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Does a Six-Month Pedometer Intervention Improve Physical Activity and Health Among Vulnerable African Americans? A Feasibility Study

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Background: Race/ethnic-specific physical activity patterns and biological responses to physical activity is one of the most understudied, yet critical aspects related to the development and adoption of physical activity recommendations. ***Methods:*** In this 6-month community walking intervention targeting African Americans, participants wore a pedometer and maintained a pedometer diary for the study duration. Outcome measures included height, weight, percent body fat, waist circumference, blood pressure, lipids and glucose. ANOVA, Pearson Correlations, and Kruskal-Wallis tests were used to examine changes in steps/day over each month of the intervention and explore associations among pedometer-determined physical activity and anthropometric/biological change scores from month 1 to 6. ***Results:*** The 83 participants were primarily African American (98%) women (94%). There was a significant increase in the average step/day beginning with 6665 (SD = 3,396) during month 1 and increasing to 9232 (SD = 3670) steps/day during month 6 ($F = 4.5$, $P < .0001$). Associations among step counts and anthropometric/biological change scores were not significant. ***Conclusions:*** While this intervention resulted in significant increases in steps/day; it exemplifies that physical activity standards may be unachievable for some vulnerable, minority communities. Methodological considerations for exploring associations between changes in pedometer-determined step counts and anthropometric/biological outcomes are emphasized through this study.

Keywords: pedometry, health promotion, community-based research, intervention study, special needs population

Physical activity recommendations aimed at promoting health outcomes in public health surfaced in the mid-1980s, and these recommendations have continued to evolve as new evidence and scientific methods for measuring physical activity have emerged.[1] For example, pedometers have grown in popularity over the last century and 10,000 steps per day has become a popular health promotion recommendation.[2] Pedometers, which are inexpensive movement counters that can easily and accurately measure the number of steps a person has taken, have greatly advanced the objective measurement of physical activity patterns in free-living populations.[3,4] A variety of pedometer-based intervention strategies have been used, including some that promote achievement and sustainability of 10,000 steps per day[5–7] and others which advocated alternative activity goals which typically involves incremental increases over baseline throughout the intervention.[8–10] In a recent systematic review of 18 observational pedometer studies and 8 randomized controlled trials, Bravata and colleagues concluded that pedometer users showed significant decreases in body mass index (BMI) and intervention participants exhibited significant decreases in systolic blood pressure.[11] In general, other health outcomes such as waist circumference, serum glucose concentrations, and lipid profiles have also shown positive improvements among pedometer users.[7,9,12] These pedometer associated health benefits have been established in a variety of adult populations including but not limited to sedentary women, overweight adults, arthritic adults, and adults with or at-risk for diabetes.[11]

Despite promising findings related to health benefits experienced by pedometer users, there is a critical lack of evidence describing race/ethnic-specific physical activity patterns and race/ethnic-specific biological responses to physical activity is relatively understudied.[11,13–15] Evidenced by Bravata and colleagues' systematic

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review (n = 2767 participant) whereby 93% of all participants were white, racial/ethnically diverse groups are clearly underrepresented in pedometer research.[11] Unfortunately, limited intervention research utilizing pedometers have targeted disadvantaged and health disparate African American communities.[16,17] There is also limited data indicating if 10,000 steps per day is an achievable or sustainable long-term goal among vulnerable populations living in rural areas where the social as well as the built environment is not encouraging of purposeful physical activity. The assessment of physical activity patterns, the achievability of established physical activity recommendations, and the evaluation of the relationship between physical activity patterns and health outcomes are needed among vulnerable racial/ethnically diverse subgroups, as this critical information will help promote physical activity and may help reduce health disparities.

