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Evaluation of a Questionnaire to Assess Sedentary and Active Behaviors in the Southern Community Cohort Study

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Abstract

Background—Low physical activity (PA) is linked to cancer and other diseases prevalent in racial/ethnic minorities and low-income populations. This study evaluated the PA questionnaire (PAQ) used in the Southern Cohort Community Study, a prospective investigation of health disparities between African-American and white adults.

Methods—The PAQ was administered upon entry into the cohort (PAQ1) and after 12–15 months (PAQ2) in 118 participants (40–60 year-old, 48% male, 74% African-American). Test-retest reliability (PAQ1 versus PAQ2) was assessed using Spearman correlations and the Wilcoxon signed rank test. Criterion validity of the PAQ was assessed via comparison with a PA monitor and a last-month PA survey (LMPAS), administered up to 4 times in the study period.

Results—The PAQ test-retest reliability ranged from 0.25–0.54 for sedentary behaviors and 0.22–0.47 for active behaviors. The criterion validity for the PAQ compared with PA monitor ranged from 0.21–0.24 for sedentary behaviors and from 0.17–0.31 for active behaviors. There was general consistency in the magnitude of correlations between the PAQ and PA-monitor between African-Americans and whites.

Conclusions—The SCCS-PAQ has fair to moderate test-retest reliability and demonstrated some evidence of criterion validity for ranking participants by their level of sedentary and active behaviors.

Keywords

physical activity questionnaire; low income; reliability; reproducibility

Recent evidence suggests that decreased physical activity (PA) and increased time spent in sedentary behaviors (ie, sitting or lying down) are associated with greater risk for colorectal, endometrial, ovarian, and prostate cancer development as well as cancer mortality in women.[1] Other studies showed that central adiposity, elevated blood glucose and insulin, and other thought to be operative in the development and progression of cancer are related to PA. Moreover, these factors are more prevalent in African Americans and low-income adults than in other US populations.[2–4] However, it remains unclear if the reported differences in the amount and patterns of PA by race/ethnicity and socioeconomic status contribute to the risk and prevalence of cancer.

These findings underscore the need for accurate assessment of PA in cohort studies designed to examine association of PA and rare outcomes such as cancer conducted in different populations.[5,6] In very large epidemiological studies, use of objective measures of PA (eg, accelerometers) is not practical for all participants, and physical activity questionnaires (PAQ) are commonly used to assess PA behaviors.[7] When implementing a PAQ in a new cohort study, it is imperative to consider the reliability and validity of the PAQ against meaningful reference instruments, such as accelerometry or another self-reported survey, to understand and consider the inherent level of measurement error in future associations' studies.

Thus, the PAQ developed using existing questionnaires[8–10] and refined for use in the Southern Cohort Community Study (SCCS) was designed to assess a broad range of active and sedentary behaviors encountered in daily life in a group of 39–79 years old African American and white men and women living in the Southern US.[11] The PAQ included several behavioral domains such as sleeping, sedentary behaviors, as well as household and occupational, transportation, walking, and recreational activities. In this study, we evaluated the measurement properties of this instrument using accelerometry and another self-report instrument as our criterion measures, and we explored potential differences between African Americans and whites in the reliability and criterion validity of the PAQ.

Methods

Study Population

The SCCS is an on-going population-based cohort study of primarily African American and non-Hispanic whites living in the southeastern United States that was designed to examine the causes for racial disparities in incidence and mortality of cancer and other chronic diseases.[11] SCCS participants were recruited from 1 of 71 participating community health centers (CHCs). The CHCs are government-funded institutions offering basic health and preventative services, mainly to the medically uninsured.[12] Eligibility requirements for the study were that participants had to be English-speaking men and women between the ages of 40–79 years, and that they had not been treated for cancer within the past year. Recruitment occurred between 2002–2009, with a total recruitment of approximately 76,000 participants. Data collection at the time of recruitment included a structured interview to measure a wide range of cancer risk factors, including health history, medication use, diet, and physical

activity. The study was approved by the institutional review boards at Vanderbilt University and Meharry Medical College in Nashville, TN.

Sample Selection

Participants for the current study were randomly selected among the SCCS study population that self-reported their race/ethnicity as African American or white enrolled in the cohort between March 2002 and June 2007, completed the PAQ at SCCS enrollment, and provided a home telephone number. Four-hundred and twenty participants were sent invitation packets that included a description of the study and an informed consent document. Forty-six packages were returned suggesting wrong address. Staff then attempted to contact participants by phone to answer questions about the study and to encourage enrollment by signing and returning the consent form. Thirty-four telephone numbers were not valid or no longer in service. Among eligible participants who could be contacted by phone in 5 attempts or fewer (n = 240), 168 (70%) provided informed consent and were enrolled in the study.

The Southern Community Cohort Study PAQ

The SCCS PAQ was developed based on questionnaires used in other studies reported at the time of questionnaire development,[13–15] our previous experience[16,17] and interviews with study participants. The questionnaire evaluated a wide range of both active and sedentary behaviors typically done at home, work, and during leisure time. To assess “usual” activity or patterns of activity, the PAQ did not request reports of behavior referenced to a specific period (eg, last week, last month, or last year). Questions about sedentary behaviors asked for time per day participants typically spent sitting in a car or bus, sitting at work, viewing television, or seeing movies, using a computer at home, and other sitting activities). Among the physically active behaviors (ie, nonsitting), time spent in light, moderate, and hard (vigorous) work were assessed for weekdays and weekend days separately. Times spent in slow and fast walking were also assessed. Questions for household/occupational activity and walking were not mutually exclusive. Summary measures of active behaviors were derived by combining time spent in light, moderate and strenuous (vigorous) occupational/household activities, as well as the leisure time sports and exercise activities. In addition, the PAQ included questions to assess past active behavior patterns by asking questions about activity level “in your 30s.”

