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# Impact of the FITKids Physical Activity Intervention on Adiposity in Prepubertal Children

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## KEY WORDS

obesity, abdominal adiposity, physical activity, physical fitness

## ABBREVIATIONS

%CFM—percentage central fat mass

%FM—percentage fat mass

CI—confidence interval

CT—computed tomography

DXA—dual-energy radiograph absorptiometry

FFMI—fat-free mass index

FITKids—Fitness Improves Thinking in Kids

FMI—fat mass index

HR—heart rate

MVPA—moderate to vigorous physical activity

RCT—randomized controlled trial

VAT—visceral adipose tissue

Dr Khan carried out the primary analyses and drafted the initial manuscript; Ms Raine, Mr Drollette, Mr Scudder, and Dr. Pontifex coordinated and supervised data collection and reduction, assisted in revising the initial manuscript, and critically reviewed the manuscript; Dr Castelli conceptualized and designed the physical activity intervention, assisted in revising the initial manuscript, and critically reviewed the manuscript; Dr Donovan assisted in revising the initial manuscript and critically reviewed the manuscript; Dr Evans developed the protocols and coordinated the assessment of body composition using dual energy x-ray absorptiometry, assisted in revising the initial manuscript, and critically reviewed the manuscript; Dr Hillman conceptualized and designed the study, assisted in revising the initial manuscript, and critically reviewed the manuscript; and all authors approved the final manuscript as submitted.

This trial has been registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (identifier NCT01334359).

(Continued on last page)



**WHAT'S KNOWN ON THIS SUBJECT:** Physical activity interventions aimed at improving body composition in childhood have had limited success and often targeted overweight children. Therefore, the efficacy of physical activity randomized controlled trials in improving body composition among children with varying adiposity levels remains unknown.



**WHAT THIS STUDY ADDS:** This randomized controlled trial demonstrated that a physical activity program designed to meet daily physical activity recommendations can improve cardiorespiratory fitness, decrease total fat mass, and prevent accumulation of central adiposity in a group of children with varying adiposity levels.

## abstract



**OBJECTIVE:** To investigate the effect of a 9-month physical activity intervention on cardiorespiratory fitness and adiposity among prepubertal children.

**METHODS:** Prepubertal children (8- to 9-year-olds,  $N = 220$ , 103 girls) were randomly assigned to a 9-month physical activity intervention or a control group. The intervention provided 70 minutes (5 days/week) of moderate to vigorous physical activity. Maximum oxygen consumption ( $V_{O_{2max}}$  percentile) and dual-energy radiograph absorptiometry measured cardiorespiratory fitness and adiposity, respectively. Intention-to-treat analysis was performed to assess baseline and follow-up cardiorespiratory fitness, percentage fat mass (%FM), percentage central fat mass (%CFM), and estimated visceral adipose tissue (VAT) area.

**RESULTS:** The intervention group increased in cardiorespiratory fitness (5.4th percentile; 95% confidence interval [CI], 1.8 to 8.9) and decreased in %FM ( $-0.7\%$ ; 95% CI,  $-1.1$  to  $-0.4$ ) and %CFM ( $-1.3\%$ ; 95% CI,  $-1.9$  to  $-0.7$ ). Reductions in %FM were evident for both nonoverweight ( $-0.62\%$ ; 95% CI,  $-1.07$  to  $-0.17$ ) and overweight or obese ( $-0.86\%$ ; 95% CI,  $-1.46$  to  $-0.25$ ) intervention participants. Conversely, the control group displayed no change in cardiorespiratory fitness while exhibiting increases in %FM (0.4%; 95% CI, 0.1 to 0.7), %CFM (0.6; 95% CI, 0.1 to 1.1), and VAT area (3.0  $\text{cm}^2$ ; 95% CI, 1.6 to 4.4). Nonoverweight control participants increased in %FM (0.52%; 95% CI, 0.13 to 0.91), and their overweight and obese counterparts increased in VAT (4.76  $\text{cm}^2$ ; 95% CI, 1.90 to 7.63).

**CONCLUSIONS:** The physical activity intervention improved cardiorespiratory fitness, reduced %FM, and prevented accumulation of %CFM among prepubertal children with varying adiposity levels. These findings provide support for daily physical activity recommendations to prevent excess fat mass accumulation in childhood. *Pediatrics* 2014;133:e875–e883

Obesity in childhood is associated with numerous comorbidities, making it the major public health concern for children's health in developed countries. Currently in the United States, >30% of 2- to 19-year-olds are overweight ( $\geq 85$ th percentile BMI for age), and the prevalence of extreme obesity ( $\geq 99$ th percentile BMI for age) has tripled since 1980.<sup>1</sup> Concomitant with this rise has been the increased prevalence of metabolic syndrome,<sup>2</sup> with implications for the early onset of type 2 diabetes, hypertension, and atherosclerosis.<sup>3</sup> This evidence has brought childhood obesity prevention to the forefront of pediatric research in industrialized nations.