This paper details pedometer-determined physical activity outcomes from the *Fit for Life* Steps intervention. This was a 6-month community based participatory research (CBPR) intervention targeting community members in Hollandale, Mississippi. Hollandale is a vulnerable community located in the rural Lower Mississippi Delta (Delta), which is one of the most impoverished regions of the United States. Approximately 70% of residents in the Delta are African American, about 34% live below poverty, and high school and bachelor's degree graduation rates are around 61% and 14%, respectively.[18] Overall health disparities including obesity, heart disease, diabetes, and hypertension are well documented in the Delta region.[19,20] The *Fit for Life* Steps intervention was developed and implemented by the Hollandale Nutrition Intervention Research Initiative (HNIRI), an initiative funded by the USDA/ Agricultural Research Service. The capacity building phase of this research included installing a one-eighth mile oval walking trail around an established community playground. Before the installation of the walking trail, no other physical activity facility, such as a gym, health club, or track, was available in Hollandale. Guided by community input and the social support and Transtheoretical Model frameworks, the intervention focused on improving health through walking teams led by supportive coaches, pedometer diary self-monitoring, and monthly educational sessions.[21–23] Intervention findings have indicated positive anthropometric and biological outcomes, along with high compliance and acceptability of maintaining a 6-month pedometer diary.[23,24] However, pedometer-determined step counts and associated health outcomes have not been previously examined.

The primary aim of this study targeting a vulnerable African American community was to examine the outcomes of a 6-month pedometer-determined physical activity intervention. Specifically this study assesses changes in monthly activity classifications for each month of the intervention and explores the associations among step count data and anthropometric and biological outcomes.

Methods

At enrollment all participants completed a medical disclaimer and informed consent as approved by the Institutional Review Boards at The University of Southern Mississippi and Alcorn State University. A complete description of the intervention and methods has been previously published.[23,24] Briefly, trained community coaches recruited community members to participate in their walking groups. Recruited participants attended an informational meeting detailing the benefits and risks of participation, and intervention requirements including participation in 3 data collection time points, wearing a pedometer and maintaining a pedometer diary for 6 months, and attending monthly nutrition and physical activity education sessions. Since no information regarding physical activity was available in this health disparate African American community and no intervention research capacity existed, this project was viewed as a feasibility study to evaluate the establishment of collaborative relationships, assess the intervention design, test protocols and data collection instruments, examine recruitment and retention strategies, and assess resource requirements. There were no exclusion criteria for this study; however, participants with a systolic BP of 160 or greater or a diastolic BP of 100 or greater were required to obtain a physician's clearance to participate.

Upon consenting and enrolling in the study each participant received a 6-month pedometer diary and a Yamax pedometer (Yamax model SW-701, Yamax corporation, Tokyo, Japan), which accurately detects steps taken under free living conditions.[4] Participants were instructed on proper use of the pedometer and taught to record the total number of daily steps taken at the end of each day. The intervention included individualized weekly goal setting; consequently no defined amount of walking was required to participate in the intervention. The participants were educated on the 10,000 steps/day recommendation, but instructed to set realistic and personalized weekly goals and write them on a designated location on their walking logs. Coaches were responsible for encouraging their team members to walk and record step counts, and for collecting and submitting their team members' diaries on a weekly basis. Outcome measures assessed at enrollment, 3 months, and 6 months were collected at the HNIRI office located in Hollandale and included height, weight, percent body fat, waist circumference, blood pressure, and fasting lipids and glucose values.

Assessing Pedometer-determined Physical Activity

The total number of steps accumulated for the month by each participant was divided by the total number of pedometer diary entries in a month to assess shifts in monthly activity classifications. Established indices were used to categorize each participant into 1 of 5 monthly activity classifications during every month of the intervention including sedentary (< 5,000 steps/day), inactive/

low active (5000–7499 steps/day), somewhat active (7500–9999 steps/day), active (10,000–12,499 steps/day), and highly active (>12,500 steps/day).[25] Changes in group means for the average number of daily steps during each month of the intervention were also assessed. Furthermore, an overall average physical activity category was determined for each participant by dividing the total number of steps accumulated by the total number of pedometer diary entries for the 6-month study duration.

