2024, Retos, 61, 792-800
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Is High Intensity Interval Training (HIIT) a feasible method for improving anthropomorphic and cardiometabolic parameters in preschool children?

¿Es el entrenamiento en intervalos de alta intensidad (HIIT) un método viable para mejorar los parámetros antropomórficos y cardiometabólicos en niños en edad preescolar?

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Abstract. Background: High Intensity Interval Training has showed to be an effective method to improve physical fitness and reduce the risk of obesity in adults. However, these effects have not been studied in the preschool population. Objective: The aim of this study was to determine the effects of a long-term High Intensity Interval Training (HIIT) program on anthropomorphic and cardiometabolic variables in preschool children with overweight and obesity. Methods: A total of 349 (164 boys and 185 girls) preschool children (age: 4.38 ± 0.62 years) participated in the study. All the participants completed a 28-week intervention based on HIIT (2 sessions/week), carried out during physical education classes at their schools. Anthropomorphic variables (body mass index, waist circumference, body fat, ∑4 skinfold fat), cardiometabolic variables (blood pressure, resting heart rate, cardiorespiratory fitness), and cardiometabolic risk were measured. Results: After intervention program, significant differences were found in ∑4 skinfold fat, body fat, blood pressure, resting heart rate, and cardiorespiratory fitness. Conclusion: 28-week HIIT training program can reduce cardiometabolic risk and improve cardiorespiratory fitness in preschool children with overweight and obesity regardless of sex.
Keywords: Preschool children; HIIT; Cardiometabolic Risk; Obesity

Resumen. Antecedentes: El entrenamiento interválico de alta intensidad (HIIT) ha demostrado ser un método eficaz para mejorar la condición física y reducir el riesgo de obesidad en adultos. Sin embargo, estos efectos no se han estudiado en la población preescolar. Objetivo: El objetivo de este estudio fue determinar los efectos de un programa de entrenamiento interválico de alta intensidad a largo plazo sobre variables antropomométricas y cardiometabólicas en niños preescolares con sobrepeso y obesidad. Métodos: Participaron en el estudio un total de 349 (164 niños y 185 niñas) niños en edad preescolar (edad: 4,38 ± 0,62 años). Todos los participantes completaron una intervención de 28 semanas basada en HIIT (2 sesiones/semana), realizada durante las clases de educación física en sus escuelas. Se midieron variables antropométricas (índice de masa corporal, circunferencia de la cintura, grasa corporal, ∑4 pliegues cutáneos), variables cardiometabólicas (presión arterial, frecuencia cardíaca en reposo, aptitud cardiorrespiratoria) y riesgo cardiometabólico. Resultados: Después del programa de intervención, se encontraron diferencias significativas en ∑4 pliegues cutáneos, grasa corporal, presión arterial, frecuencia cardíaca en reposo y aptitud cardiorrespiratoria. Conclusión: El programa de entrenamiento HIIT de 28 semanas puede reducir el riesgo cardiometabólico y mejorar la aptitud cardiorrespiratoria en niños preescolares con sobrepeso y obesidad independientemente del sexo.
Palabras clave: Niños preescolares; HIIT; Riesgo Cardiometabólico; Obesidad

Fecha recepción: 19-06-24. Fecha de aceptación: 27-09-24
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Introduction

The benefits of the regular practice of physical activity (PA) have been established in the scientific literature (Poitras et al., 2016). Specifically, PA at an early age improves health-related parameters such as bone density, cardiovascular profiles, body composition and cognitive processes (Carson et al., 2016). It should be mentioned that childhood is an essential period of life that it is important to acquire healthy habits, since the behaviors that are acquired at this age can be maintained later in life (Jones et al., 2013). Hence promoting PA in early childhood is critical for the inclusion and long-term maintenance of healthy habits (Fernandez-Jimenez et al., 2018).

In view of the importance of practicing PA at this stage of life, the World Health Organization (WHO) has developed 24-h PA guidelines for obtaining the benefits of PA (WHO, 2019). However, many young children in the age-group 0-5 years are not active enough to obtain the health benefits related with PA, since they are active for less than 4% of the day (Hnatiuk et al., 2019). Furthermore, more than 50% of children in this group can be considered sedentary, performing less than 20% of the activity recommended by WHO (Hoyos-Quintero & García-Perdomo, 2019). Thus, only a small percentage of children fully achieve the WHO guidelines (De Craemer et al., 2018). Hence, physical inactivity in young children has caused an increase in overweight and obesity at these ages which has reached epidemic proportions worldwide (Kumanyika et al., 2008); there is therefore a pressing need to develop effective interventions to increase the level of PA starting from an early age in order to change the current trend (de Onis et al., 2010).

