

## Article

# Changes in Physical Activity, Motor Performance, and Psychosocial Determinants of Active Behavior in Children: A Pilot School-Based Obesity Program

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**Abstract:** The obesity epidemic and the decline of fitness among children highlights the need for suitable interventions designed to promote Physical Activity (PA) and healthy habits. The purpose of our pilot study was to assess the feasibility of a school-based program among overweight and obese children, by examining changes in their body composition, PA, physical fitness, and some psychosocial determinants of active behavior. An additional objective was to investigate the reciprocal relationship over time between PA and body image. Self-reported PA and health-related fitness tests were administered to 18 overweight and obese children ( $11.3 \pm 0.4$  years), before and after a 6-month intervention including nutritional education, skill-learning, playful physical activities, and exercise training. Participants were assessed on body composition, perceived physical ability, body image, and pleasant and unpleasant psychobiosocial states towards PA. After treatment, children showed decreased body mass index, body fat percentage, arm and waist circumferences, and skinfold thickness. Actual and perceived physical abilities, body image, and PA also improved over six months. Cross-lagged correlations suggest body image to be an antecedent to being physically active. Results showed that the multi-component school program may have sustainable benefits in reducing adiposity indicators and improving exercise adherence, physical fitness, and psychological well-being.

**Keywords:** body composition; body image; overweight; physical activity; physical fitness

## 1. Introduction

Childhood overweight and obesity are increasing globally, with adverse physical and psychosocial consequences on health and quality of life [1]. Body image—or the perception and thoughts about one’s body—has been reported as one of the main factors related to psychological well-being that are more seriously compromised in obesity [2,3]. Moreover, body dissatisfaction seems to increase with overweight status [2,4]. Although weight loss and improved body appearance could represent primary motivators for Physical Activity (PA) in obese children [5], it is still unclear whether weight loss might induce changes in the body representation of obese children [3]. In particular, it is still unclear whether

low levels of PA are determinants or consequences of body dissatisfaction [6]. Furthermore, despite interactive effects seeming plausible [6], most of the studies addressing the relationship between PA and body image have been conducted on adults, while the few studies among children have reported mixed results [7,8].

Cross-sectional studies have demonstrated an inverse relationship between Body Mass Index (BMI) and an individual's perceptions of physical ability [9]—mainly due to movement difficulties, including poor performance on weight-bearing tasks [10]. In particular, an excessive body weight has adverse effects on actual motor skill competence [11] and, consequently, on perceived physical competence [4]. Of note, perceived competence has been linked with increased motivation towards and participation in PA [12]. In fact, perceived physical competence is deemed to mediate individual's emotional responses in PA [13] and therefore, to influence PA behaviors [14,15]. Steiner [16] argued that every action stimulates emotion, which in turn regulates our behavior [17]. In fact, positive emotional experiences associated with PA sustain commitment toward actual levels of PA [14,18]. Thus, enhancing children's self-perception of physical ability and pleasant emotions could ensure interest and adherence to PA [12,14]. Conversely, PA seems to increase body satisfaction through improvements in physical fitness and changes in perceived physical competence [19,20].

Notwithstanding these findings, a better understanding of associations over time between PA participation and the psychosocial determinants of active behavior in obese children is required [21]. Research is needed to identify effective and sustainable ways to motivate overweight and obese children to increase their PA levels. As suggested by Stodden et al. [22] and based on different theories of exercise motivation [23,24], a physically active lifestyle could be encouraged among obese children by enhancing their actual and perceived physical abilities and enjoyment. School Physical Education (PE) programs can greatly contribute to health promotion by providing a variety of enjoyable activities in which participants can monitor their progress and increase their performance satisfaction levels. A systematic review and two meta-analyses suggested that theory based, multi-component PA interventions are the most promising approaches in the school setting [25,26]. Therefore, it is important to ensure that school-based PA programs, especially around 11 years of age [27], provide children with positive experiences to promote their adherence and improve motivation [18]. However, scant research has been conducted on the relationship between psychosocial changes and weight loss, and the results are conflicting [28,29].