Time spent in sedentary behaviors was summarized as reported (hours/day), while duration reports of active behaviors (hours/day) were converted to estimates of PA energy expenditure (MET-hours/day) using common metabolic equivalent (MET) values for the specific activities assessed using the Compendium of Physical Activities.[18] Accumulating 1 MET-hour/day of PA energy expenditure is equivalent to participating in 0.5 hours of a light intensity activity (2 METS), 0.25 hours of moderate intensity activity (4 METS), or 0.125 hours of a vigorous activity (8 METS). Absolute MET values were used to classify the intensity of active behaviors as light (2.0–2.9 METS), moderate (3.0–5.9 METS), and vigorous (≥6.0 METS) activity[18] were used.

Data Collection Schedule

The data collection schedule is summarized in Figure 1. Each participant had already completed the in-person interview at enrollment into the SCCS at the CHC site (termed `PAQ1').

The schedule of assessments for the reference instruments was designed to estimate habitual levels of activity behaviors over 1 year, while minimizing seasonal and intraindividual variation in the measures. An objective PA measure was obtained by having the participants

wear an accelerometer for up to 4 7-day monitoring periods spaced approximately 3-months apart. Following the completion of each monitoring period, a telephone interview was conducted to assess activity patterns in the previous month using the Last Month Physical Activity Survey (LMPAS), a previously developed instrument that is sufficiently detailed to enable comparison with the PAQ on selected domains.[18] Finally, a second PA interview using the original PAQ (termed `PAQ2') was conducted over the phone by trained interviewers approximately 13–15 months after entry into the study.

Criterion Measures

Physical Activity Monitor—A waist-mounted 3-dimensional accelerometer (RT3, Stayhealthy, Monrovia, CA) validated in free-living adults was used as a reference instrument.[19–22] Participants received the monitor by mail with pictures and detailed instructions how to wear and maintain the accelerometer. They were instructed to wear the RT3 attached to a provided belt on the right hip for 7 consecutive days during waking (not sleeping) hours, except while bathing or during aquatic activities. Study staff called each participant on the evening before the first scheduled wearing day to answer any questions about the accelerometer, and to cue them to begin wearing the device. Participants returned the device to the study center using a prepaid mailer.

Minute-to-minute accelerometer data representing the intensity and duration of activity were processed as described previously.[23] The epoch interval was set at 1-min and output was expressed as the vector magnitude in counts per minute. Wearing time was estimated using established algorithms[24] adapted for the RT3. The 60 minutes of zero vector magnitude value setting was used to determine nonwear intervals. The vector magnitude values of greater than 10 units were required to end the nonwear interval. While these adaptations for the RT3 have not been formally tested, in the absence of such information, we believe that this approach is a pragmatic solution to implementing an automated wear time algorithm for this device. PA energy expenditure (kcal/day) was calculated by subtracting total energy expenditure (TEE kcal/d) from resting energy expenditure (REE kcal/d) values derived from the native RT3 equations.[14] Total daily physical activity levels (PAL = TEE/REE) were also calculated. Within the wearing time, sedentary behavior was estimated as time spent in activities that generated less than 100 counts/minute, while time spent in active behaviors was estimated using defined categories of counts for light (100–1316 counts/minute), moderate (1317–2636 counts/minute), and vigorous (≥2637 counts/minute) activity.[21] For the analyses, we averaged the results of repeated RT3 administrations from all available data for each participant. We considered this average as the best estimate of the participant's PA during the study period.

The Last Month Physical Activity Survey (LMPAS/CAPS)—The LMPAS was adapted from the Typical Week Physical Activity Survey developed in the Cross Cultural Activity Participation Study.[13] The instrument assesses PA performed during the last-month and it was administered up to 4 times during the study by telephone. The adaptations included expanding the period from “last week” to “last month” to cover RT3 monitor wearing period. The individual items on the survey were matched carefully to those on the SCCS PAQ by domain. The LMPAS assessed sedentary behaviors such as sitting in a car or bus, at work, TV and movies, and other) and active behaviors such as household chores, lawn and garden work, transportation, occupation, care giving, and leisure-time PA. The items differentiated between sedentary (summary value) and activity behaviors, and the latter items assessed light, moderate, and vigorous activity. Participants were asked how often they participated in each behavior, and the average duration on days of participation (hrs/d). Slow and fast walking time was combined into a single walking variable. Sleep time on weekends and weekdays were also assessed. Estimates of PA energy expenditure (MET-

hrs/d) were calculated[18] as were intensity and domain specific summary variables. Estimates for sedentary behaviors on the LMPAS were summarized in terms of duration (hrs/d) and the replicate measures were averaged for analyses.

Statistical Analysis

Of the 168 consenting individuals, 143 completed the first monitoring period and 118 participants completed at least 1 of the additional PA measures (N = 86 completed PAQ2, N = 112 completed the LMPAS, and N = 116 completed the accelerometer monitoring. Among these 118 participants, 86 had complete data for all 4 measures of PA assessment (PAQ1, PAQ2, LMPAS, and accelerometer monitoring). We used nonparametric statistic (Spearman) in our analyses due to the skewed distribution observed in our PA data. In addition, order correlation is consistent with the concept of ranking level of behavior in epidemiologic studies. To assess the test-retest reliability of the SCCS PAQ, means and standard deviations for each sedentary and active behavior were computed separately for PAQ1 and PAQ2 and the distributions were compared using the Wilcoxon signed rank test. Spearman correlations were used to evaluate the relationship between PAQ1 and PAQ2 values and to assess associations between comparable questions between the SCCS PAQ (1 and 2) and the LMPAS. Available data from RT3 and LMPAS were averaged for each participant and for each observation (season). Associations between the summary measure for the percentage of sedentary time from the accelerometer and the SCCS PAQ1 and PAQ2 questions about sleeping and sedentary behaviors were assessed using partial Spearman correlations with adjustment for age at SCCS enrollment, race, and gender. Similarly, partial Spearman correlations were used to assess the relationship between the summary measure for PA level from the RT3 accelerometer and active behaviors obtained from the SCCS PAQ1 and PAQ2. The strength of the correlations was interpreted as indicated by Landis and Koch[25] as poor (<0), slight (0.0–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect (0.81–1.00). In addition, to explore potential differences between African Americans and whites, we conducted stratified analysis.

