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Effects of the Girls on the Move randomized trial on adiposity and aerobic performance (secondary outcomes) in low income adolescent girls

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Abstract

Background: Limited, mixed evidence exists regarding the effectiveness of physical activity interventions on adiposity and aerobic performance in adolescent underrepresented populations.

Objective: To examine effects of Girls on the Move on body mass index z-scores (BMI-z), percent (%) body fat, and aerobic performance in 5th-8th grade underrepresented girls. **Methods:** A group randomized trial, involving 12 intervention and 12 control schools in low-income areas, was conducted. Participants (n=1519) were low-active girls. The 17-week intervention included: (1) physical activity club; (2) two motivational interviewing sessions; and (3) one Internet-based session. BMI-z was determined from measured height and weight; % body fat was assessed using bioelectric impedance. Aerobic performance was assessed using a shuttle run.

Demographics, physical activity (accelerometer), and pubertal development were assessed.

Linear mixed models, adjusting for baseline, were used to examine group differences in post-intervention. **Results:** No significant between-group differences in BMI-z existed at post-

intervention, but % body fat increased less among intervention than control group girls ($M_{\text{change}} = 0.43\%$ vs. 0.73%). Aerobic performance decreased less in intervention vs. control ($M_{\text{change}} = -.39$

vs. $-.57$). **Conclusions:** Although the intervention positively impacted % body fat and aerobic performance in underrepresented girls, more research is necessary to determine optimal

implementation for yielding greater effects.

Introduction

According to the 2013-2014 U.S. National Health and Nutrition Examination Survey (NHANES), the prevalence of obesity has stabilized among 6-11 year-old children¹ but increased among 12-19 year-old adolescents since 2007-2008. Furthermore, 6- to 11 year-old children who are Black or Hispanic and live in low-income environments have a greater likelihood of being overweight, compared to their White and more advantaged counterparts², and odds of obesity are higher among 10- to 19 year-old low-income girls³. Thus, interventions to prevent obesity in underrepresented groups remain a high priority.

Higher physical activity (PA) in adolescence contributes to better aerobic performance⁴, and both have been associated with a reduction in obesity⁵. Neville et al. found that if adolescents from low-income or resource-deprived environments were as fit as those from high-income or less deprived areas, the differences in obesity would disappear⁶. Unfortunately, adolescents from low-income environments and racial/ethnic minority groups are less physically active than their White⁷ and higher income counterparts⁸. In addition, PA declines with age, and girls exhibit steeper declines in PA than boys, particularly during adolescence⁷. To attenuate the rising prevalence of obesity, several researchers have designed PA interventions for adolescents across different types of environments, especially schools⁹.

Schools are one of the most common and optimal settings for physical activity interventions, given the requirements for children and adolescents to attend regularly^{10,11}. While some evidence suggests that school-based physical activity interventions can improve overall

physical activity and cardiorespiratory fitness¹², support for their effectiveness in improving variables related to body composition, especially body mass index (BMI), is limited, particularly for adolescent girls^{9,13}.

Past school- and community-based research studies that have tested effectiveness of PA interventions for improving girls' adiposity and aerobic performance outcomes have shown mixed results. Some investigations noted no effects^{9,14,15}, while others showed improvements in girls' aerobic performance¹⁶, BMI¹⁶ and percent (%) body fat^{9,15}. However, replication of intervention effects in underserved, minority adolescents is lacking¹¹, particularly for girls. The purpose of this study was to examine the impact of the Girls on the Move Intervention, which was designed for 5th-8th grade underrepresented girls, on secondary outcomes of BMI z-scores (BMI-z), % body fat, and aerobic performance (predicted VO_{2max}). Hypotheses were that the intervention would improve BMI-z, % body fat, and aerobic performance.