To the best of our knowledge, no studies have examined the relationship among changes in body composition, PA levels, motor performances, and psychosocial determinants of active behavior in obese children. Therefore, based on theories of motivation and behavioral change [23,24], we conducted a 6-month, multi-component pilot obesity program in school focused on nutritional education, skill-learning, enjoyable PA, and exercise training. Our study was part of a larger project, named "Healthy Lifestyles Intervention for Obese Schoolchildren (HeLIOS)", which explored the impact of a school-based program on health and well-being among inactive overweight and obese children over time [30]. Health can be broadly defined to include physical, psychological, and social well-being [31]. Therefore, the current study was specifically designed to examine further aspects that were, for the most part, not considered in previous research, to broaden our understanding of modifiable factors that co-exist with pediatric obesity.

In particular, the aim of our study was to assess the feasibility of a school-based program, by examining changes in body composition, physical fitness, and self-reported measures of PA, perceived physical ability, body image, and pleasant/functional and unpleasant/dysfunctional psychobiosocial states in overweight boys and girls. A secondary purpose of this study was to investigate directional influences over time between PA and one of its key correlates (i.e., body image) by using a two-wave panel design with a 6-month time lag. In particular, the objective was to estimate reciprocal relationships between PA and body image across different time points ( $T_0$  = baseline and  $T_1$  = post intervention). Drawing on the causal priority approach [32], we tested the hypotheses that baseline body image satisfaction would be positively associated with and predict higher levels of PA at  $T_1$  (Hypothesis 1) or that PA

levels at  $T_0$  would be positively related to and precede changes in body image over a 6-month period (Hypothesis 2). Support of both hypotheses would indicate a reciprocal relationship between PA and body image.

## 2. Materials and Methods

### 2.1. Participants and Procedures

Eighteen obese and overweight children (nine boys and nine girls, aged  $11.3 \pm 0.4$  years) were recruited through local pediatricians and participated in a 6-month, multi-component, school program initiated in a Pediatric Obesity Center of a University located in southern Italy. The Center offered to a middle school a pilot obesity program including nutritional education, health-related physical activities, and exercise training. Interested children aged 10 to 12 years were considered eligible if they were (a) with a BMI  $\geq$  85th percentile for age and gender, according to the Centers for Disease Control and Prevention (CDC) growth charts [33]; (b) free from conditions that would prevent PA; (c) not currently engaged in any structured exercise programs out of school or had not been involved in the 6 months prior to participation. The study protocol was formally submitted to the school head teacher and was approved by an ad hoc committee of parents and teaching staff at school. All participants and their parents provided written informed consent prior to their enrolment in the study and the admission to the hospital outpatient clinic of the Pediatric Obesity Center. The study was performed according to the World Medical Association Declaration of Helsinki and approved by the University of Foggia and the local School Council Institute (03-2015/1227/B32c).

This pilot study applied a pre-test post-test research design, with assessments at baseline ( $T_0$ ) in October and at the end ( $T_1$ ) of the program in May of the following year. The program started in November and ended in April.  $T_0$  and  $T_1$  assessments took place in four meetings a week before and a week after intervention.

### 2.2. Treatment Program

Participants followed a 6-month school-initiated obesity program, incorporating nutritional counselling and exercise training. The exercise program consisted of two 2 h sessions per week, and was conducted after school time by a single specialist instructor at the school gymnasium. Based on different theoretical approaches to exercise motivation [22–24], it included a wide variety of indoor and outdoor activities (i.e., mini and sport games, circuits, individual tasks) aimed to improve motor skills, muscle strength, power, speed, agility, and aerobic fitness, and to increase PA adherence and enjoyment. During the exercise program, the attendance was systematically recorded and was scored as presence/absence (1 or 0) for each child. Children were also encouraged to be active outside the program and invited to keep an exercise diary.

In order to educate children on the importance of PA and fitness, 30-min interactive group sessions were provided weekly. These included review of PA diaries, goal-setting, self-monitoring and self-reinforcement activities, and basic notions of body functioning and healthy behavior.

According to the Italian nutritional guidelines and recommendations [34,35], participants were also instructed to reduce fat intake and salt-rich foods, increase fruit and vegetable consumption, and make healthy beverage and snack choices. To encourage healthy food habits, children and their parents were asked to record a daily diet diary and received nutritional counselling at the baseline medical examination, at the midpoint and at the end of the intervention by a dietitian of the Pediatric Obesity Center.