Specifically, in Chile, country where this study was carried out, the increase in the prevalence of obesity has been such that the country is now ranked as having the tenth-highest level of childhood obesity in the world (Vio & Kain, 2019). A survey carried out by the Chilean Health Ministry to investigate the nutritional status of schoolchildren and preschool children concluded that kindergarten children (i.e., preschool children aged between four and five years) surpass all other grades with the highest prevalence of total

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obesity. Therefore, it is clear that there has been an unprecedented increase in obesity, especially severe obesity, in preschool children (Junaeb, 2021).

In programs intended to reduce overweight and obesity in children, high-intensity PA has shown a stronger relationship with health markers than lower intensity PA (Poitras et al., 2016). High Intensity Interval Training (HIIT) is a methods that combines brief bursts of exercises executed at high intensity, interspersed with short periods of active recovery at low intensity (Buchheit & Laursen, 2013). Also, HIIT has shown to induce greater health improvements in children and adolescents than traditional training programs (Laursen & Buchheit, 2019). Furthermore, HIIT generates cardiovascular and musculoskeletal improvements which are associated with better cardiovascular health, cardiorespiratory fitness (CRF), metabolic capacity and insulin response in children with overweight and obesity (García-Hermoso et al., 2016). Another benefit of HIIT is that it is time-efficient, since less volume and time are required to obtain health improvements. Hence, HIIT can solve the "lack of time", which is one of the most-frequently cited barriers to the practice of PA (Reichert et al., 2007).

For these reasons, HIIT intervention has been studied previously in different populations. Espinoza et al. (2023) carried out a long-term intervention based on HIIT during physical education (PE) classes at school in order to reduce overweight and obesity levels in primary school children. Keating et al. (2022) conducted a 6-week high-intensity intervention with older adults based on a HIIT program on a cycle ergometer to reduce weight and increase the muscles of the lower limbs. Wewege et al. (2017) concluded in their systematic review that HIIT can induce improvements in body composition in adults, being a time-efficient method for reducing weight in this population. Nevertheless, there is insufficient evidence to establish the best type of exercise, intensity, frequency, and program duration for improving health in children at early ages (Veldman et al., 2021).

Therefore, the aim of this study was to determine the effects of a long-term HIIT program on anthropomorphic and cardiometabolic variables in preschool children with overweight and obesity. Our main hypothesis was that a long-term HIIT program will reduce cardiometabolic risk (CR), and improve cardiorespiratory capacity and weight-for-stature (WFS) in preschool children.

Methods

Participants

In this quasi-experimental study with a longitudinal design, a total of 349 (164 boys and 185 girls) preschool children (age: 4.38 ± 0.62 years; weight: 20.94 ± 3.77 kg), joined in this study. All the participants completed a 28-week HIIT intervention. The preschool children were selected from six schools in the city of Temuco (Chile). The inclusion criteria were: a) being registered in any preschool year (1st, 2nd, or 3rd); b) no physical and/or intellectual disabilities; c) presentation of a medical certificate allowing the practice of PA; d) voluntary signature of informed consent by parents/guardians to allow the child to participate in this research.

The principles of the Declaration of Helsinki (2013) and the European Guidelines on Good Clinical Practices (111/3976/88 of July 1990) as specified in the Spanish legal framework for clinical investigation in humans (Royal Decree 561/1993 on Clinical Trials) were followed. The study was approved by the Ethics Committee of Universidad de Jaén (Jaén, Spain). The study was supported by a Chilean project (DIUFRO project DI11-0038). Because it formed part of the DIUFRO project, no control group could be included, since a specific requirement of this project was that all preschool-age children had to be included in the PA intervention in order to reduce the high levels of overweight and obesity in these age groups in the Chilean population

Anthropometric Measurement

Body mass (kg) was measured with a portable scale (TANITA, model Scale Plus UM -028, Tokyo, Japan). The children were weighed wearing light clothing and barefooted. Their height (cm) was measured with a Seca® stadiometer, model 214, Hamburg, Germany).