Methods

Design

This group randomized trial occurred in 24 urban, public schools in Michigan. Schools included a high percentage of students from low-income backgrounds and underrepresented groups. Schools were matched in pairs based on similarity in academic grades, school size, racial/ethnic composition, and percent eligible to receive free/reduced price lunch (indicator of socioeconomic status). Inclusion and exclusion criteria for schools were previously reported, as was sample size calculation¹⁷. The intervention was implemented across three years (2012-

2015), with eight schools (four intervention and four control, randomly allocated by a statistician) participating each year. Control school girls received typical school offerings (similar to intervention schools), having normal physical education and school sports, although all participants were asked not to begin school sports once enrolled in the study. The study was approved by the Michigan State University Biomedical and Health Institutional Review Board, and all study participants and their parents provided written informed assent and consent, respectively.

Participants

Recruitment took place in Septembers of 2012, 2013, and 2014. Prior to participation in the study, parents of girls completed a screening questionnaire to determine eligibility based on the following inclusion criteria: 1) not meeting moderate-to-vigorous physical activity (MVPA) recommendations of at least one hour per day¹⁸; 2) available and willing to participate in a PA club for 17 weeks; and 3) able to read and speak English. Two exclusion criteria included: 1) participating in school or community sports, organized physical activities, or lessons involving MVPA on three or more days per week and 2) having a health condition preventing safe participation in MVPA. Overall, 1519 girls in grades 5-8 met eligibility criteria, provided written informed consent, and participated in baseline data collection, with randomization occurring after. Supplemental Figure 1 shows the flow diagram of schools' and girls' participation. Primary outcome data were collected at baseline, post-intervention, and 9-month follow-up; however secondary outcome data were collected at baseline and post-intervention only. Post-

intervention measures took place in March-May of 2013, 2014, and 2015.

Intervention

Girls on the Move was a 17-week intervention designed to encourage insufficiently active middle school girls to increase time spent in MVPA. The primary outcome was MVPA, and results showed no significant improvement at post-intervention or nine-month follow-up¹⁹. Secondary goals of the intervention were to improve adiposity outcomes and aerobic performance and examine if cognitive and affective variables served as mediators¹⁷. The intervention was designed to incorporate elements of the Health Promotion Model²⁰ and Self-Determination Theory²¹. Girls on the Move included three major components: 1) 90-minute after-school PA club conducted by community-based instructors three days/week at each girl's school; 2) two face-to-face motivational interviewing sessions with a trained counselor; and 3) one motivational, interactive Internet-based session shortly after the intervention midpoint. Community-based instructors (PA club leaders) attended a four-hour training session pre-intervention and then a six-hour booster session near the midpoint of the intervention. The intervention coordinator led the training and met with instructors at each school throughout the intervention. The counselors attended two, eight-hour days of motivational interviewing training conducted by a member of the Motivational Interviewing Network of Trainers. All instructors and counselors received a copy of the policy and procedure manual. Training for counselors included role playing until the trainer decided they were proficient. Each session of the PA club included time for a healthy snack and administrative tasks at the beginning and end (10 min.

each), warm-up (5 min.), opportunity for MVPA (60 min.), and a cool-down (5 min.). The objective of the MVPA opportunity was to provide activities in which girls would engage in MVPA for at least 50% of the time (e.g., dance, active games such as forms of tag). This was assessed using direct observation (dose delivered) and accelerometry (dose received) as part of the process evaluation. Accelerometers were fitted on a sub-set of girls to reflect actual physical activity (as opposed to just opportunity for PA, which was obtained by the direct observation). The measurement coordinator trained the PA club managers to randomly select (i.e., choose every fifth girl in order of appearance to club on the first day of the week) five girls per school every other week to wear the monitors. Further details regarding the intervention components and process evaluation describing dose, reach, and fidelity to intervention implementation are published elsewhere^{17,22}. Girls were encouraged to engage in MVPA outside of the PA club.

Data Collection

Trained data collectors assessed all variables at baseline and post-intervention (1-4 weeks after the 17-week intervention was complete). All staff were certified prior to taking any measures in the field, and measures of quality control were employed during the measurement phases. The measurement coordinator re-trained any staff members who experienced lapses in accuracy and ensured all staff were blinded to condition.

