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SHORT COMMUNICATION

The effect of a 3-month moderate-intensity physical activity program on body composition in overweight and obese African American college females

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Abstract
Summary This study evaluated body composition outcomes following a 3-month exercise program for overweight/obese Black women. BMI decreased over the 3-month study despite an observed increase in body fat. Enhancements in bone marrow density and muscle density were also observed. Results show promising yet hypothesis-generating findings to explore in future research.
Introduction Few studies have evaluated the relationship between aerobic physical activity (PA) and body composition among young adult overweight/obese African American (AA) women.
Purpose The current study evaluated the effect of a 3-month moderate-intensity aerobic physical activity intervention for overweight and obese young adult women on bone, lean, and fat mass.
Methods Participants (n=15) were a randomly selected subset of AA female college students (M age=21.7 years; M BMI=33.3) enrolled in a larger PA promotion pilot study (n=31). Study protocol required participants to engage in four 30–60-min moderate-intensity aerobic PA sessions each week. Whole body composition was measured by dual-energy X-ray absorptiometry (DXA), and peripheral quantitative computed tomography (pQCT) was used to assess additional quantitative and qualitative assessment of the radius.
Results BMI decreased over the duration of the study (P= .034), reflected by a marginal decrease in body weight (P=.057). However, unexpectedly, increases in adipose tissue measures were observed, including total body fat (P=.041), percent body fat (P=.044), trunk fat (P=.031), and percent trunk fat (P=.041). No changes in DXA-measured bone outcomes were observed (i.e., bone mineral density, P=.069; bone mineral content, P=.211). Results from the pQCT assessment showed that bone marrow density increased (P=.011), but cortical density remained stable (P= .211). A marginally significant increase in muscle density (P=.053) and no changes in muscle area (P=.776) were observed.
Conclusions A 3-month moderate-intensity PA program was associated with several promising findings, including increased bone marrow and stabilization of body weight. However, the increase in adipose tissue and trend for decreased bone mineral density were unexpected and indicate the need for future studies with larger samples to further explore these outcomes.

Keywords African American · Black · Body composition · Exercise · Health disparities · Physical activity · Women

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Introduction

Participation in regular moderate-intensity aerobic activity has established health benefits, including promotion of healthy body composition [1–4]. However, the majority of studies evaluating the association between aerobic activity and body composition [1, 4, 5] have been generally focused on the relationship among White females. Few studies have examined the relationship between physical activity and body composition among African American women. Given that research suggests that African American women may physiologically respond differently to physical activity than White women [6, 7], more research is needed to examine the dose and frequency of moderate-intensity activity to promote healthy body composition in this understudied population.

The purpose of the current study was to evaluate the effect of a 3-month moderate-intensity aerobic physical activity intervention for overweight and obese young adult African American women (ages 19–30 years) on lean, fat, and bone mass. Promoting physical activity in young adulthood may be of particular benefit because this is an age period when African American women experience rapid weight gain [8], as well as culmination of peak bone mass attainment [3]. Thus, successful promotion of an appropriate and effective physical activity intervention during this critical age period has the potential to limit fat mass accrual and enhance peak bone mass.

Methods

Participants

Participants of the current study were a randomly selected subset of African American women (n=15) enrolled in a larger pilot study [9] assessing the acceptability and feasibility of an Internet-enhanced approach to promoting physical activity among young adult African American women (n=31). Inclusion criteria for the parent study from which the current subsample was recruited included (a) age of 19 and 30 years at time of study enrollment, (b) body mass index (BMI) >25, (c) self-identified as African American, (d) currently enrolled as a student in undergraduate or graduate classes at the University, and (e) absence of any self-reported medical conditions that would inhibit or limit performance of physical activity.

Intervention description

Per the parent study protocol, participants were expected to engage in minimum of four physical activity sessions each week. Specifically, participants were asked to engage in 30–60 min of moderate-intensity aerobic physical activity (defined as 50–70 % of their estimated maximum heart rate [10]; calculated using the Karvonen formula) during each of the four weekly sessions. For two weekly sessions, participants walked the indoor track of the university's recreation center at a moderate intensity while being monitored by trained research assistants. For the other two sessions, participants had the option to exercise on their own or participate in a cardiovascular-based group exercise classes sponsored by the University Recreation Center (i.e., Zumba, kickboxing, and aerobics). Participants wore pedometers and heart rate monitors to self-monitor their physical activity during the sessions. Heart rate monitors were individually programmed to alert participants if their heart rates dropped below a moderate-intensity level. Further, participants recorded data collected from wearing the pedometers and heart rate monitors in activity logs that were collected by study staff on a weekly basis.