Assessing Anthropometric and Biological Outcomes

Height was measured without shoes using a stadiometer (Shorr Height Measuring Board; Olney, MD). Body weight, body mass index and body composition were determined by bioimpedance analysis (BIA) using model TBF 310 Tanita scale (TANITA Corporation of American, Inc.; Arlington Heights, IL). Waist circumference was determined using a nonstretchable flexible measuring tape. Blood pressure was measured with the OMRON HEM-907XL (OMRON Healthcare, Inc.; Vernon Hills, IL). Fasting total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglyceride (TG) and glucose levels were determined via finger stick method using the Cholestech LDX (Choletech Corporation; Hayward, CA).

Data Treatment and Statistical Analyses

Descriptive statistics including means, standard deviations, frequencies, and percents were used to summarize demographics and changes in monthly activity classifications. Due to relatively small numbers, the active (10,000–12,499 steps/day) and highly active (>12,500 steps/day) categories were collapsed for illustrative and analysis purposes. Repeated-measures ANOVA (list-wise approach) was used to examine changes in the average number of daily steps for each month of the intervention. The associations between physical activity levels and anthropometric/biological data were assessed using 2 different statistical approaches. First, Pearson correlations were used to examine the relationship between steps/day change scores from months 6 to 1 and anthropometric/biological change scores from months 6 to 1. Second, the Kruskal-Wallis test was used to determine associations among the average pedometer-determined physical activity categories over the entire 6-month intervention (independent variable) and anthropometric and biological change scores from month 1 to month 6 (dependent variables). Using the Bonferroni correction, p-values of ≤ 0.005 (.05/10 tests = .005) were considered significant.

Previous research suggests that 3 days of pedometer data are needed to assess physical activity in a week.[27] Therefore, a participant's weekly diary was excluded from analysis (treated as missing) if less than 3 days of data were recorded for the week. Missing pedometer data were handled systematically, with no attempts to impute missing data. Quality control monitoring of the pedometer diaries focused on recording daily steps rather than setting weekly goals, so unfortunately the personalized weekly goals were not recorded with enough consistency to analyze the data by achievement of individualized goals. Finally, since coaches and participants were treated somewhat differently in this intervention, each analysis was performed using data only from the participants and then using data from the participants plus coaches. Including the coaches in the analyses did not significantly impact interpretation of the results; therefore, all results reported include data from the participants plus coaches.

Results

Eight coaches and 75 participants enrolled in the intervention. All of the coaches were African American females, and the walking participants were also primarily African American (98%) females (94%) with an average age of 44 (SD = 13) years. Of these 83 participants, 8 (10%) were normal weight, 18 (22%) were overweight, and 57 (69%) were obese. All 83 participants completed the first enrollment data collection, 77 participated in the 3-month data collection, and 66 completed the 6-month data collection, for a total retention rate of 80%. The 83 participants submitted 85% of all possible pedometer diaries, including 65 (78%) and 69 (84%) who submitted 100% and ≤ 80% of their pedometer diaries, respectively.

Figure 1 illustrates changes in activity classifications during each month of the intervention. For example, during month one, 26 (41%) of the participants were classified as sedentary compared with 6 (11%) during month 6, and 24 (38%) of the participants were classified as somewhat active or active during month 1 compared with 33 (60%) during month 6. Overall there was a desirable shift in activity, whereby 63% of participants demonstrated a positive improvement in activity classification, 25% showed no change, and 12% regressed in activity classification.

For the participants who turned in pedometer diaries with at least 3 days of data recorded each week, there was a steady and significant increase in the average number of daily steps beginning with 6665 (SD = 3396) steps/day during month 1 and increasing to 9232 (SD = 3670) steps/day during month 6 (F = 4.6, P = .001) (Figure 2). Participants increased their steps by approximately 39% or 2600 steps per day over the 6-month intervention and reported higher percent increases in the beginning months of the intervention (14% between months 1 and 2, and 10% between months 2 and 3), with a leveling off as the intervention progressed (4% between months 4 and 5, and <1% between months 5 and 6). In this ANOVA, participants with missing values at any month are excluded; hence the sample size across each month is consistent (n = 56), yet different from Figure 1.