## 2.3. Measures

### 2.3.1. Body Composition

Anthropometric assessments were performed by an experienced pediatrician of the Centre for Pediatric Obesity, according to the procedures of the International Society for the Advance of Kinanthropometry [36]. Standing height to the nearest 0.1 cm and body weight to the nearest 0.1 kg were measured using a calibrated stadiometer (Seca 220, Hamburg, Germany) and a balance scale (Seca 761, Hamburg, Germany), respectively. BMI was calculated as weight divided by height squared ( $\text{kg}/\text{m}^2$ ), and BMI centiles and z-scores were derived according to the CDC growth reference [33]. Waist, hip and arm circumferences were determined to the nearest 0.1 cm with a flexible nylon tape measure, while skinfold thickness was measured to the nearest 0.1 mm at the biceps, triceps, subscapular and suprailiac sites using a skinfold caliper (Holtain Ltd., Crymych, UK). Triplicate readings were made at each site, and the mean of the three measures was taken as the final value. Brook's [37] equation was used to assess total body density from skinfold thickness. Total body density was then converted into a percentage of fat body mass via Siri's [38] equation. For the specific purposes of the current investigation, we used the body composition data published in the Morano et al.'s [30] study and examined their relationship with data of different variables collected with other instruments.

### 2.3.2. Physical Activity Levels

General PA levels were assessed using the Physical Activity Questionnaire for Older Children (PAQ-C) [39] which is a self-administered, 7-day recall instrument designed for use with children ages 8–14 years. The PAQ-C consists of nine items scored on a five-point scale, with higher values indicating greater PA levels. Evidence was provided in support of the PAQ-C as a reliable and valid measure of general PA levels in children grades 4–8 [39–41].

### 2.3.3. Physical Fitness

Health-related physical fitness was assessed using the following four tests to measure strength, agility, speed, and coordination. These tests have been reported to be reliable and valid measures in childhood and adolescence [42–44].

The vertical jump is aimed to assess lower-limb power. Standing on a flat surface, participants were required to reach as high as they could against a flat wall. The difference between the standing reach height and the jumping reach height were recorded. The best of two attempts was registered.

The medicine ball throw is intended to evaluate upper-limb power. Children were asked to perform a two-hand overhead throw with a 2 kg medicine ball from a standing position with both feet together. The highest value of two performance measures was reported.

The 10 × 5 m shuttle-run is designed to assess agility, speed of movement, and coordination. Participants were instructed to run back and forth five times along a 10 m distance at the highest speed possible. The test was performed twice, and the lowest sprint value was recorded.

The Harre test is meant to evaluate general motor coordination and speed, requiring children to complete a specific circuit as quickly as possible. Participants were asked to perform a rolling and three consecutive passages above and below three obstacles, turning around a central cone at maximum speed (for a description, see [44]). Children were allowed two trials separated by a 5 min recovery period. The best performance was used for statistical analyses.

### 2.3.4. Perceived Physical Ability

Participants' perceptions of strength, speed, and agility were evaluated using the Perceived Physical Ability Scale [45] which consists of 10 items rated on a 5-point scale, ranging from 1 = *very much* to 5 = *not at all*. Children were required to think about their performance when involved in physical activities, and to choose for each item the response that best represented their personal feelings. Items 1, 3, 5, 7, and 9 assess positive perceptions of physical ability (i.e., quick reaction and action,

strength, and motor control), while the other five items assess the perception of movement difficulty (i.e., lack of control, clumsiness, and muscle weakness) and are reverse-scored. Higher total scores correspond to a better perceived physical ability. The scale has been widely used in previous studies, and showed good validity and reliability in children [4,45].

### 2.3.5. Body Image

Body image was examined using the Child Figure Drawings [46], which encompass seven silhouette figures of boys and girls ranging from very thin to obese. Children were asked to select two pictures representing their current and ideal body shapes. Body dissatisfaction was then calculated as the self-ideal discrepancy, with positive or negative scores indicating a desire to be thinner or heavier, respectively. Test-retest reliability coefficients and the validity data of the scale have been provided for children [46].