Results

Characteristics of the Study Population

Sixty-one females (38 African American) and 57 males (49 African American) with an average age 54.5 ± 8.4 years participated in the study. Mean body mass index (BMI) was 31.4 ± 7.6 kg/m^2 and 55.3% of participants (66% females and 43.1% males) were classified as obese (BMI > 30 kg/m^2). Median household income was less than $15,000 per year, and fewer than 20% of participants had an annual household income higher than $25,000. A third of participants had a high school education or less, and only 30% were currently employed upon entry into the cohort. Each participant had 12.12 ± 5.86 days of objectively RT3 monitored PA. The length of time between RT3 administrations was 3.08 ± 0.48 months and was not different between the groups. The average number of completed LMPAS was 2.74 ± 1.01.

Test-Retest Reliability of PAQ

Test-retest reliability of sedentary behaviors assessed in the PAQ was evaluated by comparing responses from PAQ1 and subsequent PAQ2 (Table 1). Test-retest reliability of sleep time was higher for weekdays (r = .46) than for weekend days (r = .28). Participants reported an average of 9–10 hours of total time in sedentary behaviors each day on the PAQs, and the largest single sitting source was television and movie viewing, followed by other sitting and transportation-related sitting (ie, car or bus). Correlations estimating the test-retest reliability of the sitting items ranged from 0.24–0.54, with the highest values for television and movie viewing (r = .53) and sitting at work (r = .48). Test-retest reliability for

overall sleep and sitting was consistently better for women than it was for men, but there was little difference in test-retest reliability on these questions between African Americans and whites (data not shown).

Time reported in current active behaviors was higher in PAQ1 than in PAQ2 independent of gender and race (Table 2). Test-retest reliability of occupational/household activities within each intensity category was fair. However, both surveys reported the majority of time spent in light occupational/household activity, followed by moderate and then vigorous. Strength of the test-retest reliability correlations of the MET scores from occupational/household activity, walking, and moderate sports and exercise was fair (0.21, 0.25, and 0.36 respectively. Test-retest reliability was moderate for vigorous ($r = .48$) sports and exercise, and for MET scores from sports/exercise ($r = .47$). Test-retest reliability was somewhat higher in women than in men across most PA domains (data not shown).

Similar to current PA, the total reported amount of historical PA (during the participants' 30's) was higher in PAQ1 than in PAQ2 (Table 2). Reported historical PA levels were substantially higher than current PA levels, but the test-retest reliability was similar for these domains.

Comparisons Between the PAQ and the Criterion Measures

Comparisons between the objective criterion instrument (RT3 monitor) and the PAQ are presented in Table 3. In terms of overall sitting time, the correlation between RT3 and the PAQ was between 0.21 and 0.32 in both groups. The correlation between RT3-determined sedentary time and television viewing in African Americans was between 0.30 and 0.40 ($P < .05$, data not shown). In relation to active behaviors, the RT3 was positively associated with overall household and occupational activity as well as total activity. There was general consistency in the magnitude of these correlations with the RT3 monitor between African Americans and whites, although the strength of the correlations was stronger among African Americans.

There was some variation in the strength of the correlations between the LMPAS and PAQ1 and PAQ2 (Table 4). Correlations between measures for sleeping ranged from 0.22–0.70 and were slightly stronger among whites than African Americans. In terms of sedentary behaviors, the correlation for overall sitting time ranged between 0.36 and 0.57, with somewhat stronger relations for sitting at work, and television viewing. In terms of the active behaviors, comparisons for overall household and occupational activity between instruments ranged from 0.31–0.51 in whites and 0.16–0.21 in African Americans and results for sports and exercise were similar in strength.

Discussion

In this study, we evaluated the test-retest reliability and criterion validity of an interviewer-administered PA questionnaire that was designed to assess a range of both sedentary and active behaviors in the past year among African American and white participants in the SCCS. Results indicated that while there was a substantial amount of random error in the PAQ measures over a 12-month period, the PAQ values were positively correlated with both self-reported and objective criterion measures. In particular, comparisons between the PAQ and the LMPAS provided some evidence that the 2 measures could rank order individuals in the population with respect to time spent sleeping and in sedentary behaviors. Evidence of validity from comparison of active behaviors on the PAQ relative to the LMPAS was somewhat weaker, but the results from the objective measure of PA were consistent with several other PA validation studies that employed a similar design,[15] including 1 study

conducted among African American women.[26] This suggests that the PAQ captures these varied PA domains sufficiently to rank order SCCS participants by reported PA level.

The PAQ instrument was designed to assess all the major types of physical activity behaviors encountered each day (ie, sleeping, sedentary behaviors, and occupational, household, and leisure time activity). A unique aspect of the instrument was the inclusion of several questions that assessed a wide range of sedentary behaviors, including sitting while driving, sitting at work, viewing television and movies, using a computer, or in other sedentary pursuits. Recent studies have highlighted the adverse effect of too much sitting on reduced energy expenditure[27,28] poor metabolic health,[29] and early mortality,[30–32] and thus comparisons between the current results and other studies is more limited. In general, our reliability results are somewhat lower than those found in other studies, but this may be due to the short interval between measures used in those studies (ie, 1–12 weeks). However, our results with respect to overall sedentary time are similar to a recent study in Australian adults by Marshall and colleagues[33] who reported validity coefficients between PAQ and accelerometer for overall sitting time of 0.32–0.39 on weekdays and 0.05–0.21 on weekend days.

