegal, K. M., Nicholls, D., & Jackson, A. A. (2007). Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ*, 335(7612), 194. doi.org/10.1136/bmj.39238.399444.55.

Corder, K., Sharp, S. J., Atkin, A. J., Griffin, S. J., Jones, A. P., Ekelund, U., & van Sluijs, E. M. (2015). Change in objectively measured physical activity during the transition to adolescence. *British Journal of Sports Medicine*, 49(11), 730-736. doi: 10.1136/bjsports-2013-093190.

Costigan, S. A., Eather, N., Plotnikoff, R. C., Taaffe, D. R., Pollock, E., Kennedy, S. G., & Lubans, D. R. (2015). Preliminary efficacy and feasibility of embedding high intensity interval training into the school day: a pilot randomized controlled trial. *Preventive Medicine Reports*, 2, 973-979. doi: 10.1016/j.pmedr.2015.11.001.

Cvetković, N., Stojanović, E., Stojiljković, N., Nikolić, D., Scanlan, A. T., & Milanović, Z. (2018). Exercise training in overweight and obese children: Recreational football and high-intensity interval training provide similar benefits to physical fitness. *Scandinavian Journal of Medicine & Science in Sports*, 28, 18-32. doi: 10.1111/sms.13241.

Delgado-Floody, P., Latorre-Román, P., Jerez-Mayorga, D., Caamaño-Navarrete, F., & García-Pinillos, F. (2019). Feasibility of incorporating high-intensity interval training into physical education programs to improve body composition and cardiorespiratory capacity of overweight and obese children: A systematic review. *Journal of Exercise Science and Fitness*, 17(2), 35-40. doi: 10.1016/j.jesf.2018.11.003.

Dias, K. A., Ingul, C. B., Tjønna, A. E., Keating, S. E., Gomersall, S. R., Follestad, T., Hosseini, M.S., Hollekim-Strand, S. M., Ro, T. B., Haram, M., Huuse, E. M., Davies, P. S. W., Cain, P. A.,Leong, G. M., & Coombes, J. S. (2018). Effect of high-intensity interval training on fitness, fat mass and cardiometabolic biomarkers in children with obesity: a randomised controlled trial. *Sports Medicine*, 48(3), 733-746. doi: 10.1007/s40279-017-0777-0.

Donnelly, J. E., Hillman, C. H., Castelli, D., Etnier, J. L., Lee, S., Tomporowski, P., Lambourne, K., & Szabo-Reed, A. N. (2016). Physical activity, fitness, cognitive function, and academic achievement in children: a systematic review. *Medicine and Science in Sports and Exercise*, 48(6), 1197. doi: 10.1249/MSS.0000000000000901.

Drummy, C., Murtagh, E. M., McKee, D. P., Breslin, G., Davison, G. W., & Murphy, M. H. (2016). The effect of a classroom activity break on physical activity levels and adiposity in primary school children. *Journal of Paediatrics and Child Health*, 52(7), 745-749. doi: 10.1111/jpc.13182.

Engel, F. A., Wagner, M. O., Schelhorn, F., Deubert, F., Leutzsch, S., Stolz, A., & Sperlich, B. (2019). Classroom-based micro-sessions of functional high-intensity circuit training enhances functional strength but not cardiorespiratory fitness in school children—a feasibility study. *Frontiers in*

Public Health, 291. doi: 10.3389/fpubh.2019.00291.

García-Hermoso, A., Alonso-Martínez, A. M., Ramírez-Vélez, R., Pérez-Sousa, M. Á., Ramírez-Campillo, R., & Izquierdo, M. (2020). 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*, 174(6), 200223-200223. doi: 10.1001/jamapediatrics.2020.0223.

Granacher, U., Goesele, A., Roggo, K., Wischer, T., Fischer, S., Zuerny, C., Gollhofer, A., & Kriemler, S. (2011). Effects and mechanisms of strength training in children. *International Journal of Sports Medicine*, 32(05), 357-364. doi: 10.1055/s-0031-1271677.

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1· 6 million participants. *The Lancet Child & Adolescent Health*, 4(1), 23-35. doi: 10.1016/S2352-4642(19)30323-2.

Klika, B., & Jordan, C. (2013). High-intensity circuit training using body weight: Maximum results with minimal investment. *ACSM's Health & Fitness Journal*, 17(3), 8-13. doi: 10.1249/FIT.0b013e31828cb1e8

Larsen, M. N., Nielsen, C. M., Helge, E. W., Madsen, M., Manniche, V., Hansen, L., Hansen, P. R., Bangsbo, J., & Krustrup, P. (2018a). Positive effects on bone mineralisation and muscular fitness after 10 months of intense school-based physical training for children aged 8–10 years: the FIT FIRST randomised controlled trial. *British Journal of Sports Medicine*, 52(4), 254-260. doi: 10.1136/bjsports-2016-096219.

