Increased motor performance and responsivity in physical fitness after high-intensity functional training in excess weight adolescents

Aumento del rendimiento motor y respuestas físicas tras entrenamiento funcional de alta intensidad en adolescentes con exceso de peso

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Abstract

Introduction: Motor competence (MC) is essential for motor development and an active lifestyle. However, adolescents with excess weight face challenges like low physical fitness and cardiometabolic alterations that affect MC. While high-intensity functional training (HIFT) improves physical fitness and reduces cardiometabolic risks, its effects on MC remain underexplored.
Objective: This study aimed to investigate the impact of different types of physical training on motor competence and physical fitness in excess weight adolescents.
Methodology: The sample had 46 adolescents of both sexes, aged 10 to 16 years, distributed into HIFT(n=10), high-intensity interval training (HIIT, n=12), moderate-intensity continuous training (MICT, n=12), and control group (CG, n=12). Anthropometric measurements, body composition, physical fitness, and motor competence with supine-to-stand time (STS_{TIME}) were assessed before and after the intervention. Repeated measures ANOVA, effect size, and prevalence of respondents were used for statistical analysis.
Results: HIFT had a decrease in BMI (p=0.04), WHtR (p=0.050), and %FM (p<0.001), an increase in %FFM (p<0.001), ABD strength (p<0.01), and flexibility (p<0.03), and very beneficial improvement in STS_{TIME} (p< 0.001) in relation to the other groups. On the other hand, HIIT (p<0.003) and MICT (p<0.02) had greater handgrip strength than HIFT. Furthermore, higher frequencies of HIFT respondents had a decrease in BMI and %FM and an increase in %FFM (p<0.05), flexibility, and STS_{TIME} in relation to the other groups (p=0.001).
Conclusions: HIFT was significantly more effective than the other protocols in improving body composition, abdominal strength, flexibility, and floor rise time.

Keywords

Adolescent; motor competence; high intensity; moderate intensity; physical fitness.

Resumen

Introducción: La competencia motora (MC) es esencial para el desarrollo motor y un estilo de vida activo. Sin embargo, los adolescentes con exceso de peso enfrentan baja forma física y alteraciones cardiometabólicas que afectan la MC. Aunque el entrenamiento funcional de alta intensidad (HIFT) mejora la condición física y reduce riesgos cardiometabólicos, sus efectos en la MC siguen poco explorados.
Objetivo: Investigar el impacto de diferentes tipos de entrenamiento físico sobre la competencia motora y la forma física en adolescentes con exceso de peso.
Metodología: La muestra incluyó 46 adolescentes (10–16 años, ambos sexos) divididos en HIFT (n=10), entrenamiento interválico de alta intensidad (HIIT, n=12), entrenamiento continuo de intensidad moderada (MICT, n=12) y grupo control (GC, n=12). Se evaluaron medidas antropométricas, la composición corporal, la forma física y MC (tiempo *supine-to-stand*, STS_{TIME}) antes y después de la intervención. Se aplicaron ANOVA de medidas repetidas, tamaño del efecto y prevalencia de respondedores.
Resultados: HIFT tuvo una disminución en IMC (*p*=0.04), WHtR (*p*=0.050), y %FM (*p*<0.001), incrementos en %FFM (*p*<0.001), fuerza ABD (*p*<0.01), flexibilidad (*p*<0.03), y mejora en STS_{TIME} (*p*<0.001) respecto a otros grupos. HIIT (*p*<0.003) y MICT (*p*<0.02) destacaron. Más frecuencias de respondedores en HIFT presentaron mejoras en IMC, %FM, %FFM, flexibilidad y STS_{TIME} (*p*=0.001).
Conclusiones: HIFT fue más eficaz que los otros protocolos para mejorar composición corporal, fuerza abdominal, flexibilidad y el tiempo de subida al suelo.

Palabras clave

Adolescente; competencia motriz; alta intensidad; intensidad moderada; aptitud física.

Introduction

Motor competence (MC), defined as the ability to perform motor skills effectively and efficiently, plays a vital role in the motor development of adolescents (Gallahue et al., 2013). Well-developed motor skills during this stage of life are directly associated with a physically active lifestyle in adulthood. The lifestyle established in childhood and adolescence, which includes low levels of physical activity, inadequate eating habits, and risky behaviors, is associated with cardiometabolic changes (Tozo et al., 2020) and reduced cardiorespiratory fitness (Menezes-Junior et al., 2020) and muscle strength (Lopes et al., 2013). excess weight and sedentary behavior decrease physical performance and fitness levels (Tadiotto et al., 2021) and may change MC, especially in adolescence (Stodden et al., 2014) which is the period of transition toward autonomy, although its inadequate lifestyle habits may lead to health risks (Moura et al., 2018). Furthermore, there is an even greater concern with young people, given the crucial importance of physical fitness being intrinsically related to improving health and quality of life (Guthold et al., 2020).

