







The effectiveness of a high-intensity interval games intervention in schoolchildren: A cluster-randomized trial

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The aim of this study was to assess the effectiveness of a high-intensity interval training (HIIT) intervention based on playground games (MOVI-daFit!) on improvements in adiposity, physical fitness, and cardiometabolic risk factors in schoolchildren. A cluster-randomized controlled trial (RCT) was performed that included 562 schoolchildren (9–11 years) from 10 schools in Cuenca, Spain. The intervention consisted of four 60-min sessions per week in the school setting. Analyses were conducted on the intention-to-treat basis. Changes in physical fitness parameters (cardiorespiratory fitness: main outcome), body composition, blood pressure, and biochemical cardiometabolic risk parameters were analyzed using both mixed linear and logistic regression models, controlling for baseline covariates, Tanner stages, health dietary score index, body mass index, and cluster factor school. In boys, no significant differences in any outcome measure were noted except for the standing long jump test (10.13 cm; 95% CI 2.94 to 17.32; $p = 0.006$) between the intervention group (IG) and the control group (CG). Improvements in mean arterial pressure (-1.68 mmHg; 95% CI -3.28 to -0.08 ; $p = 0.039$), the triglyceride/HDL-c ratio (-0.36 mg/dl; 95% CI -0.59 to -0.13 ; $p = 0.002$), C-reactive protein (-0.23 mg/L; 95% CI -0.43 to -0.03), VO_2 max (1.44 ml/kg/min; 95% CI 0.52 to 2.36, $p = 0.002$), 20-m shuttle run test (3.64 laps; 95% CI 0.51 to 6.78), and standing long jump test (7.04 cm; 95% CI 1.21 to 12.87;

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$p = 0.018$) were observed in girls in the IG compared with those in the CG. Body composition parameters did not change significantly in either boys or girls. Additionally, children with lower fitness levels obtained greater improvements than children with higher fitness levels. In conclusion, MOVI-daFit! may represent a good strategy for incorporating HIIT into playground games, although its implementation may need to be improved to extend the benefits to children and enhance its adherence.

KEYWORDS

children, effectiveness, HIIT, physical fitness

1 | INTRODUCTION

Atherosclerotic cardiovascular disease (CVD) is the most common cause of death in wealthy countries.¹ Although atherosclerotic-related events are almost exclusively limited to adulthood and old age, the atherosclerotic process begins in the first decade of life through the abnormal accumulation of lipids in the intima of the arteries^{2,3} with early changes observed in the fetus.⁴ Although it is true that genetic influences and diabetes are major predictors of atherosclerosis, from a population perspective, the clustering of multiple risk factors in children is the most common subclinical disorder associated with premature atherosclerosis.⁵ Moreover, consistent evidence supports that obesity plays a predominant role in this clustering that begins in infancy and continues into adolescence to adulthood.^{6,7} Thus, it has been preconized that childhood is the age at which the prevention of atherosclerotic CVD is most feasible and cost effective.⁸

A Cochrane systematic review and meta-analysis⁹ reported that unlike children aged 0–5 years, where interventions that include improvements in diet are the most effective in reducing obesity, there is no evidence that diet interventions are effective in children aged 6–12 years. However, moderate certainty evidence supports that physical activity interventions significantly reduce body mass index (BMI). Moreover, this review⁹ suggested that these interventions have not resulted in health inequalities. Similarly, a further meta-analysis¹⁰ concluded that school-based interventions, including high-intensity physical activity, were effective in modestly improving most cardiometabolic risk factors without adverse effects.

Physical fitness is associated with the cardiometabolic risk profile in children and adolescents.¹¹ It has been stated that an aerobic capacity below 42 and 35 ml/kg/min for boys and girls, respectively, represents the levels of cardiorespiratory fitness (CRF) below which children

and adolescents are at an elevated cardiovascular disease risk.¹² Given the importance of physical fitness for the health of children, it seems inexcusable to include physical fitness indicators as outcomes of physical activity interventions in schoolchildren.

Previous school-based physical activity interventions of our group conducted in both 9- to 11-year-old children^{13–15} and 4- to 7-year-old children¹⁶ showed greater benefits in girls than in boys. Based on the results of these and other interventions, there has been a debate about which type of school-based physical activity promotion interventions are most appropriate: those targeted to a particular group (gender, weight status, and physical fitness level categories) or those targeted to the entire school population. The characteristics of our MOVI interventions^{13,16} seem only compatible with those population-based programs (extracurricular, play-based non-competitive programs that include traditional playground games of moderate to vigorous intensity).¹⁷

Greater benefits of high-intensity interval training (HIIT) to cardiometabolic profile and body composition compared with traditional moderate-vigorous physical activity programs in adolescents have been reported,^{18–20} although the optimal conditions (frequency, intensity, and duration) to implement these programs remain a debatable issue.²¹ Because typical physical activity patterns in children consist of short bursts of intense physical activity combined with intervals of low-moderate intensity,²² it seems that HIIT programs are appropriate given the nature of children's physical activity patterns.

The effectiveness of incorporating the HIIT strategy into school-based programs focused on playground games suitable for all children has been rarely evaluated.²³ Thus, the objective of this study was to assess the effectiveness of a HIIT intervention based on playground games (MOVI-daFit!) on improvements in adiposity, physical fitness, and cardiometabolic risk factors in schoolchildren.

2 | MATERIAL AND METHODS

2.1 | Study design and participants

The MOVI-daFit! study was a cluster-randomized controlled trial (NCT03236337) including 10 schools from Cuenca, Spain. The methods of MOVI-daFit! study have been described in detail elsewhere.²⁴ A total of 562 children belonging to fourth and fifth grades of primary school were involved in the study. The CONSORT 2010 statement for cluster-randomized trials²⁵ was followed to report the results of this trial.

The study protocol was approved by the Clinical Research Ethics Committee of Virgen de la Luz Hospital in Cuenca (REG: 2016/PI021). Moreover, directors and schoolboards were informed about the aims and methods of the study and asked for approval. After approval, researchers informed all parents of children in fourth and fifth grades on the objectives and methods of the study, and parents were invited to allow their children to participate by signing informed consent. Moreover, schoolchildren were informed of the characteristics of the study, and they assented to participate. Once school councils agreed to participate in the study, the schools were randomized to the intervention (IG) and control (CG) groups. In total, 10 schools from 10 towns of the province in Cuenca, Spain, agreed to participate (Figure 1).

2.2 | The MOVI-daFit! intervention

The program was performed from October 2017 to May 2018. MOVI-daFit! promotes recreational and noncompetitive physical activity, focusing on a HIIT protocol adapted to the age of children. The details of the games used in this study are available in an e-book of the program.²⁶

Children participated in training sessions 4 times a week for a duration of 53 min each day during extracurricular hours and in the school setting. Each session was structured as follows: 15 min of activation and warm-up activities; 28 min of traditional games using the HIIT protocol divided into 4 blocks alternating 4-minute game of high-intensity activity (at 85%–90% of the maximum heart rate), and a game involving recovery activity lasting 3 min (at 65%–75% of the maximum heart rate). Finally, children played a 10-min low-intensity game for cool down. Two physical activity and sport sciences graduates designed the MOVI-daFit! program, and trainers who would perform it with children received lessons for standardization and appropriate implementation of the program. Trainers changed exercise characteristics when intensity was not satisfactory based on data from children's heart rates, which were randomly measured in each session

using heart rate (HR) monitors (Polar; FITM, Finland). Both intervention and control children continued with their standard physical education curriculum throughout the intervention period (two regular 50-min sessions per week).