Outcome Measures

BMI-z Score and % Body Fat. To obtain BMI-z, height and weight were assessed according to standard procedures with shoes and socks off and heavy outer clothing removed. Height was

measured to the nearest 0.1 cm using a portable stadiometer (Shorr Productions, Olney, MD). Weight and % body fat were assessed to the nearest 0.1 kg and 0.1% with a foot-to-foot bioelectric impedance analysis (BIA) scale (Tanita, Tokyo, Japan). Two measures within 0.4 cm and 0.2 kg were taken and averaged. BMI was calculated as kg/m^2 , which was then converted into a percentile using age- and sex-specific reference values from the Centers for Disease Control and Prevention (CDC) growth charts (www.cdc.gov) to determine BMI-z and weight status. Validity ($r > 0.8$ with skinfolds) and reliability ($\text{ICC} > 0.97$) of the Tanita BIA scale in adolescents have been reported²³.

Aerobic Performance. Aerobic performance was assessed via estimation of maximal oxygen consumption ($\text{VO}_{2\text{max}}$) using the Progressive Aerobic Capacity Endurance Run (PACER). The PACER consisted of a 15- or 20-m endurance shuttle run, depending on space. Testing took place in a gymnasium with small groups of girls (10-20 girls, which was 3-4 per data collector). After number of laps completed was recorded, we determined the mile equivalency. The mile equivalency value was then entered into the Cureton equation²⁴, according to FitnessGram recommendations at the time the study began.

Covariates. Demographic information including age, academic grade, race, ethnicity, and eligibility for free/reduced-price lunch were obtained from student and parent self-report. Pubertal stage was used as a covariate and determined with the Pubertal Development Scale (PDS)²⁵. Validity and reliability of the PDS have been established with girls as young as those in 5th grade^{25,26}. Girls rated themselves, as compared to other girls of similar age, on body hair,

breast development, and menstruation. Girls reporting no menstruation and having a summed score for the three characteristics of 2, 3, or >3 were in the pre-pubertal, early, or middle pubertal stage, respectively. A summed score of ≥ 7 or 8 (hair and breast development plus menstruation) indicated the late or post-pubertal stage, respectively.

Baseline MVPA was used as a covariate in the analyses for both outcomes. MVPA was assessed using ActiGraph GT3X+ accelerometers that collected data in raw mode and were processed using ActiLife software. Girls were asked to wear the monitor for seven days (five weekdays and two weekend days) on an elastic belt at the waist, with the monitor worn over the right hip. Monitors began collecting data at 5:00 A.M. on the day after they were distributed to girls by data collectors at each school, and data collectors picked up the monitors at school the following week. Data were re-integrated to 15-second epochs and processed using intensity cut-points for MVPA $\geq 2,296$ counts per minute²⁷. Accelerometer data were aggregated to minutes of MVPA per hour.

Missing Data and Statistical Analyses

Missing data existed at the individual level, mostly for MVPA. Sparse missing data were present in individual-level demographic, BMI-z (2% at baseline and 11% at post-intervention), % body fat ($<1\%$ at baseline and 10% at post-intervention), and aerobic performance data ($<1\%$ at baseline and 10% at post-intervention). Missing data were imputed assuming a missing at random mechanism²⁸. The imputation model included baseline demographics and baseline and post-intervention outcomes. Linear mixed models were used to analyze the intervention effects

on BMI-z, % body fat, and aerobic performance according to intention-to-treat, with school pairs treated as a random effect and students nested within school and treatment condition.

Models for BMI-z, % body fat, and aerobic performance analysis

Three separate models were used to examine the effects of the intervention on BMI-z, % body fat, and aerobic performance. All models included the main intervention predictor (binary predictor for control or intervention), incorporated the cluster random effect of the design specified school pairs via a random intercept for school pairs, and controlled for the following fixed effects: continuous predictors for baseline BMI-z, % body fat, or aerobic performance (depending on model), baseline age (centered around 12 years; % body fat model only), and baseline MVPA/hour, and dummy-coded categorical predictors, race (Black, with non-Black being the reference level), SES (enrollment in free/reduced-price school lunch, not enrolled as reference level), ethnicity (Hispanic, not-Hispanic as reference level), baseline pubertal stage (early onset as reference), and study year cohort (Year 1 as reference). Age was not included in the BMI-z or aerobic performance models because the measures inherently took age into account (i.e., age is part of the calculation). The BMI-z model did not include aerobic performance because the prediction equation for VO_{2max} included BMI. Adiposity measures were not used as a covariate for aerobic performance because BMI was included in the variable calculation.

