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Self-Reported Physical Activity and Measured Energy Expenditure using Accelerometers: Results of a SAGE Sub-Study in India

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INTRODUCTION

Once considered a disease of affluence and confined to industrialized nations, obesity has emerged as a major health concern in nearly every country in the world (WHO, 2000). The prevalence of obesity has reached unprecedented levels in most developing countries; in much of Asia, North Africa, and Latin America, obesity is continuing to increase at a rate that far outpaces that of developed nations (Popkin, 2003; WHO/FAO, 2003; Kelly et al., 2008). The WHO (2000) now recognizes obesity as a global epidemic, reflecting the widespread distribution of the condition, its status as a disease with metabolic and endocrine abnormalities, and its well-established association with numerous negative health outcomes.

The growing challenge of obesity and other chronic diseases in the developing world is closely related to lifestyle changes that occur with economic development, a topic that is attracting increasing attention (Huss-Ashmore et al., 1992; Snodgrass, 2012). The mechanisms responsible for this health transition remain incompletely understood, although reduced activity levels and dietary change (increased consumption of saturated fats and simple carbohydrates, and overall energy intake increases) are implicated as key factors. Although macro-level socioeconomic indicators associated with this health transition have been identified, it has been difficult to link specific behaviors and individual lifestyle factors to health change.

Energetics provides a key to understanding the health changes associated with economic development, as lifestyle transitions are often related to shifts in energy intake and expenditure. Decreased energy expenditure is generally considered to be an important factor in the increase in obesity and several chronic degenerative diseases seen with economic development, since traditional economies are characterized by intensive reliance on human physical labor and relatively simple technology, while industrialized economies rely less on human physical labor (WHO/FAO, 2003). Few studies, however, have accurately quantified and compared energy costs of activity between populations at different levels of economic development. In large measure, the major impediment to progress on this issue has been the methodological challenge of accurately quantifying energy expenditure in free-living human populations.

Recently, technological advances in accelerometry have provided researchers with a new tool with which to estimate total daily energy expenditure (TDEE) and physical activity level (PAL) in free-living populations (Plasqui and Westerterp, 2007; Snodgrass, 2012). Accelerometers are motion sensors that are typically worn at the waist, and objectively measure movement of the body by detecting and recording acceleration in one or multiple planes. Participants wear an accelerometer such as the Actigraph GT3X (Pensacola, FL) or the Respironics/MiniMitter Actical (Bend, OR) for 1-7 days and then the unit is returned and data downloaded. Further, several accelerometers have been validated and show high correlations with doubly labeled water (DLW) based studies of activity (Westerterp, 2009). Although accelerometry has been increasingly used in Western research settings, especially in clinical

studies and among athletes, but also in the several waves of the US National Health and Nutrition Examination Survey (NHANES) (Hawkins et al., 2009; Vallance et al., 2011), this technology has not been extensively applied in non-Western population studies (but see Madimenos et al., 2011). Further, few population-level studies have applied accelerometry to measure activity among older adults (Copeland and Eslinger, 2009), despite the obvious utility for better understanding the increasing prevalence rates of obesity among elderly populations in the United States and several other countries.

The present study was conducted among 200 older adults in urban India and combines seven days of accelerometry with a sociodemographic/lifestyle questionnaire in order to: 1) examine differences in activity patterns by sex and age; 2) examine links between activity and measures of health and fitness, including grip strength and timed walk; and 3) compare accelerometry data with self-report measures of activity, including that estimated using the Day Reconstruction Method (DRM).

METHODS

SAGE & SAGE-PA

The present study, part of a validation sub-study of the World Health Organization's Study on global AGEing and adult health (SAGE), addresses the issue of self-reported physical activity reliability in order to more accurately estimate activity levels in older adults. SAGE is a longitudinal study with nationally representative cohorts of persons aged 50 years and older in China, Ghana, India, Mexico, Russian Federation, and South Africa, with comparison samples of younger adults aged 18-49 years in each country, which aims to study health and health-related outcomes and their determinants.

This SAGE physical activity (SAGE-PA) sub-study was implemented as a face-to-face household interview in Jodhpur, Rajasthan, India in 2010. As with many self-reported health measures, a level of bias is understood to exist in reporting physical activity levels. However, it is not known how well the Global Physical Activity questions used in SAGE reflect true activity levels in older adults. In order to target modifiable risk factors for chronic diseases with increasing age, we need to have reliable and robust estimates of activity, or to understand the biases so that adjustments can be developed for future analyses.

The SAGE-PA survey instrument used many of the same modules and questions used in the main SAGE questionnaire, covering a range of topics, including household and respondent information, health and its determinants, disability, risk factors, chronic conditions, social networks, subjective well-being and time use. Anthropometrics (weight and height) as well as a set of performance tests (timed walk, grip strength) and balance measures were also completed.

Study Location & Participants

Pilot research was conducted in Jodhpur, Rajasthan, India among urban adults. Accelerometry data was collected from 200 adults (72 males, 128 females) between the ages of 49 and 90. Two participants were excluded because of corrupt data files. Of the 198 participants with complete data, 153 (52 males, 101 females) were considered older adults (49-65 years old), while 45 (20 males, 25 females) were considered elderly (>65 years old).