Measures

Demographics

Demographic data were collected by having participants complete a self-administered survey at baseline.

Body mass index

Height and weight were measured by trained study staff in order to calculate BMI. Height was measured to the nearest inch using the Digi-kit stadiometer by Measurement Concepts and Quick Medical (North Bend, WA). Weights were measured to the nearest kilogram using a Scaletronix (Wheaton, IL) digital scale. To ensure consistency of height measurements, the same research staff member assessed height for all participants.

Body composition

Whole body composition was measured by dual-energy X-ray absorptiometry (DXA) using a GE Lunar Prodigy densitometer (GE LUNAR Radiation Corp., Madison, WI). Participants were scanned in light clothing, while lying flat on their backs with arms at their sides. Due to size limitations, women not fitting within the scanning box were right-sided hemi-scanned with the left side estimated as per instrument protocol.

For additional quantitative aspects as well as qualitative assessment at the radius, a peripheral quantitative computed tomography (pQCT) scan using the Stratec 3000XCT (White Plains, NY) was performed. The radial length was measured from the radius head to the styloid process (mm). One slice was taken at 4 % (representing primarily trabecular bone) and 66 % (representing primarily cortical bone) of the total length defined by a region of interest and then analyzed using the macro software to quantify total area, total density, trabecular area, trabecular density, cortical area, cortical density, and stress strain index.

Procedures

At baseline, informed consent was obtained, demographic data were collected, height and weight were assessed, and participants completed their initial DXA and pQCT scans. At the end of the 3-month intervention, participants had their weight re-assessed and completed follow-up DXA and pQCT scans. All study procedures were approved by the university's

Institutional Review Board, and informed consent was obtained from all individual participants.

Statistical analysis

Descriptive statistics (mean and standard deviation or median and range) were computed for demographic characteristics. Wilcoxon matched-pairs signed rank tests were used to evaluate pre- and post-intervention changes in body composition. Analyses were conducted using SPSS (version 21) and statistical significance was set a $P \leq .05$.

Results

On average, women (n=15) were age 21.7 (SD=3.4) years and obese (M BMI=33.3 (SD=6.5). All participants were single and the 80 % (n=12) were undergraduate students. Participants completed 67.6 % (SD=24.8 %, median= 75.0 %, range= 14–100 %) of the recommended four physical activity sessions each week, which equates to participants engaging in approximately 2.7 moderate-intensity exercise sessions each week. The average duration of physical activity performed during each session was 40.61 min (SD=9.35, median=41, range= 10.00–78.00) and the mean percent heart rate expended by participants at each session was 74.90 % of their estimated maximum (SD=8.97 %, median=76.5 %, range= 42.5–92.93 %).

Pre- and post-intervention changes in anthropometric and body composition outcomes are presented in Table 1. BMI significantly decreased over the duration of the study (P= .034), reflected by a marginal decrease in body weight (P=.057). Significant increases in adipose tissue measures, including total body fat (P=.041), percent body fat (P=.044), trunk fat (P=.031), and percent trunk fat (P=.041), were observed. No pre- and post-intervention changes in DXA-measured bone outcomes were observed (i.e., bone mineral density [BMD], P=.069; bone mineral content [BMC], P=.211).

Results from the pQCT assessment showed that bone marrow density significantly increased over the 3-month study (P=.011), but cortical density remained stable (P= .211). Additionally, a marginally significant increase in muscle density (P=.053) and no changes in muscle area (P=.776) were observed.

Due to the variability of exercise session adherence among participants, correlation analyses were conducted to examine relationships between pre- and post-intervention changes in body composition and physical activity session adherence, average duration of activity performed at each session, and average intensity of physical activity performed at each session (as measured by percent of maximum heart rate). Results indicated no significant associations between body composition outcomes and variables associated physical activity session adherence, duration, or intensity (Table 2), suggesting that participants who were more adherent to the physical program demonstrated similar study outcomes as those who were less adherent.

Discussion

It is well documented that African American females are disproportionately burdened by obesity. Late adolescence/ early adulthood represents an opportune time for intervention as this is a period in which long-term body composition trajectories become established. Whereas physical activity has well-established benefits on body composition, implementation of programs specifically targeting this population is lacking. Further, the consistent reports of higher bone mineral density among African Americans, relative to White and Asian counterparts, has generated an under-appreciation for evaluating bone parameters in young African American women. However, increased fracture incidence and osteoporosis in African Americans [11] highlight the need to consider strategies that may improve bone parameters during the culminating period of bone deposition among African Americans. Results of the current study showed that among a small cohort of African American college students, a moderate-intensity exercise program was associated with positive outcomes, including maintenance of body weight, increased bone marrow quality, and marginal, although not statistical significant, increase in muscle quality (assessed by pQCT). Conversely, an increase in adipose tissue and a marginal decrease in BMD assessed by DXA were observed. While this was unexpected, given the paucity of investigations exploring the effect of physical activity on body composition in African American young women, further research is warranted.