### 2.3.6. Psychobiosocial States

Participants' psychobiosocial states were evaluated using a 14-item list including pleasant/functional (7 items) and unpleasant/dysfunctional (7 items) descriptors [47]. Each item was composed of two or three descriptors of an emotion-related experience. Participants were required to think about how they usually feel when involved in PA, and to rate each item on a 4-point scale, ranging from 0 = *not at all* to 4 = *very, very much*. Research has provided support for the scale as a valid and reliable measure to assess individuals' experiences in the PE context [47,48].

## 2.4. Data Analysis

A 2 (gender)  $\times$  2 (time:  $T_0$  vs.  $T_1$ ) repeated measures analysis of variance was performed to assess the differences for each dependent variable. Effect size ( $\eta_p^2$ ) estimates were determined for all significant findings. To investigate the relationships among body fatness, psychosocial variables, and physical performances, Pearson's correlation coefficients ( $r$ ) were calculated for each time point.

Using a cross-lagged procedure [32], multiple linear regression analyses were performed (a) to determine across-time relationships between PA levels and body image (i.e., each variable was regressed onto each other at a different point in time), and (b) to examine their temporal ordering over a 6-month period. Gender and age were used as covariates. To explore whether body image predicted changes in PA levels (Hypothesis 1), PA at  $T_1$  was first entered as the dependent variable, while the covariates (gender and age) and PA at  $T_0$  served as independent variables. The baseline body image was then added. To test the reverse hypothesis (Hypothesis 2), body image at  $T_1$  was regressed on baseline PA levels while controlling for gender, age, and the stability of the dependent variable at  $T_0$ . Direction is inferred when one relationship is significantly higher than the other, while reciprocity is supported if the cross-lagged relations are equal. Statistical significance was set at  $p \leq 0.05$ . Analyses were conducted using SPSS version 26.0 (SPSS Inc., Chicago, IL, USA).

## 3. Results

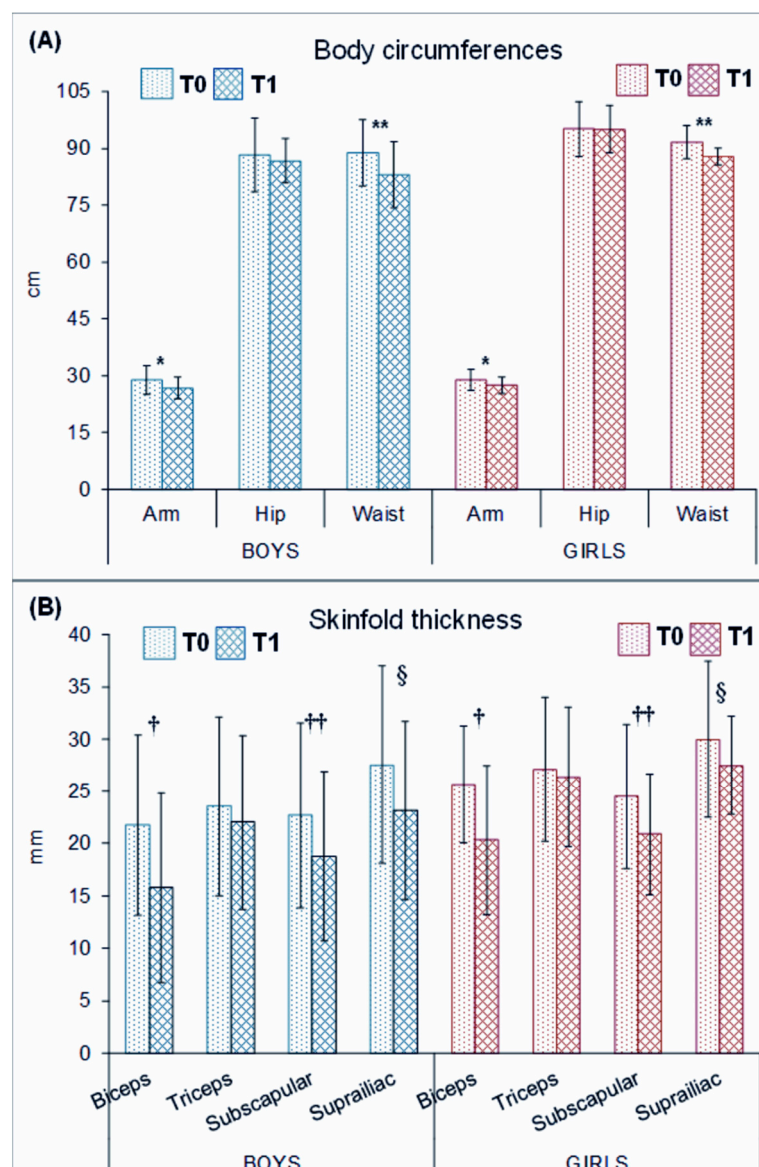
All children completed the intervention and the mean attendance for the exercise program was 82% (range 71–88%). Descriptive statistics and repeated-measures analyses of variance results for each variable by time of assessments ( $T_0$  vs.  $T_1$ ) are reported in Table 1. The differences across measurements for body circumference and skinfold thickness mean values are represented in Figure 1. Significant main effects by gender were found only for body fat percentage ( $F_{1,16} = 6.00, p = 0.026, \eta_p^2 = 0.27$ ) and hip circumference ( $F_{1,16} = 5.75, p = 0.029, \eta_p^2 = 0.26$ ), with females reporting higher values than males. Gender  $\times$  time interaction effects did not emerge, suggesting that changes over time were similar for boys and girls.