The prevalence of insufficient levels of physical activity in children and adolescents is increasing worldwide (Guthold et al., 2020). Consequently, low levels of muscle strength have been associated with low MC and functional limitations in adolescents (García-Hermoso, Ramírez-Campillo, et al., 2019), which were further exacerbated by a prolonged period of isolation during the COVID-19 pandemic. These conditions negatively impacted motor performance, physical fitness, and vitamin D concentrations (Moraes et al., 2025). Moreover, obesity can worsen MC development in adolescents (Faigenbaum et al., 2020), as body weight overload can hinder their motor skills and negatively influence proprioception and body awareness, which are essential for precision in movement (Lopes et al., 2012).

Some cross-sectional studies with different motor function assessment instruments, such as Körperkoordenationstest für Kinder (KTK) (Chagas et al., 2021), Test of Gross Motor Development (TGMD) (Martins et al., 2023), and Supine-to-stand (STS) (Tadiotto et al., 2021), demonstrated a correlation between MC and body fat. Moreover, MC predicts body fat, thus highlighting recommendations for activities that favor MC development in early adolescence to prevent obesity.

Regular physical exercise (PE) has a positive impact on adolescents' physical health (García-Hermoso, Ramírez-Vélez, et al., 2019; Tadiotto et al., 2023). The World Health Organization recommends that adolescents perform at least 60 minutes of moderate to vigorous physical activity every day of the week (Bull et al., 2020), and the American College of Sports Medicine mostly recommends moderate-intensity continuous training (2021) in combination with resistance exercises (García-Hermoso et al., 2018). However, MICT takes longer to practice, whereas lack of time, school activities, finances, tiredness, motivation, and excess weight are the most common barriers that negatively influence the participation of adolescents in physical exercise (Alharbi et al., 2017; Ferreira-Silva et al., 2022; Purim et al., 2022). On the other hand, high-intensity interval training (HIIT) and functional training (HIFT) are performed in less time and have been indicated for reducing cardiometabolic risk factors and increasing physical fitness (Duncombe et al., 2022; Li et al., 2023; Solera-Martínez et al., 2021).

Vigorous exercise can bring greater health benefits than moderate-intensity exercise and takes less time to perform, followed by recovery periods (Box et al., 2019). Although HIIT is not new, it has recently gained increasing interest because it significantly improves various physical fitness domains in less total training time (Yin et al., 2020).

HIFT, which is derived from HIIT, involves multi-joint movements and large segments of the body, recruiting complex motor patterns in various planes. It includes resistance exercises in the same training session to further stimulate strength gain and muscle power while stimulating cardiovascular capacity (Feito et al., 2018). Due to its characteristics, HIFT can generate greater satisfaction among adolescents and be a strategy for their adherence to exercises, as they initially do not enjoy performing physical exercise or spending much time training (Heinrich et al., 2014).

Studies included in the review research on the effect of high-intensity exercise on children and adolescents reported favorable health improvements in schoolchildren (Duncombe et al., 2022). However, no research was found that evaluated the impact of MICT, HIIT, and HIFT on obese adolescents' MC. Therefore, this study aimed to investigate the impact of different types and intensities of physical training on MC improvement and physical fitness in excess weight adolescents.

Method

Ethical Approval

This clinical trial was a longitudinal quasi-experimental study whose participants were distributed into four groups. The research complied with the human research regulatory guidelines and was approved by the Ethics Committee of the UniDomBosco University Center (CAAE 62963916.0.0000.5223). The trial was conducted by the Quality-of-Life Center of the Federal University of Paraná (NQV-UFPR), and participants and their parents/guardians received a detailed explanation about the assessments and training programs. After agreeing to the study procedures, they signed an informed consent form and the adolescents signed an informed assent form, as outlined in the research project.

Participants

Participants were selected based on the selection criteria: excess weight adolescents of both sexes, aged 10 to 16 years. The exclusion criteria were participants with muscle injuries, any contraindication for carrying out the tests or practicing physical exercise, and participation in any type of regular physical activity other than regular physical education classes at school. Adolescents were recruited through invitations made in schools and advertising on electronic media. Volunteers were distributed into groups based on the availability of schedules and transportation for training.

Interventions

The intervention protocols were carried out three times a week on alternate days for 12 weeks of intervention. They were led by experienced and properly trained physical educators. The research had three experimental groups and one control group, as follows; (I) HIFT: high-intensity interval functional exercise protocol; (II) HIIT: high-intensity interval exercise protocol on a stationary bicycle; (III) MICT: moderate-intensity continuous exercise protocol on a stationary bicycle; (IV) CG: control group.

