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Pedometer-Determined Physical Activity among Multiethnic Low-Income Housing Residents

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Abstract

Purpose—We sought to characterize pedometer-determined physical activity among a predominantly racial and ethnic minority sample of adults residing in low-income housing.

Methods—Data were collected from 433 participants at baseline in a randomized colon cancer prevention intervention trial conducted within low-income housing communities. Using random effects models to control for clustering within housing sites, we examined variation in daily steps by several sociodemographic characteristics.

Results—Participants recorded a mean of 5326 (± 3871 SD) daily steps over a 5-d sampling period. Significantly lower levels of pedometer-determined physical activity were found among older-aged participants ($P < 0.0001$), women ($P = 0.02$), those who were overweight and obese ($P = 0.03$), those reporting no weekly exercise ($P = 0.04$), as well as among nonworking individuals ($P < 0.0001$). No significant differences were found by education or income. In multivariable analyses, age, gender, body mass index, and employment status remained significantly associated with steps.

Conclusions—These findings suggest a high prevalence of physical inactivity among low-income housing residents. These data, derived from a well-characterized sample, provide useful estimates for the investigation of pedometers as measures of total accumulated physical activity among lower-income, racial and ethnic minority populations.

Keywords

Race/Ethnicity; Exercise; Socioeconomic Status; Minority; Pedometers

The chronic disease burden associated with physical inactivity may disproportionately affect socially disadvantaged populations. Racial and ethnic minority populations are consistently shown to be less physically active during leisure time compared with whites (1). In 2000, the prevalence of having no physical activity during leisure time was 54% among Hispanics, 52% among blacks, and 35% among whites (1). Numerous population surveys have similarly reported a positive association between leisure-time physical activity and measures of social

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class (8,17,22). Approximately 72% of adults with less than a ninth-grade education do not regularly participate in leisure-time physical activity, compared with 25% of college graduates (1).

The methodological challenges associated with valid measurement of physical activity using self-report measures (14,16) may be magnified in studies involving lower-income populations. Few self-report measures are designed to assess activity accumulated through nonleisure sources (e.g., domestic, occupational, transportation), which may be more common and account for a larger proportion of total physical activity among lower-income populations. Individuals in lower-income populations are overrepresented in physically active occupations (i.e., construction, maintenance, housekeeping, factory work). Particularly in urban settings, individuals of lower income may have a higher likelihood of engaging in ambulatory activity for transportation purposes (e.g., walking to work, school, or a bus stop). This is a key concern, because it is largely unclear whether the recommended guidelines for daily physical activity (18) are met or exceeded by those in lower-income populations through these often unmeasured activity sources. For example, in two large, randomized intervention studies conducted among more than 4000 lower-income, multiethnic adults, our group recently found much higher, accelerometer-validated, rates of self-reported physical activity than would be expected based on the available literature (10,21). Results of these and other (5) studies highlight the need to assess total accumulated physical activity in these groups, using reliable and externally valid measurement strategies.

A variety of motion sensor technologies (i.e., pedometers, accelerometers) have been developed to overcome the compromised validity associated with many self-report physical activity indexes (28). Pedometers capture the vertical accelerations associated with normal ambulation and demonstrate excellent concordance with accelerometer-derived physical activity (median correlation of 0.86), and can objectively detect gradations in walking behavior (4,11,28). Walking is the most frequently adopted type of regular physical activity (16,28), particularly among some racial and ethnic minority groups, (16) yet it is among the least reliably recalled activity types (16,28). Given their accuracy, low unit cost ($10–20), and ease of use, pending continued rigorous validation, pedometers hold great promise as measures of total physical activity among lower-income, multiethnic populations.

Emerging data provide expected reference values for daily steps by a variety of sociodemographic characteristics (20,27,29). Higher daily steps are generally found among men (24,29), those of younger age (20,27,30), and the employed (7,30). Some evidence suggests that pedometer-determined daily steps are inversely associated with measures of socioeconomic position and are generally higher among whites (27). Few studies, however, have measured physical activity using pedometers in well-characterized, population-based samples that include individuals from lower-income and racial and ethnic minority groups.