**Table 1.** Descriptive statistics and repeated-measures analysis of variance results by time of assessments (T<sub>0</sub> vs. T<sub>1</sub>).

Variable	Boys (n = 9)		Girls (n = 9)		Analysis of Variance		
	Pre-Treatment M ± SD	Post-Treatment M ± SD	Pre-Treatment M ± SD	Post-Treatment M ± SD	F <sub>time(1,16)</sub>	p-Value	η <sub>p</sub> <sup>2</sup>
Height (cm)	149.10 ± 7.51	150.24 ± 6.64	151.89 ± 4.44	154.32 ± 4.87	5.16	0.037	0.24
Weight (kg)	57.27 ± 13.22	53.80 ± 9.70	61.46 ± 8.19	59.88 ± 7.17	2.11	0.166	0.12
BMI (kg/m <sup>2</sup> )	25.58 ± 4.44	23.83 ± 4.09	26.59 ± 2.92	25.11 ± 2.35	10.28	0.006	0.39
BMI percentile	95.06 ± 3.56	90.71 ± 6.36	96.37 ± 1.94	94.38 ± 2.67	18.52	0.001	0.54
BMI z-score	1.84 ± 0.54	1.47 ± 0.51	1.87 ± 0.31	1.64 ± 0.30	16.53	0.001	0.51
Body fat (%)	37.02 ± 6.43	33.17 ± 7.57	42.89 ± 4.21	40.00 ± 3.88	19.67	<0.001	0.55
Physical activity levels	1.66 ± 0.39	2.48 ± 0.64	1.84 ± 0.50	2.58 ± 0.79	38.12	<0.001	0.70
Physical fitness							
Vertical jump (cm)	19.58 ± 6.28	22.57 ± 8.47	15.78 ± 8.17	17.83 ± 4.39	5.76	0.029	0.27
Medicine ball throw (m)	4.08 ± 0.65	4.50 ± 0.88	3.53 ± 0.65	4.07 ± 0.67	36.85	<0.001	0.70
10 × 5 m agility shuttle run (s)	23.77 ± 1.76	22.79 ± 2.13	25.20 ± 1.86	24.27 ± 1.68	46.64	<0.001	0.75
Harre circuit test (s)	31.55 ± 6.05	28.28 ± 4.48	34.75 ± 8.00	30.73 ± 5.50	33.76	<0.001	0.68
Perceived physical ability							
Positive perceptions	14.44 ± 2.19	17.89 ± 2.21	15.22 ± 1.72	19.44 ± 2.01	37.20	<0.001	0.70
Negative perceptions	15.78 ± 2.49	20.89 ± 3.22	17.67 ± 2.06	23.11 ± 2.21	60.27	<0.001	0.79
Body dissatisfaction	1.72 ± 0.62	0.92 ± 0.50	1.50 ± 0.50	1.17 ± 0.56	13.06	0.002	0.45
Psychobiosocial states							
Pleasant/functional	2.25 ± 0.81	2.56 ± 0.76	2.73 ± 1.12	2.89 ± 0.53	0.96	0.342	0.57
Unpleasant/dysfunctional	1.08 ± 1.10	0.57 ± 0.43	0.84 ± 1.02	0.54 ± 0.61	2.78	0.115	0.15

Notes: η<sub>p</sub><sup>2</sup> = partial eta squared; BMI = body mass index.