The HIIT group exercised on a stationary bicycle for approximately 35 minutes per session, in three 4-week stages with increasing intensity ranging from 80% to 100% of the heart rate reserve (HRR) and subjective perception of effort (SPE) between 7 and 10, with active pauses at an intensity of 5-6 SPE and 50% HRR. The protocol was based on the concept of interdependent volume and intensity, with a warm-up period, followed by a series of high-intensity exercises, interspersed with active rest (Gibala et al., 2012).

The MICT group likewise exercised on a stationary bicycle for approximately 60 minutes per session for 12 weeks, divided into three 4-week stages with increasing intensity ranging from 35% to 75% HRR and 5-8 SPE.

The HIFT group protocol was similar to HIIT, but performing functional exercises without equipment, just using body weight as overload. It consisted of exercises such as jumps, squats, push-ups, sit-ups, and running to improve different physical capabilities in an integrated approach (Feito et al., 2018). The 40-minute sessions included warm-ups and functional educational exercises that would be used in the following stage. The main training had three blocks with eight exercises each; exercises were performed for 40 seconds, with 20 seconds for rest and station change and a 3-minute break between each block.

The HIIT and MICT protocols used stationary bicycles (Schwinn® IC). The resistance used on bicycles was self-selected. HIFT was carried out on a school's multisport court. All training sessions had sound stimulation with a playlist of songs selected by the teachers. Individuals were instructed to maintain the length of training, the established training range, and the stimuli, according to the pre-established target HR. Intensity was individually controlled during the sessions based on the HR, using a heart monitor (Polar®), and the SPE scale (Borg, 1982). The caloric expenditure per session was calculated and kept equivalent between the modalities ($\chi^2(3)=2.00$; p=0.368).

The CG was instructed to maintain their usual physical activities during the study period. At the end of their participation in the research, they received guidance on regular physical exercise and were invited to participate in the experimental groups' treatment.

Measures

Anthropometry

Anthropometric measurements were performed as described in the Anthropometric Standardization Reference Manual (Lohman et al., 1988). The body mass (kg) was measured on a Welmy® digital scale, model W200/50®; the height (cm) was measured on an Avanutri® portable stadiometer, and the BMI z-score was calculated in the WHO Anthro Plus® program (Onis et al., 2007). The waist circumference was measured with an anthropometric tape over the skin between the ribs and the iliac crest. The waist-to-height ratio (WHtR) was calculated as the quotient between waist circumference (cm) and height (cm). The participant's sitting height was measured with them sitting on a 50-cm-high bench under the stadiometer. The length of their lower limbs was calculated as the difference between their height and sitting height (Lohman et al., 1988).

Body Composition

Body composition was measured with bioelectrical impedance during the morning. Participants had fasted for 12 hours and were asked to lie in the supine position. Fat-free mass (FFM) and percentage of fat mass (%FM) were calculated using the equation validated by Houtkooper et al. (1992).

Biological maturation

Biological maturation was assessed according to somatic maturation, a mathematical model based on anthropometry, age, and sex, determining through predictive equations the Peak Height Velocity (PHV) (Mirwald et al., 2002). The age at PHV (APHV) was also calculated by subtracting the maturity offset from the chronological age.

Motor Competence Test

MC and performance assessment was determined by the STS_{TIME} and STS_{MC}, based on the protocols suggested by VanSant (1988). The test was carried out on a flat surface, where the participant was invited to lie in the supine position on the floor, with the upper limbs extended along the body and lower limbs. They were instructed to get up as quickly as possible in the way they wanted and maintain the standing position, after an audible command. No demonstration was carried out to avoid influences on the participant's movement patterns. Three attempts were made; the first one was used as familiarization, while the other two were filmed in the sagittal plane, with a digital camera for subsequent analysis using the Kinovea® program. The shortest execution time was used to determine performance on the STS_{TIME}. In turn, STS_{MC} was evaluated based on the motor patterns used to get up from the floor, classified according to the sequences of movements proposed by VanSant (VanSant, 1988) for upper limbs, lower limbs, and axial body region.

Physical Fitness Tests

Cardiorespiratory fitness (CRF) was assessed with the Shuttle Run Test (Léger et al., 1988), carried out at the school's sports arena. The protocol consists of multiple progressive stages of running with increasing intensity, in which the participant needs to move between two 20-meter markers, keeping the pace established by an audible signal. The initial speed was 8.5 km/h, increasing 0.5 km/h per stage.

A heart rate monitor (Polar® A300) was used to measure maximum heart rate, and the test was only interrupted at the participant's request or when they did not reach the line marked for the sound signal during two consecutive laps. The adolescents were already familiar with the test, and the CRF was later estimated by a specific equation for adolescents proposed by Menezes-Junior et al. (2019).

