Original Research

Does a Physical Education Bout Alter Percent Body Fat and the Adiposity Health Risk Classification When Using Leg-to-leg Bioelectrical Impedance Analysis in Girls?

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ABSTRACT

Int J Exerc Sci 3(3): 126-133, 2010. The purposes of this investigation were to determine: 1) whether a structured in-school physical education exercise bout altered the leg-to-leg bioelectrical impedance analysis (LBIA) determined percent body fat (%BF) value; and 2) whether the potential exercise-induced %BF magnitude of change altered the health risk classification of the child. Seventy-six girls (age: 12.2±1.0 yr; height: 153.9±7.5 cm; body mass: 51.9± 15.5 kg; BMI: 21.7±5.4 kg/m²) participated in this investigation. LBIA measured %BF values were obtained immediately before and within 5-min after completing a structured, in-school, physical education class. Significant reductions ($p < 0.001$) in mean %BF (25.0±10.2 *vs.* 24.4±10.3 %) were observed for the group following the physical education class. For the majority of the girls (88%), the %BF alteration was less than ± 2.0 %BF. More specifically, the %BF magnitude of change was ±1.0 %BF in 64.5% of the girls, between 1.1 and 2.0 %BF in 23.7% of the girls, and by more than 2.0 %BF in 11.8% of the girls. Regardless of the %BF magnitude of change, all girls remained in the same adiposity classification category (healthy vs. unhealthy body fat) following exercise. Adhering to the pre-test exercise guideline appears unnecessary when using LBIA to categorize the health risk of an adolescent girl.

KEY WORDS: Physical education, body composition, bioelectrical impedance analysis

INTRODUCTION

The rising number of children classified as overweight and obese has become a primary health concern in the United States (6,9,14,18,19,22). According to body mass index (BMI), over 33% of children/adolescents, ages 6 – 19 years, have been classified as overweight or obese (BMI ≥ 85th percentile) (6,18,19). If current trends continue the prevalence of overweight in children is expected to double by the year 2030 (22). In an attempt to monitor this growing epidemic, school districts across the country use BMI to assess a child's risk of weight-related health problems (16). The BMI method does not actually provide an estimate of percent body fat (%BF) but rather compares the child's weight and height ratio against population specific norms. Because the BMI measurement is easy to perform, inexpensive and noninvasive, it is more often used than direct measures of body fat

which can be time-consuming, invasive and costly (i.e. air - displacement plethysmography, hydrostatic weighing, skinfold method). Although convenient, BMI results must be interpreted with caution due to the inconsistent pattern of growth and development in this age group (6,22).

A method of assessing %BF that school districts may find as an attractive alternative to the BMI measurement is leg-to-leg bioelectrical impedance analysis (LBIA). During the LBIA assessment, a low level electrical current is introduced into the body and impedance, or resistance to the current flow is measured as the participant stands on a scale-like analyzer (17). Using the calculated impedance value, %BF can be estimated using pre-programmed prediction equations that have been specifically developed for children (10,17). LBIA is simple to perform, quick (less than 30 seconds), noninvasive and portable; all characteristics that increase its' appeal. It can be used in diverse settings including private clinicians' offices, wellness centers, and hospitals and across a spectrum of ages, body weights, and disease states (10,17).

Several studies have examined the validity of LBIA in children and their findings are inconsistent (7,11,13,20,21). In normal weight children, ages 5 – 10.9 years, a high correlation (r= 0.94) was found between %BF by LBIA and dual-energy X-ray absorptiometry (DXA); however, while LBIA overestimated mean %BF by 2.5% (21). Hosking et al. (11) also reported high correlations between %BF by DXA and LBIA for boys (r= 0.92) and girls (r= 0.95) but again mean %BF values were

significantly different (boys: %BFDXA − %BFLBIA = 0.9%; girls: %BFDXA − %BFLBIA = 3.3%). Lazzer et al. (13) and Goldfield et al. (7) reported significant correlations between LBIA and DXA %BF, but found large intra-subject variations in overweight/obese adolescents (13) and preadolescents (7). Conversely, Sung et al. (21) reported no mean %BF differences between LBIA (28.9 ± 12.8%) and DXA (27.3 ± 10.3%) in Chinese children ages 7 – 16 years.