Given the limitations of the current literature, the primary aimof the present study was to discern patterns of pedometer-determined physical activity by a range of sociodemographic characteristics in a predominately racial and ethnic minority population of low-income housing residents.

METHODS

These data were collected in the prerandomization, baseline phase of the Open Doors to Health (ODH) study, a randomized physical activity promotion and colon cancer screening intervention trial being conducted in collaboration with 12 metropolitan Boston low-income housing communities. We include data from participants in the first seven sampled housing sites.

Participant recruitment began with housing site representatives sending letters announcing the study to their eligible residents. Eligibility criteria for the study survey included (a) housing site residence, (b) age of at least 18 yr, and (c) fluency in English or Spanish. Residents were provided the ability to opt out of the study by contacting either a housing site representative or member of the research staff. Following the initial announcement letter, a random sample (in larger housing sites, > 300 units) or census sample (in smaller housing sites, < 300 units) of potential participants was drawn, and individuals were contacted by telephone and home visits to inquire about their interest in participating. Study staff attempted to recruit 1728 potentially eligible individuals. Of these, 626 (36.2%) were unreachable, 342 (19.8%) refused, and 64 (3.7%) did not show for appointments, leaving 696 (40.3%) with complete data.

After enrollment, participants provided informed consent and completed an interviewer-administered survey. Age was coded into 5-yr intervals. Participants were asked to report their race or ethnicity as black, white, Hispanic, Asian, American Indian, or other. Participants were permitted to select more than one option; those who selected Hispanic were coded as such, regardless of other options selected. Participants choosing more than one of the other five race or ethnicity options were assigned to a ‘‘mixed race or ethnicity’’ category. Participants reported their highest level of educational attainment, which was collapsed into three levels because of small numbers (less than high school, high school or vocational school, any post–high school education). Participants’ self-reported income was collected in seven categories and grouped into four categories (< $10,000; $10,000–19,999; $20,000–39,999; ≥ $40,000) because of small numbers in some categories. Participants’ current employment status, which was collected in seven categories, was also grouped into four levels (working full-time, working part-time, disabled from working, not working, including retired and homemaker) because of small numbers in some groups. Based on their reported place of birth, we categorized participants as U.S.-born or foreign-born. Foreign-born individuals also reported their number of years in the United States. Body mass index (BMI) was calculated from self-reported height and weight and limited to the following standard categories: normal ($< 25\ \mathrm{kg \cdot m^{-2}}$); overweight ($25–29.9\ \mathrm{kg \cdot m^{-2}}$); obese ($\geq 30\ \mathrm{kg \cdot m^{-2}}$).

Pedometers

Following completion of the survey, participants were oriented to the pedometer sampling protocol and provided with a kit containing the pedometer (with lanyard to secure the pedometer), sampling log, and instructions (with photos) in a storage container. Research staff explained the functions of the pedometer, reset it, and taped the pedometer shut, blinding participants to the step count. Staff stressed that participants should maintain their normal daily routine while wearing the pedometer. Staff demonstrated proper pedometer placement, use of the lanyard, and reviewed instructions for completion of the sampling log.

Participants were asked to wear the pedometer at all times for 5 d, except while bathing, showering, swimming, and sleeping. Participants were asked to put the pedometer on each morning after awakening. On the sampling log, participants recorded (a) time of awakening, (b) whether the pedometer was worn, (c) time pedometer was removed, (d) whether the pedometer was removed during the day, and (e) the amount of time it was off (e.g., while swimming). On day 5, participants were asked to remove the pedometer and place it in the storage container before going to bed; the pedometer was not to be removed from the container until it was returned to study staff. On receipt of the pedometer, staff removed the tape and immediately recorded the accumulated steps.