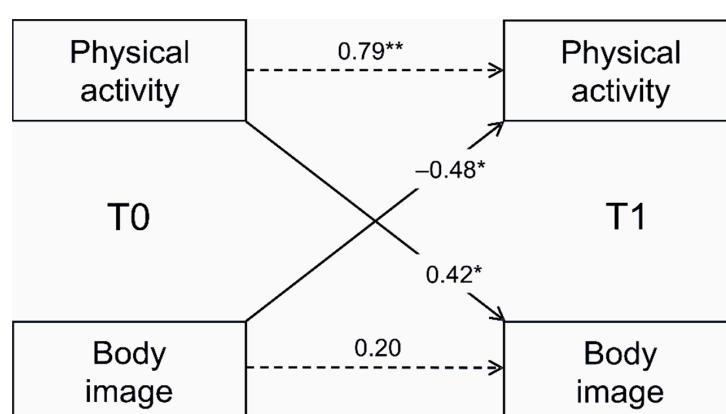
**Figure 1.** Mean values of body circumferences and skinfold thickness. Notes: \*  $F_{\text{time}}(1,16) = 12.10$ ,  $p = 0.003$ ,  $\eta_p^2 = 0.43$ ; \*\*  $F_{\text{time}}(1,16) = 11.34$ ,  $p = 0.004$ ,  $\eta_p^2 = 0.42$ ; †  $F_{\text{time}}(1,16) = 24.88$ ,  $p < 0.001$ ,  $\eta_p^2 = 0.61$ ; ††  $F_{\text{time}}(1,16) = 9.23$ ,  $p = 0.008$ ,  $\eta_p^2 = 0.37$ ; §  $F_{\text{time}}(1,16) = 17.18$ ,  $p = 0.001$ ,  $\eta_p^2 = 0.52$ .

From T<sub>0</sub> to T<sub>1</sub>, height significantly increased, whereas BMI values and percent body fat declined. Arm and waist circumferences, and skinfold thickness of the biceps, subscapular and suprailiac regions also decreased over time. With regard to physical fitness, there were significant changes in all motor tests, with children showing better performances at T<sub>1</sub> compared to T<sub>0</sub>. Significant time effects were shown for behavioral and psychosocial outcomes, with participants presenting lower body dissatisfaction and reporting higher PA and perceived physical ability scores after treatment.

For each time point, negative correlations were found between BMI and vertical jump (T<sub>0</sub>:  $r = -0.63$ ; T<sub>1</sub>:  $r = -0.56$ ), and positive correlations between speed times in the shuttle-run (T<sub>0</sub>:  $r = 0.59$ ; T<sub>1</sub>:  $r = 0.57$ ), and Harre circuit test (T<sub>0</sub>:  $r = 0.63$ ; T<sub>1</sub>:  $r = 0.52$ ). Similarly, negative correlations were found among percent body fat and vertical jump (T<sub>0</sub>:  $r = -0.60$ ; T<sub>1</sub>:  $r = -0.58$ ), shuttle-run (T<sub>0</sub>:  $r = 0.73$ ; T<sub>1</sub>:  $r = 0.69$ ), and Harre circuit test scores (T<sub>0</sub>:  $r = 0.55$ ; T<sub>1</sub>:  $r = 0.48$ ). It is interesting to note that BMI at T<sub>0</sub> was positively associated with body dissatisfaction ( $r = 0.61$ ), while PA was positively correlated with pleasant/functional psychobiosocial states ( $r = 0.58$ ) and negatively with unpleasant/dysfunctional

states ( $r = -0.49$ ). At  $T_1$ , unpleasant/dysfunctional states correlated with the BMI ( $r = 0.55$ ), shuttle-run ( $r = 0.54$ ), and Harre circuit test scores ( $r = 0.52$ ). The magnitude of all these correlation coefficients ranged from moderate to moderately high [49].