Accelerometry

Participants wore ActiGraph GT3X accelerometers at the hip (~1 cm toward the midline from the iliac crest) for 7 consecutive days, with the accelerometer set to record data for all three axes, and the epoch set at 60 seconds. Accelerometers were set to begin data collection at midnight (12:01 am) the day after the participant was given the accelerometer. The participant then began wearing the accelerometer upon awakening the next morning. Participants were instructed to wear the accelerometer at all times except when showering, bathing, or swimming; also, participants removed the accelerometer when sleeping. At the end of the 7-day period, an interviewer visited the participant's

home, retrieved the accelerometer, and conducted an interview using the SAGE Physical Activity Validation Questionnaire. Accelerometers were then downloaded to a computer using ActiLife software.

Physical Activity Levels (PALs; Total Daily Energy Expenditure/Basal Metabolic Rate) were calculated to control for body size. Daily average activity counts were calculated for the duration of activity monitoring. Calorie counts were calculated using a combination of the Freedson and Work Energy Theorem equations. BMR was estimated based on the age- and sex-specific Oxford equations (Henry, 2005).

Statistical Analysis

One-way ANOVA tests were used to evaluate sex differences in anthropometric (weight and body mass index [BMI]) and physical activity measurements (PAL and daily average activity counts). Correlation coefficients were calculated to examine the associations among age, anthropometrics, activity measures, and self-reported fitness levels, risk factors, and preventative health measures. Bivariate Pearson product-moment correlations (r) were used to evaluate the relationship between two continuous variables, while Spearman non-parametric correlations (ρ) were used to assess the association between two rank-order variables, or between a continuous and a rank-order variable. All correlations were conducted separately for males and females. Comparisons were considered statistically significant at $P < 0.05$. All statistical analyses were performed using SPSS 18.0.

PRELIMINARY RESULTS

Age and Sex Differences

Males had a mean weight of 68.70 (15.97) kg and a mean BMI of 23.20 (5.04) kg/m², while females had a mean weight of 63.98 (16.36) kg and a mean BMI of 25.71 (6.65) kg/m². PALs ranged from 1.02 to 1.50, with a mean PAL of 1.16 (0.09) for males and 1.16 (0.08) for females. Daily average activity counts ranged from 22,286.00 to 483,020.70 counts per day, with a mean of 175,752.24 (91,988.65) for males and 164,915.60 (82,974.33) for females. For males, age was negatively correlated with weight ($r = -.30, P = .012$) and BMI ($r = -.30, P = .010$). For females, age was negatively correlated with PAL ($r = -.28, P = .001$) and daily average activity counts ($r = -.31, P < .001$).

There were no significant differences in PALs, daily average activity counts, or weight between males and females, yet there was a significant sex difference in BMI ($P = .006$). For females, PAL was positively correlated with weight ($r = .25, P = .005$) and BMI ($r = .21, P = .018$). For males, PAL was not significantly correlated with weight or BMI. When sexes were further divided by age group, we found that in the elderly sample, females had higher BMI levels than males ($P = .005$), while males had higher daily average activity counts than females ($P = .040$).

Fitness and Self-Report Health Measures

Average measures of grip strength ranged from 11.5 to 70 kg, with a mean grip strength of 36.81 (8.36) for males and a mean of 24.49 (9.10) for females; males had a significantly greater grip strength than females ($P < .001$). Average grip strength positively correlated with PAL values ($r = .29, P = .002$) and average daily activity counts ($r = .29, P = .002$) for females; however, these correlations were non-significant for males.

Measures of mean walking time were 5.84 (1.52) seconds for males and 6.39 (2.74) seconds for females, yet sex differences in walking time were non-significant ($P = .118$). For females only, walking time was negatively correlated with PAL ($r = -.17, P = .05$) and average daily activity counts ($r = -.20, P = .026$).

Self-report measures of health status significantly differed between males and females ($P = .001$), with 74.8% of females but only 45.0% of males reporting moderate to bad health. Furthermore, there was a significant difference in PAL values for females in relation to self-reported health ($P = .013$);

females who reported good or very good health had higher PALs than those who reported moderate to bad health.

Self-Report Risk Factors and Preventative Health Measures

Self-reports of time spent travelling to work and time spent performing moderate- and/or vigorous-intensity activities at work were collected. For both males and females, time spent travelling to work and time spent on moderate and/or vigorous activities at work were not significantly correlated with BMI or activity measures. Self-reports of time spent performing moderate- and/or vigorous-intensity recreational activities were also collected. On average, males spent 6.48 (18.75) minutes per day on moderate- and/or vigorous-intensity recreational activities, while females spent 35.24 (97.08) minutes per day on these activities; these differences between males and females were significant ($P = .014$). However, self-reported time spent on moderate- and/or vigorous-intensity recreational activities did not significantly correlate with BMI or activity measures for both males and females.

In relation to disease risk, 12.70% of males and 19.70% of females self-reported that they were previously diagnosed with diabetes. A previous diagnosis of diabetes was positively correlated with BMI ($\rho = .20$, $P = .026$) for females only. Furthermore, 36.60% of males and 43.30% of females were previously diagnosed with hypertension. For females, a previous diagnosis of hypertension was positively correlated with BMI ($\rho = .20$, $P = .023$), yet negatively correlated with PAL ($\rho = -.18$, $P = .048$) and daily average activity counts ($\rho = -.25$, $P = .005$).

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