Upper limb strength was measured through handgrip, obtained by using a hand-held hydraulic dynamometer (Saehan®), in which the grip was adjusted for each participant, with the elbow flexed at an angle of 90° with the forearm in a neutral position. Participants were instructed to tighten the equipment gradually and continuously until reaching maximum strength. Two runs were performed, with a 60-second interval between attempts, and the highest value achieved by the participant was recorded in kilograms. Abdominal resistance was measured based on the maximum number of repetitions of crunches performed on the floor for 1 minute; participants were required to touch their lower limbs with their elbows to validate the repetition (Plowman & Meredith, 2013). Flexibility was determined with Wells' bench and sit-and-reach test (Wells & Dillon, 1952).

Data analysis

The data were subjected to the Kolmogorov-Smirnov normality and Levene homogeneity tests. Descriptive statistics were presented as mean and standard deviation, and differences between experimental and control groups were tested using a one-way analysis of variance for parametric variables and the Kruskal-Wallis test for non-parametric variables. Repeated measures analysis of variance (ANOVA) was used to compare the effects of the intervention between the groups, followed by Bonferroni Post Hoc for analyses adjusted for sex, age, and PHV. Effect size (ES) confidence intervals (95%) were calculated to determine the magnitude of the intervention effect. Clinical inference (CI) was performed according to the magnitude of the standardized ES, considering trivial (≤0.2), possibly beneficial/harmful (0.20-0.39), beneficial/harmful (0.40-0.79), and very beneficial/harmful (>0.80) (Hopkins, 2007). Individual responsiveness frequencies were obtained according to the theoretical model considering the magnitude of the individual effect by dividing the delta values (final value-initial value) by the grouped standard deviation (SD), calculated with the formula "√((SD12+SD22)/2)". The cutoff point used responsivity to present an ES ≥ 0.20 or ≤ -0.20 (Bonafiglia et al., 2016). The difference in frequency between groups was analyzed using generalized linear models. SPSS software, version 26, was used for statistical analysis, and the level of significance was set at p < 0.05.

Results

The study sample had 46 adolescents (52.2% boys and 47.8% girls), divided into HIFT (n=10), HIIT (n=12), MICT (n=12), and CG (n=12), with no differences in age (14±1.8 years) (χ^2(3)=2.29; *p*=0.515), APHV ($F_{3\ 23}$=2.766; *p*=0.065) and sex proportion between the groups (χ^2(3)=2.985; *p*=0.394).
Table 1 presents the descriptive characteristics and comparisons in the initial phase and after 12 weeks and the ES and IC results for the groups. Their anthropometric and body composition were similar in the initial phase (*p*>0.05). After 12 weeks, only the HIFT group improved body composition variables in relation to the other training groups and the control group, with a trivial reduction in BMI [F(1 39)=2.416; *p*=0.04], WHtR [F(1 39)=2.963; *p*=0.050], beneficial reduction in %FM [F(1 39)=5.225; *p*<0.001], and beneficial increase in %FFM [F(1 39)=5.225; *p*<0.001]. In the physical fitness variables, the HIIT and MICT groups had a beneficial increase in handgrip strength [F(1 39)=8.326; *p*<0.003 and *p*<0.02], while the HIFT group had a beneficial increase in ABD variables [F(1 39)=3.339; *p*<0.01] and flexibility [F(1 39)=3.099; *p*<0.03] and very beneficial improvement in STS_{TIME} [F(1 39)=4.683; *p*<0.001].

Table 1. Comparison before and after intervention, effect size, and clinical inference between training models.