A potential limitation to the utilization of LBIA technology in school districts may be the need to follow a series of pretesting guidelines designed to control for fluctuations in hydration status, which could affect the accuracy of measurement (5,10). For instance, no physical exercise 12 hours prior to the LBIA assessment is a recommended guideline (10). If necessary, this restriction significantly reduces the usability of these analyzers in schools where controlling a child's pre-testing behavior may be quite difficult. A few investigations have examined the effect that aerobic exercise has on LBIA-measured %BF values in children. Reductions in %BF have been reported following both laboratory-controlled treadmill (1,2) and cycle ergometry (8) exercise. More recently, Andreacci et al. (3) reported that mean LBIA-determined %BF was reduced following a 60-min after-school exercise bout in thirty-three children. Although statistically significant, the %BF reductions following the after-school exercise bout were minimal (female = 1.6%; male = 0.4%). Given the relatively small magnitude of change, the authors suggested that adhering to the pre-test exercise guideline may be unnecessary in instances such as a

school physical where a 1.0-2.0% measurement error may have little effect on the adiposity classification of a child (3). However, data comparisons against adiposity-based health risk percentiles were not preformed in that study. Given the potential use of LBIA in the school setting, the impact that a structured in-school physical education class has on LBIA %BF measurements and the childs' adiposity-based health risk classification is in need of clarification. Therefore, the purposes of this investigation were to determine: 1) whether participation in a structured in-school physical education class altered the LBIA-determined %BF value; and 2) whether the potential exercise-induced %BF magnitude of change altered the health risk classification of the child.

METHODS

Subjects
Seventy-six girls (age: 12±1 y; height: 153.9 ± 7.5 cm; body mass: 51.9 ± 15.5 kg; BMI: 21.7 ± 5.4 kg/m2) participated in this investigation. Prior to participation, parents' informed written consent and subjects' written assent were obtained according to the requirements established by the Bloomsburg University Institutional Review Board and the Shikellamy Area School District.

Testing procedures-Physical Education Class
During each physical education class, prior to beginning the exercise activity, participants were led through 3-5 min of structured warm-up/stretching. Following the warm-up/stretching, participants performed a variety of exercises based on the unit in physical education class for approximately 25-30 min. Each unit (i.e.

daily lesson) included both fitness-based (i.e. circuit based exercise) and skill-based game/activity (i.e. field hockey and soccer). All units were designed towards increasing physical fitness/activity and meeting state regulated recommendations. The circuit-based exercises (e.g. jumping rope, push-ups, sit-ups, squats, bicep curls, etc) were done preceding the skill-based game/activity. At the end of each exercise class participants were led through a cool-down period of stretching, lasting approximately 2-3 min. All participants had their LBIA body composition assessed twice (pre- and post-exercise) while participating in the physical education class.

Leg-to-Leg Bioelectrical Impedance Analysis
Body composition was assessed using a LBIA analyzer (Tanita Model #TBF-300A; Tanita Corporation of America Inc., Arlington Heights, IL, USA). LBIA measures of %BF were obtained immediately before and within 5-min of completing the physical education class. Prior to the LBIA assessment, height was determined using a Detecto (Webb City, MO) physician's scale. Gender, age, and height (cm) were entered into the LBIA system. The 'standard' mode was used for all LBIA measurements, as recommended by the manufacturer. Girls stood erect with bare feet placed properly on the contact electrodes. Leg-to-leg impedance of the lower extremities and body weight (kg) were measured simultaneously while the child stood on the scale. The %BF was then automatically calculated using the analyzer's pre-programmed prediction equations.

In order to assess the intensity of the physical activity experienced during the physical education class, girls were randomly selected to wear a heart rate monitor (Polar Electro, Inc., Woodbury, NY). Heart rate was measured continuously throughout the physical education class and averaged, for each child, over the entire session. Girls were permitted to consume water ad libitum during the physical education class.