Although the etiology of obesity has expanded to include genetic predisposition and epigenetic impact at critical developmental periods,<sup>4,5</sup> promotion of physically active lifestyles may be an effective strategy in reversing obesity among children.<sup>6</sup> More than 50% of 6- to 11-year-olds and 90% of 12- to 15-year-olds in the United States fail to meet the recommended 60 minutes/day of moderate to vigorous physical activity (MVPA).<sup>7</sup> Decreasing physical activity and increasing sedentary behaviors are independent predictors of adult obesity.<sup>8</sup> In contrast, maintaining a physically active lifestyle during childhood may protect against increased central obesity in adulthood.<sup>9</sup> Given that the pathophysiology of cardiovascular disease begins in childhood, early behavioral interventions are needed to prevent accumulation of excess fat mass and onset of cardiovascular disease.<sup>8</sup>

The success rate of pediatric intervention studies in producing significant reductions in weight status is  $\sim 50\%$ .<sup>10–12</sup> Failure to provide adequate levels of physical activity during the intervention may be 1 reason for this low success rate.<sup>13</sup> Furthermore, the efficacy of providing MVPA among children

with varying degrees of adiposity has rarely been examined. Successful randomized controlled trials (RCTs) among children that provide only physical activity, without dietary intervention, have shown decrements in relative adiposity (ie, percentage fat mass [%FM]) and visceral adipose tissue (VAT) area by providing  $\sim 80$  minutes (5 days/week), with at least 35 minutes at a vigorous intensity.<sup>13,14</sup> However, additional RCTs that provide adequate daily physical activity among children with varying degrees of adiposity are needed to further validate current recommendations for daily physical activity, which are targeted to all children regardless of weight status.

Accordingly, the primary aim of this study was to investigate the effect of a 9-month randomized controlled physical activity intervention on changes in whole body and central adiposity among prepubertal children varying in weight status. We hypothesized that participation in the intervention would increase cardiorespiratory fitness and prevent accumulation of total and central adiposity among intervention participants.

## METHODS

### Participants

An RCT design was used with prepubertal children (8–9 years old), who were recruited from 7 schools in east-central Illinois to participate in a 9-month after-school physical activity research trial (Fitness Improves Thinking in Kids [FITKids; trial NCT01334359]). The intervention was held during the academic school year and took place among 4 cohorts between 2009 and 2013.

FITKids aimed to use physical activity to increase cardiorespiratory fitness, with the goal of improving cognitive function in children. Therefore, the trial was advertised as a physical activity study, not a weight loss study. All

children in third to fifth grade were targeted, and those who expressed interest were screened for physical disabilities that could limit participation in the after-school program. Exclusion criteria included use of medications that may affect metabolism and presence of cardiovascular disease (Fig 1). Parents completed a detailed questionnaire assessing participant demographics, including socioeconomic status.<sup>15</sup>

Baseline and follow-up testing were conducted over the summer and late spring, respectively. Research staff was blinded to group assignment. The institutional review board at the University of Illinois at Urbana–Champaign approved all study protocols and consent and assent forms. Participants and their legal guardians provided written informed assent or consent.

### Sexual Maturation

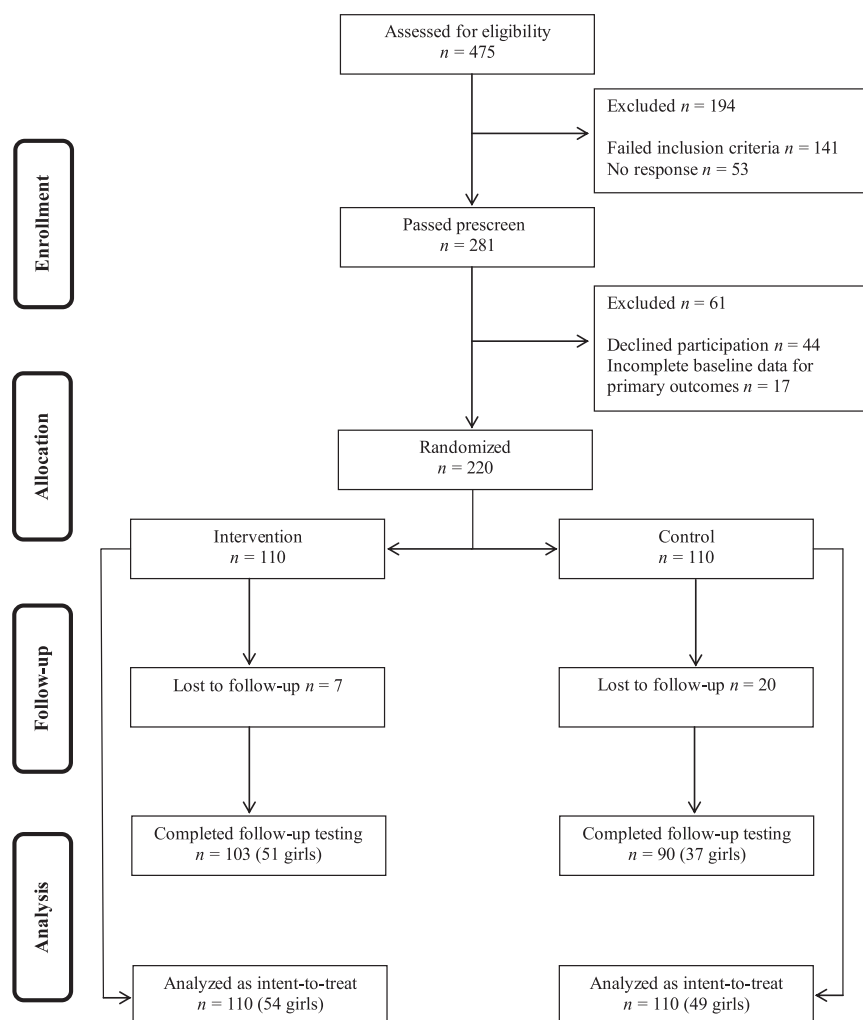
A modified Tanner staging system questionnaire<sup>16,17</sup> was used to confirm prepubertal status. Participants and their legal guardians collaborated to complete the questionnaire.