Study pedometers were the Yamax SW200 models, which demonstrate high concordance with accelerometers under laboratory conditions and in field settings (19). Bassett et al. (3) found that a Yamax pedometer with comparable architecture demonstrated correlations of r = 0.80, 0.86, and 0.93 (all significant at the $P < 0.01$, two-tailed level) with the CSA Model 7164

(Shalimar, FL; using the manufacturer and Hendleman equations), Caltrac (Muscle Dynamics Fitness Network, Torrance, CA), and Kenz (Select 2 model, Nagoya, Japan) accelerometers, respectively. The Yamax SW200 has been recommended in a number of validation studies as a preferred model for measuring daily steps in free-living populations (15,23). All pedometers were fully tested before use according to the suggested strategy (29). The study protocol was approved by the human subjects committee at the Harvard School of Public Health. Participants were provided a $25 grocery store card incentive on completion of the data collection protocol.

Statistical analysis

A total of 696 participants completed the survey. A subset of participants (N = 137) were deemed ineligible to collect pedometer data because they were either not ambulatory or their literacy levels were too low to complete the sampling log. We excluded from our analyses participants who did not wear the pedometer for at least 3 d (as recorded in the logs) (N = 52), those who returned broken pedometers (N = 2), those who became incapacitated during the sampling period (N = 3), and those whose log data was incomplete (N = 15), leaving 487 participants. To aid in interpretation of the findings, we limited our analyses to participants who reported being Hispanic, non-Hispanic black, or non-Hispanic white, leaving 433 participants. To examine the association between sociodemographic variables and daily steps, we used random effects model to control for clustering of participants within housing sites. Multivariable models included all variables reaching P < 0.10 in bivariate associations.

RESULTS

Study participants were mostly black (50%) or Hispanic (42%) and were predominantly female (65%) (Table 1). Almost half of participants were foreign-born (46%), and most reported an annual income under $20,000 (78%). Less than a third (31%) of participants were of normal weight; mean BMI was 29.9 $kg \cdot m^{-2}$. Participants tended to be older, with 40% over age 60. Nearly 40% of participants had less than a high school education; 25% had completed high school, and the remaining 36% had some education after high school. Excluded participants did not significantly differ on age, gender, education, or income.

Participants' daily steps ranged from 3 to 17,134, with a mean (± SD) of 5326 (± 3871). Significant variation was seen across housing sites, with site means ranging from 2151 (± 1607) to 7622 (± 4584) daily steps. Age was significantly associated with daily steps ($F_{df = 5}$ = 4.09, P < 0.0001) (Table 2). Participants under age 25 recorded significantly more steps per day than participants aged 60–64 (P = 0.05), 65–69 (P = 0.004), and more than 70 yr (P < 0.0001). Women recorded 922 fewer steps per day than men (F = 5.82, P = 0.02). Neither education (F = 0.77, P = 0.47) nor income (F = 1.90, P = 0.13) were significantly associated with daily steps. Employment status, however, was significantly associated with steps per day (F = 13.45, P < 0.0001), such that those employed full-time recorded 2876 more daily steps (P < 0.0001) than those who reported not working. Physical activity among U.S.-born participants did not differ from that of foreign-born participants (F = 0.22, P = 0.64); among foreign-born participants, number of years in the United States was similarly unrelated to daily steps (F = 1.69, P = 0.20). Reported days per week of exercise was associated with daily steps (F = 3.22, P = 0.04), as was BMI (F = 3.61, P = 0.03). Overweight participants recorded 182 fewer steps (P = 0.69), and obese participants recorded 1066 fewer steps (P = 0.01), compared with normal-weight participants.

In multivariable analyses, the association between reported days of exercise and daily steps became nonsignificant (P = 0.04–0.09). Age, gender, BMI, and employment status remained significantly associated with daily steps.