BMI was calculated by dividing the weight of the individual by the height squared (kg/m^2). The BMI was used to classify each participant as normal weight, overweight (OW) or obese (OB). The weight status of the participants was determined by percentile (p) according to the following criteria: OW—BMI between p 85 < p 95; OB—BMI > p 95 (Stewart et al., 2011). The waist circumference (WC) was measured with a tape measure (Seca®, model 201, Hamburg, Germany) at the height of the navel (Khoury et al., 2013). The percentage of body fat (BF) was evaluated from bicipital, tricipital, subscapular, and suprailiac measurements using Slaughter's equation (Slaughter et al., 1988). The assessment was carried out with a skinfold caliper model 102-602 L (Minneapolis, MN, USA).

Cardiometabolic Risk (CR)

To assess CR, waist to height ratio (WHR) was evaluated. WHR is a useful tool that gives more specific information about CR in children by estimating the level of fat concentrated in the central part of the body (Khoury et al., 2013). It allows metabolic alterations to be detected in children without differentiating between sex and age, using a cut-off point ≥ 0.5 (Browning et al., 2010).

Blood Pressure (BP)

BP (diastolic and systolic) was assessed with a portable digital device (OMRON® model HEM 7114; Lake Forest, IL, USA). The same device was used to measure resting heart rate (RHR). Each measurement was carried out one day before the start of the HIIT program (pre-test), and one day after completion (post-test). The children were kept

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seated for five minutes to relax before the assessment was carried out, consequently they were calm at the moment of the evaluation.

Cardiorespiratory fitness (CRF)

CRF was evaluated by the Six Minute Walk Test (6MWT) adapted for children. This test assesses the distance that the participant is able to walk in 6 min, consequently a greater distance implies greater CRF (Geiger et al., 2007). The 6MWT was conducted out of doors on a flat surface. The track was 30m x 5m, marked by cones placed at a distance of 30m to indicate the length of the circuit. The participants had to walk a circuit round the cones; visible marks were placed every 3m to help to the evaluators to record the distance walked by the participants. The test was conducted by physical education (PE) teachers during their classes. To maintain motivation and concentration among the participants, words of encouragement (standardized and protocolized) were given during the test.

Procedures

The protocol applied in the current study was a HIIT based on CRF assessed through the 6MWT adapted for children. The HIIT program was conducted by PE teachers (who joined the study voluntarily) during their practical PE classes. The intervention was carried out over 28 weeks (two sessions/week) from April to October (i.e., in termtime). Thus, a total of 56 sessions were performed by the participants, each lasting around 40-50 min (the usual duration of PE class). All the sessions had similar structure: they started with a 5 min warm-up consisting of games performed at low-medium intensity; they continued with the main part (30 min) performed at high intensity; at the end there was a 5-min cooling-down period to decrease the children's heart-rate. In order to include a larger number of participants, the same protocol was carried out over the same period in several schools, all of which decided to participate in the study voluntarily.

The HIIT program was based on high-intensity games, play activities such as traditional games. Outdoor activities such as chase games and races were carried out in parks and forest areas in order to reach the high intensity required and comply with the principles of HIIT. Each activity or game lasted for 4-6 min with an active recovery period of 1-2 min between activities. The work ratio was 1:1, i.e., the children played for 30–60s and had the same recovery time before starting the next high-intensity action. These strategies were based on previous research (Galdames-Maliqueo et al., 2017; Weiss et al., 2015). The intensity of each activity was adjusted using the 10 point Borg scale modified for children; the activities performed at above 8 points on this scale were defined as high-intensity (Rodríguez & Gatica, 2016). A familiarization with Borg scale was conducted during three weeks (i.e., 6 sessions). During these familiarization' sessions, similar activities performed with different intensities were conducted during PE classes, so the children could understand how this scale works. Also, the intensity that they had to reach during the HIIT protocol.