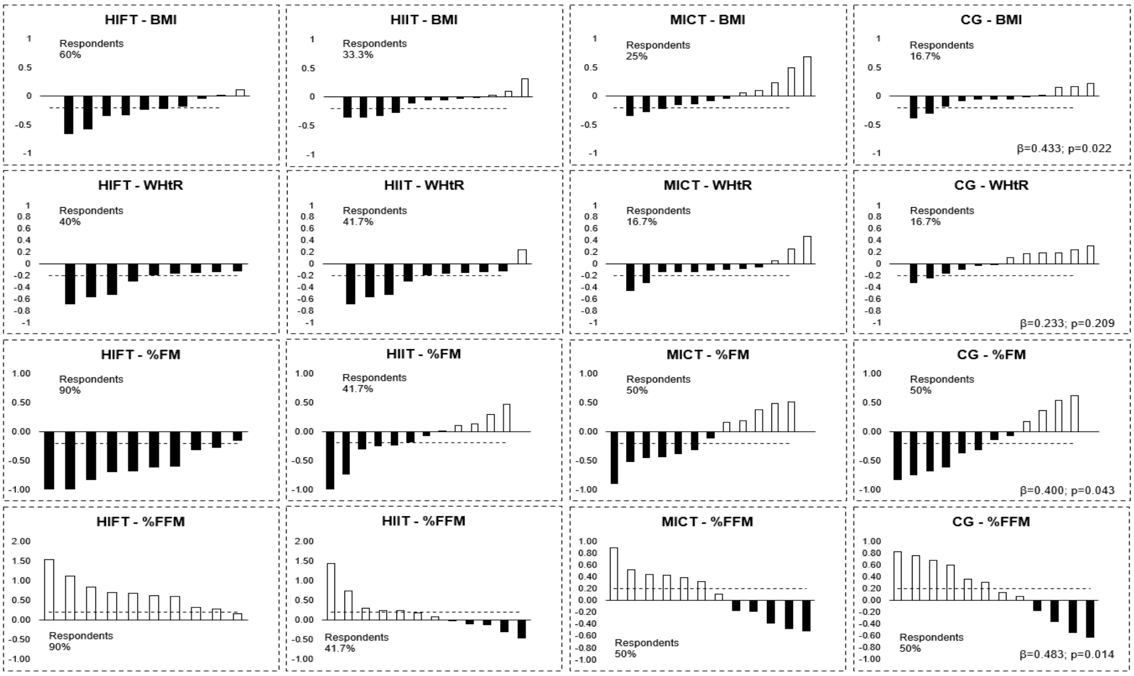
Variables	HIFT (n=10)					HIIT (n=12)					MICT (n=12)					CG (n=12)				
	Before	After	p	ES	CI	Before	After	p	ES	CI	Before	After	p	ES	CI	Before	After	p	ES	CI
BMI (kg/m²)	28.3±4.2	27.5±4.3	0.04	-0.17	T	29.2±3.9	29.0±3.9	1.00	-0.06	T	27.6±2.6	27.7±2.5	1.00	0.01	T	29.71±4.6	29.5±4.6	1.00	-0.03	T
BMI z-score	2.14±0.6	1.99±0.8	0.85	-0.20	PB	2.48±0.9	2.38±2.3	1.00	-0.10	T	2.20±0.7	2.17±0.7	1.00	-0.04	T	2.55±0.6	2.49±0.6	1.00	-0.09	T

WC (cm)	83.4±10.2	81.7±10.9	0.59	-0.15	T	89.9±8.9	89.0±9.3	1.00	-0.09	T	86.5±9.8	86.6±9.4	1.00	0.00	T	86.7±10.2	87.4±10.2	1.00	0.06	T
WHtR	0.51±0.06	0.50±0.07	0.05	-0.18	T	0.55±0.06	0.54±0.06	0.34	-0.14	T	0.54±0.05	0.54±0.04	1.00	-0.05	T	0.54±0.05	0.54±0.06	1.00	0.01	T
%FM	39.3±7.65	35.4±8.2	<0.001	-0.48	B	38.0±5.6	37.1±7.3	1.00	-0.13	T	37.6±5.0	37.1±5.0	1.00	-0.08	T	37.59±5.8	36.9±5.1	1.00	-0.12	T
%FFM	60.6±7.6	64.5±8.2	<0.001	0.48	B	61.9±5.6	62.8±7.3	1.00	0.09	T	62.3±5.1	62.8±5.0	1.00	0.15	T	62.4±5.2	63.0±5.1	1.00	0.12	T
CRF_{abs} (L/min)	2.04±0.2	2.08±0.2	1.00	0.15	T	2.20±0.2	2.27±0.2	0.47	0.25	PB	2.09±0.2	2.04±0.1	1.00	-0.21	PH	2.09±0.2	2.04±0.1	1.00	-0.27	PH
CRF_{rel} (ml/kg.min)	28.3±5.3	29.5±6.5	0.391	0.18	T	29.1±5.6	29.9±5.8	1.00	0.12	T	29.0±3.7	30.2±3.8	0.43	-0.27	PB	27.4±4.1	28.2±6.2	1.00	-0.19	T
Handgrip (kg)	25.9±6.0	26.0±6.4	1.00	-0.01	T	23.6±5.8	26.5±6.5	0.003	0.47	B	21.1±3.9	24.5±5.3	0.02	0.71	B	25.6±4.3	24.5±3.5	1.00	-0.29	PH
ABD (rep/min)	23.6±11.1	30.5±12.9	0.01	0.57	B	25.0±14.6	28.8±14.2	0.24	0.26	PB	19.8±7.6	21.6±9.3	1.00	0.21	PB	16.5±9.0	16.5±8.5	1.00	0.00	T
Flexibility (cm)	24.0±8.0	29.3±7.1	0.03	0.69	B	22.8±9.7	24.3±6.3	1.00	-0.18	T	20.5±10.6	22.4±11.9	1.00	0.16	T	21.9±7.2	21.1±7.0	1.00	-0.10	T
STS_{TIME} (s)	2.67±0.3	2.27±0.4	<0.001	-0.99	VB	2.41±0.4	2.32±0.4	1.00	-0.19	T	2.67±0.8	2.53±0.7	1.00	-0.18	T	2.56±0.5	2.51±0.4	1.00	-0.10	T
STS_{MC} (points)	7.50±1.9	8.60±2.3	0.24	0.51	B	6.75±2.4	7.41±2.4	0.62	0.26	PB	6.08±2.1	7.08±2.2	0.09	0.45	B	5.58±1.2	6.33±1.4	1.00	0.54	B

ES effect size; CI clinical inference; p ANOVA of repeated measure; BMI body mass index; BMI-z body mass index z-score; WC waist circumference; WHtR Waist-to-height ratio; %FM fat mass; %FFM fat-free mass; CRF_{rel} relative cardiorespiratory fitness; CRF_{abs} absolute cardiorespiratory fitness; ABD abdominal; STS_{TIME} supine-to-stand time; STS_{MC} supine-to-stand motor competence. *Diferencias significativas, p< .05.
Nota: Moraes et al. (2024).