2.3 | Process evaluation

Attendance and adverse effects were recorded in each session by the monitor. To improve adherence to the program, participants attending at least 70% of the sessions received small gifts depicting the logo of the program's mascot as a reward (t-shirts, fidget spinners, etc.). Satisfaction with the program was assessed four months after the start of the intervention through a questionnaire for parents and schoolchildren. Monthly contacts with monitors were held by phone and e-mail to obtain information on whether the program was well accepted by the children or whether there were barriers to implementing the program sessions as designed. Additionally, the research team carried out several visits during sessions with the aim of assessing and appropriately monitoring the progress of the intervention, and the physical education teachers maintained direct contact with the monitors across the entire program, visiting them on various occasions.

2.4 | Study variables

Physical examinations were performed in the school by trained researchers at baseline (September 2017) and after the intervention (June 2018) under standard conditions. The evaluators were blinded to the group to which the participants were assigned at baseline, but measurements at the end of follow-up were not blinded.

2.4.1 | Anthropometric variables and body composition

Weight and *height* were measured with children wearing light clothing and barefoot, maintaining a straight back. A scale (Seca 861, Vogel and Halke, Hamburg, Germany) and a wall stadiometer (Seca 222, Vogel and Halke) were used to estimate these measurements, respectively. All variables were measured twice to obtain the average as the valid outcome for the analyses. *Body mass index* (BMI) was calculated as weight (kg)/height (m)². Schoolchildren were classified as normal weight, overweight, and obese.²⁷ *Waist circumference* (WC) was based on the average of three measurements at the medium point between the last rib and the iliac crest taken at the end of a normal expiration using

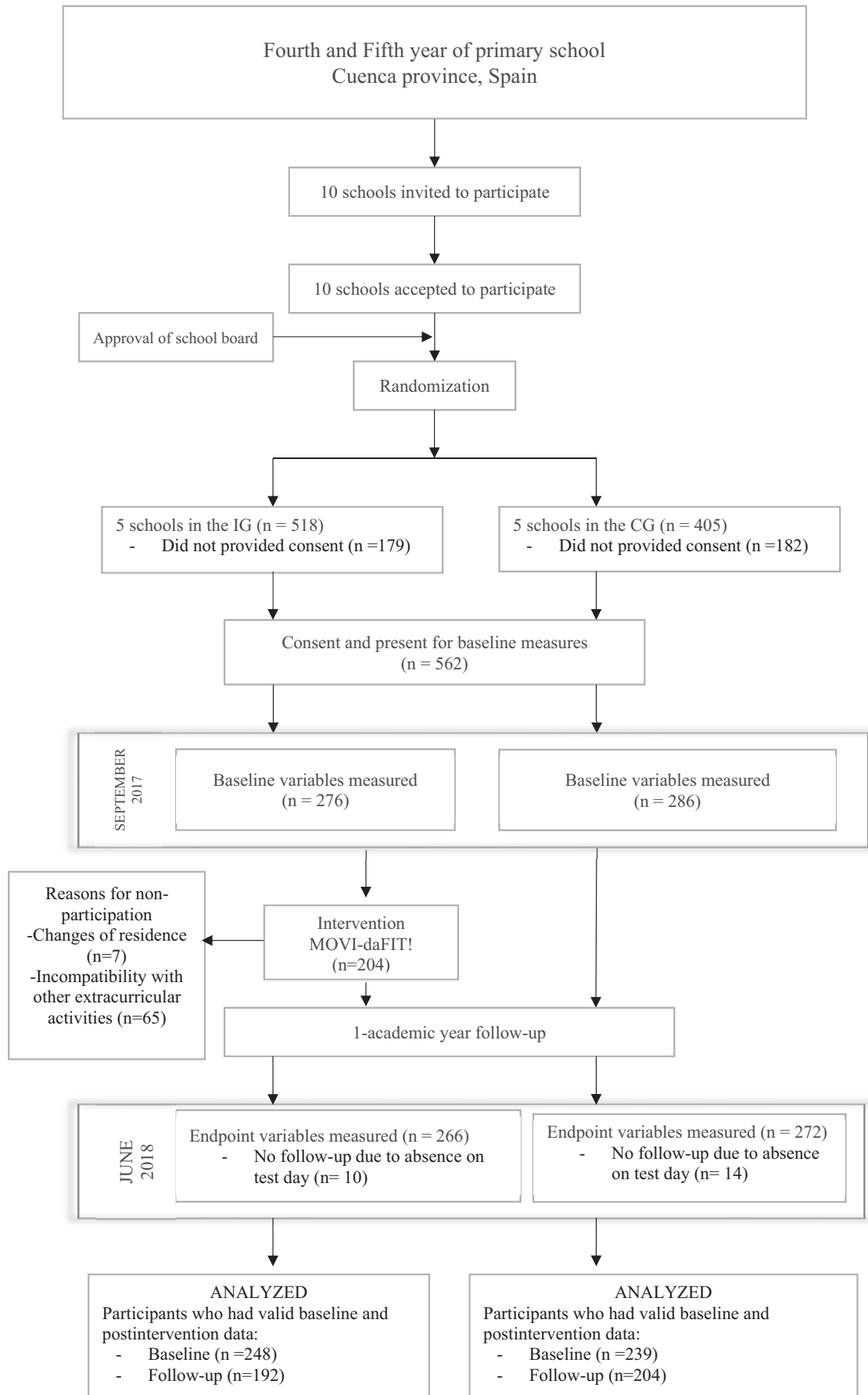


FIGURE 1 Flow chart of trial participants. CG, control group; IG, intervention group

flexible tape. *The waist circumference to height ratio* (WtHR) was also calculated. In addition, *fat mass percentage* (FM%) was determined with an eight-electrode bioimpedance system (TANITA Corporation, Tokyo, Japan). Children had to be in conditions of fasting, after urination and resting for 15 min before the measurement.

2.4.2 | Blood pressure

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured twice with an OMRON-M5-I device (Omron Healthcare UK Ltd.) in a quiet room, and a 5-minute wait period was observed between each determination. Children were asked to rest 5 min before the measurement and were sitting in a chair without crossing their legs. Researchers measured the arm circumference of each child to select the correct cuff size for the determination.

The average of two measurements of SBP and DBP were considered for analyses, and mean arterial pressure (MAP) was calculated as $DBP + (0.333 \times [SBP-DBP])$. Pulse pressure (PP) was calculated by subtracting the (average) DBP from the (average) SBP value.

2.4.3 | Biochemical determinations

Blood sampling was obtained from the cubital vein between 9.00 and 10.00 a.m. under conditions of 12-h fasting. Total cholesterol, high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), triglycerides, fasting plasma glucose (FPG), insulin, glycated hemoglobin A1c (HbA1c), and C-reactive protein (CRP) were determined. Lipid profile and FPG were determined using the Cobas 8000 Roche Diagnostics system. Insulin was determined using the Architect i2000 Abbot Diagnostic system. HbA1c was measured using high-performance liquid chromatography (HPLC) with the ADAMS HA 8180V Menarini Diagnostic analyser, which was standardized for the Diabetes Control and Complications Trial (DCCT) and the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). CRP was measured using the Cobas 6000 Roche Diagnostic system. Samples were refrigerated during transport to the laboratory. The HOMA-IR index and TG/HDL-c ratio were calculated to determine the metabolic syndrome index.

2.4.4 | Physical fitness

The ALPHA fitness test battery²⁸ was used to measure physical fitness variables after a 4-min warm-up.