Statistical Analysis

Statistical software SPSS v.22.0 for Windows (SPSS Inc., Chicago, IL, USA) was used to analyze the data. Descriptive data are reported in terms of means ± standard deviation (SD), and in percentages. Kolmogorov-Smirnov and Levene's tests were conducted to verify the normal distribution and homogeneity of the data. Analysis of covariance (ANCOVA 2 x 2) with repeated measures, including increasing age as a covariable, was performed on the quantitative variables. McNemar-Bowker's test was conducted to analyze the qualitative variables. Pearson's correlation was performed, adjusted to the ages of the participants. The size of effect was calculated by Cohen's d and described as: trivial (<0.2), small (0.2–0.49), moderate (0.5–0.79), or large (>0.8) (Cohen, 1988). The significance level was set at $p<0.05$.

Results

Anthropometric data of the participants, and the variables related with CR, are listed in Table 1. Note that the BF percentage was reduced after HIIT intervention, with significant differences ($p=0.009$). Girls showed a greater reduction in BF than boys ($p<0.001$) after the HIIT program. Moreover, a decrease in ∑4 skinfold was obtained in boys and girls in the post-test assessment ($p<0.001$). The post-test WHR values showed significant changes in boys and girls with respect to pre-test values ($p<0.001$).

Table 1.
Results of the cardiometabolic risk variables after 28 weeks of HIIT intervention

		Total Mean (SD)	Boys Mean (SD)	Girls Mean (SD)	P-value (Inter-group)	Cohen's d
BMI (kg/m^2)	Pre	17.70 (2.20)	17.52 (2.16)	17.85 (2.24)	0.529	0.149
	Post	17.38 (2.33)	17.35 (2.17)	17.41 (2.46)	0.658	0.025
	p-value (-intra)	0.055	0.260	0.165		
	Cohen's d	0.141	0.078	0.187		
WC (cm)	Pre	55.54 (5.22)	55.59 (4.85)	55.50 (5.54)	0.612	0.017
	Post	54.95 (4.8)	54.69 (4.29)	55.19 (5.22)	0.914	0.104
	p-value (-intra)	0.090	0.200	0.361		
	Cohen's d	0.117	0.196	0.057		
WHR	Pre	0.50 (0.04)	0.50 (0.38)	0.51 (0.04)	0.033	0.037
	Post	0.49 (0.40)	0.49 (0.03)	0.49 (0.04)	0.948	0.001
	p-value (-intra)	<0.001	<0.001	<0.001		
	Cohen's d	0.035	0.037	0.500		
∑4 skinfold fat (mm)	Pre	34.73 (12.62)	34.01 (11.30)	35.34 (13.64)	0.271	0.106
	Post	32.01 (12.29)	31.95 (11.43)	32.06 (13.01)	0.383	0.008

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	p-value (-intra)	<0.001	<0.001	<0.001		
	Cohen's d	0.218	0.181	0.246		
Body fat (%)	Pre	17.46 (4.88)	15.64 (4.76)	19.07 (4.14)	<0.001	0.768
	Post	16.53 (4.51)	16.36 (4.35)	16.67 (4.66)	0.190	0.068
	p-value (-intra)	0.009	0.694	<0.001		
	Cohen's d	0.197	0.157	0.544		
BP Systolic (mmHg)	Pre	97.68 (12.79)	105.08 (11.76)	98.09 (13.12)	0.698	0.561
	Post	104.81 (12.91)	97.71 (10.66)	104.52 (13.87)	0.233	0.550
	p-value (-intra)	<0.001	<0.001	<0.001		
	Cohen's d	0.554	0.656	0.476		
BP Diastolic (mmHg)	Pre	60.69 (12.32)	60.09(11.22)	61.22 (13.22)	0.854	0.317
	Post	64.90 (14.12)	64.08 (13.79)	65.61 (14.40)	0.529	0.108
	p-value (-intra)	<0.001	0.016	0.001		
	Cohen's d	0.317	0.317	0.317		
RHR (bmp)	Pre	90.29 (13.64)	90.58 (13.09)	90.03 (14.14)	0.443	0.040
	Post	99.36 (13.87)	99.05 (12.99)	99.64 (14.63)	0.484	0.042
	p-value (-intra)	<0.001	<0.001	<0.001		
	Cohen's d	0.659	0.649	0.667		

BMI: Body mass index; WC: Waist circumference; BP: Blood pressure: RHR: Resting heart rate; WHR: Waist to height ratio

Regarding the intensity reached by the participants through all HIIT sessions, figure 1 shows the score obtained in Borg scale of each intervention week.