Figure 1 shows the frequency of body composition respondents after the 12-week intervention for the HIFT, HIIT, MICT, and CG groups. Significant frequencies of respondents were found to reduce BMI and %FM and increase %FFM in the HIFT group in relation to the other groups (p<0.05).

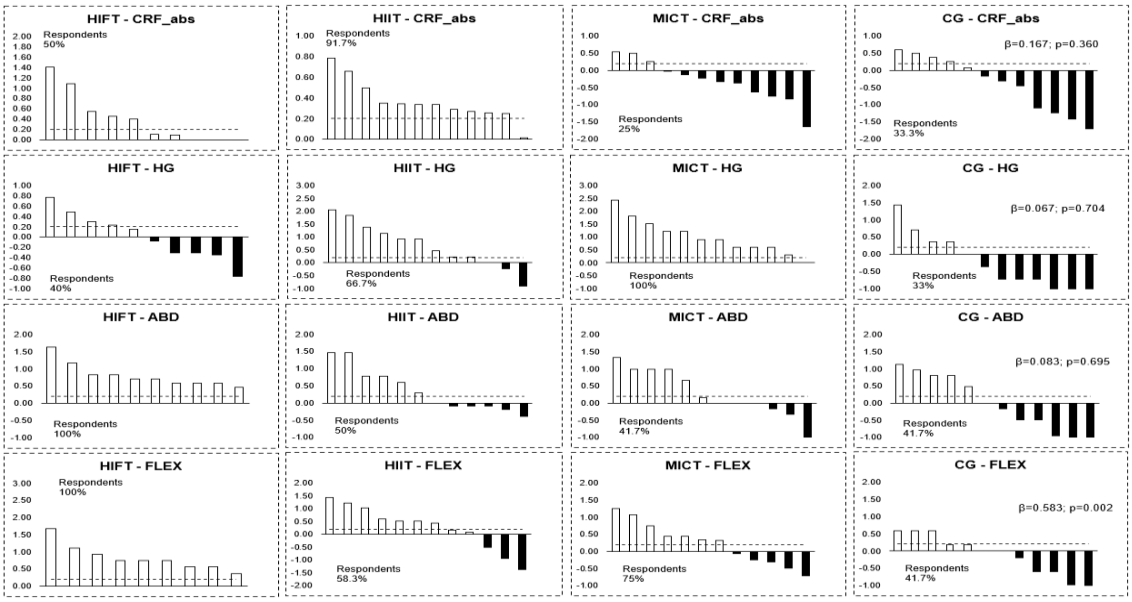
Figure 1. Frequency of the respondents' body composition in the HIFT, HIIT, MICT, and CG groups after 12 weeks of intervention.



Fuente: Moraes et al. (2024).

Figure 2 shows the frequency of respondents' physical fitness per group after 12 weeks. Flexibility was the only variable with significance in the frequency of respondents between the groups, with HIFT showing a total of 100% of the sample responded to the proposed training model.

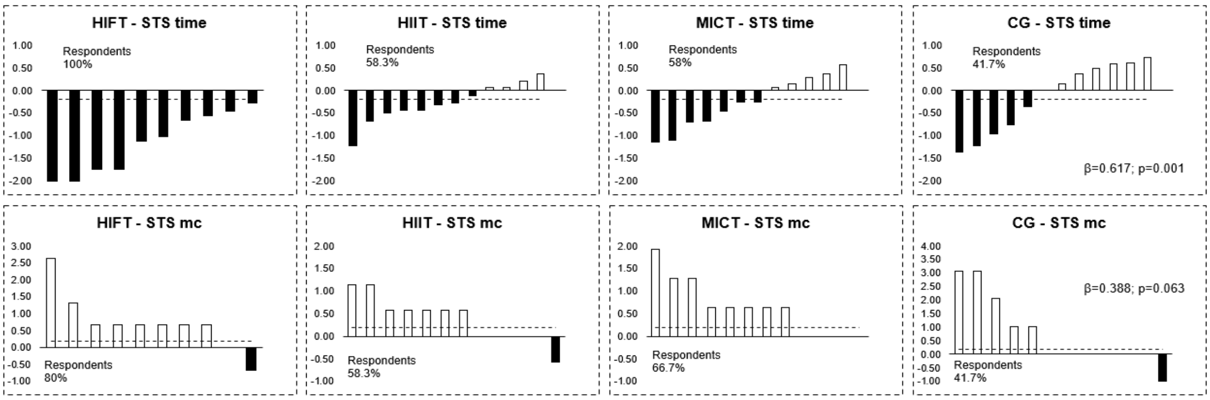
Figure 2. Frequency of respondents' physical fitness in the HIFT, HIIT, MICT, and CG groups after 12 weeks of intervention.