In another recent study, Pettee Gabriel and colleagues[34] evaluated the reliability and validity of 5 commonly used physical activity questionnaires (PAQ) in women aged 45–65 yr with varying PA levels. They reported intraclass correlation coefficients (ICC) between administrations of the PAQs were reproducible and relatively stable over time (ICC = 0.32–0.91) and were associated with total PA (counts per day). The PAQ test-retest reliability in our study was fair and moderate and may reflect either unreliability in reporting on the PAQ, or true variation in behaviors between the PAQ1 and PAQ2 assessments completed 12 months apart.

Given the potential for correlated errors in both the PAQ and the other self-reported instrument (LMPAS) to overestimate validity of the PAQ[35,36] we focused our assessment of validity of the SCCS PAQ on results from the objective criterion measure, the RT3 monitor. The RT3 measurements were repeated 2–4 times over the course of a year to account for seasonality and reduce intraindividual variation in the criterion measures. The RT3 accelerometer has previously been shown to provide a close estimate of group total PA, but does have some variation and error at the individual level.[20] As with other accelerometers, the RT3 may not always completely capture certain activity behaviors, such as carrying heavy loads, walking on stairs, cycling, and water-related activities.[37] Another reference standard for validating PAQ could have been the doubly labeled water method;[38] however, this method is very costly, logistically challenging to implement over a wide geographic area, and would not provide information on the duration, frequency, type, and intensity of PA we obtained using the criterion measures selected for this study. We found a slight to moderate relationship between the RT3 and our PAQ measures.

Other studies in adults also have found significant positive associations between PA questionnaires and accelerometer data.[15,16,26] For example, in comparing the PAQ used in the Black Women's Healthy Study to an accelerometer, Carter-Nolan and colleagues[26] reported correlations of 0.28 for total activity, 0.26 for walking, −0.04 for moderate intensity activity, and 0.40 for vigorous activities. Freidenreich and colleagues[15] evaluated a comprehensive PAQ instrument against an accelerometer among Canadian adults and reported an overall correlation of 0.18, and a correlation of 0.30 in men and 0.10 in women. Results in the current study for the PA behaviors are consistent with these reports. Evaluation of PA within a lower socioeconomic status and ethnically diverse population presents additional methodological challenges, and absolute amounts of PA may not be directly comparable to other populations.[39] Groups with lower income and lower education

generally report lower levels of leisure-time PA and higher levels of occupational activity. Rohm Young and colleagues[40] have suggested that the validity of PAQs may be lower among African Americans. In contrast, some studies indicate that evaluated PAQs perform similarly for whites and African Americans.[8,41,42] In addition, the results from other studies conducted among African Americans are not unlike studies conducted in whites.[43,44] Thus, the inclusion of both African American and white adults from a similar socioeconomic background is an important strength of this study. To our knowledge, limited number of studies has assessed the validity of an interviewer-administered PAQ in African American and white adults with low-income and relatively low-education level.[39,43,44] Recently, Meyer and colleagues[45] examined the test-retest reliability of a PA questionnaire used in the Women's Health Initiative (WHI) study. The questionnaire demonstrated moderate to substantial test-retest reliability in a diverse sample of postmenopausal women measured using the intraclass correlation (ICC) coefficient to estimate reliability in household and yard activities (ICC = 0.60 and 0.71, respectively). The authors did not observed meaningful differences by race/ethnicity, age, time between test and retest, and amount of reported PA. In our study, although we had limited power to assess differences by race, we found the reliability of the PAQ to be roughly similar between white and African American participants.

Our study has several limitations that should be considered. First, the study included relatively small samples sizes within sex-race groups and this precluded the evaluation of small or modest differences between men and women and African American and whites. In addition, response rates were lower than anticipated, in part, because we elected to conduct a more demanding study among randomly selected SCCS participants across a wide geographic area and from many participating CHCs, rather than using a small convenience sample derived from a single center. This element of our design necessitated use of both in-person and telephone-based PAQ administration, which may have contributed to inconsistency in our results. Moreover, we experienced more difficulty in locating and contacting many of the low-income adults who had enrolled in the SCCS than we anticipated. However, all analyses were based on within-individual comparisons and thus were internally valid. An additional limitation may have been the length of time between PAQ1 and PAQ2 administrations, and the timing of the criterion measures relative to the PAQ administrations. For our criterion measures, we used a “sampling approach,” which uses several administrations of the criterion measures within the study period, and takes the average of the repeat administrations of these measures as our “best” estimate of physical activity in the study period. A plausible explanation for the correlations observed between the PAQ and our criterion measure is that both instruments captured useful information about long-term activity levels during the study period. One might hypothesize that the validity coefficients would be stronger for the PAQ2 measures, in part because of the criterion measures reflect activities participants engaged in before completing the PAQ2 at the end of the study, and we did observe consistently stronger validity coefficients for the PAQ2 measures among African Americans, but not among whites. In addition, there is potential for interindividual error in converting self-reported PA into units of energy expenditure. The values from the Compendium of Physical Activities used in the conversion algorithm relies on group averages to estimate activity intensity, and these estimates may be imprecise for certain individuals.[18] The RT3 counts cut points used for the PA activity levels categorization[23] were obtained in young men and therefore, could lead to mis-categorization of some activities in this study and affect the relative validity of the PAQ. There is also a possibility PAQ missed some modes of activity such as transportation and child or elderly care.