### Dietary Assessment

Dietary intake information was collected among a subset of participants ( $n = 135$ ) by using one 24-hour food recall conducted by a registered dietitian at baseline and follow-up. Nutrition Data System for Research (Nutrition Coordinating Center, Minneapolis, MN) was used to analyze dietary intake.

### Body Composition Assessment

Height and weight were measured by using a stadiometer (Seca; model 240) and a Tanita WB-300 Plus digital scale, respectively. The averages of 3 measurements of height and weight were used for the analyses. The Centers for Disease Control and Prevention growth charts were used to determine BMI for age percentile and BMI z scores.<sup>18</sup>



**FIGURE 1**  
Participant flow through the study.

Body composition was assessed by dual-energy radiograph absorptiometry (DXA) using a Hologic QDR 4500A bone densitometer (software version 13.4.2; Hologic, Bedford, MA). DXA is an accurate and valid measure of body composition in the pediatric population.<sup>19</sup> Percentage central fat mass (%CFM) was expressed by using the standard software measures of fat mass located in the abdominal region of interest. VAT area was estimated by using an automated algorithm that models subcutaneous abdominal adipose tissue at the fourth lumbar vertebra and subtracts it from regional abdominal fat to estimate VAT. This estimated VAT correlates ( $r = 0.92$ ,  $P <$

.01) with computed tomography (CT) values of VAT.<sup>20</sup> Fat mass index (FMI [total fat mass/height<sup>2</sup>]) and fat-free mass index (FFMI [total lean mass/height<sup>2</sup>]) were calculated to assess intervention effects on fat mass and lean mass while normalizing for height growth.<sup>21</sup>

### Cardiorespiratory Fitness Assessment

$V_{O_{2max}}$  was measured by using a modified Balke treadmill protocol.<sup>22</sup> Oxygen consumption was measured by using a computerized indirect calorimetry system (True Max 2400; ParvoMedics, Sandy, UT) with averages for  $V_{O_2}$  and respiratory exchange ratio assessed

every 20 seconds.  $V_{O_{2max}}$  was based on maximal effort, as evidenced by a peak heart rate (HR)  $\geq 185$  beats per minute<sup>22</sup> and a HR plateau,<sup>23</sup> respiratory exchange ratio  $> 1.0$ ,<sup>24</sup> a score on the children's OMNI ratings of perceived exertion scale  $> 8$ ,<sup>25</sup> or a plateau in oxygen consumption corresponding to an increase of less than 2 mL/kg per minute despite an increase in workload.<sup>22</sup> Age and gender-matched percentile values were derived by using previously described normative values.<sup>26</sup>

### Physical Activity Intervention

After baseline testing, participants were randomly assigned to an intervention

( $n = 110$ ) or control ( $n = 110$ ) group. Randomization was performed by an independent researcher who was not involved in the data collection. Pairs of participants were matched for demographics and fitness, and a coin was flipped to determine group assignment. Parents of the control participants were provided with written information, immediately after randomization, requesting that their child maintain his or her regular after-school routine. The control group was not contacted again until follow-up. A \$100 incentive was provided at pretest and follow-up. No monetary incentive was provided for participation in the after-school intervention, which was provided at no cost.

The intervention group received a 2-hour intervention (5 days/week for 9 months) based on the Child and Adolescent Trial for Cardiovascular Health (CATCH) curriculum.<sup>27</sup> This is an evidence-based physical activity program that provides MVPA in a non-competitive environment.<sup>28–30</sup> The sessions consisted of 70 minutes of intermittent MVPA (recorded by E600 Polar HR monitors; Polar Electro, Kempele, Finland). Each session began with 20 to 25 minutes at physical activity stations focused on a health-related fitness component (eg, cardiorespiratory fitness, muscular strength). After the fitness activities, a healthful snack was provided during the 15-minute educational component (topics included goal setting, self-management, and self-efficacy). After the educational component, participants engaged in 50 to 55 minutes of organizational games or sport-oriented activities (eg, dribbling a basketball). The sessions concluded with a 15-minute cool-down period. A target heart zone for each child was established as 55% to 80% of the child's maximum HR, and time below, time in, and time above the target heart zone was recorded.<sup>31</sup> Trained research staff

members encouraged participants to maintain their HR within the target zone throughout the session, with the exception of the time spent in the educational component.