Larsen, M. N., Nielsen, C. M., Madsen, M., Manniche, V., Hansen, L., Bangsbo, J., Krustrup, P., & Hansen, P. R. (2018b). Cardiovascular adaptations after 10 months of intense school-based physical training for 8-to 10-year-old children. *Scandinavian Journal of Medicine and Science in Sports*, 28, 33-41. doi: 10.1111/sms.13253.

Loprinzi, P. D., Davis, R. E., & Fu, Y. C. (2015). Early motor skill competence as a mediator of child and adult physical activity. *Preventive Medicine Reports*, 2, 833-838. doi: 10.1016/j.pmedr.2015.09.015.

Mayorga-Vega, D., Viciana, J., & Cocca, A. (2013). Effects of a circuit training program on muscular and cardiovascular endurance and their maintenance in schoolchildren. *Journal of Human Kinetics*, 37, 153. doi: 10.2478/hukin-2013-0036.

Nevill, A. M., Duncan, M. J., & Sandercock, G. (2020). Modeling the dose–response rate/associations between VO2max and self-reported Physical Activity Questionnaire in children and adolescents. *Journal of Sport and Health Science*, 9(1), 90-95. doi.org/10.1016/j.jshs.2019.05.001.

Nyberg, G. A., Nordenfelt, A. M., Ekelund, U., & Marcus, C. (2009). Physical activity patterns measured by accelerometry in 6-to 10-yr-old children. *Medicine and Science in Sports and Exercise*, 41(10), 1842-1848. doi: 10.1249/MSS.0b013e3181a48ee6.

Paradisis, G. P., Zacharogiannis, E., Mandila, D., Smirtiotou, A., Argeitaki, P., & Cooke, C. B. (2014). Multi-stage 20-m shuttle run fitness test, maximal oxygen uptake and velocity at maximal oxygen uptake. *Journal of Human Kinetics*, 41, 81-87. doi: 10.2478/hukin-2014-0035.

Plowman, S. A., & Meredith, M. D. (2013). *Fitnessgram/Activitygram reference guide*. Dallas, Texas: The Cooper Institute.

Sallis, J. F., Bull, F., Guthold, R., Heath, G. W., Inoue, S., Kelly, P., Oyeyemi, A. L., Perez, L. G., Richards, J., Hallal, P. C., & Lancet Physical Activity Series 2 Executive Committee. (2016). Progress in physical activity over the Olympic quadrennium. *The Lancet*, 388(10051), 1325-1336. doi: 10.1016/S0140-6736(16)30581-5.

Sember, V., Morrison, S. A., Jurak, G., Kovac, M., & Starc, G. (2018). Differences in physical activity and academic performance between urban and rural schoolchildren in Slovenia. *Montenegrin Journal of Sports Science and Medicine*, 7(1), 67-72. doi: 10.26773/mjssm.180309.

Seo, Y. G., Lim, H., Kim, Y., Ju, Y. S., Choi, Y. J., Lee, H. J., Jang, H. B., Park, S. I., & Park, K. H. (2021). Effects of circuit training or a nutritional intervention on body mass index and other cardiometabolic outcomes in children and adolescents with overweight or obesity. *PLoS ONE*, 16(1), 0245875. doi: 10.1371/journal.pone.0245875.

Weiss, M. R., Phillips, A. C., & Kipp, L. E. (2015). Effectiveness of a school-based fitness program on youths' physical and psychosocial health outcomes. *Pediatric Exercise Science*, 27(4). doi: 10.1123/pes.2015-0011.

Weston, K. L., Azevedo, L. B., Bock, S., Weston, M., George, K. P., & Batterham, A. M. (2016). Effect of novel, school-based high-intensity interval training (HIT) on cardiometabolic health in adolescents: project FFAB (fun fast activity blasts)-an exploratory controlled before-and-after trial. *PLoS One*, 11(8), e0159116. doi: 10.1371/journal.pone.0159116.

Yomoda, K., & Kurita, S. (2021). Influence of social distancing during the COVID-19 pandemic on physical activity in children: A scoping review of the literature. *Journal of Exercise Science & Fitness*, 19(3), 195-203. doi.org/10.1016/j.jesf.2021.04.002.

DOI 10.26773/mjssm.220904