Post-hoc analyses

We conducted exploratory post-hoc models to determine if the three outcomes differed for the intervention girls, based on club attendance. Girls who attended more than the median

(38% of classes) were in the high attenders group, and girls who attended below the median were in the low attenders group, and this decision was made based on previous literature²⁹. The percentage of girls who attended all three days per week was very small (~15%), and the overall average attendance was slightly over 1 day/week. These models controlled for the same characteristics as the main models, with the random term being the intervention school. In addition, we also conducted post-hoc moderation models amongst the intervention girls: a BMI-z model to compare girls who were with obesity/overweight with those who are normal/underweight, a % body fat model to compare girls who had a higher % body fat (> 32%) with those whose % body fat was lower³⁰, and an aerobic performance model to compare girls with aerobic performance that was above the median reported baseline aerobic performance for this sample. Process evaluation showed that girls spent an average of approximately 22 minutes engaging in MVPA during club sessions.

All analyses were implemented in IBM SPSS Statistics for Windows [version 22.0] and R statistical software [version 3.2.4], using the MICE package for imputation³¹ and the “lme4” package for mixed models.³²

Results

Sample characteristics for the 1,519 participants (753 intervention, 766 control) are reported in Table 1. Girls in the control group were slightly taller and heavier, with corresponding larger BMI (not statistically different), than those in the intervention group. A

higher percentage of Black girls were in the control (54.3%) than intervention group (45.2%; $p < .001$).

Intervention Effects on BMI-z

No significant difference occurred between intervention and control groups in post-intervention BMI-z ($B = -0.02$, $p = .191$, 95% CI [-0.05, 0.01]) (Table 2). The estimated marginal means were 0.99 for the treatment group and 1.01 for the control group. BMI-z increased from baseline to post-intervention in both groups, with the intervention group (baseline 0.92 vs. post-intervention 0.95) similar to the control group (baseline 1.02 vs. post-intervention 1.06; M change intervention = 0.03 vs. M change control = 0.04). Further, results from post-hoc analyses showed no significant difference between high and low attenders in post-intervention BMI-z after controlling for baseline BMI-z and demographic factors ($B = -0.01$, $p = .542$, 95% CI [-0.06, 0.03]). Similarly, the intervention effects on BMI-z did not differ significantly according to baseline weight status ($B = -0.02$, $p = .466$, 95% CI [-0.09, 0.04]), even in comparison to the control group.

Intervention Effects on % Body Fat

Post-intervention % body fat was significantly lower among intervention group girls than control group girls ($B = -0.37$, $p = .007$, 95% CI [-0.64, -0.10]) (Table 2). The estimated marginal means were 30.30% for the treatment group and 30.67% for the control group. Percent body fat increased from baseline to post-intervention in both groups, but the increase was significantly less for the intervention group (baseline 29.48% vs. post-intervention 29.91%), than control

group (baseline 30.44% vs. post-intervention 31.17%; M change intervention=0.43% vs. M change control=0.73%). Further, results from post-hoc analyses indicated that the intervention effects on % body fat were significantly influenced by club attendance ($B=-0.56$, $p=.006$, 95% CI [-0.95, -0.16]). Specifically, after adjusting for baseline % body fat and demographics, high club attenders had significantly lower % body fat than low club attenders at post-intervention. However, the intervention effects did not significantly differ between girls with high vs. low % body fat ($B=-0.08$, $p=.809$, 95% CI [-0.71, 0.56]).