Discussion

In our initial examination of pedometer-determined physical activity among a predominately racial or ethnic minority sample of lower-income housing residents, we found that, on average, participants took just over 5300 steps each day, suggesting that much of our sample is currently sedentary. Tudor-Locke et al. (29) reviewed 32 studies evaluating pedometer-determined physical activity, which led them to conclude that daily steps ranged from (a) 7,000–13,000 for healthy adults; (b) 6000–8500 for healthy older adults; and (c) 3500–5000 for sedentary individuals and those with disabilities or chronic illness. In our sample, 56% of participants fell below their sedentary index of 5000 steps per day. Further highlighting the high rates of sedentary behavior, only 24% of all participants took between 7,000 and 13,000 steps, and only 8% of participants over age 50 yr took between 6000 and 8500 steps. Consistent with previous findings, we also found significant sociodemographic variation by age, gender, BMI, and occupational status. Our findings extend previous research in a number of ways. First, they demonstrate the utility of pedometers to assess physical activity in population-based samples of individuals in lower-income settings, given appropriate methodological considerations. Particularly in population health research, where use of more objective measurement strategies may be unfeasible, our findings demonstrate that pedometers can be used effectively in traditionally understudied populations to assess physical activity in a manner that is largely devoid of the recall biases that can have an impact on self-report measures. Next, these data are useful to ensure sociodemographic representation in the ongoing efforts to compile expected reference categories for daily steps (29). Finally, our findings would appear to support national self-reported survey data indicating a higher prevalence of physical inactivity among individuals in lower social class groups. This highlights the importance of directing additional research attention to the design of interventions to promote physical activity among this segment of the U.S. population.

Our findings are comparable to those of several recent studies that investigated pedometer-determined physical activity (13,27,30). Tudor-Locke et al. (27) found, among a sample of 209 residents of Sumter County, SC, that participants took a mean of 5931 steps per day; significant variation in steps was found for race (white vs nonwhite), age, education, income and BMI. Tudor-Locke's sample was more heterogeneous than our own with respect to socioeconomic makeup, which may account for their finding of slightly higher daily steps. Our findings are slightly higher than those studies conducted among more racially or ethnically diverse samples, such as those of Whitt et al. (20,27,30) and Henderson et al. (12), who found daily steps of 4770 ± 5171 among a sample of 200 African American and American Indian women.

Consistent with previous self-report (6) and pedometer data (20,25,27), we found that women recorded significantly fewer steps per day than did men. Studies utilizing self-report measures have also often found racial or ethnic variation in physical activity patterns, particularly during leisure time (5,6,9); we found no such racial or ethnic differences in our sample. Given the restricted socioeconomic range in low-income housing, it was not surprising that daily steps did not vary by either education or income. Occupational status may arguably be a more sensitive socioeconomic measure among those in this setting. At a minimum, employed participants would be expected to accumulate higher additional daily steps owing to their occupational activities and transportation to and from work. Indeed, we found that, compared with those who reported not working, individuals working in part-time jobs had more than 1450 additional daily steps, whereas those in full-time positions attained almost 3000 additional daily steps. The average number of daily steps among those who reported not working was well within the sedentary range (4526 ± 3435). These findings would appear to highlight the centrality of work to regular physical activity among individuals in lower-income settings. Rates of current employment in our sample, however, were low; only 33% reported current employment, and only 19% were employed in full-time positions. However, we cannot discount the possibility that unmeasured factors ormisclassification of income (given the narrowrange in this sample) may have had a more profound impact on daily steps among those healthy enough to work.

As might be expected, we found an inverse association between age and daily steps, such that participants over age 70 yr accumulated almost 3000 fewer daily steps compared with those under age 25 yr. In our formative research in this population, we found that many older-aged participants reported being largely socially isolated. With the exception of regular housing site programming, many reported having few opportunities for regular participation in physical activity. Given the extant data indicating health benefits of physical activity among older-aged individuals (2), these data indicate the need (and tremendous potential opportunity) to implement physical activity promotion interventions for this group. Lower-income housing residents aged 50 yr and older will be a primary target for intervention efforts in the ODH study.