### Statistical Analysis

Assuming a small effect size ( $d = 0.3$ ), reliability of the within-subjects factor ( $\rho = 0.8$ ), 2-sided  $\alpha$  of 0.05, and 80% power, the necessary sample size was 90 to 100 participants per group. Intention-to-treat analyses were performed among all children who completed baseline assessment ( $N = 220$ ) and were randomly assigned (Fig 1). Missing data at follow-up were imputed with values observed at baseline.<sup>32</sup> Baseline differences in cardiorespiratory and body composition variables were assessed by using an independent-samples  $t$  test. Cardiorespiratory fitness and adiposity measures were submitted to a 2 (gender: male, female)  $\times$  2 (group: intervention, control)  $\times$  2 (time: baseline, follow-up) repeated-measures analysis of variance. Change scores (follow-up value – baseline value) in cardiorespiratory fitness and body composition were calculated and differences between groups were analyzed by using an independent-samples  $t$  test. Data were checked for normality using graphical methods (Q–Q plots) and the Shapiro–Wilk test. All analyses were performed by using SPSS (version 21; IBM SPSS Statistics, IBM Corporation), and the  $\alpha$  level was set at 0.05.

## RESULTS

### Baseline Characteristics

Baseline demographic characteristics and weight status are described in Table 1. There were no significant differences between the groups in age, cardiorespiratory fitness, and body composition (all  $P$ s  $> .05$ ) at baseline (Tables 2 and 3).

### Program Evaluation

Attendance for the 150-day program ranged from 37% to 99%, with 85% of the participants attending  $\geq 70\%$  of the intervention sessions. The mean HR over the 70 minutes of activity during the intervention was 137.3 beats per minute ( $SD = 8.3$  beats per minute). The percentages of time the children had an average HR below, within, and above the target heart zone were 13%, 55%, and 32%, respectively. Therefore, participants spent an average of 87% of the intervention time performing MVPA.

The study retention rate was 88%, with 27 participants (7 intervention and 20 control) lost to follow-up (Fig 1). Among the intervention participants

**TABLE 1** Participant Demographic Characteristics and Weight Status at Baseline

	Intervention ( $n = 110$ )	Control ( $n = 110$ )
Age (y)	8.8 $\pm$ 0.5	8.8 $\pm$ 0.6
Gender (boys, girls)	56, 54	61, 49
Sexual maturity, $n$ (%) <sup>a</sup>		
Tanner stage 1	70 (63)	68 (62)
Tanner stage 2	39 (36)	42 (38)
Tanner stage 3	1 (1)	0
Socioeconomic status, $n$ (%) <sup>b</sup>		
Low	43 (39)	50 (45)
Medium	26 (24)	25 (23)
High	41 (37)	35 (32)
Race, $n$ (%)		
White	52 (47)	58 (53)
Black or African American	25 (23)	29 (26)
Asian	17 (15)	10 (9)
Other and multiracial	16 (15)	13 (12)
BMI for age percentile, $n$ (%) <sup>c</sup>		
Underweight	5 (5)	3 (3)
Normal weight	59 (54)	65 (59)
Overweight	16 (14)	18 (16)
Obese	30 (27)	24 (22)

<sup>a</sup> Assessed by using a modified Tanner pubertal staging questionnaire (stages 1–5).<sup>16,17</sup>

<sup>b</sup> Determined by using a trichotomous index based on participation in free or reduced-price meal program at school, the highest level of education obtained by the mother and father, and number of parents who worked full time.<sup>15</sup>

<sup>c</sup> Participants categorized by using the Centers for Disease Control and Prevention growth charts.<sup>18</sup>

**TABLE 2** Comparisons of Baseline and Follow-Up Measures of Cardiorespiratory Fitness and Body Composition Among Intervention Group Participants