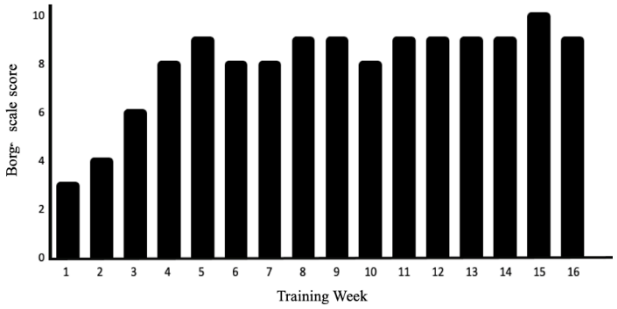

Figure 1. Weekly intensity achieved by the participants through 16 weeks of intervention

Figure 2 shows the performance of the participants (distance achieved) in the 6MWT. Boys and girls improved on their initial values, with significant differences between evaluations (p<0.001).

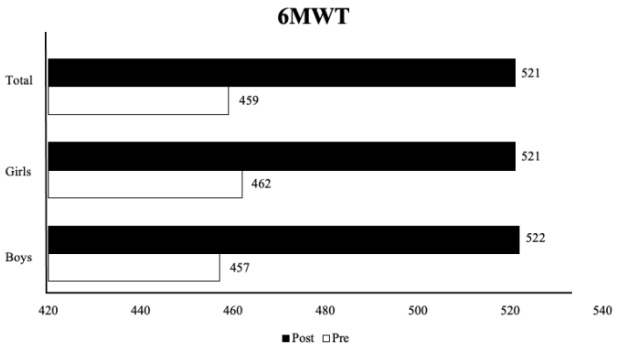

Figure 2. Mean distance achieved by the participants in the 6MWT (m)

The changes in nutritional group are listed in Figure 3. A significant reduction in overweight children was found (p<0.001), as well as an increase in the percentage of normal weight children (p<0.001). However, this intervention was not sufficient to the reduce the percentage of obesity in boys and girls; on the contrary, this increased, by 10.8% in girls and by 8.7% in boys.

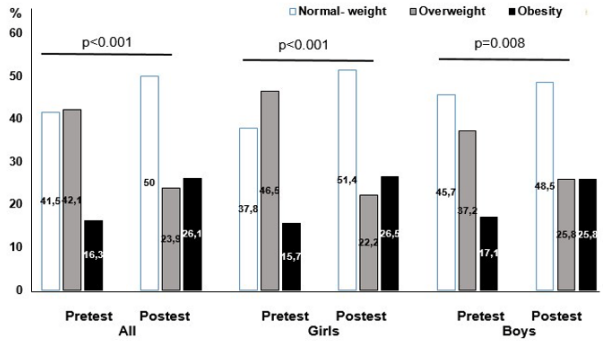

Figure 3. Nutritional status of the participants (pre- and post-intervention).

The changes in the percentage of children with CR, as defined by WHR greater than or equal to the cut-off point (0.5), are shown in Figure 4. The girls' group showed a significant reduction between assessments (p<0.001), whereas the boys' group obtained a reduction but the difference was not significant (p=0.115).

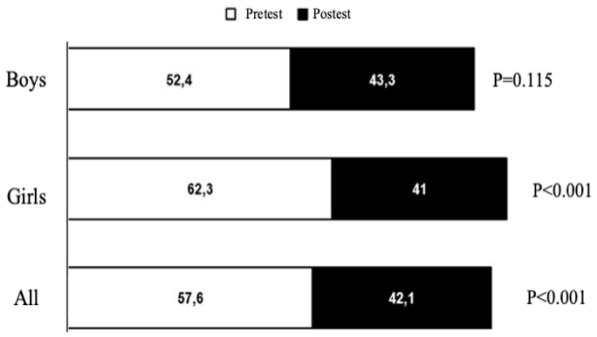

Figure 4. Changes in cardiometabolic risk defined by WHR values, expressed in percentages.

A weak significant correlation was found in the relationship between the results of the 6MWT, the improvement in CR, and BF percentage. This test may therefore not be suitable for analyzing the relationship between CRF and CR in preschool children. The changes obtained between pretest and post-test (i.e., the increment) in all the variables analyzed, separated by sex, are listed in Table 2.