Intervention Effects on Aerobic Performance

Post-intervention aerobic performance was significantly higher among intervention group girls than control group girls ($B=0.20$, $p=.018$, 95% CI [0.03, 0.36]) (Table 3). The estimated marginal means were $37.51 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for the treatment group and $37.32 \text{ ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ for the control group. Aerobic performance decreased from baseline to post-intervention in both groups, but the decrease was significantly less for the intervention (baseline 38.12 vs. post-intervention 37.73) than control group (baseline 37.61 vs. post-intervention 37.04; M change intervention=-.39 vs. M change control=-.57). Further, results from the post-hoc analyses showed that the intervention effects on aerobic performance were significantly influenced by club attendance ($B=0.30$, $p=.014$, 95% CI [0.06, 0.54]), with high club attenders having significantly better aerobic performance than low club attenders. The intervention effects did not significantly differ between girls with high vs. low aerobic performance ($B=-0.21$, $p=.162$, 95% CI [-0.50, 0.08]).

Discussion

Intervention girls who participated in Girls on the Move experienced maintenance in % body fat (versus modest increase in the control group) at post-intervention, but no change in BMI-z. They also experienced lower decline in aerobic performance than girls in the control group. These outcomes occurred despite no intervention effect on overall MVPA. Barbeau et al.¹⁶, found intervention girls had a small, but significant increase in aerobic performance based on assessment via a multi-stage treadmill test, and Barbeau¹⁶ and Bayne-Smith et al.¹⁵ noted a small, but significant decline in % body fat among intervention girls at post-intervention, compared to controls. Both the Barbeau et al. and Bayne-Smith et al. studies included a high percentage of Black girls from low-income backgrounds with high % body fat, similar to the current investigation. However, PA sessions were offered 5 days/week in those studies versus 3 days/week in the current study. Regardless, minimal intervention effects may limit the clinical significance of the three studies, indicating that more investigations are needed to identify optimal implementation approaches.

Average attendance in the Barbeau et al. study was 54% (~2.5 days/week)¹⁶, while average attendance in the current investigation was 41% (~1.2 days/week). Although Bayne-Smith et al. did not report attendance data, other researchers who have conducted PA interventions noted similar attendance rates³³. The findings of the present study are particularly noteworthy, given that the dose of the intervention was higher in both the Barbeau et al. and Bayne-Smith et al. studies than the present investigation. In contrast to this study, Barbeau and colleagues found that higher attendance was not associated with greater cardiovascular fitness,

suggesting that taking advantage of a PA opportunity may not always translate directly into desired effects when the intervention ends. Similar findings emerged in our study and Barbeau et al. showing that better attendance was related to greater changes in % body fat. Although the average effect size was small in the Barbeau et al. study¹⁶, the authors noted that changes in central (visceral), but not peripheral, adiposity occurred due to their intervention and suggested that measuring intervention-related changes in visceral fat may be important. Other researchers have also noted that central adiposity is more related than peripheral adiposity to health outcomes such as cardiovascular risk factors^{34,35}. Although central and peripheral adiposity were not specifically assessed in the present study, measurement in future investigations may be warranted.

The lack of significant BMI-z effects was not surprising. Several previous studies¹⁴ and literature reviews^{9,36} noted that physical activity interventions have minimal effects on BMI. One probable reason is that BMI-z as a measure may not possess the appropriate level of sensitivity to change³⁷ in a 17-week intervention, especially when adolescents are undergoing physical changes due to growth and maturation, because BMI-z does not account for changes in lean body mass and fat mass. Similar to a previous study¹⁶, we controlled for effects of pubertal development in analyses, so it is not likely that pubertal development played a role. However, it should be noted that some researchers have shown that BMI-z is not appropriate for assessing longitudinal data³⁸, and others have noted it does not work well in populations with severe obesity, particularly those

≥97th percentile³⁹. In general, any BMI-related measure is not likely to account for changes in fat mass and fat-free mass as well as a measure of % body fat does⁴⁰.

Our team encountered several challenges with engaging adolescent girls in PA of at least moderate intensity, but we were able to elicit ~22 minutes of MVPA during club (37% of allotted time). Process evaluation data showed that instructors also spent ~22 minutes of club time managing the girls (coaxing them to line up, moving them to the next activity, etc.). Anecdotal evidence from PA club instructors indicated that despite offering several choices of activities, girls did not always want to engage. Also, despite repeated discussions with club leaders regarding how to optimize time spent in MVPA, we were not able to reach our desired goal of 50% of time in MVPA. On the other hand, it is quite common in the literature on physical education and after-school programs not to reach the 50% goal⁴¹. Girls also experienced difficulties at home that often prohibited their club attendance (e.g., babysitting younger siblings). Process evaluation data also showed excellent participation in counseling sessions (98% for face-to-face and 95% in online sessions) and that sessions were well received. However, it remains unknown if participating in the counseling sessions motivated girls to engage in more MVPA.