With regard to the cross-lagged analysis, PA levels and body image were not reciprocally related across time (Figure 2). As shown in Table 2, baseline body image was associated with levels of PA at  $T_1$  ( $\beta = -0.48$ ,  $p = 0.02$ ) beyond PA at  $T_0$  ( $\beta = 0.66$ ,  $p = 0.01$ ), and after controlling for the effects of covariates (i.e., gender and age). These findings suggest that the larger the body dissatisfaction of children before the intervention, the larger the increase in levels of PA six months later. The second hypothesis on the reverse relationship was not supported, given that PA at  $T_0$  and body image at  $T_1$  were not significantly related ( $\beta = 0.42$ ,  $p = 0.16$ ).



**Figure 2.** Across-time relationships between physical activity and body image ( $N = 18$ ). Notes: Standardized regression coefficients ( $\beta$ ) are reported. Dashed arrows reflect the correlation of each variable with itself at two points in time ( $T_0$ ,  $T_1$ ); solid arrows indicate the causal relationships over time between variables. \*  $p = 0.02$ , \*\*  $p = 0.001$ .

**Table 2.** Multiple linear regression analyses testing for reciprocal relationships between physical activity and body image ( $n = 18$ ).

Dependent Variables	Entered Variables	$\beta$	F	$R^2$
Physical Activity ( $T_1$ )	Step 1		3.85 *	0.45
	Gender	0.05		
	Age	0.06		
	PA ( $T_0$ )	0.66 **		
	Step 2		5.87 **	0.64
	Gender	0.16		
	Age	0.12		
Body image ( $T_1$ )	PA ( $T_0$ )	0.79 ***		
	Body image ( $T_0$ )	-0.48 *		
	Step 1		0.76	0.37
	Gender	-0.27		
	Age	-0.15		
	Body image ( $T_0$ )	0.30		
	Step 2		1.19	0.52
	Gender	-0.14		
	Age	-0.29		
	Body image ( $T_0$ )	0.20		
	PA ( $T_0$ )	0.42		

Notes:  $\beta$  = standardized regression coefficients;  $R^2$  = square correlations values; PA = physical activity;  $T_0$  = time 1;  $T_1$  = time 2; \*  $p \leq 0.05$ , \*\*  $p \leq 0.01$ , \*\*\*  $p \leq 0.001$ ; unmarked values were non-significant.



#### 4. Discussion

This was an uncontrolled, pilot study to assess the feasibility of implementing a school-based obesity program. Although limited by the small sample size and no control group, after the intervention we observed changes in obese boys and girls in almost all targeted variables. All the children who started the program completed it and showed improvements over six months in the measures of adiposity, actual and perceived physical abilities, PA levels, and body image. We did not find significant changes on the psychobiosocial state scores at  $T_1$  compared to  $T_0$ , which was most likely due to initially high scores of pleasant/functional states and low scores of unpleasant/dysfunctional states reported by both girls and boys in the whole sample. These results are consistent with those of several previous studies conducted in the context of school PE [48,50–52], which suggest a general experience of a pleasant educational atmosphere.

In the present study, significant gender differences were observed only in body fat percentage and hip circumference, with girls having higher values than boys at both  $T_0$  and at  $T_1$ . These values may be an expression of maturational differences by gender. As was found in previous studies [30,53,54], gender  $\times$  time interaction effects did not emerge, suggesting that obese boys and girls may respond comparably to a non-competitive PA program at school and show improvements in almost all study variables after intervention. During treatment, all children performed a variety of non-competitive activities and enjoyable forms of individualized tasks in a supportive learning environment that enabled them to experience pleasant emotional states and improve. Although enjoyable skill-based activities may not conform to classical exercise training guidelines, a recent systematic review suggests that enjoyable interventions in overweight and obese children are needed to increase their actual and perceived physical abilities, which in turn, may lead to long-term adherence to PA participation [55]. Children PA enjoyment depends, to a large extent, on their perceived physical ability [15], which is thought to mediate the relationship between children's motor competence and subsequent PA [56]. In a previous longitudinal study, the perception of physical ability was found to be an antecedent to PA rather than an outcome [53]. Therefore, to encourage overweight and obese children to adhere to a PA program, it is important to increase their perceived physical ability first [53].