	Nonoverweight ( <i>n</i> = 64)			Overweight or Obese ( <i>n</i> = 46)		
	Baseline, Mean (SD)	Follow-Up, Mean (SD)	Difference, Mean (95% CI)	Baseline, Mean (SD)	Follow-Up, Mean (SD)	Difference, Mean (95% CI)
Height (cm)	134.7 (6.3)	138.8 (6.5)	4.1 (3.7 to 4.5)	140.7 (8.6)	144.4 (8.5)	3.7 (2.9 to 4.4)
Weight (kg)	30.0 (4.6)	32.5 (5.1)	2.5 (2.1 to 2.9)	46.1 (10.8)	49.1 (12.4)	3.1 (2.1 to 4.0)
BMI (kg/m <sup>2</sup> )	16.4 (1.5)	16.8 (1.7)	0.3 (0.1 to 0.5)	23.0 (4.1)	23.3 (4.7)	0.3 (−0.1 to 0.7)
BMI z score	0.03 (0.77)	−0.03 (0.78)	−0.06 (−0.16 to 0.04)	1.76 (0.61)	1.66 (0.64)	−0.11 (−0.18 to −0.04)
V <sub>02max</sub> (L/min)	1.2 (0.2)	1.4 (0.2)	0.1 (0.1 to 0.2)	1.5 (0.4)	1.7 (0.4)	0.2 (0.1 to 0.3)
V <sub>02max</sub> (mL/kg per minute)	40.5 (5.4)	42.0 (5.7)	1.5 (0.5 to 2.6)	33.3 (5.8)	35.6 (6.5)	2.3 (0.6 to 3.9)
V <sub>02max</sub> percentile	24.3 (22.2)	30.4 (26.5)	6.0 (0.4 to 11.7)	6.5 (4.7)	10.9 (13.6)	4.4 (0.9 to 7.8)
Fat-free mass (kg)	21.4 (3.2)	23.4 (3.6)	1.9 (1.7 to 2.1)	28.3 (6.0)	30.4 (6.4)	2.1 (1.6 to 2.6)
Fat mass (kg)	8.8 (2.5)	9.2 (2.6)	0.5 (0.3 to 0.7)	17.7 (6.0)	18.4 (6.6)	0.7 (0.2 to 1.2)
FFMI (kg/m <sup>2</sup> )	12.2 (1.1)	12.5 (1.2)	0.3 (0.2 to 0.4)	14.7 (2.1)	15.0 (2.2)	0.4 (0.2 to 0.5)
FMI (kg/m <sup>2</sup> )	5.0 (1.3)	4.9 (1.2)	0.0 (−0.2 to 0.1)	9.1 (2.8)	9.1 (3.0)	−0.1 (−0.3 to 0.2)
Central fat mass (kg)	0.6 (0.2)	0.6 (0.2)	0.0 (−0.03 to 0.03)	1.6 (0.8)	1.6 (0.9)	0.0 (−0.1 to 0.1)
%FM	28.7 (5.6)	28.0 (5.4)	−0.6 (−1.1 to −0.2)	37.8 (5.2)	37.0 (5.5)	−0.9 (−1.5 to −0.2)
%CFM	18.6 (6.5)	17.5 (6.0)	−1.1 (−1.8 to −0.3)	30.5 (7.9)	28.9 (7.6)	−1.6 (−2.7 to −0.5)
Estimated VAT area (cm <sup>2</sup> )	28.7 (10.9)	28.0 (9.5)	−0.7 (−2.1 to 0.6)	57.7 (22.4)	58.5 (24.5)	0.9 (−1.7 to 3.4)

**TABLE 3** Comparisons of Baseline and Follow-Up Measures of Cardiorespiratory Fitness and Body Composition Among Control Group Participants

	Nonoverweight ( <i>n</i> = 68)			Overweight or Obese ( <i>n</i> = 42)		
	Baseline, Mean (SD)	Follow-Up, Mean (SD)	Difference, Mean (95% CI)	Baseline, Mean (SD)	Follow-Up, Mean (SD)	Difference, Mean (95% CI)
Height (cm)	136.0 (6.5)	139.1 (6.8)	3.0 (2.6 to 3.5)	140.3 (8.1)	143.9 (8.0)	3.5 (2.8 to 4.3)
Weight (kg)	30.3 (4.9)	32.9 (5.8)	2.6 (2.0 to 3.1)	46.5 (12.1)	50.5 (13.2)	4.0 (3.2 to 4.9)
BMI (kg/m <sup>2</sup> )	16.3 (1.5)	16.9 (1.8)	0.59 (0.37 to 0.80)	23.3 (4.2)	24.1 (4.6)	0.83 (0.39 to 1.26)
BMI z score	−0.05 (0.71)	0.09 (0.82)	0.14 (0.02 to 0.26)	1.78 (0.63)	1.75 (0.72)	−0.03 (−0.11 to 0.05)
V <sub>02max</sub> (L/min)	1.3 (0.2)	1.4 (0.3)	0.1 (0.1 to 0.2)	1.5 (0.3)	1.7 (0.3)	0.2 (0.1 to 0.2)
V <sub>02max</sub> (mL/kg per minute)	42.4 (5.4)	43.0 (5.3)	0.6 (−0.2 to 1.3)	33.6 (6.1)	34.4 (6.1)	0.8 (0.0 to 1.6)
V <sub>02max</sub> percentile	30.5 (25.0)	30.3 (25.2)	−0.2 (−4.1 to 3.7)	8.0 (8.6)	9.3 (8.8)	1.2 (−0.6 to 3.0)
Fat-free mass (kg)	22.4 (3.3)	24.1 (3.8)	1.6 (1.4 to 1.9)	28.5 (6.1)	30.5 (6.7)	2.0 (1.5 to 2.4)
Fat mass (kg)	7.9 (2.4)	8.7 (2.8)	0.8 (0.6 to 1.0)	18.2 (6.6)	19.8 (7.5)	1.6 (1.0 to 2.1)
FFMI (kg/m <sup>2</sup> )	12.5 (1.0)	12.8 (1.1)	0.2 (0.2 to 0.3)	14.8 (1.8)	15.1 (2.0)	0.2 (0.1 to 0.4)
FMI (kg/m <sup>2</sup> )	4.4 (1.1)	4.6 (1.3)	0.2 (0.1 to 0.3)	9.4 (2.9)	9.7 (3.1)	0.3 (0.0 to 0.5)
Central fat mass (kg)	0.5 (0.2)	0.5 (0.2)	0.1 (0.0 to 0.1)	1.6 (0.8)	1.9 (0.9)	0.2 (0.1 to 0.3)
%FM	25.7 (4.7)	26.3 (5.1)	0.5 (0.1 to 0.9)	38.1 (6.0)	38.3 (6.3)	0.2 (−0.4 to 0.8)
%CFM	15.0 (4.9)	15.9 (5.1)	0.9 (0.3 to 1.5)	31.0 (8.5)	31.2 (8.8)	0.2 (−0.7 to 1.1)
Estimated VAT area (cm <sup>2</sup> )	26.8 (10.7)	28.7 (10.7)	1.9 (0.5 to 3.4)	55.4 (21.9)	60.2 (23.2)	4.8 (1.9 to 7.6)