The Course-Navette test (20-m shuttle run test) was used to estimate CRF. Participants had to run between the two lines for 20 m, starting with 8.5 km/h and increasing their speed progressively (0.5 km/h each minute) based on a sound signal of a pre-recorded tape. Maximal oxygen intake (VO_2 max; ml/kg/min) was calculated using the Leger's formula.²⁹ The number of laps completed (20 m) was also used in the analyses.

Muscular strength was measured twice for each hand with a handgrip dynamometer TKK 5401 Grip-DW (Takeya, Tokyo, Japan), and the average of four measurements was calculated. Lower explosive body strength was assessed with the standing long jump. Children stood behind the jump line with feet separated a distance equal to shoulder width. Children were asked to jump as far as possible for a total of three times, and the best result was registered. Additionally, upper and lower body muscular strength were calculated as dynamometry/weight and standing long jump/weight, respectively.

The 4×10 test run and turn at maximum speed (4×10 m) was used to assess speed agility. Children were asked to run as fast as possible 4 times between 2 lines 10 m apart. The best of 2 results was recorded in seconds and multiplied by -1 for analyses, where lower values represent better performance.

Flexibility was evaluated with the sit-and-reach test. Children had to sit on the floor with their feet placed against a box and try to reach with their fingertips the maximum distance possible without knee flexion. The best of 3 attempts was registered.

2.4.5 | Confounding variables

Parents were asked to complete the following questionnaires:

The Children's Eating Habits Questionnaire (CEHQ)³⁰ was used to estimate food consumption and the health dietary score index. Higher scores indicate a better quality of diet.

The Spanish Epidemiology Society Scale³¹ was used to assess family socioeconomic status. Tanner stages^{32,33} were used to define the pubertal status and sexual maturation of children. Moreover, birth weight, breastfeeding, and gestational age were also registered.

2.5 | Statistical analyses

The sample size was calculated considering the main outcome variable CRF (VO_2 max., ml/kg), since this is the main variable for which the most modest results are expected, and of greater clinical significance in terms of public health

improvements.³⁴ Sample size was estimated, taking into account the cluster nature of the study design, using Donner and Klar's models³⁵ considering an effect size of 0.3 difference mean change between the IG and the CG in CRF (VO_2 max; ml/kg/min) based on results from a previous intervention assessment of our group³⁶ and the pooled estimates reported by previous systematic reviews and meta-analyses.^{19,36–38} The estimates were calculated considering an alpha error of 0.05 and statistical power of 0.80.

First, exploration of outlier values was performed to assess the effectiveness of the randomization processes, and the normal distribution of the variables was assessed using the Kolmogorov-Smirnov test and graphs. Then, winsorization was performed using the 1st percentile and 99th percentile of the distribution of variables.

Analyses were conducted on the intention-to-treat basis. To test differences between the intervention and control groups, mixed regression³⁹ and logistic regression models were used to assess the change between baseline and postintervention measurements for the total sample as well as by sex and aerobic capacity (VO_2 max) levels (students were classified into two fitness levels using the median value, as the cutoff point). Subgroup analyses were unplanned and not included in the trial registration. Each outcome was considered the dependent variable, and the intervention was considered a fixed effect. Covariates included baseline data of the outcome variable, age, Tanner stages, health dietary score index, BMI, and cluster factor school. The effect estimates for quantitative outcomes describe the adjusted difference between groups over time. The effect estimates for categorical outcome variables (weight status) were obtained from logistic regression models and presented as odds ratios with 95% confidence intervals (CIs). Additionally, the results were expressed as the crude difference between the mean change in the IG and CG as (IG end – IG basal) – (CG end – CG basal).

Finally, an explanatory analysis (not included in the registered study) was conducted to assess whether the adherence rate (as number of absences/total number of sessions) was associated with the magnitude of changes in outcome variables from end of follow-up to baseline among IG.

Researchers entering participants' outcomes in the database and conducting the analyses were blinded to the participant's allocation. The analyses were performed using STATA16.0 software and were considered statistically significant at $p < 0.05$.

3 | RESULTS

The flow diagram of schools and participants is presented in Figure 1. The 10 invited schools and 562 children agreed

to participate in the study. Because the difficulties for gathering data of dropouts and because we do not know if they were missing at random, only the 487 participants who had valid baseline and postintervention data were included in the analysis. Among the children allocated to the IG, 276 (53.28%) participants agreed to participate. The participation rate in both the intervention and control groups was similar for boys and girls. Descriptive baseline characteristics (mean \pm SD) of the study are shown in Table 1. Girls and boys from the IG and CG had similar baseline characteristics, except for total cholesterol, non-HDL cholesterol, glucose, HbA1C, and standing long jump test.

3.1 | Effects on body composition, blood pressure, biochemical, and physical fitness parameters

Figure 2 and Tables 2 and 3 depict the differences in the standardized mean change in each outcome from baseline to the end of follow-up, and their effect size estimates between the IG and CG in boys and girls, controlling for baseline outcome values, age, Tanner score, health dietary index, BMI, and cluster factor school. Overall, in boys (Table 2), no significant differences in the mean changes in body composition, blood pressure, and lipid and metabolic profiles were observed. Regarding physical fitness parameters, improvements in lower body strength were higher in the IG than in the CG for the standing long jump test (10.13 cm; 95% CI 2.94 to 17.32; $p = 0.006$) and lower body strength index (0.24 cm/kg; 95% CI 0.16 to 0.46; $p = 0.035$). In girls (Table 3), significant improvements were observed in CRF stages (0.44 stages; 95% CI 0.07 to 0.81; $p = 0.017$), VO_2 max (1.44 ml/kg/min; 95% CI 0.52 to 2.36, $p = 0.002$), 20-m shuttle run test (3.64 laps; 95% CI 0.51 to 6.78), DBP (–1.60 mm Hg; 95% CI –3.12 to –0.07; $p = 0.039$), MAP (–1.68 mm Hg; 95% CI –3.28 to –0.08; $p = 0.039$), triglycerides (–10.90 mg/dl; 95% CI –20.48 to –1.31; $p = 0.026$), ratio of triglycerides/HDL-c (–0.36 mg/dl; 95% CI –0.59 to –0.13; $p = 0.002$), C-reactive protein (–0.23 mg/L; 95% CI –0.43 to –0.03), standing long jump test (7.04 cm; 95% CI 1.21 to 12.87; $p = 0.018$), and lower body muscular strength (0.22 cm/kg; 95% CI 0.08 to 0.35; $p < 0.001$) in the IG versus CG. More detailed results for both sexes are presented in Table S1 (online supplementary material).