As illustrated in Table 1, correlations among changes in steps/day and changes in anthropometric/biological change scores from months 6 to 1 were not significant. There was a slight trend for changes in steps/day to be negatively correlated with changes in triglycerides

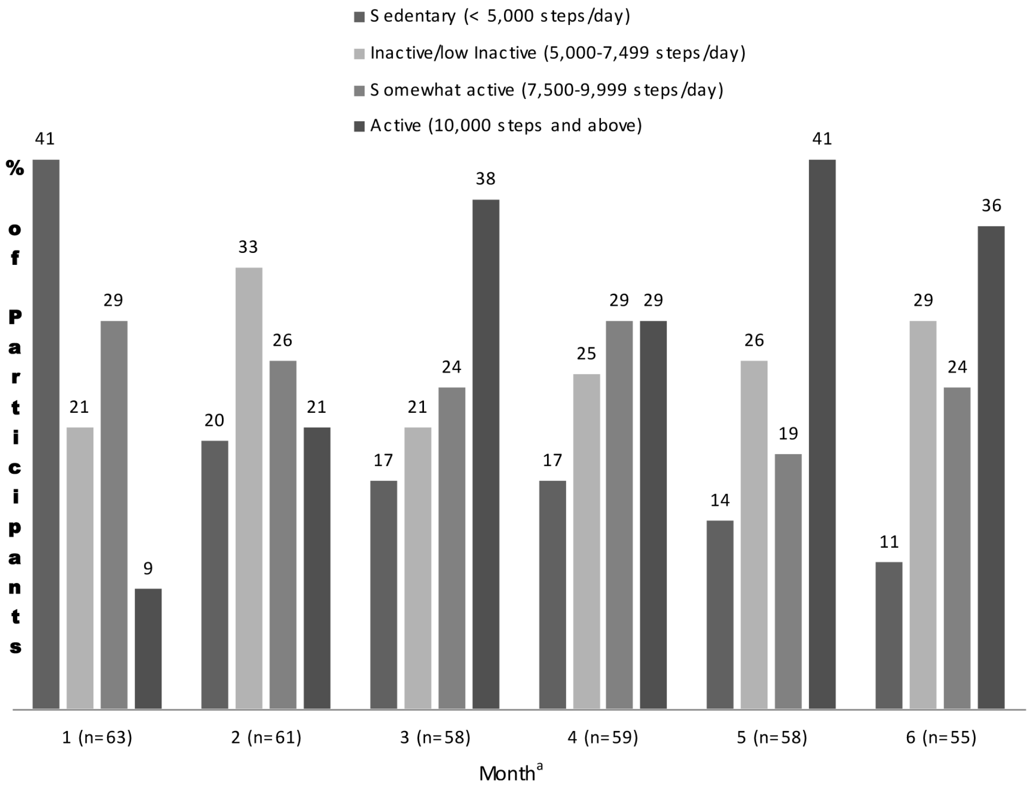

Figure 1 — Comparison of activity categories by monthly intervals.
[a] Across each month, sum of numbers differs according to number of completed diaries submitted.