lost to follow-up, 1 was overweight and 6 were obese at baseline. Control participants lost to follow-up included 12 normal weight, 4 overweight, and 4 obese children. The participants who were lost to follow-up had a significantly higher BMI z score (mean difference of 0.60; confidence interval [CI], 0.15 to 0.20) compared with trial completers.

### Changes in Dietary Intake

Baseline and follow-up dietary intakes for the subset of participants (*n* = 135) are summarized in Table 4. There were no significant changes in energy in-

take or macronutrient distribution over the intervention period among either intervention or control group participants.

### Intervention Effects on Fitness and Body Composition

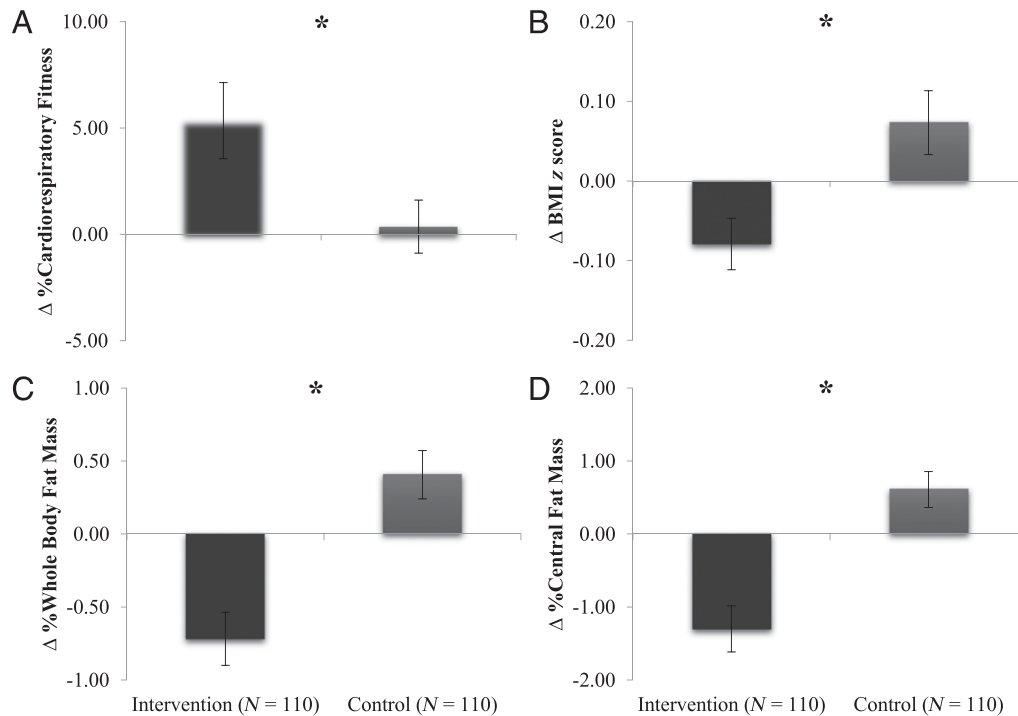
Comparisons of baseline and follow-up measures, separated by weight status, are presented in Tables 2 and 3. Differences between groups in cardiorespiratory fitness, BMI z score, %FM, and %CFM change values are illustrated in Fig 2. All interactions terms involving gender were nonsignificant.

The primary outcome for cardiorespiratory fitness analyzed here is V<sub>02max</sub> percentile. There was a significant group by time interaction for cardiorespiratory fitness,  $F(1,216) = 4.68$ ,  $P = .03$ ,  $d = 0.29$ , such that the intervention group exhibited an increase in cardiorespiratory fitness (5.35th percentile; 95% CI, 1.79 to 8.90), whereas the control group did not change (0.4th percentile; 95% CI, −2.1 to 2.8).