A unique and encouraging finding of this intervention was the increase in marrow density (P= .011). This is highly relevant, particularly in the context of a stable cortical density and a marginal decrease in BMD. While weight loss is often associated with decreased BMD, the maintenance of weight in our sample and decrease in BMD may appear a concern. However, the increase in marrow density, which has been suggested to represent the quality of the marrow and capacity of the marrow compartment to promote bone remodeling for improved bone strength, supports a beneficial contribution to bone health [12, 13]. This is also supported by the increase in muscle density without change in lean mass or area. It has been demonstrated that muscle density can be used as a proxy for fat infiltration in the muscle such that a greater density represents less intramuscular fat [14]. On the other hand, quantitative outcomes associated with bone and muscle health have demonstrated a disconcordance, such that greater BMD and BMC as well as lean mass in obese and diabetic

Table 1 Body composition outcomes (n=15)

	Baseline		3 months		Baseline to 3-month mean difference	Wilcoxon *Z*	*p* value[a]
	Mean (SD)	Median	Mean (SD)	Median			
Anthropometric outcomes							
Body weight	202.513 (45.310)	192.200	198.980 (44.687)	194.000	−3.533 (5.957)	1.903	.057
BMI	33.273 (6.530)	31.700	32.573 (6.621)	31.100	0.700 (1.047)	2.076	.038
DXA-measured outcomes							
Bone mineral density	1.291 (.092)	1.254	1.282 (.025)	1.262	−.008 (.017)	1.820	.069
Bone mineral content	2,834.73 (345.297)	2,890.000	6,824.013 (15,461.843)	2,894.300	3,989.287 (15,426.889)	1.250	.211
Total fat (g)	37,631.070 (13,924.090)	35,439.00	36,501.730 (13,894.491)	36,183.000	−1,129.33 (1,781.768)	2.045	.041
Total percent fat	40.413(6.9305)	40.600	39.633(7.4905)	40.600	−.780 (1.509)	2.017	.044
Trunk fat (g)	18,157.40 (7,344.952)	15,899.000	17,510.333 (7,259.334)	16,349.000	647.067 (967.866)	2.017	.031
Trunk percent fat	42.333 (8.246)	44.500	41.307 (9.1939)	44.700	1.027 (1.8560)	2.047	.041
Total lean mass (g)	50,263.53 (7,602.198)	49,454.040	50,207.870 (7,148.914)	48,661.000	55.667 (1,341.820)	.057	.955
pQCT-measured outcomes							
Muscle density	57.666 (24.572)	68.930	66.300 (19.677)	74.530	8.634 (32.275)	1.931	.053
Muscle area	6,368.384 (3,515.64)	7,388.800	6,174.336 (3,032.640)	6,635.520	−194.048 (4,641.353)	.284	.776
Cortical density	1,017.531 (53.244)	1,008.530	1,034.948 (46.333)	1,038.480	17.419 (51.933)	1.250	.211
Marrow density	13.725 (14.665)	10.450	29.492 (19.223)	32.570	15.767 (19.846)	2.556	.011

SD standard deviation, *BMI* body mass index, *DXA* dual-energy X-ray absorptiometry, *pQCT* peripheral quantitative computed tomography

Table 2 Correlation coefficients between pre- and post-intervention changes body composition outcomes and exercise session adherence measures

	Percent physical activity sessions completed	Mean duration of physical activity sessions	Mean intensity of physical activity sessions[a]
Anthropometric outcomes			
Body weight	−.301	−.386	−.089
BMI	−.293	−.307	.246
DXA-measured outcomes			
Bone mineral density	.022	−.131	.240
Bone mineral content	−.325	−.100	−.021
Total fat (g)	−.309	−.404	.293
Total percent fat	−.067	−.441	.300
Trunk fat (g)	−.247	−.343	.443
Trunk percent fat	−.039	−.386	.409
Total lean mass (g)	−.245	−.204	−.039
pQCT measured outcomes			
Muscle density	−.013	−.054	−.269
Muscle area	−.354	−.200	.011
Cortical density	−.063	.450	−.154
Marrow density	.381	.057	−.136

All correlations are Spearman. No correlations were statistically significant at the $P<.05$ level

BMI body mass index, *DXA* dual-energy X-ray absorptiometry, *pQCT* peripheral quantitative computed tomography

[a] Mean intensity of physical activity sessions was calculated by percent of estimated maximum heart rate expended at each session

individuals do not afford protection from musculoskeletal compromise [15]. Thus, qualitative improvement may be better long-term contributors to overall health.