Subgroup analysis based on aerobic capacity levels (VO_2 max) (online Tables S2 and S3) showed greater improvements in children with lower CRF levels. Thus, children with lower fitness levels exhibited significant improvements in CRF (stages) (0.39 stages; 95% CI 0.02–0.77; $p = 0.037$), VO_2 max (1.06 ml/kg/min; 95% CI 0.04 to 2.09; $p = 0.041$), 20-m shuttle run test (3.46 laps; 95% CI 0.21

TABLE 1 Baseline characteristics among the intervention versus control groups stratified by sex

	Boys		Girls	
	Intervention (n = 120)	Control (n = 113)	Intervention (n = 128)	Control (n = 126)
Age (years)	9.89 ± 0.71	10.12 ± 0.69	10.03 ± 0.69	10.04 ± 0.72
Birth weight (kg)	3.29 ± 0.55	3.33 ± 0.63	3.17 ± 0.66	3.18 ± 0.53
Breastfeeding (months)	7.72 ± 6.38	9.22 ± 8.23	7.86 ± 8.23	8.27 ± 8.62
Gestational age (weeks)	38.75 ± 2.39	38.72 ± 2.52	39.00 ± 2.24	38.73 ± 2.44
Waist circumference (cm)	65.97 ± 10.14	67.39 ± 9.51	66.18 ± 9.51	64.26 ± 9.40
Ratio waist circumference (cm)/ Height (cm)	0.47 ± 0.06	0.48 ± 0.06	0.46 ± 0.06	0.45 ± 0.05
% Fat mass	21.60 ± 6.98	23.15 ± 6.43	25.88 ± 6.43	24.82 ± 6.08
Fat-free mass (kg)	27.58 ± 4.79	28.10 ± 5.22	27.11 ± 5.22	26.42 ± 5.16
BMI (kg/m ²)	18.00 ± 3.81	18.51 ± 3.91	18.51 ± 3.81	17.89 ± 3.60
BMI (z-score)	-0.06 ± 0.99	0.08 ± 1.04	0.06 ± 1.00	-0.07 ± 0.95
Underweight (%)	12.7	11.9	16.3	14.6
Overweight (%)	17.2	26.7	24.1	16.6
Obesity (%)	10.4	5.9	9.2	6.6
Tanner stage (%)				
Stage 1	50.6	53.3	55.2	67.9
Stage 2	48.1	42.4	31.0	24.1
Stage ≥3	1.3	4.3	13.8	8.0
Socioeconomic level (%)				
Lower/lower middle	26.9	18.3	20.3	20.5
Middle	50.9	55.0	49.6	51.5
Middle upper/upper	22.2	26.7	30.1	28.0
Health dietary score index ^c	65.50 ± 6.34	65.83 ± 8.25	64.71 ± 6.41	65.81 ± 7.17
SBP (mm Hg)	99.33 ± 8.99	100.55 ± 9.76	97.80 ± 9.31	97.68 ± 8.83
DBP (mm Hg)	63.32 ± 6.28	63.77 ± 6.55	63.87 ± 6.51	63.51 ± 6.53
PP (mm Hg)	36.01 ± 7.50	36.77 ± 7.08	33.92 ± 6.98	34.16 ± 7.49
MAP (mm Hg)	75.33 ± 6.39	76.03 ± 7.01	75.18 ± 6.81	74.90 ± 6.48
Total cholesterol (mg/dl)	155.45 ± 24.91	165.53 ± 26.25	159.05 ± 26.13	163.83 ± 20.29
HDL cholesterol (mg/dl)	60.28 ± 12.71	62.18 ± 15.31	58.97 ± 13.70	57.48 ± 11.58
LDL cholesterol (mg/dl)	90.72 ± 22.84	94.11 ± 22.95	94.40 ± 23.90	95.52 ± 17.07
Triglycerides (mg/dl)	64.71 ± 32.27	69.27 ± 39.13	72.84 ± 30.96	77.10 ± 32.59
TG/HDL-C (mg/dl)	1.19 ± 0.90	1.30 ± 1.23	1.39 ± 1.01	1.49 ± 1.07
Non-HDL cholesterol (mg/dl)	95.16 ± 24.95	103.34 ± 25.76	100.07 ± 25.24	106.34 ± 18.86
Glucose (mg/dL)	87.20 ± 8.11	89.82 ± 7.57	85.03 ± 6.85	88.56 ± 6.85
Insulin (μIU/ml)	7.18 ± 4.62	8.23 ± 7.99	8.99 ± 7.55	8.38 ± 4.45
Log_insulin (μIU/ml)	1.81 ± 0.55	1.88 ± 0.61	2.00 ± 0.56	2.00 ± 0.49
HbA1c (%)	5.21 ± 0.24	5.14 ± 0.19	5.14 ± 0.19	5.13 ± 0.21
Metabolic syndrome index ^d	-0.02 ± 0.43	0.01 ± 0.39	-0.03 ± 0.41	-0.03 ± 0.45
C-reactive protein (mg/L)	1.65 ± 1.70	3.32 ± 13.71	1.90 ± 0.41	1.43 ± 2.19
CRF (stages)	4.12 ± 1.94	4.53 ± 2.11	2.98 ± 1.46	3.54 ± 1.50
CRF (VO ₂ max estimate, ml/kg/ min)	47.21 ± 4.67	47.61 ± 5.27	44.06 ± 3.66	45.23 ± 3.87
CRF (total laps)	33.12 ± 16.94	36.90 ± 19.02	23.24 ± 12.43	27.91 ± 12.99
Velocity/agility (se)	13.38 ± 1.24	13.73 ± 1.51	13.73 ± 1.27	13.95 ± 1.35
Flexibility (cm)	20.01 ± 6.64	21.42 ± 6.73	25.90 ± 5.96	24.41 ± 6.67
Handgrip strength (kg)	12.67 ± 3.21	12.93 ± 4.24	11.98 ± 3.05	12.03 ± 3.28

(Continues)

TABLE 1 (Continued)

	Boys		Girls	
	Intervention (<i>n</i> = 120)	Control (<i>n</i> = 113)	Intervention (<i>n</i> = 128)	Control (<i>n</i> = 126)
Upper body muscular strength ^a	0.36 ± 0.09	0.35 ± 0.12	0.33 ± 0.08	0.34 ± 0.08
Standing long jump test (cm)	122.18 ± 21.01	120.91 ± 21.83	107.79 ± 17.42	116.38 ± 19.59
Lower body muscular strength (cm/kg) ^b	3.64 ± 1.16	3.49 ± 1.14	3.11 ± 0.99	3.50 ± 1.12

Note: Values are mean ± standard deviation. Changes between the intervention and control groups were calculated using generalized mixed lineal models (continuous variables) or logistic regression (categorical variables) adjusted by cluster factor school.

Abbreviations: BMI, body mass index; CRF, cardiorespiratory fitness; DBP, diastolic blood pressure; HbA1C, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MAP, mean arterial pressure; PP, pulse pressure; SBP, systolic blood pressure; TG, triglycerides.

^aUpper body muscular strength is reported as dynamometry (kg)/weight (kg).

^bLower body muscular strength reported as standing long jump test (cm)/weight (kg).

^cHigher scores indicate a better quality of diet.

^dMetabolic syndrome index is reported as the sum of the age-sex standardized scores of waist circumference, TG/HDL-c ratio, MAP, and fasting insulin.

^e≥2 scores indicating poorer cardiometabolic health.

to 6.70; $p = 0.037$), standing long jump (11.92 cm; 95% CI 6.44 to 17.41; $p < 0.001$), and lower body muscular strength (0.32 cm/kg; 95% CI 0.16 to 0.48; $p < 0.001$). Conversely, in those with higher fitness levels, no beneficial changes in body composition, blood pressure, or physical fitness parameters were found.

3.2 | Process evaluation of the intervention

3.2.1 | Compliance

Of the 276 schoolchildren who participated in the baseline measurements in the IG, 204 (73.9%) were enrolled in MOVI-daFit! Of these, 24.7% of the children attended greater than 70% of the 117 sessions, and 50% attended greater than half of the sessions. Table S4 (online supplementary material) shows the correlation coefficients between the adherence rate to the program and change in outcome variables from baseline to the end of follow-up in the IG. The adherence rate was positively associated with handgrip strength and upper body muscular strength in boys. Otherwise, the adherence rate was inversely associated with %fat mass, SBP, DBP, MAP, triglycerides, the TG/HDL cholesterol ratio, and metabolic syndrome index in girls.