Statistical Analyses

Statistical analyses were performed using SPSS 16.0 for Windows (SPSS Inc, Chicago, IL). All values are expressed as mean ± standard deviation (SD). Statistical significance was established a priori at P<0.05. Paired sample t-tests (pre- vs. post-exercise) were used to examine the LBIA body composition and heart rate data for the girls. Bland-Altman plots (4) were used to assess individual differences in %BF and impedance from pre- to post-exercise. Previously established age appropriate body composition percentiles in U.S. children and adolescents (15) were used to determine whether the %BF change post-exercise altered the subjects' adiposity-based health risk classification. As suggested by Mueller and colleagues (15), the 85th percentile was considered the cutoff point to determine cardiovascular risk related to adiposity level (>85th percentile = unhealthy body fat).

RESULTS

The LBIA body composition data are presented as a function of time in Table 1. Significant reductions (p<0.0001) were observed for %BF, impedance, body mass and fat mass in the girls when compared to

pre-exercise values (Table 1). Significant increases (p<0.0001) were observed for fat free mass when compared to pre-exercise values (Table 1). Mean heart rates during the physical education class were 152± 14

Table 1. Body composition determined by LBIA before and after the physical education class.

	Female (n = 76)	
	Pre	Post
Percentage of body fat (%)	25.0 ± 10.2	24.4 ± 10.3*
Impedance (ohms)	549.4 ± 67.1	541.9 ± 66.3*
Body Mass (kg)	51.9 ± 15.5	51.8 ± 15.5*
Fat Mass (kg)	14.4 ± 10.2	14.0 ± 10.2*
Fat Free Mass (kg)	37.5 ± 5.9	37.8 ± 5.9*
Total Body Water (kg)	27.5 ± 4.3	27.7 ± 4.4*

All values are mean ± SD. * $p < .0001$ as compared to pre.

beats per min.

Bland-Altman plots (4) exploring for individual differences in %BF are depicted in Figure 1. The difference in %BF from pre- to post-exercise is plotted against body mass (Figure 1). According to the Bland-Altman plot (4), body mass had no apparent influence on the magnitude of the %BF change post-exercise. Total sample difference in %BF pre- to post-exercise (mean ± SD) was 0.7 ± 0.9 %BF. As shown in Figure 1, participating in the physical education class resulted in a %BF reduction in the majority of the girls (73.7%). However, in 19.7% the %BF value increased and 6.6% of the girls experienced no change pre- to post-exercise. More specifically, the %BF magnitude of change was ±1.0 %BF in 64.5% of the girls, between ±1.1 and ±2.0

%BF in 23.7% of the girls, and by more than 2.0 %BF in 11.8% of the girls (Figure 1).