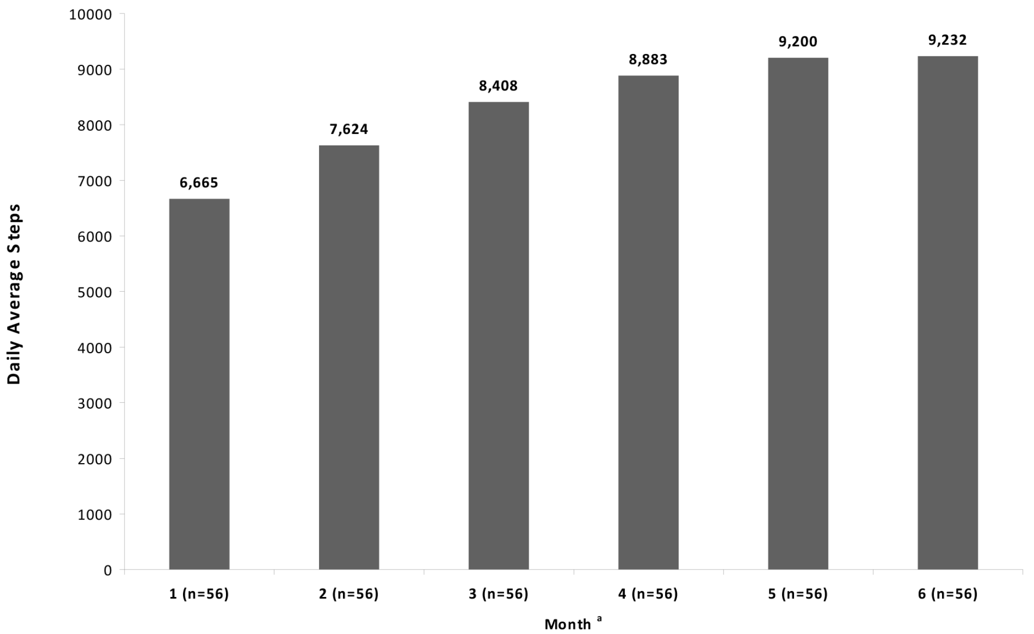

Figure 2 — Daily average steps by monthly intervals.
[a] ANOVA (list-wise approach) only considers participants with complete data across every month (F = 4.6, P = .001).

Table 1 Correlation of Change in Steps/Day With Change in Anthropometric and Biological Outcomes (N = 55)[a]

Measures	Pearson Correlation Coefficient	*p*-value
Body Mass Index (BMI) (kg/m2)	–.17	0.10
Waist circumference (in)	–.02	0.44
Systolic BP (mm/Hg)	–.09	0.27
Diastolic BP (mm/Hg)	–.21	0.06
Glucose (mg/dL)	–.15	0.14
Total cholesterol (mg/dL)	–.03	0.41
LDL-C (mg/dL)	.14	0.15
HDL-C (mg/dL)	–.20	0.06
Triglycerides (mg/dL)	–.23	0.04
Body fat (%)	.13	0.16

[a] For steps/day and all anthropometric and biological measures, change scores were calculated as Month 6 – Month 1.

Table 2 Associations Among Average Pedometer-Determined Activity Category and Changes in Anthropometric and Biological Outcomes (n = 66)[a]

	Means (SD)					
	Pedometer-determined physical activity category[b]					
Measures[c]	Sedentary	Inactive/low active	Somewhat active	Active	Total (n = 66)	*p*-value[d]
Body Mass Index (BMI) (kg/m2)	0.6 (2.2)	–0.8 (1.2)	–0.3 (1.5)	–0.3 (1.4)	–0.3 (1.5)	0.12
Waist circumference (in)	–1.1 (1.7)	–1.7 (1.5)	–1.4 (3.8)	–1.7 (2.5)	–1.5 (2.7)	0.53
Systolic BP (mm/Hg)	–4.9 (14.7)	2.1 (22.4)	–7.3 (12.0)	–7.0 (13.4)	–4.6 (16.0)	0.62
Diastolic BP (mm/Hg)	5.9 (14.9)	3.1 (9.8)	–2.8 (7.9)	–1.6 (9.6)	0.1 (10.2)	0.23
Glucose (mg/dL)	9.3 (16.0)	–6.0 (18.2)	0.2 (15.8)	6.1 (40.7)	1.6 (26.5)	0.31
Total cholesterol (mg/dL)	–6.8 (34.5)	10.3 (29.3)	8.3 (24.7)	14.0 (30.7)	8.7 (29.0)	0.45
LDL-C (mg/dL)	–25.5 (29.8)	0.6 (25.2)	–2.6 (30.5)	1.1 (28.0)	–3.5 (29.0)	0.17
HDL-C (mg/dL)	9.5 (11.0)	9.1 (7.9)	6.9 (10.3)	8.3 (7.4)	8.2 (8.8)	0.85
Triglycerides (mg/dL)	3.0 (72.9)	15.1 (42.3)	2.8 (38.7)	23.3 (56.6)	12.2 (50.0)	0.57
Body fat (%)	–0.9 (0.8)	–1.1 (2.4)	1.6 (4.0)	2.3 (4.6)	0.9 (3.9)	0.01