3.2.2 | Compliance with the planned high-intensity characteristics of the program

The mean HR during the session was 163 beats/min (77.6% of peak heart rate). The mean HR was 189 beats/min (94% of peak heart rate) during games of high-intensity activity and 120 beats/min (60% of peak heart rate) during recovery

games. Eighty percent of the instructors reported that the proposed games almost always reached the planned heart rate, and 100% declared that children always participated with interest in all activities. The most commonly used strategies reported by monitors to increase intensity were new rules to avoid children staying still, such as doing an exercise in place, such as squats, jumping, planks, skipping, etc., while waiting for their turn in a relay game or to be saved in a tag game; reducing the play space; and increasing the number of taggers, not eliminating children from games, and instead awarding penalty points per player.

3.2.3 | Satisfaction with the program

To assess satisfaction with the program activities, children and their parents completed a questionnaire.²⁴ In total, 93.3% of the children stated that they had fun attending MOVI-daFit!, and 80% of the children declared that their parents did not have to remind them to go to the program. Furthermore, 93.2% of the parents stated that their children had fun with the developed activities, and 46.9% of the parents stated that their children were more physically active since they had been involved in MOVI-daFit!. Moreover, 90.6% of parents stated that they were satisfied or very satisfied with the program.

3.3 | Adverse outcomes

Dizziness during baseline venipuncture occurred in 2% of the children at baseline and in 1.1% of the children at the end of the study. No other adverse events were reported by students during health examinations or physical activity sessions.

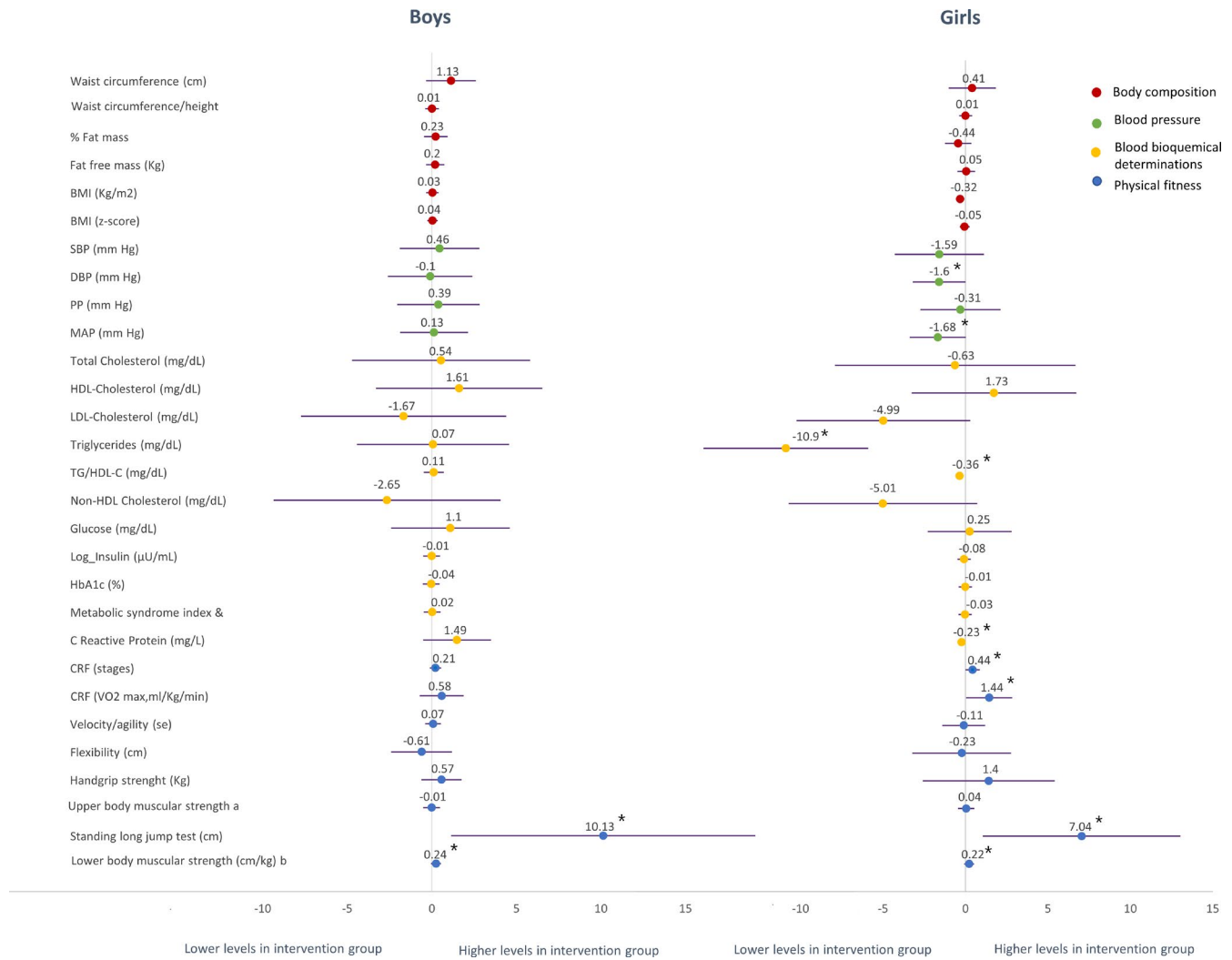


FIGURE 2 Changes in body composition, blood pressure, blood biochemical determinations, and physical fitness from baseline to end of follow-up among the intervention versus control group, in boys and girls. * $p \leq 0.05$. Effect size estimate describes the difference between mean change in the intervention group and mean change in the control group, using generalized mixed linear models (continuous variables), adjusted by baseline outcomes, age, Tanner total score, health dietary score index, body mass index, and cluster factor school. Abbreviation: BMI, body mass index; CRF, cardiorespiratory fitness; DBP, diastolic blood pressure; HbA1C, glycated hemoglobin; MAP, mean arterial pressure; SBP, systolic blood pressure. [&] Metabolic syndrome index reported as the sum of the age-sex standardized scores of waist circumference, TG/HDL-c ratio, MAP, and fasting insulin. ^a Upper body muscular strength reported as dynamometry (kg)/weight (kg). ^b Lower body muscular strength reported as standing long jump test (cm)/weight (kg)

4 | DISCUSSION

This study is the first to assess the effectiveness of a school-based intervention incorporating HIIT principles to playground games for improvements of adiposity, cardiometabolic risk factors, and aerobic capacity (VO₂ max, ml/kg/min) in schoolchildren. Our data, according to previous studies in this age group, support gender differences in the effect of this intervention. Specifically, compared with the CG, the program resulted in improvements in strength parameters (long jump test and lower body strength index) in boys. However, in girls, significant improvements in blood

pressure, lipid profile, aerobic capacity, and strength parameters were observed. In addition, subgroup analysis based on CRF categories revealed greater improvements in children with lower CRF levels. Finally, the MOVIdaFit! intervention had few adverse effects and was of negligible importance.

However, a low adherence rate was observed, probably due to the high number of weekly sessions offered and the wide range of extracurricular activities available to children of this age group. This fact should be considered in the design of future interventions.