In summary, we evaluated the SCCS PAQ over a 13–15 month study period among randomly selected cohort participants. The instrument had fair to moderate test-retest

reliability on repeat administrations, but compared with the RT3 accelerometer the PAQ had similar level of validity when compared with other instruments that have been developed to assess active and sedentary behaviors in population-based studies. There was general consistency in the magnitude of correlations between the PAQ and accelerometer data between African Americans and whites. Thus, we expect that the PAQ will be useful in extending our knowledge of the relation between active and sedentary behaviors and disease risk in African Americans and whites, and will help us understand more completely whether disparities in these modifiable behaviors contribute to differences in disease risk between these groups in this unique cohort.

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References

1. Lynch BM. Sedentary behavior and cancer: a systematic review of the literature and proposed biological mechanisms. Cancer Epidemiol Biomarkers Prev. 2010; 19(11):2691–2709. 10.1158/1055-9965.epi-10-0815. PubMed doi:10.1158/1055-9965.EPI-10-0815. [PubMed: 20833969]
2. Adams SA, Der Ananian CA, DuBose KD, Kirtland KA, Ainsworth BE. Physical activity levels among overweight and obese adults in South Carolina. South Med J. 2003; 96(6):539–543. PubMed doi:10.1097/01.SMJ.0000073569.34104.67. [PubMed: 12938778]
3. Healy GN, Dunstan DW, Salmon J, et al. Objectively Measured light-intensity physical activity is independently associated with 2-h plasma glucose. Diabetes Care. 2007; 30(6):1384–1389. PubMed doi:10.2337/dc07-0114. [PubMed: 17473059]
4. Hu FB, Li TY, Colditz GA, Willett WC, Manson JE. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. JAMA. 2003; 289(14):1785–1791. PubMed doi:10.1001/jama.289.14.1785. [PubMed: 12684356]
5. van Poppel MNM, Chinapaw MJM, Mokkink LB, van Mechelen W, Terwee CB. Physical activity questionnaires for adults: a systematic review of measurement properties. Sports Med. 2010; 40(7): 565–600. PubMed doi:10.2165/11531930-000000000-00000. [PubMed: 20545381]
6. Lagerros Y, Lagiou P. Assessment of physical activity and energy expenditure in epidemiological research of chronic diseases. Eur J Epidemiol. 2007; 22(6):353–362. 10.1007/s10654-007-9154-x. PubMed doi:10.1007/s10654-007-9154-x. [PubMed: 17599242]
7. Shephard RJ. Limits to the measurement of habitual physical activity by questionnaires. Br J Sports Med. 2003; 37(3):197–206. 10.1136/bjsm.37.3.197. PubMed doi:10.1136/bjsm.37.3.197. [PubMed: 12782543]
8. Chasan-Taber L, Erickson JB, McBride JW, Nasca PC, Chasan-Taber S, Freedson PS. Reproducibility of a self-administered lifetime physical activity questionnaire among female college alumnae. Am J Epidemiol. 2002; 155(3):282–289. PubMed doi:10.1093/aje/155.3.282. [PubMed: 11821254]
9. Chasan-Taber S, Rimm EB, Stampfer MJ, et al. Reproducibility and validity of a self-administered physical activity questionnaire for male health professionals. Epidemiology. 1996; 7(1):81–86. PubMed doi:10.1097/00001648-199601000-00014. [PubMed: 8664406]
10. Craig CL, Marshall AL, Sjöström M, et al. International Physical Activity Questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003; 35(8):1381–1395. PubMed doi: 10.1249/01.MSS.0000078924.61453.FB. [PubMed: 12900694]
11. Signorello LB, Hargreaves MK, Steinwandel MD, et al. Southern community cohort study: establishing a cohort to investigate health disparities. J Natl Med Assoc. 2005; 97(7):972–979. PubMed. [PubMed: 16080667]
12. Signorello L, Hargreaves M, Blot W. The Southern Community Cohort Study: investigating health disparities. J Health Care Poor Underserved. 2010; 21(1 Suppl):26–37. [PubMed: 20173283]

13. Ainsworth BE, Irwin ML, Addy CL, Whitt MC, Stolarczyk LM. Moderate physical activity patterns of minority women: the Cross-Cultural Activity Participation Study. J Womens Health Gend Based Med. 1999; 8(6):805–813. PubMed doi:10.1089/152460999319129. [PubMed: 10495261]

14. Carlsson S, Andersson T, Wolk A, Ahlbom A. Low physical activity and mortality in women: baseline lifestyle and health as alternative explanations. Scand J Public Health. 2006; 34(5):480–487. PubMed doi:10.1080/14034940600551293. [PubMed: 16990159]

15. Friedenreich CM, Courneya KS, Neilson HK, et al. Reliability and validity of the Past Year Total Physical Activity Questionnaire. Am J Epidemiol. 2006; 163(10):959–970. 10.1093/aje/kwj112. PubMed doi:10.1093/aje/kwj112. [PubMed: 16524954]

16. Matthews CE, Ainsworth BE, Hanby C, et al. Development and testing of a Short Physical Activity Recall Questionnaire. Med Sci Sports Exerc. 2005; 37(6):986–994. PubMed. [PubMed: 15947724]

17. Matthews CE, Freedson PS, Hebert JR, Stanek EJ III, Merriam PA, Ockene IS. Comparing physical activity assessment methods in the Seasonal Variation of Blood Cholesterol Study. Med Sci Sports Exerc. 2000; 32(5):976–984. PubMed doi:10.1097/00005768-200005000-00015. [PubMed: 10795789]

18. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc. 2000; 32(9, Supplement):S498–S516. PubMed. [PubMed: 10993420]

19. Lyden K, Kozey S, Staudenmeyer J, Freedson P. A comprehensive evaluation of commonly used accelerometer energy expenditure and MET prediction equations. Eur J Appl Physiol. 2011; 111(2):187–201. 10.1007/s00421-010-1639-8. PubMed. [PubMed: 20842375]