percentile for body fat), 7 girls were classified as "overfat" (85th – 95th percentile for body fat) and 14 girls were classified as "obese" (≥ 95th percentile for body fat), Following the exercise class: only
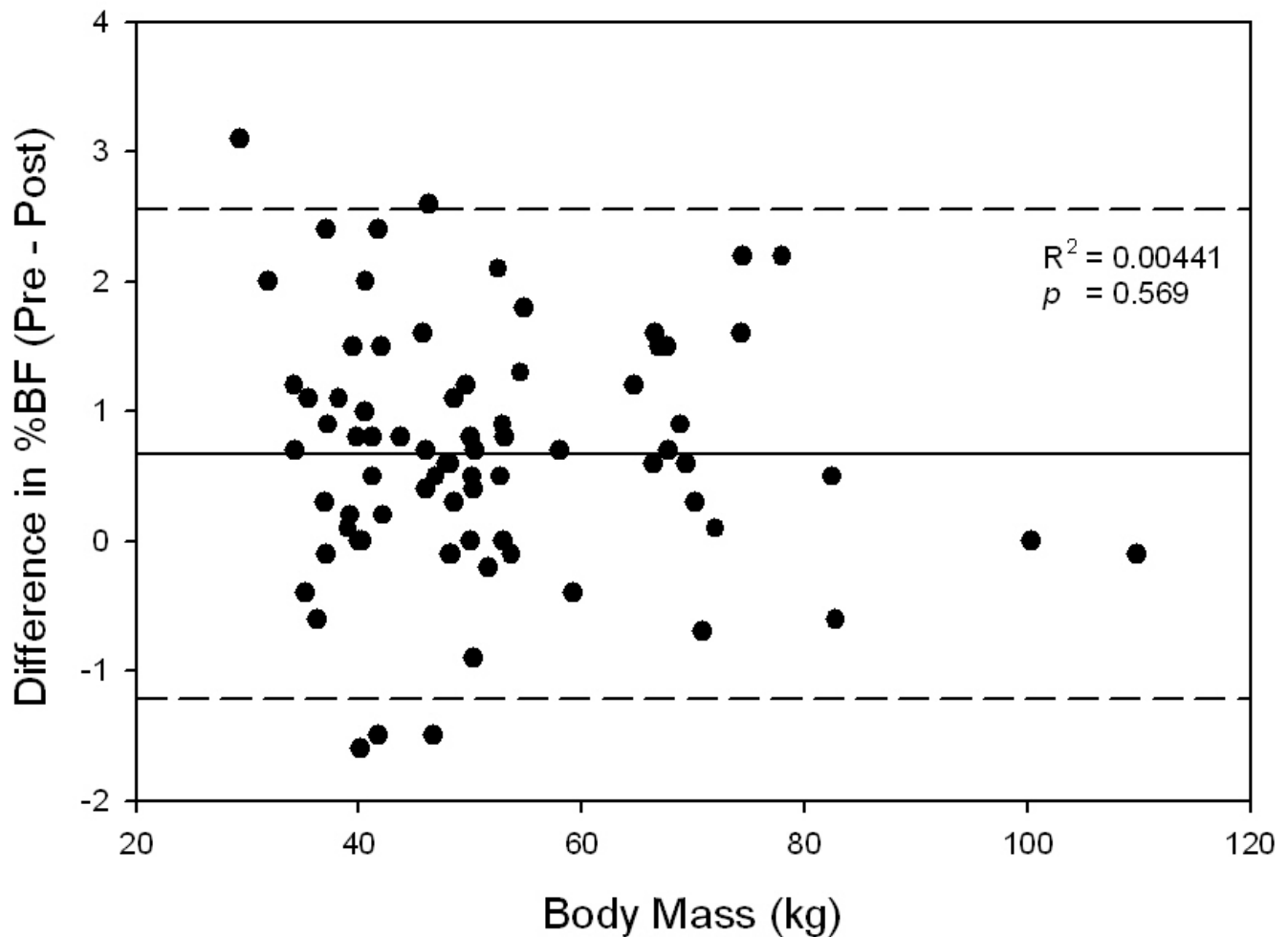

Figure 1. Scatter plot exploring individual differences in %BF following the physical exercise class. The differences between pre- and post-exercise %BF are plotted against body mass. Values greater than zero indicate a decrease from pre- to post-exercise. The solid line represents the mean difference, and the dashed lines represent ± 2 SD from the mean.

Prior to the start of the exercise class: 12 girls were classified as "underfat" (<5th percentile for body fat), 43 girls were classified as "healthy-fat" (5th to 85th

2 girls had changed classification categories: 1 from the "healthy-fat" to "underfat" category and 1 from the "obese" to "overfat" category. Despite these two changes, when using the 85th percentile as the cutoff point to determine cardiovascular

risk related to adiposity level (>85th percentile = unhealthy body fat), both girls remained in the same adiposity classification category (healthy vs. unhealthy) following exercise.