Both physical activity and CRF are independently associated with cardiometabolic risk parameters in children.⁴⁰

TABLE 2 Changes in body composition, blood pressure, blood biochemical determinations, and physical fitness from baseline to end of follow-up among the intervention versus control group, in boys

	Baseline		End of follow-up		Crude change	Effect size	<i>p</i> value
	Intervention (<i>n</i> = 120)	Control (<i>n</i> = 113)	Intervention (<i>n</i> = 87)	Control (<i>n</i> = 101)	ΔIG- ΔCG ^e	Estimate, (95% CI) ^c	
Body composition							
Waist circumference (cm)	65.97 ± 10.14	67.39 ± 10.13	67.44 ± 10.62	68.05 ± 10.37	0.81	1.13 (−0.61 to 2.34)	0.063
Ratio waist circumference (cm)/height (cm)	0.47 ± 0.06	0.48 ± 0.06	0.46 ± 0.06	0.47 ± 0.06	0.00	0.01(−0.01 to 0.01)	0.127
% Fat mass	21.60 ± 6.98	23.21 ± 6.92	22.00 ± 7.25	23.24 ± 6.88	0.37	0.23 (−0.46 to 0.94)	0.508
Fat-free mass (Kg)	27.58 ± 4.79	28.10 ± 5.11	29.44 ± 5.19	29.53 ± 5.37	0.43	0.20 (−0.34 to 0.75)	0.467
BMI (Kg/m ²)	18.00 ± 3.81	18.50 ± 3.91	18.40 ± 4.05	18.82 ± 3.91	0.08	0.03 (−0.34 to 0.41)	0.849
BMI (z-score)	−0.06 ± 0.99	0.08 ± 1.04	−0.03 ± 1.04	0.06 ± 1.02	0.05	0.04 (−0.05 to 0.13)	0.411
Underweight (%)	12.7	11.9	7.8	11.1	−4.10	0.60 ^d (0.25 to 1.42)	0.250
Overweight/obesity (%)	27.6	32.6	26.6	38.1	−6.50	1.33 ^d (0.39 to 4.50)	0.639
Blood pressure							
SBP (mm Hg)	99.33 ± 8.99	100.55 ± 9.76	98.21 ± 9.01	98.94 ± 8.22	0.49	0.46 (−1.90 to 2.83)	0.700
DBP (mm Hg)	63.32 ± 6.28	63.77 ± 6.55	62.55 ± 6.83	62.74 ± 5.63	0.26	−0.10 (−2.60 to 2.39)	0.934
PP (mm Hg)	36.01 ± 7.50	36.77 ± 7.08	35.65 ± 7.48	36.19 ± 7.32	0.22	0.39 (−2.05 to 2.83)	0.754
MAP (mm Hg)	75.33 ± 6.39	76.03 ± 7.01	74.44 ± 6.76	74.81 ± 5.64	0.33	0.13 (−1.87 to 2.15)	0.892
Blood biochemical determinations							
Total cholesterol (mg/dl)	155.45 ± 24.91	165.53 ± 26.25	159.85 ± 24.95	164.56 ± 27.07	5.37	0.54 (−4.73 to 5.82)	0.839
HDL cholesterol (mg/dl)	60.28 ± 12.71	62.18 ± 15.31	67.56 ± 14.80	65.55 ± 15.38	3.91	1.61 (−3.32 to 6.53)	0.523
LDL cholesterol (mg/dl)	90.72 ± 22.84	94.12 ± 22.95	90.28 ± 23.62	93.96 ± 25.85	−0.28	−1.67 (−7.74 to 4.39)	0.224
Triglycerides (mg/dl)	64.71 ± 32.27	69.27 ± 39.13	66.31 ± 31.38	67.30 ± 29.22	3.57	0.07 (−0.03 to 0.19)	0.187
TG/HDL-C (mg/dl)	1.19 ± 0.90	1.30 ± 1.23	1.10 ± 0.79	1.14 ± 0.77	0.07	0.11 (−0.44 to 0.27)	0.160
Non-HDL cholesterol (mg/dl)	95.16 ± 24.95	103.34 ± 25.76	92.29 ± 27.63	99.01 ± 29.04	1.46	−2.65 (−9.37 to 4.06)	0.439
Glucose (mg/dl)	87.21 ± 8.11	89.82 ± 7.57	91.60 ± 6.71	92.02 ± 6.75	2.19	1.10 (−2.41 to 4.62)	0.539
Log_insulin (μU/ml)	1.81 ± 0.55	1.88 ± 0.61	1.93 ± 0.62	2.07 ± 0.44	−0.07	−0.01 (−0.21 to 0.19)	0.917
HbA1c (%)	5.21 ± 0.24	5.14 ± 0.19	5.14 ± 0.22	5.09 ± 0.21	−0.02	−0.04 (−0.01 to 0.01)	0.107

TABLE 2 (Continued)

	Baseline		End of follow-up		Crude change	Effect size	
	Intervention (n = 120)	Control (n = 113)	Intervention (n = 87)	Control (n = 101)	ΔIG- ΔCG ^e	Estimate, (95% CI) ^c	p value
Metabolic syndrome index ^f	-0.02 ± 0.46	0.01 ± 0.39	-0.01 ± 0.26	0.01 ± 0.18	0.01	0.02 (-0.07 to 0.13)	0.698
C-reactive protein (mg/L)	1.65 ± 1.70	1.91 ± 2.16	1.80 ± 4.54	1.77 ± 4.27	0.29	1.49 (-0.51 to 3.51)	0.145
Physical fitness							
CRF (stages)	4.12 ± 1.94	4.53 ± 2.11	4.56 ± 2.01	4.77 ± 2.11	0.20	0.21(-0.12 to 0.54)	0.215
CRF (VO ₂ max,ml/Kg/min)	47.21 ± 4.67	47.61 ± 5.27	47.28 ± 4.91	47.41 ± 5.36	0.27	0.58 (-0.71 to 1.88)	0.308
CRF (total laps)	33.12 ± 16.94	36.90 ± 19.02	37.03 ± 18.01	39.08 ± 19.11	1.73	0.43 (-3.35 to 4.22)	0.823
Velocity/agility (se)	13.38 ± 1.24	13.73 ± 1.51	13.07 ± 1.37	13.28 ± 1.21	0.14	0.07 (-0.39 to 0.53)	0.759
Flexibility (cm)	20.01 ± 6.64	21.42 ± 6.73	19.04 ± 5.83	20.68 ± 6.74	-0.23	-0.61 (-2.41 to 1.19)	0.509
Handgrip strength (Kg)	12.67 ± 3.21	12.93 ± 4.24	14.50 ± 3.26	14.95 ± 3.04	-0.19	0.57 (-0.61 to 1.77)	0.345
Upper body muscular strength ^a	0.36 ± 0.09	0.35 ± 0.12	0.38 ± 0.08	0.39 ± 0.08	-0.02	-0.01 (-0.03 to 0.01)	0.218
Standing long jump test (cm)	122.18 ± 21.01	120.91 ± 21.83	134.79 ± 26.05	126.42 ± 24.60	7.51	10.13 (2.94 to 17.32)	0.006
Lower body muscular strength (cm/kg) ^b	3.64 ± 1.16	3.49 ± 1.14	3.76 ± 1.27	3.45 ± 1.16	0.16	0.24 (0.16 to 0.46)	0.035

Note: Values are mean ± standard deviation. Bold values indicate statistical significance $p \leq 0.05$.

Abbreviations: BMI, body mass index; CG, control group; CRF, cardiorespiratory fitness; DBP, diastolic blood pressure; HbA1C, glycated hemoglobin; IG, intervention group; MAP, mean arterial pressure; PP, pulse pressure; SBP, systolic blood pressure.

^aMuscular strength reported as dynamometry (kg)/weight (kg).

^bMuscular strength reported as standing long jump test (cm)/weight (kg).