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Table 2.
Changes between pre- and post-test (i.e. increment) in all variables analyzed

	Total	Boys	Girls	p-value
Δ BMI	-0.31 (3.05)	-0.17 (3.09)	-0.44 (3.02)	0.908
Δ WC	0.58 (6.48)	0.89 (6.03)	0.31 (6.87)	0.773
Δ WHR	-0.01 (0.05)	-0.01 (0.05)	-0.01 (0.05)	0.115
Δ BF	-0.93 (6.38)	0.72 (6.46)	-2.39 (5.95)	0.006
Δ∑4 Skinfold fat	-2.72 (6.11)	-2.06 (5.56)	-3.27 (6.50)	0.597
Δ RHR	9.07 (15.28)	8.47 (13.85)	9.60 (16.47)	0.964
Δ 6MWT	62.71 (84.24)	58.44 (87.46)	66.49 (81.34)	0.085

BMI: Body mass index; WC: Waist circumference; WHR: Waist to height ratio; BF: Body fat; RHR: Resting heart rate; 6MWT: 6 minutes walking test.

Discussion

The aim of this study was to determine the effects of a long-term High Intensity Interval Training (HIIT) program on anthropomorphic and cardiometabolic variables in preschool children with overweight and obesity. The most interesting finding in the current study was that a HIIT program lasting 28 weeks had an effect on the ∑4 skinfold fat, BF, BP, RHR, and CR, since the initial values of these variables were reduced. In addition, an improvement in CRF was found since the distance achieved in the 6MWT by boys and girls was increased after intervention. These results imply that an improvement in health status was achieved since all the variables mentioned above are important health markers. Consequently, our main hypothesis has been corroborated.

In relation to BMI, the participants in the study showed a slight reduction in this variable. This is an important finding since weight reduction may be associated with improvements in some outcomes related with cardiometabolic variables (Rajjo et al., 2016). These results agree with those of a previous intervention based on HIIT in the school context with a similar duration (28 weeks), carried out in a primary school population, where a reduction in BMI was found after a HIIT intervention during physical education classes in overweight and obese children (Espinoza et al., 2023). Furthermore, OsiPov et al. (2023) concluded in their research that BMI values decreased after a HIIT program conducted during PE classes, although the intervention was shorter (16 weeks) than in the current study. These findings also agree with those of Jurić et al. (2023), where the authors carried out a 12-week HIIT intervention of 2 sessions/week during PE classes in a school context. One possible explanation for the similarity of these results, despite the differences in intervention time between the studies, may be related with the exercises carried out during intervention, and/or with the age of the participants.

In addition, the total percentages of overweight children among the participants in the current study were reduced, among girls by 24.3%, and among boys by 11.4%. However, the numbers in the obesity group increased for both sexes, which may possibly be explained by lower adherence of these children to this type of training. Furthermore, there are several external variables that should be considered such as the lack of diet control, the number of hours' sleep, and the physical activity practiced by the participants outside school, since these will have an impact not only on BMI, also on nutritional status (San Mauro, 2015).

The BF percentage was reduced in both boys and girls after the HIIT intervention. A reduction in ∑4 skinfold fat was also found in both boys and girls; this is another important finding of the current study, since previous research has concluded that accumulation of subcutaneous fat deposits increases the risk of cardiovascular diseases in children (Medrano et al., 2022). These results agree with the study carried out by Blüher et al. (2017), in which the authors conducted a HIIT intervention over six months (2 sessions/week) in adolescents outside the school context. Moreover, our findings agree with those reported by Lau et al. (2015). In their study, the authors concluded that body composition improved after a HIIT intervention in which the participants performed 12 intervals of 15s with 15s rest between intervals (i.e. work ratio 1:1; 6 minutes) with an intensity of 120% of the maximal aerobic speed of the participants. Similar results were found after a 12-week HIIT intervention consisting of three sets of high-intensity interval runs separated by 3 minutes of passive rest (3 times per week) (Cvetković et al., 2018). Nevertheless, these findings conflict with those reported by Dias et al. (2018); they carried out a 12-week HIIT intervention consisting of 4x4-min bouts at 85–95% maximum heart rate, also with 3 min of active recovery between bouts (3 times/week), and found no reduction in BF. Our results also results differ from those reported by Thivel et al. (2011), where an intervention of 120 min per week for 6 months (60 min per session; 2 times/week) based on psychometric activities and exercises to improve coordination, flexibility, strength, speed, and endurance did not induce a reduction of BF percentage, although this program was effective in terms of improving aerobic and anaerobic physical fitness. These discrepancies among studies may be due to the protocol used during the HIIT intervention, and/or by differences between the types of assessment applied in each study.