20. Maddison R, Jiang Y, Hoorn S, et al. Estimating energy expenditure with the RT3 triaxial accelerometer. Res Q Exerc Sport. 2009; 80(2):249–256. PubMed. [PubMed: 19650390]

21. Rowlands AV, Thomas PWM, Eston RG, Topping R. Validation of the RT3 Triaxial Accelerometer for the assessment of physical activity. Med Sci Sports Exerc. 2004; 36(3):518–524. PubMed doi:10.1249/01. MSS.0000117158.14542.E7. [PubMed: 15076796]

22. Sloane R, Snyder DC, Demark-Wahnefried W, Lobach D, Kraus WE. Comparing the 7-Day Physical Activity Recall with a Triaxial Accelerometer for measuring time in exercise. Med Sci Sports Exerc. 2009; 41(6):1334–1340. 10.249/MSS.0b013e3181984fa8. PubMed doi:10.1249/MSS.0b013e3181984fa8. [PubMed: 19461530]

23. Buchowski M, Acra S, Majchrzak KM, Sun M, Chen KY. Patterns of physical activity in free-living adults in the Southern United States. Eur J Clin Nutr. 2004; 58(5):828–837. PubMed doi:10.1038/sj.ejcn.1601928. [PubMed: 15116087]

24. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc. 2008; 40(1):181–188. PubMed. [PubMed: 18091006]

25. Landis J, Koch G. The measurement of observer agreement for categorical data. Biometrics. 1977; 33(1):159–174. PubMed doi:10.2307/2529310. [PubMed: 843571]

26. Carter-Nolan P, Adams-Campbell L, Makambi K, Lewis S, Palmer J, Rosenberg L. Validation of physical activity instruments: Black Women's Health Study. Ethn Dis. 2006; 16(4):943–947. PubMed. [PubMed: 17061751]

27. Levine JA, Eberhardt NL, Jensen MD. Role of non-exercise activity thermogenesis in resistance to fat gain in humans. Science. 1999; 283(5399):212–214. 10.1126/science.283.5399.212. PubMed doi:10.1126/science.283.5399.212. [PubMed: 9880251]

28. Westerterp KR. Pattern and intensity of physical activity. Nature. 2001; 410(6828):539. PubMed doi:10.1038/35069142. [PubMed: 11279482]

29. Dunstan DW, Salmon J, Owen N, et al. Physical activity and television viewing in relation to risk of undiagnosed abnormal glucose metabolism in adults. Diabetes Care. 2004; 27(11):2603–2609. 10.2337/diacare.27.11.2603. PubMed doi:10.2337/diacare.27.11.2603. [PubMed: 15504993]

30. Clark B, Sugiyama T, Healy G, Salmon J, Dunstan D, Owen N. Validity and reliability of measures of television viewing time and other non-occupational sedentary behaviour of adults: a

review. Obes Rev. 2009; 10(1):7–16. PubMed doi:10.1111/j.1467-789X.2008.00508.x. [PubMed: 18631161]

31. Dunstan DW, Barr ELM, Healy GN, et al. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Circulation. 2010; 121(3):384–391. 10.1161/circulationaha.109.894824. PubMed doi:10.1161/CIRCULATIONAHA.109.894824. [PubMed: 20065160]
32. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. Med Sci Sports Exerc. 2009; 41(5):998–1005. PubMed doi: 10.1249/MSS.0b013e3181930355. [PubMed: 19346988]
33. Marshall SJ, Jones DA, Ainsworth BE, Reis JP, Levy SS, Macera CA. Race/ethnicity, social class, and leisure-time physical inactivity. Med Sci Sports Exerc. 2007; 39(1):44–51. PubMed doi: 10.1249/01.mss.0000239401.16381.37. [PubMed: 17218883]
34. Pettee Gabriel K, McClain JJ, Lee CD, et al. Evaluation of physical activity measures used in middle-aged women. Med Sci Sports Exerc. 2009; 41(7):1403–1412. 10.249/MSS. 0b013e31819b2482. PubMed doi:10.1249/MSS.0b013e31819b2482. [PubMed: 19516161]
35. Ferrari P, Friedenreich C, Matthews CE. The Role of measurement error in estimating levels of physical activity. Am J Epidemiol. 2007; 166(7):832–840. 10.1093/aje/kwm148. PubMed doi: 10.1093/aje/kwm148. [PubMed: 17670910]
36. Kipnis V, Subar AF, Midthune D, et al. Structure of Dietary Measurement Error: Results of the OPEN Biomarker Study. Am J Epidemiol. 2003; 158(1):14–21. 10.1093/aje/kwg091. PubMed doi: 10.1093/aje/kwg091. [PubMed: 12835281]
37. Matthew CE. Calibration of accelerometer output for adults. Med Sci Sports Exerc. 2005; 37(11 Suppl):S512–S522. PubMed doi:10.1249/01.mss.0000185659.11982.3d. [PubMed: 16294114]
38. Schoeller D, Ravussin E, Schutz Y, Acheson K, Baertschi P, Jequier E. Energy expenditure by doubly labeled water: validation in humans and proposed calculation. Am J Physiol. 1986; 250:R823–R30. PubMed. [PubMed: 3085521]
39. Wolin K, Heil D, Askew S, Matthews C, Bennett G. Validation of the International Physical Activity Questionnaire-Short among Blacks. J Phys Act Health. 2008; 5(5):746–760. PubMed. [PubMed: 18820348]
40. Young DR, Jee SH, Appel LJ. A comparison of the Yale Physical Activity Survey with other physical activity measures. Med Sci Sports Exerc. 2001; 33(6):955–61. [PubMed: 11404661]
41. Evenson KR, McGinn AP. Test-retest reliability of adult surveillance measures for physical activity and inactivity. Am J Prev Med. 2005; 28(5):470–478. PubMed doi:10.1016/j.amepre. 2005.02.005. [PubMed: 15894151]
42. Wolf AM, Hunter DJ, Colditz GA, et al. Reproducibility and Validity of a self-administered physical activity questionnaire. Int J Epidemiol. 1994; 23(5):991–999. 10.1093/ije/23.5.991. PubMed doi:10.1093/ije/23.5.991. [PubMed: 7860180]
43. Resnicow KEN, McCarty F, Blissett D, Wang T, Heitzler C, Lee RE. Validity of a Modified CHAMPS Physical Activity Questionnaire among African-Americans. Med Sci Sports Exerc. 2003; 35(9):1537–1545. PubMed doi:10.1249/01. MSS.0000084419.64044.2B. [PubMed: 12972874]
44. Smitherman T, Dubbert P, Grothe K, et al. Validation of the Jackson Heart Study Physical Activity Survey in African Americans. J Phys Act Health. 2009; 6(Suppl):S124–S132. PubMed. [PubMed: 19998858]
45. Meyer A-M, Evenson KR, Morimoto L, Siscovick D, White E. Test-retest reliability of the Women's Health Initiative Physical Activity Questionnaire. Med Sci Sports Exerc. 2009; 41(3): 530–538. PubMed doi:10.1249/MSS.0b013e31818ace55. [PubMed: 19204598]