Regardless of the expression of adiposity, all results indicated that the intervention group had favorable improvements in body composition, whereas the control did not. The group by time interactions

**TABLE 4** Comparisons of Baseline and Follow-Up Dietary Intake by Group

	Intervention (n = 73)			Control (n = 62)		
	Baseline, Mean (SD)	Follow-Up, Mean (SD)	Difference, Mean (95% CI)	Baseline, Mean (SD)	Follow-Up, Mean (SD)	Difference, Mean (95% CI)
Energy (kcal)	1876 (605)	1733 (831)	-142 (-362 to 78)	1943 (592)	1792 (578)	-151 (-334 to 32.8)
%kcal from carbohydrate	51.1 (10.9)	51.5 (9.4)	0.5 (-2.7 to 1.5)	52.5 (8.7)	51.4 (9.4)	-1.1 (-3.5 to 1.3)
%kcal from protein	15.8 (4.9)	15.9 (4.5)	0.1 (-1.2 to 1.5)	15.0 (4.4)	16.0 (4.4)	1.0 (-0.4 to 2.3)
%kcal from fat	33.1 (8.6)	32.5 (7.1)	-0.6 (-2.7 to 1.5)	32.6 (7.2)	32.6 (8.1)	-0.1 (-1.9 to 1.9)



**FIGURE 2**

Baseline to follow-up changes. A, Cardiorespiratory fitness. B, BMI z score. C, Percentage whole body fat. D, Percentage central fat mass. All values are mean (SEM). \*Change from baseline to follow-up is significantly different between intervention and control groups ( $P < .05$ ).

were significant for BMI z scores,  $F(1,216) = 8.64$ ,  $P = .004$ ,  $d = 0.40$ ; %FM,  $F(1,216) = 21.57$ ,  $P < .001$ ,  $d = 0.65$ ; FMI,  $F(1,216) = 13.1$ ,  $P < .001$ ,  $d = 0.49$ ; %CFM,  $F(1,216) = 22.8$ ,  $P < .001$ ,  $d = 0.65$ ; and VAT,  $F(1,216) = 10.59$ ,  $P = .01$ ,  $d = 0.44$ . BMI z scores decreased in the intervention group ( $-0.08$ ; 95% CI,  $-0.14$  to  $-0.02$ ,  $P = .004$ ) and remained unchanged in the control group ( $0.07$ ; 95% CI,  $-0.01$  to  $0.15$ ). The intervention participants decreased in %FM ( $-0.7\%$ ; 95% CI,  $-1.1$  to  $-0.4$ ), whereas the control participants increased in %FM ( $0.4\%$ ; 95% CI,  $0.1$  to  $0.7$ ). FMI did not change among intervention participants

( $-0.1$  kg/m<sup>2</sup>; 95% CI,  $-0.2$  to  $0.1$ ) and increased in the control group ( $0.2$  kg/m<sup>2</sup>; 95% CI,  $0.1$  to  $0.4$ ). %CFM decreased among the intervention participants ( $-1.3\%$ ; 95% CI,  $-1.9$  to  $-0.7$ ), whereas the control group increased ( $0.6\%$ ; 95% CI,  $0.1$  to  $1.1$ ) in %CFM. VAT remained unchanged among intervention participants ( $-0.08$  cm<sup>2</sup>; 95% CI,  $-1.4$  to  $1.24$ ) while increasing among control participants ( $3.0$  cm<sup>2</sup>; 95% CI,  $1.61$  to  $4.43$ ). Finally, the change in FFMI was not different between groups, but both the intervention ( $0.3$  kg/m<sup>2</sup>; 95% CI,  $0.2$  to  $0.4$ ) and control ( $0.2$  kg/m<sup>2</sup>; 95% CI,  $0.1$  to  $0.3$ ) groups increased in FFMI.

To assess adiposity changes based on weight status within study group, we divided participants into nonoverweight ( $<85$ th percentile BMI for age) and overweight or obese ( $\geq 85$ th percentile BMI for age) groups at baseline. Nonoverweight intervention participants ( $n = 64$ ) exhibited decreases in %FM ( $-0.62\%$ ; 95% CI,  $-1.07$  to  $-0.17$ ) and %CFM ( $-1.07\%$ ; 95% CI,  $-1.84$  to  $-0.30$ ). Overweight and obese children in the intervention group ( $n = 46$ ) decreased in BMI z score ( $-0.11$ ; 95% CI,  $-0.18$  to  $-0.04$ ), %FM ( $-0.86\%$ ; 95% CI,  $-1.46$  to  $-0.25$ ), and %CFM ( $-1.62\%$ ; 95% CI,  $-2.70$  to  $-0.55$ ). In contrast,

nonoverweight ( $n = 68$ ) control children increased in BMI z score (0.14; 95% CI, 0.02 to 0.26), %FM (0.52%; 95% CI, 0.13 to 0.91), %CFM (0.88%; 95% CI, 0.29 to 1.46), and VAT (1.94 cm<sup>2</sup>; 95% CI, 0.50 to 3.38). Overweight and obese children in the control group ( $n = 42$ ) exhibited increased VAT (4.76 cm<sup>2</sup>; 95% CI, 1.90 to 7.63) over the 9-month period.