Similar to several previous investigations, we found a significant inverse association between BMI category and daily steps that became marginally associated in multivariable analyses. Obese participants took almost 1100 fewer steps than those of normal weight. Tudor-Locke et al. (24) have proposed preliminary ranges of daily steps that are associated with BMI categories to identify individuals who might benefit from physical activity intervention. Based on these findings, we would call for some modification to those ranges. We concur with the previously established range for obese individuals (4600–6000 daily steps); however, integration of the current data suggests that the step ranges for normal-weight and overweight individuals should be adjusted to accommodate the lower daily steps taken among lower-income individuals. As others have suggested (27), it is notable that relatively few individuals (17% in our sample) attained more than 9000 steps per day, a threshold associated with reduced obesity in this and previous investigations. Given the cross-sectional nature of our data, however, we are unable to establish causality of the association between BMI and daily steps; a bidirectional association almost certainly exists.

Those who reported not exercising took significantly fewer steps than those reporting exercise on 5 d or more of the week; however, the difference (1186 daily steps) was not as large as might have been expected and became nonsignificant in multivariable analysis. This finding suggests the limitations of relying exclusively on leisure-time estimates for measuring physical activity in lower-income populations. Future studies should investigate this finding using more comprehensive measures of exercise behaviors. Tudor-Locke et al. (23) have proposed that daily steps in excess of 8000 may be roughly equivalent to the accumulation of 30 min of moderate-intensity activity on a single day. By that measure, only about 20% of our sample would meet current Centers for Disease Control and American College of Sports Medicine recommendations for daily physical activity (18). Although this estimate is inherently biased (because pedometers are incapable of measuring activity intensity, a primary component of the national guidelines), nevertheless it may constitute a useful target for population-based physical activity promotion efforts.

Several considerations may limit interpretation of these findings. We chose to blind pedometers to study participants to prevent reactivity and to minimize the potential threats to sampling log validity presented by low literacy levels in the sample. Participants were instructed to wear the pedometer for 5 d, and we staggered participant start day; thus we have only one blinded 5-d iteration without a weekend day. Results from a recent validation study, however (26), suggest that any 3 d (weekday or weekend) are sufficient for the reliable estimation of physical activity performed in a free-living week. We found sizeable site-specific variation in daily steps, and thus we estimated random effects models to control for these differences. We adopted a conservative analytic approach that resulted in the exclusion of 72 participants whose pedometer data were in some way compromised; however, sociodemographic characteristics of this group did not differ those participants included in it. A higher response rate would have been desirable, although it is clear that recruitment challenges experienced in the initial two housing sites (during the startup phase of the study) had a most negative impact on the estimate. Excluding the first two sites, the response rate improved dramatically (66.8% for the latter five sites combined). Allowing room for such improvement is an important consideration in the conduct of community-based research of this type. Finally, despite the some-what nonnormal distribution (skewness = 0.98, kurtosis = 0.56) of daily steps, we chose to report analyses in which the variable was modeled as normal for consistency with previous investigations and ease of interpretation. However, in bivariate analyses using the transformed outcome (using the square root daily steps), gender was not significant ($P = 0.06$), and income was of significance to merit consideration for multivariable analysis ($P = 0.07$). The statistical significance of all other variables was un-changed. In multivariable analysis with the transformed outcome, no change was seen in variable significance, and income became nonsignificant ($P = 0.72$)

Despite their promise, we recognize that pedometers have limitations as measures of total accumulated physical activity. Compared with accelerometers, pedometers are not designed to measure the intensity or duration of physical activity, and thus they are unable to determine concordance with national guidelines for regular physical activity. Nevertheless, given the challenges with self-report measures (particularly for lower-income groups) and the high costs and logistical considerations associated with accelerometers, pedometers may be useful in population-based studies of physical activity among lower-income and multiethnic audiences where the primary form of physical activity is walking.

This report constitutes the largest collection of pedometer-determined physical activity conducted in the United States to date. Our work extends the results of previous studies by suggesting that pedometers might be useful in the measurement of physical activity among a lower-income, multiethnic population.