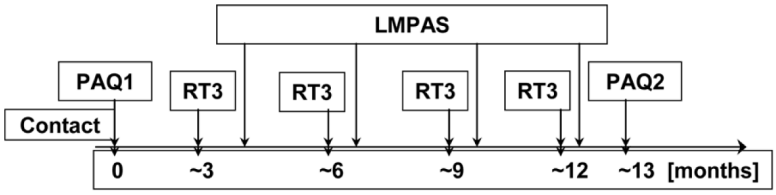

Figure 1.

Data collection schedule. PAQ1 and PAQ2—Southern Community Cohort Study Physical Activity Questionnaire, administered at the beginning of the study (PAQ1) and approximately 1 year later (PAQ2). LMPAS = last month physical activity survey; RT3 = 7-day free-living physical activity measurement using an activity monitor (RT3, StayHealthy, Monrovia, CA). The PAQ1 was administered as an in-person interview at enrolment and all other questionnaires were administered by phone.

Table 1

Test-Retest Reliability of Sleeping and Sitting Comparing Either the Baseline or Follow-Up Physical Activity Questionnaire (PAQ1 or PAQ2) in the Southern Community Cohort Study Physical Activity Questionnaire Substudy, 2004–2008

		PAQ1		PAQ2				
	N	Mean	SD	Mean	SD	*P*-value[a]	Spearman	*P*-value[b]
Sleeping (hours/day)								
Weekday	86	7.05	1.95	6.88	1.27	0.49	0.46	<0.0001
Weekend	85	7.61	2.76	7.06	1.35	0.10	0.28	0.01
Average	85	7.20	2.05	6.92	1.24	0.27	0.41	<0.0001
Sitting (hours/day)								
In car or bus	85	1.39	1.83	1.28	1.00	0.37	0.33	0.002
At work	86	0.89	1.99	1.03	1.74	0.21	0.48	<0.0001
Viewing TV / movies	86	4.76	3.41	3.75	2.08	0.005	0.53	<0.0001
Using home computer	85	0.28	0.79	0.58	1.09	0.02	0.25	0.02
Other	86	2.39	2.38	2.36	2.12	0.94	0.24	0.02
Total sitting (hours/day)	84	9.74	5.95	9.06	3.77	0.79	0.33	0.002

[a] *P*-value from Wilcoxon signed rank test comparing PAQ1 and PAQ2.

[b] *P*-value for null hypothesis that Spearman correlation = 0.

Table 2

Reproducibility of Active Physical Activity (PA) Behaviors Currently and During 30s Comparing Either the Baseline or Follow-Up PAQ (PAQ1 or PAQ2) in the Southern Community Cohort Study Physical Activity Questionnaire (SCCS-PAQ) Substudy, 2004–2008

		PAQ1			PAQ2					
	N	% reporting[a]	Mean	SD	% reporting[a]	Mean	SD	*P*-value[b]	Spearman correlation	*P*-value[c]
Current PA behavior[d,e]										
Occupational/household										
Light (hours/day)	86	81	2.72	2.53	92	2.15	1.89	0.11	0.08	0.48
Moderate (hours/day)	86	87	2.55	2.33	84	1.35	1.49	<0.0001	0.06	0.55
Vigorous (hours/day)	86	17	0.52	1.69	12	0.19	0.80	0.15	0.04	0.70
Total (MET-hours/day)	86	95	19.55	17.49	97	11.51	10.32	<0.0001	0.21	0.06
Sports/exercise										
Moderate (hours/day)	86	16	0.05	0.18	10	0.04	0.15	0.28	0.36	0.0007
Vigorous (hours/day)	86	24	0.11	0.31	15	0.04	0.14	0.02	0.48	<0.0001
Total (MET-hours/day)	86	30	1.16	3.04	21	0.50	1.36	0.04	0.47	<0.0001
Overall PA (MET-hours/day)	86	97	20.72	18.53	97	12.00	10.39	<0.0001	0.19	0.07
Walking										
Slowly (hours/day)	85	89	2.85	3.04	89	2.16	1.88	0.19	0.24	0.03
Fast (hours/day)	85	41	0.82	1.73	31	0.42	1.08	0.09	0.26	0.01
Total (MET-hours/day)	86	92	9.90	10.51	91	6.82	6.50	0.03	0.24	0.03
Historic PA behavior (in 30s)[e,f]										
Occupational/household										
Light (hours/day)	85	88	6.02	4.10	93	5.33	3.22	0.28	0.14	0.20
Moderate (hours/day)	84	90	4.69	3.63	86	3.05	2.52	0.002	0.09	0.43
Vigorous (hours/day)	84	60	3.70	4.12	55	2.42	3.29	0.02	0.13	0.22
Total (MET-hours/day)	83	99	54.92	31.25	99	38.81	21.90	0.0001	0.23	0.04
Sports/exercise										
Moderate (hours/day)	85	53	0.42	0.72	51	0.91	1.13	0.0004	0.21	0.06
Vigorous (hours/day)	85	49	0.31	0.52	44	0.57	0.82	0.002	0.41	<0.0001
Total sports (MET-hours/day)	85	58	4.52	6.47	62	9.14	10.19	0.0001	0.32	0.003
Overall PA (MET-hours/day)	83	100	59.52	32.21	99	48.18	25.54	0.02	0.17	0.14

[a] % reporting = percent of participants who reported participating in various PA intensities.