DISCUSSION

The primary finding of this investigation was that although the structured in-school physical education class reduced LBIA-determined %BF estimates these changes had no effect on the health risk classification of the girls. Our finding of a small, but statistically significant reduction in mean %BF (~0.6%) observed in the girls is consistent with the %BF reductions (range 1.2 – 1.6%) that have been previously reported in the laboratory setting (1,2,8). Recently, Andreacci et al. (3) also reported that mean %BF decreased following an after-school exercise program in eighteen girls. The magnitude of the mean %BF reduction following the after-school exercise session was greater than found presently (1.6% vs. 0.6%). Previous research suggests that the exercise-induced %BF alterations may be influenced by the intensity and/or duration of the exercise bout (1,2). Possible causes for LBIA-determined %BF changes include increases in blood flow to active muscle tissue, cutaneous blood flow, and skin temperature during the exercise bout (12). Given that the intensity of the after-school and in-school exercise bouts were similar, 76% and 73% of age-predicted maximal heart rate, the larger reduction in mean %BF following the after-school exercise bout may have been due to the differences in duration. In the present study, the LBIA post-exercise assessments were conducted immediately following the physical education class, which lasted approximately 35 min, whereas the after-school exercise program was approximately one-hour in length. The comparison of this data suggests that exercise duration may influence the magnitude of %BF change. It appears that exercise beyond 35 min may cause a larger physiological disruption and %BF alteration; however, most physical education programs will be completed within the duration examined presently.

Although mean %BF data provides information regarding the entire group, it does not necessarily give accurate estimates for all individuals within that group. As such, the Bland-Altman (4) method was used to better explore individual variability for our sample. Overall, performing exercise prior to the LBIA assessment resulted in a reduction in %BF for the majority of girls (~74%) whereas no change (6%) or an increase (20%) was observed in the others. Regardless of whether %BF was increased or decreased the %BF alteration was less than ± 2.0 %BF in 88% of the girls in this study. Similar percentages have been reported for girls in the after-school exercise study and in previous laboratory-designed research, 93% and 86%, respectively (1-3). It is apparent from these investigations that performing sub-maximal and maximal intensity exercise prior to the LBIA assessment will result in %BF alterations of less than 2.0 %BF for most girls. To determine whether this magnitude of change had any practical significance we compared the pre- and post-exercise %BF values to previously published body composition percentiles. Mueller and colleagues (15), developed reference percentiles for %BF by ethnicity, sex and age in U.S. adolescents ages 8 – 17

years. As suggested in that paper, values of %BF above which cardiovascular risk variables increase are located at the 85th percentile (15). As such, this percentile was used as the cut-off point for the definition of excessive (unhealthy) body fat in this study. Despite the exercise-induced %BF alterations observed pre- to post-exercise, all 76 girls remained in the same health-risk classification category (either above or below the 85th percentile) following the physical education class.

This was not a LBIA validation study and the current body of evidence is limited and the findings are inconsistent (7,11,13,20,21). As such, we are not recommending that school districts replace the BMI assessment with LBIA technology at this time. Additional LBIA validation preferably against multi-component models (e.g. three-component, four-component) is needed to more clearly determine the accuracy of LBIA technology in this population. Only then may it be considered as an alternate or supplemental method to the current health-risk assessment program. Another limitation to the current study was that this investigation included girls ranging in age from 10 – 14 years. Given the complexity of growth and development that is observed during this time period, these findings cannot be generalized to children who differ by age or gender than those examined presently.

In summary, our laboratory previously reported minimal changes in %BF as a result of laboratory-based exercise and a field-based after-school exercise bout in children. The present investigation was an extension of the use of LBIA into an actual in-school, structured, physical education

setting. The intensity of the physical exercise class was moderate corresponding to approximately 73% of the girls' age predicted maximal heart rate. This study demonstrated that although exercise altered the LBIA-determined %BF estimate, the magnitude of change was relatively small and had no impact on the child's subsequent adiposity-based health risk classification category (healthy vs. unhealthy body fat). As such, adhering to the pre-test exercise guideline appears unnecessary when using LBIA to categorize the health-risk of an adolescent girl. This information is important for those that currently use or are considering the use of this technology in adolescents.

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