Thus, involving children in enjoyable experiences has the potential to increase PA levels, ensure continued interest and participation, and ultimately improve long-term health outcomes, hopefully reducing the prevalence of obesity [14,18,55]. Conversely, fatigue, muscular strain, discomfort, or pain derived from PA may be related to low levels of perceived competence and discourage children's participation [21]. It is important to consider that obese children can experience more rapid fatigue on motor tasks requiring horizontal propulsion and vertical lifting of the body mass (e.g., walking, running, jumping) compared to their normal-weight peers [4,10]. In the current study, the negative associations found between BMI and body fat percentage with most health-related fitness tests (i.e., vertical jump, shuttle-run, and Harre) are in line with the contention that overweight and obesity can have adverse effects on motor performances [4,10,11,30]. Our post-intervention results also suggest that body-mass-dependent motor performances (i.e., shuttle-run and Harre circuit) were positively related to unpleasant/dysfunctional states. Therefore, especially in the early phases of an obesity intervention, weight-bearing tasks should be proposed gradually to enable successful performance, improve actual and perceived physical abilities, and thereby promote positive attitudes towards PA [54].

Interestingly, findings in this study showed baseline BMI positively related to body dissatisfaction, indicating that obese children are dissatisfied with their body appearance. There is also evidence suggesting that body image may serve as a protective factor against BMI increase [57] and may motivate exercise behavior [6]. It seems plausible that children who are dissatisfied with their body appearance are less likely to engage in self-care behaviors that may enhance one's ability to maintain a healthy weight over time. For instance, previous study findings found a direct relationship between body dissatisfaction and low PA levels [58,59]. As stated in our first hypothesis on the positive prediction of PA levels by body image, cross-lagged analysis results suggested that body image at  $T_0$  was directly related to and predicted changes in PA levels at  $T_1$ , whereas the effect of PA to body image did not

emerge. Therefore, in contrast to our second hypothesis, body image was found to be an antecedent to PA rather than a consequence of PA.

Based on the observed relationship between body satisfaction and engagement in PA, improving body image in obese children can be an important step to promote their participation in PA. A school-based health curriculum should simultaneously strive to improve body satisfaction and increase PA [60] through programs focused on behavioral change and not just on weight per se. However, programs centered on body image changes should be implemented with caution, because raising awareness on body weight may enhance body dissatisfaction among obese children. Educators should provide a variety of enjoyable activities aimed at developing students' actual and perceived physical competence and intrinsic motivation. Programs aimed at enhancing the perceptions of physical ability rather than physical appearance are expected to reduce body dissatisfaction [19,20] and result in increased PA levels.

Given the pilot nature of our study, there are some limitations that should be acknowledged. First, the small sample size limits the generalizability of the results, despite the fact that they represent valuable pilot data requiring confirmation in larger samples. Second, the study design involving only an experimental group does not allow us to establish the specific effects of the intervention. These limitations were also due to the public nature and complexity of the intervention that required the cooperation of parents and professionals (i.e., pediatricians, dietitians, and teachers) in a school setting. Beyond these limitations, a key strength of our intervention was the high attendance of the children, which suggests that they enjoyed the program. Another strength of the study is the use of self-reported measures of PA levels, perceived physical ability, body image, and psychobiosocial states together with objective assessments of physical fitness. Furthermore, body composition was assessed using multiple measures (i.e., waist circumference, skinfold thickness, and body fat) to provide a better indication of changes in adiposity than BMI alone [61]. Finally, the pre-test post-test study design allowed us to address the issue of directionality between PA and body image in children treated for obesity.

## 5. Conclusions

In conclusion, the results of this pilot study indicate that a multi-component, school-based obesity program—focused on nutritional education, skill-learning, enjoyable PA, and exercise training—is feasible and may have important benefits for participants. Furthermore, findings provide useful information for tailoring interventions to the special needs of overweight and obese children, highlighting the importance of a comprehensive healthy lifestyle program that includes physical, psychosocial, and behavioral factors. Using a larger sample size and a comparison group, further research that considers strategies to improve clinical–family interaction at school and interventions with a large follow-up (>12 months) is required to determine whether changes in PA, physical fitness, and psychosocial co-morbidities of obesity can be established and maintained for a sufficient length of time to have a significant and lasting impact on children's health.

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