[a] Includes the 66 participants who completed the enrollment and 6-month outcome data collections.

[b] The total number of steps was the average number of steps achieved by each participant over the 6-month intervention (total number of accumulated steps was divided by total number of pedometer diary entries). Sedentary = <5,000 steps/day; inactive/low active = 5,000–7,499 steps/day; somewhat active = 7,500–9,999 steps/day; active = 10,000–12,499 steps/day; and highly active = >12,500 steps/day.

[c] Dependent variable is change scores (month 6 – month 1) for all anthropometric/biological measures.

[d] Nonparametric Kruskal-Wallis tests.

and HDL-C; however, the HDL trend is in the opposite direction as hypothesized. For inclusion in this analysis, participants had to have completed the enrollment and 6-month data collections, and completed pedometer diaries at months 1 and 6 (n = 55).

Similarly, associations among average physical activity categories over the entire 6-month intervention and anthropometric/biological change scores from month 1 to month 6 were not significant (Table 2). There was a trend for participants in the sedentary and inactive/low active categories to show greater improvements in percent body fat as compared with participants in the somewhat active and active categories. For inclusion in this analysis, participants had to have completed data collections at enrollment and 6 months (n = 66).

Discussion

This 6-month walking intervention targeting a vulnerable African American population resulted in an overall desirable shift in activity classification and significant increases in steps/day as the intervention progressed. However, there were no associations among step counts and changes in anthropometric/biological outcomes. Major strengths of this research include continuous monitoring of physical activity and the targeted understudied, at-risk African American population. Primary limitations of this study were the inability to monitor changes in physical activity intensity and the relatively small sample size, which restricts the statistical power needed to thoroughly explore associations between step counts and anthropometric/biological outcomes.

It is important to note during month one, when motivation was likely at its highest, the majority of participants (n = 40 of 63, 63%) were classified in sedentary or inactive/low active categories. Furthermore, the popularly promoted 10,000 steps per day were not, on average, achieved among participants. During the final month, only 20 of 55 (36%) participants averaged 10,000 or more steps per day. Our findings support previous evidence which suggests 10,000 steps per day may not be attainable for some populations, including those that are overweight or previously sedentary.[8,26] Even if 10,000 steps/day was attainable, little information is available regarding the sustainability of 10,000 steps/day or how a program requirement or goal of 10,000 steps might have impacted attrition rates.[25] For example, one walking program reported an 89% dropout rate in a 12-week program promoting 10,000 steps/day.[27]

Since step-count protocol has tremendous potential to impact participation, attrition rates, and health outcomes, controlled trials are needed to investigate the effects of setting alternative step-count goals in diverse populations. As suggested by previous researchers, it may be more appropriate to use pedometers for self-directed goal setting, rather than endorsing absolute increases.[28,29] Bravata and colleagues found pedometer interventions that required participants to keep a diary and those interventions which used goal setting resulted in significant increases in daily steps from baseline, compared with interventions which did not use diaries or goal setting.[11] However, relative benefits of imposing a 10,000 step goal as a participation requirement versus promoting individualized goal setting remains unclear. For example, in this study, an expectation to achieve a higher step count could have produced stronger relationships among step counts and anthropometric/biological outcomes, or it could have promoted greater attrition rates.