## DISCUSSION

Participation in the 9-month physical activity intervention improved body composition and cardiorespiratory fitness among prepubertal boys and girls, with intervention participants exhibiting modest decreases in total and central adiposity. Furthermore, these changes were observed among both nonoverweight and overweight or obese intervention participants. In contrast, the control group had unfavorable changes in BMI z score, FMI, %FM, %CFM, and VAT, without alterations in cardiorespiratory fitness. Given that the FITKids intervention was designed to provide children with the recommended 60 minutes of MVPA per day,<sup>30</sup> these findings provide support for current physical activity recommendations to reduce adiposity and increase cardiorespiratory fitness in the preadolescent population to potentially prevent future risks for obesity and cardiovascular disease in adulthood.

One of the strengths of our study was the assessment of changes in weight status as well as fat mass and distribution. The intervention group decreased in %FM, whereas the control group increased in %FM. However, the reduction in %FM, though significant, is of a lower magnitude than that observed in similar physical activity-only RCTs among normal and overweight or obese prepubertal children. Barbeau et al<sup>14</sup> showed a decrease of  $-1.4\%$  ( $SD = 3.5$ ) among 8- to 12-year-old black girls participating in a 10-month

physical activity trial. Using a similar intervention, Howe et al<sup>13</sup> observed a % FM reduction of  $-2.25$  ( $SD = 0.57$ ) among 8- to 12-year-old black boys. These dramatic reductions in %FM may be attributed to the emphasis placed on intensity because both trials incorporated 35 minutes of daily vigorous physical activity. Although HR was monitored, the FITKids protocol did not dedicate a period for maintaining vigorous activity. However, FITKids provided 70 minutes of intermittent MVPA and showed positive shifts in body composition among its participants over the 9-month period. Conversely and importantly, the increase in %FM among control participants observed by Barbeau et al<sup>14</sup> and the FITKids RCTs demonstrates a movement toward an unfavorable body composition profile in the absence of structured daily physical activity.

Central adipose tissue, particularly VAT, has been implicated in insulin resistance and cardiovascular disease.<sup>33–35</sup> Owens et al<sup>36</sup> observed decreased % FM and an attenuated increase in VAT (assessed by MRI) among obese children participating in a 4-month (5 days/week) physical activity program without a diet intervention compared with a control group. However, FITKids decreased %CFM in a sample of children with varying degrees of adiposity, increasing the generalizability of our findings. Furthermore, VAT remained unchanged in the intervention group and increased among control participants. In another study, Gutin et al<sup>37</sup> reduced %FM and VAT among obese 13- to 16-year-olds participating in a program of either lifestyle intervention plus moderate physical activity or lifestyle intervention plus vigorous physical activity (8 months, 5 days/week). Interestingly, Gutin et al<sup>37</sup> did not find any effect of physical activity intensity on changes in VAT tissue, suggesting that even moderate levels of physical

activity can reduce central adiposity. Because the FITKids trial decreased % CFM and prevented accumulation of VAT among intervention participants by providing MVPA, our findings are in agreement with this implication.

Although this RCT demonstrates the importance of MVPA for weight management in prepubescent children, there are several limitations to the current study. The expression of  $V_{O_2}$  in relation to body weight presents an analytical challenge because changes in the denominator may singularly drive the ratio. This is an enduring issue in the field of exercise physiology that is more complicated when applied to the pediatric population. In addition, the lack of assessment of nonintervention physical activity limits the interpretation of the findings because daily physical activity has been negatively correlated with %FM in both cross-sectional and longitudinal studies.<sup>38</sup> It should also be noted that, although FITKids had a high retention rate, a large proportion of the participants lost to follow-up were overweight or obese at baseline. However, the use of intention-to-treat analysis and the success of the intervention in reducing adiposity among both normal and overweight and obese children reduces the likelihood that retention of the noncompleters would have significantly altered the findings of the study. Finally, DXA-estimated VAT values are not equivalent to those generated by direct CT imaging. However, DXA has been recently shown to provide accurate estimates of VAT while using only a fraction of the radiation of CT, making DXA a suitable alternative for use in pediatric populations.

## CONCLUSIONS

The FITKids intervention, designed to provide 70 minutes per day (5 days/week) of intermittent MVPA reduced total adiposity and prevented gains in



central adiposity among prepubertal children with varying levels of fat mass. These findings support the current recommendations for daily physical activity among children to prevent accumulation of excess fat mass in childhood. Future research studies should assess the potential impact of ethnicity and gender on cardiorespiratory fitness and adiposity

in larger samples that may detect differences between specific subgroups of the population. Given that physical activity declines rapidly after puberty,<sup>39</sup> it is crucial that lifestyle interventions target prepubertal children to prevent the development of obesity-related morbidities during development and into adulthood.

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## Impact of the FITKids Physical Activity Intervention on Adiposity in Prepubertal Children

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