A unique and potentially adverse yet hypothesis-generating finding was the increase in fat parameters (total body fat and trunk fat). While there was a significant decrease in BMI, due to a decrease in body weight, increased adiposity was not anticipated. Studies show that compared to White women, African American women have lower fat oxidation and appear to fail to switch fat and carbohydrate oxidation under varied conditions [16, 17]. It is possible that disordered substrate use may explain the findings in our study. We have also observed in a moderate-intensity walking program an increase in LDL cholesterol in young African American women following a 6-month moderate-intensity walking program (unpublished data). We speculate that while aerobic activity promotes release of fatty acids into circulation, African American women may not shift toward use of fat during this type of activity. That is, fat mass may reflect a diversion of mobilized fat from oxidation in muscle to lipid storage. This diversion would enhance partitioning of lipids toward storage in adipocytes, thereby promoting fat mass gain. Further examination of fat oxidation capacity of both adipose and skeletal muscle would be relevant and will be considered in future studies. Another explanation may be due to energy compensation. Weinsier et al. [18] reported a reduction in total energy expenditure among African American (not observed in White women) participating in an activity-based weight loss intervention. The authors suggest that energy expended during the intervention is later compensated for by a reduction in daily total energy expenditure. Taken together with increased fat mobilization and metabolic inflexibility, fat mass gain could be expected. Further studies objectively quantifying daily energy expenditure among this group are needed.

Another interesting outcome was that correlational analyses did not show significant associations between pre- and post-intervention changes in body composition measures and exercise session adherence, average duration of each exercise session, or heart rate expenditure. This was unexpected because we anticipated that participants engaging in more frequent, longer-duration and higher-intensity physical activity would report more favorable body composition outcomes. We hypothesize that this outcome may be due to our small sample size. However, we note that an alternative explanation may be due to women performing additional physical activity outside of the context of the study's physical activity sessions that was not reported to study staff. Larger studies are needed for further explore the dose–response relationship of physical activity and body composition outcomes among young adult overweight and obese African American women.

Several study limitations must be noted. Due to the small sample size of the study ($n=15$), we were underpowered to detect significant changes in anthropometric outcomes of body weight and BMI (i.e., we calculated post hoc power of .066 and .073 for changes in body weight and BMI, respectively) and likely underpowered to detect significant changes in several DXA- and pQCT-measured body composition variables. Similarly, the lack of a control group limits inferences of causality as we were unable to control for threats to internal validity such as maturation or history. Adherence to the prescribed four physical activity sessions each week was also less than ideal with participants completing, on average, 67.6 % of the recommended sessions. However, we note that this modest adherence was slightly higher than the adherence observed in similar 6-month study conducted by our research team (i.e., 59.4 %) [19] and higher than adherence to a recent weight loss study targeting older African American women (i.e., 53 %) [20]. An additional limitation includes the homogenous nature of our sample (i.e., overweight and obese AA women enrolled in undergraduate and graduate coursework), which limits generalization of findings to AA women not enrolled in college or to middle-aged to older AA women. Despite these limitations, the current study has strengths. This is one of few studies assessing body composition outcomes associated with a physical activity intervention among young adult overweight and obese African American women. Thus, findings add to the limited research on the relationship between physical activity and body composition among young adult overweight/obese African American women. Other strengths include having participants engage in supervised exercise sessions which helped increase the fidelity of the physical activity intervention, and the use of DXA and pQCT to assess body composition outcomes.

Conclusions

The current study adds to the limited research on body composition outcomes associated with physical activity engagement among overweight and obese young adult African American women. Findings of our study showed that a 3-month moderate-intensity physical activity program was associated with several promising findings, including increased bone marrow, stabilization of body weight, and a marginal, although not statistical significant, increase in muscle quality. Conversely, the increase in adipose tissue and trend for decreased BMD were somewhat unexpected and indicate the need for future studies to further explore the relationship between physical activity and body composition among overweight and obese young adult African American women. Young adulthood represents an opportune time to intervene and promote sustained physical activity among African American women. Results of this study highlight the need for additional, longer-term research with larger samples to evaluate the effect of moderate-intensity physical activity on lean, fat, and bone mass in this underserved population.

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Conflicts of interest None.

Statement of human rights All study procedures were performed in accordance with the ethical standards of the institutional and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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