Although we previously documented overall significant improvements in waist circumference (–1.45 inches), systolic blood pressure (–4.32 mmHg), and HDL cholesterol (+7.89 mg/dL) ($P < .001$) from enrollment to 6 months among participants in this intervention,[23] through this study we could not attribute these changes to a threshold level of steps achieved. About 41% of enrolled participants had metabolic syndrome at baseline (at least 3 of the 5 defined criteria), which likely contributed to large variability and unpredictable fluctuations in the lipid measures, especially considering that residents in the targeted community remain medically undertreated. It is also noteworthy that the largest improvements in anthropometric and biological change scores rarely occurred among the active category; however, this nonsignificant trend should be interpreted cautiously. While numerous studies have documented benefits of physical activity and shown pedometer users can successfully and significantly increase their daily steps, there is relatively less information indicating if health improvements are a function of increases in daily steps.[1,7,9,11,12,25]

Unlike controlled clinical trials which firmly defined inclusion/exclusion criteria (ie, BMI ≥ 25 or blood pressure > 120/80), community-based interventions such as this one, where the focus in on improving the health of the community, set inclusion/exclusion criteria to allow for involvement of nearly all interested community members. Consequently, increased variability among health indicators for participants and large standard deviations associated with change scores increases the sample size needed to determine statistically significant relationships among variables. In fact, small sample sizes have been recognized as a key limitation in the pedometer literature.[11] Furthermore, our intervention provided group nutrition education sessions but we did not assess changes in dietary intake which could also impact anthropometric/biological changes. While it is difficult to speculate how a larger sample size or accounting for dietary changes would have impacted our findings, it is important for future researchers to carefully consider these issues when designing, sampling, and planning for analyses of their community-based pedometer studies.

Two further considerations involve the limitations of using pedometers to measure changes in physical activity and concerns surrounding missing pedometer data. Pedometers cannot detect all kinds of physical activity and cannot detect changes in the intensity of physical activity. It is possible that nonwalking activity changed or walking intensity increased in our participants, without a corresponding change in the absolute number of steps, which could have impacted our findings. Related to missing pedometer data, a semisimulated study by Kang and colleagues examines unique concerns in recovering missing step-count data.[30] Based on numerous issues identified in Kang's study, we did not attempt to estimate missing values in this study. For example, in our pedometer data set, the large standard deviations indicate relatively large day-to-day intraindividual variability and large interindividual variability, which would have greatly decreased the precision of imputations. In attempts to increase the validity of pedometer-determined physical activity, standardized approaches are needed to account for missing pedometer data.

Despite the study limitations, feasibility studies such as this one are necessary to evaluate and test protocols, establish standard deviations, and estimate participation and attrition rates. Furthermore, these findings highlight the usefulness of continuously tracking step counts, as opposed to limiting step count assessment at 2 to 7 days at intermittent time points over the intervention as is common with pedometer research methodology.[14,28,31–34] Continuous tracking of pedometer data are undoubtedly more resource intensive; however, it provides a rich data set and strong mechanism to track participants which proved to be useful in this understudied community.

In conclusion, in vulnerable communities where there is little data regarding physical activity and the built environment does not support physical activity (ie, lack of gyms, health clubs, walking tracks), it is important to first understand participants' ability to meet physical activity standards to avoid the risk of imposing unachievable daily step goals which may deter participation and cause higher attrition rates. In order for minority communities to fully benefit from pedometer-based physical activity interventions, this study exemplifies the need for adequately powered, controlled studies aimed at assessing the impact of alternative step goals and evaluating if health outcomes are a function of daily step increases. Finally, statistical manipulations of missing pedometer data deserves further investigation as this will allow researchers to link absolute steps taken as well as progression over the intervention with changes in anthropometric/biological outcomes.

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