According to the CR-related variables assessed, the CR decreased in both groups. Consequently, the WHR cut-off point was reduced below 0.5 after the intervention, to define a cut-off point for determining CR in children (Browning et al., 2010). Specifically, the values for the boys' group were found to be 9.1% below the cut-off point, while a greater reduction was found in the girls' group (21.3%). Furthermore, a reduction in BP (systolic and diastolic) was obtained in boys and girls; it should be noted that high BP during childhood can be associated with a greater risk of hypertension in adulthood (Juhola et al., 2011). In the current study, BP values were reduced significantly in both boys and girls after the intervention, bringing them within the normal range of BP values for their age according to the reference values (Barba et al., 2014). These findings agree with a previous meta-analysis of interventions in schools, which concluded that HIIT was the only strategy that was proven to be effective in reducing CR factors (Pozuelo-Carrascosa et al., 2018). Furthermore, García-Hermoso et al. (2016) conducted a systematic re-

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view, concluding that HIIT may be considered a time-efficient training method to improve both BP and aerobic capacity levels of children; consequently, their results agree with those obtained in the present study. It should be noticed that Lambrick et al. (2016) carried out a HIIT intervention twice-weekly for 6 weeks, based on active games during PE classes, and also obtained similar results to those of the present study. A reasonable explanation for this concordance among studies despite the difference protocol carried out may be the lack of knowledge in the scientific literature about which HIIT protocol, in terms of minimum duration and frequency, induces the greatest health benefit in child populations (Reyes-Amigo et al., 2017).

Another important finding in this study was that the CRF of both boys and girls improved after the intervention, since an improvement in the distance achieved in the 6MWT was found. The values obtained by the participants in this study were slightly higher than the reference values for this age (Lammers et al., 2008). Furthermore, our findings agree with a previous meta-analysis in which the authors concluded that education center-based interventions, based on vigorous intensity similar to that carried out in this intervention, are an effective method of improving CRF in children (García-Hermoso et al., 2016). Moreover, the CRF findings in this research agree with the study carried out by Jurić et al. (2023), in which the authors concluded that after a school intervention based on HIIT lasting for 12 weeks, 2 sessions/week, the participants showed an improvement in their CRF. Note that a 20m shuttle run test was conducted to evaluate CRF instead of the 6MWT. The consistency of these CRF improvements, despite the differences between interventions and evaluation protocols, may be explained by the effectiveness of HIIT over other training methods (Liu et al., 2020). In addition, the ecological framework in which the interventions were carried out – in the educational center – and the use of a collective rather than an individual intervention, may also help to explain these CRF improvements in children (Szeszulski et al., 2019).

Strengths and Limitations

The most important limitation of the present study lies in the fact that no control group was included for comparison of the results. Hence there is no control for age and growth factors such as height, which could play an important role at this age. Unfortunately, it was not possible to include a control group, since the main requirement of the DIUFRO project was that all preschool-age children have to be included in the PA intervention in order to reduce the high levels of overweight and obesity at these ages in the Chilean population. Another limitation that should be mentioned was that the daily habits of the participants such as eating habits, daily calorie intake, and sedentary time outside school were not controlled.

On the other hand, a strength of the present study is that a total of 349 preschool children performed a 28-week intervention based on HIIT without any dropouts due to injury, boredom, or lack of interest in the proposed activities. The results obtained show that such a program can help to improve the health of children at early age, and encourage them to acquire – and maintain in later life – healthy lifestyle habits related to the practice of PA.

Conclusion

To sum up, the results of this research show that a HIIT training program lasting 28 weeks had a positive effect on anthropometric variables and helped to reduce CR. Furthermore, an improvement in CRF was obtained in the preschool children (boys and girls). Thus, the results obtained in the current study indicate that HIIT could be a safe and effective training program to improve health in early life stages.

Further research needs to be conducted to establish the minimum time necessary to obtain similar results in this population, and the optimal weekly frequency of training. In addition, some health-related habits, such as daily calorie intake and sedentary lifestyle, could be controlled to obtain a more objective vision of the effect of a HIIT intervention at this age.

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