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TABLE 1

Demographic distribution of participants and average daily steps (N = 433).

	N	%	Daily Steps	SD
Race or ethnicity				
Hispanic	184	42	5937	3971.1
Black	215	50	4688	3695.2
White	34	8	6051	3925.7
Gender				
Male	153	35	5844	4373.7
Female	280	65	5043	3556.1
Education				
Less than high school	170	39	5019	3924.8
High school or vocational school	106	25	5001	3773.5
Any post high school	155	36	5861	3885.6
Age (yr)				
<25	40	9	6587	4083.6
25–29	23	5	7382	4231.1
30–34	28	7	6335	3962.5
35–39	27	6	7510	4247.2
40–44	35	8	6449	3684.3
45–49	33	8	6227	3949.4
50–54	32	7	5167	3862.2
55–59	43	10	4984	4233.2
60–64	48	11	4617	3373.1
65–69	55	13	4104	2999.0
70+	68	16	3285	2873.3
Place of birth				
U.S. born	234	54	5031	3866.3
Foreign born	199	46	5673	3857.8
Body mass index ($kg \cdot m^{-2}$)				
<25	135	31	5999	4203.0
25–29.9	136	32	5505	3552.4
≥30	162	37	4615	3743.3
Income				
<$10,000	156	43	4887	3706.7
$10,000–$19,999	126	35	5179	4052.9
$20,000–$39,999	60	17	6707	4214.5
≥$40,000	18	5	6786	3470.0
Employment				
Working full-time	76	19	7864	4240.7
Working part-time	56	14	6432	4314.8
Disabled	92	23	4396	3336.4
Not working	182	45	4526	3435.0

	N	%	Daily Steps	SD
Days of exercise per week				
None	103	24	4852	3544.9
1–4	193	45	5207	3766.3
≥5	137	32	5851	4205.3

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TABLE 2

Associations of daily steps with sociodemographic characteristics.

	Bivariate Associations				Multivariable	
	Coefficient	SE	F	*P* Value	F	*P* Value
Race or ethnicity			0.99	0.37		
Hispanic*						
Black	−579	411.5		0.16		
White	−159	742.5		0.83		
Female	−922	382.4	5.82	0.02	8.62	0.003
Education			0.77	0.47		
Less than high school	−292	433.4		0.50		
High school	−578	468.9		0.22		
Any post high school*						
Age			4.09	<0.0001	2.81	0.002
<25*						
25–29	951	943.9		0.31		
30–34	−217	884.5		0.81		
35–39	671	902.4		0.46		
40–44	−49	835.7		0.95		
45–49	−297	854.8		0.73		
50–54	−1486	861.2		0.09		
55–59	−1500	806.6		0.06		
60–64	−1567	793.0		0.05		
65–69	−2256	785.1		0.004		
70+	−2938	749.6		0.0001		
Foreign born	180	382.9	0.22	0.64		
Years in United States (foreign-born only)	−5	3.8	1.69	0.20		
BMI categorical			3.61	0.03	3.14	0.04
<25*						
25–29.9	−182	448.6		0.69		
≥30	−1066	431.5		0.01		
Income			1.90	0.13		

	Bivariate Associations				Multivariable	
	Coefficient	**SE**	**F**	***P* Value**	**F**	***P* Value**
<$10,000	−1163	952.6		0.22		
$10,000 – $19,999	−1262	952.8		0.19		
$20,000 – $39,999	−25	1005.0		0.98		
≥$40,000						
Employment			13.45	<0.0001	8.96	<0.0001
Working full-time	2876	507.2		<0.0001		
Working part-time	1463	560.7		0.01		
Disabled	−279	475.1		0.55		
Not working*						
Reported days of exercise per week			3.22	0.04	2.46	0.09
None	−1186	480.4		0.01		
1–4	−732	418.5		0.08		
≥5*						

*Reference group