^cEffect estimate describes the difference between mean change in the intervention group and the mean change in the control group, using generalized mixed linear models (continuous variables) or logistic regression

^d(categorical variables), adjusted by baseline outcomes, age, Tanner total score, health dietary score index, body mass index, and cluster factor school,

^eCrude change describes differences between mean change in the intervention group and mean change in the control group, (IG end - IG basal) - (CG end - CG basal).

^fMetabolic syndrome index reported as the sum of the age-sex standardized scores of waist circumference, TG/HDL-c ratio, MAP, and fasting insulin.

In addition, different systematic review and meta-analysis concluded that low CRF levels are associated with higher cardiovascular risk in children and adolescents.^{12,41} Our data support that HIIT could be a useful strategy to improve physical fitness, particularly in girls, in which both muscular strength and CRF improved, whereas muscular strength but not CRF was improved in boys in the IG. Although the magnitude of the effect on the parameters of fitness might seem small, we have to consider that the capacity of exercise programs to improve fitness is limited given that genetics is the most important determinant of fitness.⁴² In addition, our intervention is population based (i.e., it includes all children attending schools in the participating municipalities, and not only children with, for

example, obesity or low fitness levels), and children with high fitness levels have potentially minimal or no capacity to improve their fitness levels. Finally, it should also be considered that the MOVI-daFit! intervention exhibits two differential characteristics, compared with other previous interventions from our group: its HIIT approach and a higher number of weekly sessions. This increase in the frequency of sessions could be responsible for the low adherence rate because our program competed with the children's extra time in the evening for foreign language learning, homework, etc. However, our data regarding program satisfaction suggest that HIIT could be an important approach for inclusion in playground game-based programs.

TABLE 3 Changes in body composition, blood pressure, blood biochemical determinations, and physical fitness from baseline to end of follow-up among the intervention versus control group, in girls

	Baseline		End of follow-up		Crude change Δ IG- Δ CG ^e	Effect size Estimate, (95% CI) ^c	p value
	Intervention (n = 128)	Control (n = 126)	Intervention (n = 105)	Control (n = 103)			
<i>Body composition</i>							
Waist circumference (cm)	66.18 ± 9.51	64.26 ± 9.40	66.26 ± 9.13	64.22 ± 8.98	0.12	0.41 (−0.63 to 1.43)	0.444
Ratio waist circumference (cm)/height (cm)	0.47 ± 0.06	0.45 ± 0.05	0.46 ± 0.05	0.44 ± 0.05	0.00	0.01 (−0.01 to 0.01)	0.778
% Fat mass	25.90 ± 6.43	24.83 ± 6.08	25.45 ± 5.63	24.75 ± 6.02	−0.37	−0.44 (−1.21 to 0.32)	0.225
Fat-free mass	27.11 ± 5.22	26.42 ± 5.16	28.82 ± 5.57	28.41 ± 5.51	−0.28	0.05 (−0.76 to 0.11)	0.817
BMI (Kg/m ²)	18.51 ± 3.81	17.89 ± 3.60	18.66 ± 3.73	18.37 ± 3.72	−0.33	−0.32 (−0.53 to 0.05)	0.145
BMI (z-score)	0.06 ± 1.00	−0.07 ± 0.95	0.03 ± 0.96	−0.05 ± 0.97	−0.05	−0.05 (−0.25 to 0.14)	0.580
Underweight (%)	16.3	14.6	8.2	10.3	−3.80	0.01 ^d (0.01 to 2.58)	0.114
Overweight/Obesity (%)	33.3	23.2	32.1	24.2	−2.20	0.48 ^d (0.17 to 1.34)	0.163
<i>Blood pressure</i>							
SBP (mm Hg)	97.80 ± 9.31	97.68 ± 8.83	96.62 ± 9.04	96.72 ± 8.39	−0.22	−1.59 (−4.30 to 1.11)	0.248
DBP (mm Hg)	63.87 ± 6.51	63.51 ± 6.53	62.89 ± 5.76	62.72 ± 5.67	−0.19	−1.60 (−3.12 to −0.07)	0.039
PP (mm Hg)	33.92 ± 6.98	34.16 ± 7.49	33.73 ± 7.03	34.01 ± 8.18	−0.04	−0.31 (−2.43 to 1.83)	0.783
MAP (mm Hg)	75.18 ± 6.81	74.90 ± 6.48	74.13 ± 6.19	74.05 ± 5.48	−0.20	−1.68 (−3.28 to −0.08)	0.039
<i>Blood biochemical determinations</i>							
Total cholesterol (mg/dl)	159.05 ± 26.13	163.83 ± 20.29	161.13 ± 24.88	164.56 ± 27.07	1.35	−0.63 (−7.30 to 6.03)	0.852
HDL cholesterol (mg/dl)	58.97 ± 13.70	57.48 ± 11.58	65.29 ± 14.44	60.67 ± 12.92	3.13	1.73 (−2.27 to 5.74)	0.396
LDL cholesterol (mg/dl)	94.40 ± 23.90	95.52 ± 17.07	91.67 ± 22.80	92.83 ± 20.65	−0.04	−4.99 (−10.27 to 0.28)	0.064
Triglycerides (mg/dl)	72.84 ± 30.96	77.10 ± 32.59	69.10 ± 27.71	77.09 ± 31.51	−3.73	−10.90 (−20.48 to −1.31)	0.026
TG/HDL-C (mg/dl)	1.39 ± 1.01	1.49 ± 1.07	1.14 ± 0.63	1.38 ± 0.87	−0.14	−0.36 (−0.59 to −0.13)	0.002
Non-HDL cholesterol (mg/dl)	100.07 ± 25.24	106.34 ± 18.86	95.84 ± 24.81	100.21 ± 22.28	1.90	−5.01 (−10.74 to 0.70)	0.086
Glucose (mg/dl)	85.03 ± 6.85	88.56 ± 6.85	90.04 ± 7.73	91.33 ± 6.47	2.24	0.25 (−2.04 to 2.55)	0.828
Log ₁₀ insulin (μU/ml)	2.00 ± 0.56	2.00 ± 0.49	2.12 ± 0.53	2.18 ± 0.48	−0.06	−0.08 (−0.12 to 0.07)	0.289
HbA1c (%)	5.19 ± 0.21	5.13 ± 0.217	5.09 ± 0.21	5.08 ± 0.24	−0.05	−0.01 (−0.07 to 0.04)	0.644
Metabolic syndrome index	−0.03 ± 0.46	0.01 ± 0.39	−0.01 ± 0.26	0.01 ± 0.18	0.02	−0.03 (−0.07 to 0.23)	0.581
C-reactive protein (mg/L)	1.91 ± 2.16	1.43 ± 2.19	1.75 ± 2.50	1.33 ± 2.17	−0.06	−0.23 (−0.43 to −0.03)	0.026

TABLE 3 (Continued)