Our study had several strengths and limitations. Strengths included: a large percentage of Black girls; assessment of pubertal development; school-level randomization to conditions after baseline data collection; and use of multiple imputation to address missing data. Limitations included an inability to isolate effects of different intervention components, no longer-term

follow-up to see if intervention effects were sustained over time, and possibly reduced generalizability of findings due to sampling from a limited geographical area. Although considerable pilot work took place prior to designing the intervention, the intervention itself still had a few limitations. One was that space for conducting intervention-related activities was not optimal across sites. All schools signed a memorandum of understanding agreeing that they would provide space, but at some schools, spaces to which our team thought they would have access were taken by other, existing activities. Although some type of space was provided, intervention staff sometimes needed to modify how activities were delivered due to less-than-optimal conditions. Another limitation was ability to conduct counseling sessions, which was sometimes challenging in terms of matching counselors' schedules with school schedules, ability of girls to leave class, and availability of space. Sometimes, a counseling session had to be conducted during PA club time. This happened on a limited basis. A third limitation was the initial manner by which our staff offered choice of activities to girls. Too many choices were initially offered, and girls needed to be provided with a limited number of choices instead. A fourth limitation was that some girls, despite agreeing to participate in the study, simply did not want to engage in PA, even when offered choices of activities. A final limitation was the fact that girls had external factors outside of their control affecting their participation in the PA club. If parents/guardians needed or wanted them to do other things (e.g., babysit younger siblings) after school, girls could not attend the club.

Also, some researchers may view use of BIA, in addition to our purposeful inclusion of low-active girls, as limitations. Although reliability of BIA has been reported as adequate (intraclass correlations ≥ 0.82), contradictory evidence exists regarding validity⁴⁰. Beyond this, there has been inadequate validation of BIA in racially diverse samples⁴⁰. One study that did examine BIA validity in a racially diverse sample noted that Black girls had 1.6 kg more fat-free mass than Hispanic, non-Hispanic, and mixed-race girls⁴². We acknowledge the potential limitations of BIA but also note that % body fat would have been underestimated in Black girls according to Going et al.⁴² Given that the control group in this study had more Black girls than the intervention group, it is likely that the effects on % body fat in this sample were underestimated, since the control group had a significantly higher proportion of Black girls. However, in field-based studies the two most feasible assessment methods for % body fat are skinfolds and BIA. We decided not to use skinfolds in the current investigation due to potential presence of weight-related body image concerns in an all-adolescent female population. Additionally, Barreira et al. noted that there were no differences between BIA and dual-energy x-ray absorptiometry in Black boys and girls⁴³. In future studies, use of a more accurate BIA device (e.g., RJL Systems) and a race-specific equation could improve estimates of % body fat⁴².

Conclusion

Findings from the present study suggest that it was possible for a PA intervention alone (with no nutrition component), delivered in an after-school setting, to positively impact % body fat and aerobic performance in underrepresented adolescent girls. Because effect sizes were

small, increasing intervention dose, particularly through attendance, along with adding other components, such as environmental or family-based approaches that also focus on diet, may improve effects and potentially decrease BMI-z, which is likely less amenable to change than % body fat. Additionally, programs need to be tailored to the unique needs of underrepresented populations, which may include offering programs at alternate times such as before school, summer, or other times their presence may not be required at home. It may also be time to consider different outcome variables more relevant to the population such as stress reduction, improvement in mood, classroom behavior variables, or resilience.

Conflicts of Interest

The authors declare that they have no conflicts of interest. The contents of this manuscript are solely the responsibility of the authors and do not necessarily represent the official views of NIH.

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Figure Caption

Supplemental Figure 1. Flow diagram of participants through trial

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