[b] *P*-value from Wilcoxon signed rank test comparing PAQ1 andPAQ2.

[c] *P*-value for null hypothesis that Spearman correlation = 0.

[d] PA behaviors at the time of SCCS enrollment.

[e] PA behaviors at ages 30–39 years old.

[f] MET values to classify the intensity of active behaviors used were light (2.0–2.9 METS), moderate (3.0–5.9 METS), and vigorous (≥6.0 METS).

Table 3

Spearman Correlations[a] Between Criterion Physical Activity (PA) Measures From Accelerometer (RT3) and Either the Baseline or the Follow-Up Physical Activity Questionnaire (PAQ1 and PAQ2), by Race, in the Southern Community Cohort Study Physical Activity Questionnaire (SCCS-PAQ) Substudy, 2004–2008

	Whites				African Americans			
	PAQ1		PAQ2		PAQ1		PAQ2	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Correlations with sedentary time measure from RT3								
Sedentary behaviors (hours/day)	0.17	0.47	0.29	0.20	0.30	0.03	0.21	0.10
Correlations with PAL summary measure from RT3[b]								
Household/occupation (MET-hours/day)	0.36	0.10	0.28	0.20	0.08	0.60	0.37	0.005
Sports/exercise (MET-hours/day)	−0.04	0.90	0.07	0.80	−0.13	0.30	0.02	0.90
Total active behaviors (MET-hours/day)[c]	0.31	0.20	0.28	0.20	0.06	0.60	0.36	0.006
Walking total (MET-hours/day)	0.01	0.90	0.22	0.30	0.10	0.50	0.17	0.20

[a]Adjusted for age at baseline SCCS interview and gender. Sedentary behaviors, active behaviors, total sports/exercise, and total active behaviors were also adjusted for occupational status (currently working or not working).

[b]PAL summary measure = physical activity level (total energy expenditure / resting energy expenditure).

[c]Total active behaviors include light, moderate, and vigorous household/occupational work plus moderate and vigorous sports and exercise.

Table 4

Spearman Correlations[a] Between Self-Reported Physical Activity (PA) Measures From the Last Month Physical Activity Survey (LMPAS) and Either the Baseline or the Follow-Up Physical Activity Questionnaire [PAQ1 or PAQ2], by Race, in the Southern Community Cohort Study (SCCS) Physical Activity Questionnaire (SCCS-PAQ) Substudy, 2004–2008

	Whites				African Americans			
	PAQ1		PAQ2		PAQ1		PAQ2	
	r	*P*[b]	*r*	*P*[b]	*r*	*P*	*r*	*P*[b]
Sleeping (hours/day)								
Weekday	0.70	0.0003	0.45	0.04	0.24	0.07	0.58	<0.0001
Weekend	0.42	0.06	0.51	0.02	0.32	0.01	0.41	0.001
Average	0.59	0.005	0.49	0.02	0.22	0.09	0.55	<0.0001
Sedentary behaviors (hours/day)								
Sitting								
Car or bus	0.40	0.07	0.28	0.20	0.23	0.09	0.26	0.06
At work	−0.12	0.60	0.42	0.06	0.16	0.20	0.72	<0.0001
Watching TV/movies	0.51	0.02	0.40	0.07	0.36	0.005	0.49	0.0001
Home computer	0.01	0.90	0.28	0.20	0.25	0.06	0.33	0.01
Other	0.28	0.20	0.18	0.40	0.19	0.20	0.24	0.07
Total	0.57	0.01	0.51	0.02	0.06	0.70	0.36	0.008
Active behaviors								
Household/occupation								
Light (hours/day)	0.54	0.01	0.30	0.19	0.11	0.40	0.17	0.20
Moderate (hours/day)	0.48	0.03	−0.06	0.80	0.03	0.80	0.30	0.02
Vigorous (hours/day)	0.14	0.50	0.22	0.34	0.15	0.30	0.56	<0.0001
Total (MET-hours/day)	0.51	0.02	0.31	0.17	0.16	0.20	0.23	0.08
Total sports/exercise (MET-hours/day)	0.35	0.10	0.39	0.10	0.20	0.10	0.36	0.006
Total active behaviors (MET-hours/day)[c]	0.09	0.70	−0.11	0.60	0.08	0.50	0.15	0.30
Walking								
Slowly (hours/day)	−0.41	0.06	0.20	0.40	0.26	0.05	0.27	0.04
Fast (hours/day)	0.26	0.25	0.40	0.07	0.35	0.007	0.36	0.005
Total (MET-hours/day)	−0.31	0.16	0.29	0.20	0.32	0.01	0.37	0.003

[a] Adjusted for age at baseline SCCS interview, and gender. Sedentary behaviors, active behaviors, total sports/exercise, and total active behaviors were also adjusted for occupational status (currently working or not working).

[b] Value for null hypothesis that Spearman correlation = 0.

[c] Total active behaviors include light, moderate, and vigorous household/occupational work as well as moderate and vigorous sports and exercise.