	Baseline		End of follow-up		Crude change Δ IG- Δ CG ^e	Effect size Estimate, (95% CI) ^c	p value
	Intervention (n = 128)	Control (n = 126)	Intervention (n = 105)	Control (n = 103)			
<i>Physical fitness</i>							
CRF (stages)	2.98 ± 1.46	3.54 ± 1.50	3.50 ± 1.54	3.63 ± 1.62	0.43	0.44 (0.07 to 0.81)	0.017
CRF (VO ₂ max estimate)	44.06 ± 3.66	45.23 ± 3.87	44.57 ± 3.95	44.61 ± 4.14	1.13	1.44 (0.52 to 2.36)	0.002
CRF (total laps)	23.24 ± 12.43	27.91 ± 12.99	27.60 ± 13.22	28.83 ± 14.30	3.44	3.64 (0.51 to 6.78)	0.023
Velocity/agility (se)	13.73 ± 1.27	13.95 ± 1.35	13.26 ± 1.17	13.39 ± 1.26	0.09	-0.11 (-0.49 to 0.26)	0.552
Flexibility (cm)	25.90 ± 5.96	24.41 ± 6.67	24.72 ± 6.15	23.87 ± 7.09	-0.64	-0.23 (-1.39 to 0.92)	0.690
Handgrip strength (Kg)	11.98 ± 3.05	12.03 ± 3.28	14.33 ± 3.59	14.49 ± 3.50	-0.11	1.40 (-1.61 to 4.42)	0.361
Upper body muscular strength ^a	0.33 ± 0.08	0.34 ± 0.08	0.37 ± 0.09	0.38 ± 0.08	0.00	0.04 (-0.03 to 0.12)	0.291
Standing long jump test (cm)	107.79 ± 17.42	116.38 ± 19.59	134.79 ± 26.05	122.77 ± 23.90	20.61	7.04 (1.21 to 12.87)	0.018
Lower body muscular strength (cm/kg) ^b	3.11 ± 0.99	3.50 ± 1.12	3.31 ± 0.99	3.44 ± 1.14	0.26	0.22 (0.08 to 0.35)	0.001

Note: Values are mean ± standard deviation. Bold values indicate statistical significance $p \leq 0.05$.

Abbreviations: BMI, body mass index; CG, control group; CRF, cardiorespiratory fitness; DBP, diastolic blood pressure; HbA1C, glycated hemoglobin; IG, intervention group; MAP, mean arterial pressure; PP, pulse pressure SBP, systolic blood pressure.

^aMuscular strength reported as dynamometry (kg)/weight (kg).

^bMuscular strength reported as standing long jump test (cm)/weight (kg).

^cEffect estimate describes the difference between mean change in the intervention group and mean change in the control group, using generalized mixed linear models (continuous variables) or logistic regression (categorical variables), adjusted by baseline outcomes, age, Tanner total score, health dietary score index, body mass index, and cluster factor school

^eCrude change describes differences between mean change in the intervention group and mean change in the control group, (IG end - IG basal) - (CG end - CG basal).

^fMetabolic syndrome index reported as the sum of the age-sex standardized scores of waist circumference, TG/HDL-c ratio, MAP, and fasting insulin.

Not all exercise interventions in children have reported gender differences in their effectiveness estimates,⁴³ but the effect differences in favor of girls in all our previous school-based exercise interventions^{13–16} raise several scientific and ethical dilemmas. First, the consistency with which these differences in favor of girls are present in all of our MOVI interventions^{13–16} and the fact that the fitness parameters improved to a greater extent in girls in all of these interventions lead to the assumption that the improvement in fitness is responsible for the improvements in cardiometabolic parameters. The main reason behind this greater increase in fitness parameters in girls could be due to their lower fitness baseline levels (confirmed with the findings for low fit students). Second, in ethical terms, the dilemma about whether educational and gender equity values should prevail over efficiency values focuses on whether ethical criteria should take precedence over cost effectiveness criteria. In our opinion, educational values, socialization, respect for others, development of team-work competences, and self-efficacy should be taken into account. In the meantime, studies using a qualitative design are probably the most appropriate to provide an understanding of the key factors for designing cost-effective physical activity interventions for both girls and boys.

The latest Cochrane systematic review addressing the effect of interventions for preventing obesity in children aged 6 to 12 years, including 14 RCTs, reported moderate certainty evidence that physical activity interventions reduce BMI by a mean of -0.10 kg/m^2 compared with controls. However, z-BMI was not significantly reduced. Consistent with most of the recently published similar studies, our study did not significantly reduce adiposity parameters. To understand this lack of improvement, it is worth remembering that for interventions such as MOVI-daFit! that are capable of improving strength (and therefore probably muscle mass),^{13–15} the weight may even be increased because the density of lean mass is greater than that of fat mass.

Regarding lipids and lipoproteins, a systematic review and meta-analysis by our group¹⁰ reported that school-based physical activity interventions may result in modest reductions in WC, DBP, and fasting insulin. However, the authors mentioned that there were not a sufficient number of studies to conduct subgroup analysis based on gender. Overall, compared with our previous interventions based on other physical activity strategies, such as those based primarily on aerobic exercise¹⁶ or combining aerobic exercise with resistance exercise,^{13,15} the MOVI-daFit! intervention yields no effect in boys and some modest effects on some cardiometabolic parameters, such as DBP, MAP, triglycerides, triglyceride/HDL-c ratio, and CRP, in girls.

Our study has some strengths and innovations that may be highlighted. First, similar to previous interventions

from our group and other groups,^{23,44,45} this intervention is characterized by its noncompetitive nature and appropriateness for all children with the exception of those with serious disabilities. Moreover, in this case, our data also suggest that HIIT interventions are appropriate for inclusion as a part of playground games and that, as expected, those children with low CRF levels benefited the most from this type of intervention. Second, the intervention was conducted in the school setting, so no children were excluded based on gender, ethnic group, fitness status, or motor skills. Third, the intervention is generally free of adverse effects. Fourth, because the intervention is based on games, it has good acceptance. Fifth, because the games and activities of MOVI-daFit! are standardizable and inexpensive, this intervention is highly standardizable.

However, our study also has some limitations that should be acknowledged. First, the program was performed in mostly rural schools, and this characteristic limits its generalizability to other school settings. Second, although baseline outcome evaluators were blinded to the group to which the participants were assigned, end of follow-up measurements could not be blinded. Third, the low rate of adherence suggests that 4 sessions/week was not acceptable. In addition, given the small sample size, subgroup analyses based on categories of adherence were not conducted; however, a positive association between adherence rate and benefits in cardiometabolic parameters suggests a dose-response effect. Fourth, in this sense, because our study was not designed on a compulsory basis, it is not possible to make inferences about what the results would have been if participation was compulsory. Fifth, physical activity patterns were not controlled in the participants, and it is possible that those most active during the MOVI-daFit! sessions would exhibit compensatory behaviors during the remainder of the day and even on the weekend, which would mitigate the effects of the intervention.

5 | PERSPECTIVES

Our data suggest that MOVI-daFit! an intervention focused on promoting non-competitive physical activity with a HIIT strategy, is effective for improving cardiometabolic and CRF in girls. However, the sustainability of the intervention is potentially high because it is implemented using the school facilities, does not require the involvement of families nor to modify the school curriculum, and could be a useful and enjoyable after-school activity in the controlled setting of school premises. Although it is true that the scalability of MOVI-daFit! is a debatable issue, especially when compared with other recently reported HIIT alternatives in the classroom⁴⁴ or in the physical

education lessons,⁴⁵ the lack of effectiveness on improving health and fitness parameter of these interventions, as well as their very high dropout rate⁴⁵ suggest that MOVIdaFit! may represent a good strategy for incorporating HIIT into playground games, although its implementation may need to be improved to extend the benefits to both girls and boys.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS


VM-V, MG-M, MS-L, and IC-R conceptualized and designed the study with the support of AS-C, CB-M, and JAM-H. VM-V drafted the initial manuscript, and together with MS-L, AS-C and MG-M approved the final manuscript as submitted, VM-V and MS-L designed the data collection instruments and coordinated and supervised data collection. EPM, VMM, CB-M, JAM-H, and MS-L were involved in the analysis and interpretation of data and reviewed the manuscript, approving the final manuscript as submitted.


DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author (MG-M) upon reasonable request.

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