Fuente: Moraes et al. (2024).

In Figure 3, HIFT likewise presents the maximum percentage of the frequency of improvement in the STS motor test in its performance assessment (STS_{TIME}) in relation to the other groups (β=0.617; *p*=0.001). There was no frequency of reduction in STS_{MC} in any training model.

Figure 3. Frequency of respondents' motor competence in the HIFT, HIIT, MICT, and CG groups after 12 weeks of intervention.



Fuente: Moraes et al. (2024).

Discussion

The main findings of this research suggest that 12 weeks of training with the HIFT protocol was more effective and had a beneficial effect in improving the execution time of the motor ability to get up from the floor, in comparison with the other types of exercises tested (HIIT and MICT). HIFT also had beneficial effects on physical fitness variables, such as abdominal resistance and flexibility, and improved body composition compared to the other groups. Hence, we emphasize that globally, functionally, and intensely training the body, as proposed by HIFT, is an important factor in increasing obese adolescents' physical fitness and MC.

Our training program aimed for the effect of three different types of physical training, as they establish the benefits of physical exercise, but the magnitude can vary according to frequency, intensity, duration, volume, and type of exercise (Liguori et al., 2021). The MICT aerobic exercise protocol has been recommended for reducing body fat, maintaining body composition, and improving cardiometabolic factors (Meng et al., 2022; Yin et al., 2020). Since body weight overload is a barrier to adherence to physical exercise, we performed the MICT on stationary bicycles to reduce the impact on the participants' joints, although the body overload promotes neuromuscular adaptations in excess weight individuals (Moraes et al., 2018). Despite the lack of significant body composition and CRF results, as suggested in the literature, our investigation demonstrated that the MICT and HIIT groups improved their handgrip strength, probably thanks to bicycle handlebar grip during training sessions.

Furthermore, interval exercises are performed in a shorter session time due to their high intensity, with active intervals between sets, and are recommended to improve vascular function and increase physical fitness (Duncombe et al., 2022), besides providing greater satisfaction (Heinrich et al., 2014). The HIIT protocol has proved to be more efficient than MICT in improving cardiovascular health in adolescents (Wang et al., 2024).

We highlight that both HIIT and HIFT protocols are high intensity, but HIIT is based on cyclical aerobic activities, such as running and cycling, while HIFT aims to work together on resistance and aerobic exercises in a cyclical way, with high intensity and short duration, using primarily body weight as resistance. Thus, it makes it possible to achieve many body movements, which emphasizes the improvement of global MC (Gibala et al., 2012). HIIT effectively improves multiple health outcomes such as cardiometabolic risk, CRF, body composition, cognition, and well-being in school-aged children and adolescents (Duncombe et al., 2022). However, we did not find significant improvements in the variables investigated for the HIIT group. In a recent study, HIIT performed with a running and gaming model improved anthropometric variables and reduced cardiometabolic risk in excess weight schoolchildren (Espinoza Silva et al., 2023). We believe that the divergence occurred because our exercise program was carried out on stationary bicycles, unlike other studies that involved supporting the body during intense activities.

HIFT aims to integrate cardiovascular, neuromotor, and muscular efforts, through strategies such as selecting exercises for the entire body that maximize oxygen consumption, rapid movements, and the use of body weight. Like HIIT, this type of exercise also significantly improves both motor functions related to physical fitness (Wilke & Mohr, 2020) and cognitive performance regarding task speed and precision in adults (Molinaro et al., 2023). Due to the characteristics of the exercises, our hypothesis was confirmed, that HIFT would be the best protocol compared to the others in improving adolescents' physical fitness and MC indicators, since it emphasizes the use and control of body weight, resulting in more stimuli and greater muscle activation. The investigation demonstrated the ability of HIFT to improve physical fitness and MC analyzed through STS performance.

Motor assessment is extremely important in this context, as it enables a better diagnosis of MC, defined as the degree of qualified performance in a wide range of motor tasks (Stodden et al., 2008). Functional capacity assessment protocols in children and adolescents make it easier to identify changes in motor performance over time (VanSant, 1988). This is the first study to compare the effects of HIFT, HIIT, and MICT training on the MC of excess weight adolescents in the STS analysis. A negative association of MC with BMI was recently reported in schoolchildren and adolescents assessed with the TGMD test, in which researchers suggest that MC development may have a greater impact on preschoolers above the recommended weight (Martins et al., 2023). The study by Tadiotto et al. (2021), verified that performance on the STS test is related to adiposity and physical fitness in Brazilian adolescents. Hence, our results were positive in using intervention to improve MC and they make it possible to compare different types of training that aim to improve the physical fitness of adolescents and promote their adherence in a healthy environment.

Li et al. (2023) in a sample of same-age adolescents with adequate weight, found that both HIIT and HIFT protocols successfully improved indicators of cardiorespiratory fitness and muscular strength in adolescents. Also, as in our results, HIFT was more efficient than HIIT in most physical fitness tests. Another study that evaluated micro sessions with 6-minute HIFT training in children with adequate weight, 4 times a week, for 4 weeks, also showed no improvement in variables related to aerobic resistance performance – although, like our study, it found improvements in some functional force parameters (Engel et al., 2019).

The functioning of all components of physical fitness is an important factor in child development, resulting in a fundamental role in motor development (Cattuzzo et al., 2016). The motor response is developed in a particular way according to individual motor experiences. The frequency of responsiveness was verified due to the importance of interindividual variability, considering each intervention and the specificity of each adolescent's response to the exercises. A frequency of responsiveness was observed in improving body composition, demonstrating that adolescents responded favorably to the proposed exercise protocols, especially in the HIFT group in reducing %FM and increasing %FFM. It also presented maximum prevalence in physical fitness, ABD, flexibility, and motor performance in the STSTIME. A study that compared HIFT and HIIT in adolescents suggests that the increase in strength and FFM is related to anaerobic glycolytic enzyme activities due to the characteristics of functional exercises (Li et al., 2023).

STS is a simple, easily applicable test to assess MC, verifying the ability to get up from the floor, from a lying down position to a standing position – an essential motor skill movement that has been proposed as an alternative for MC analysis (Nesbitt et al., 2018). The ability to rise from the floor to a standing position is important for the development of other fundamental skills and is associated with functional capacity in adulthood (Nesbitt et al., 2018). STS is a highly regarded test that may be a feasible choice, as it assesses flexibility, strength, locomotion, balance, and MC together (Duncan et al., 2017). Because of its importance for assessing motor function and informing strength and conditioning programs, it is related to other aspects of physical fitness (Ng et al., 2013).

The movement quality assessment in this research (STSMC) did not change in any of the groups, perhaps due to the need for a longer-lasting intervention so that adolescents can better develop and incorporate new movements – even though changes occurred in STSTIME, which evaluates the movement execution time – i.e., STS performance. This may have occurred due to the direct relationship between STSTIME and body composition variables and its inverse relationship with physical fitness (Tadiotto et al., 2021). In our study, HIFT was able to improve physical fitness variables: flexibility, abdominal endurance strength, and body composition. This can be attributed to the fact that functional exercises improve both the range of movement and the strength of the central muscles and spinal stabilizers, muscles that are important when performing the STS test.

Previous motor experiences, stimulated through traditional games and playful activities, can significantly enhance motor skills (Falconí, Almeida, Labanda, & Cahuana, 2025). In this context, it is essential for physical training programs, such as HIFT, prioritize the development of fundamental motor skills, especially during childhood and adolescence. MC development is directly related to improving physical performance, and consequently to reducing body fat (Martins et al., 2022). From a practical standpoint, HIFT does not require equipment, has no space restrictions, and stimulates participants with more different movements and functionalities than other training. It aims not only at caloric expenditure but also the development of motor skills, which allow the construction of the motor repertoire to acquire more complex skills, necessary in games, sports, and other activities during childhood and adulthood (Robinson et al., 2015). Thus, MC plays a fundamental role in the active and healthy lifestyle of adolescents.

This is the first study that investigated the effect of HIFT training on MC in comparison to other training groups in excess weight adolescents. HIFT can be incorporated into school activities integrated into physical education classes. Therefore, the results of this study have important clinical implications in fighting obesity and sedentary behavior, particularly on the joint effect on the MC of excess weight adolescents. Future studies with larger samples and analyses stratified by sex may provide additional information about the effects of different protocols on MC in excess weight adolescents.

Conclusions

In conclusion, our study showed that 12 weeks of high-intensity training based on functional exercises was more effective in improving the task time in getting up from the floor than the other types of exercises tested. Moreover, there was an improvement in some physical fitness components, such as flexibility and abdominal strength. Thus, HIFT is an efficient alternative for improving physical fitness and motor performance, with the ease of a short-term protocol that can be carried out in any space, promoting physical activity and habit change in excess weight adolescents.

The beneficial effects of exercise are already well established. However, what we bring in this study is not just a comparison between models, but rather a new possibility of expanding the motor repertoire through the diversity of movements, incorporating functional exercises into curricular activities as recommendations to develop MC, a fundamental factor in the prevention of obesity and sedentary lifestyle in children and young people.

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