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Meeting U.S. Healthy People 2010 Levels of Physical Activity: Agreement of 2 Measures across 2 years

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Abstract

Background—Measuring the way people vary across time in meeting recommended levels of physical activity should be a fundamental component of public health surveillance. However, we were unaware of prospective cohort studies that had examined this in a population base using convergent measures.

Purpose—We examined agreement between two validated measures used to estimate periodic change in the rate of meeting U.S. Healthy People 2010 guidelines for participation in moderate or vigorous physical activity.

Methods—A cohort (N=497) from a random, multi-ethnic sample of adults living in Hawaii was assessed every 6-months for 2 years starting spring 2004. Latent transition analysis classified people as meeting or not meeting the guidelines. Intra-class kappa statistics and multinomial logistic regression analysis were used to evaluate agreement.

Results—Agreement for classifying stable classes of people who met or did not meet the guideline each time was substantial for vigorous activity (kappa ~ .65 - .70) but fair-to-moderate for moderate activity (kappa ~ .38 - .48). Agreement was poorer for classifying people who transitioned between meeting and not meeting the vigorous guideline (kappa ~ .45) or the moderate guideline (kappa ~ .21 - .29).

Conclusion—Rates of meeting the guidelines varied across time and were estimated differently by the two measures, especially for moderate activity. This illustrates an understudied problem for public health promotion. Accurate classification of change within people is necessary for determining exposure in outcome studies, personal determinants of sufficient activity, and for evaluating whether interventions are successful in sustaining increases in rates of meeting physical activity guidelines.

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Keywords

Asian American; inter-rater agreement; latent transition analysis; Native Hawaiian/Pacific Islander; public health policy

Despite its importance for public health,¹ the physical activity of many U.S. adults is below levels regarded as sufficient for health promotion.² Although 3 of 4 adults say they engaged in some form of leisure-time physical activity during the past month,³ less than half participated regularly at currently recommended levels⁴ of moderate physical activity for at least 30 minutes 5 or more days per week or vigorous physical activity for at least 20 minutes 3 or more days per week.^{5,6} Insufficient physical activity is more likely among women, minorities, and those having low socioeconomic status.⁷

Surveillance systems that estimate point-prevalence of physical activity in successive years monitor group trends in a population.^{8,9} However, they do not provide measures of change within people or how patterns of change differ between people, which are pre-requisites to quantifying exposure in outcome studies and identifying environmental and inter-personal factors that might be modified to increase the rate of meeting physical activity guidelines.¹⁰ Measuring within-person change using a prospective cohort design has not been feasible in national surveys, but it can be more easily achieved in smaller cohorts. As far as we knew, this had not as yet been done in a population of adults.

Consistent with reporting standards,¹¹ we describe here periodic (i.e., every six-months) change across 2 years in the rates of meeting the U.S. Healthy People 2010 recommendations for regular participation in moderate or vigorous physical activity⁶ in a cohort of adults living in Hawaii. Population surveys have mainly been limited to self-reporting by participants, which will vary among methods. Hence, our main purpose was to determine the agreement between two widely used measures of physical activity for classifying whether people met the recommendations. Commonly used, validated measures were used that were feasible for administration by interview in a population-based survey and that provided estimates of weekly time spent in moderate and vigorous physical activity during the past 7 days¹² or in a week.¹³

Methods

Participants

This longitudinal, cohort study used a random sample of 700 non-institutionalized adults (18 years or older) from Hawaii (62.6% female; 31.1% Asian; 22.1% Native Hawaiian/Pacific Islander; 37.3% White; 8.6% Other (African American, Mexican, Puerto Rican, American Indian, Mixed non-Hawaiian); 51.4% Married; mean age=47.0 years; mean education=14.6 years; median income=\$40,000 to \$50,000). Corresponding rates from our previous 2002 surveys of Hawaii's non-institutionalized adults¹⁴ were: 50.1% female; 36.8% Asian; 16.7% Native Hawaiian/Pacific Islander; 34.1% White; 57.2% Married; mean age=45.9 years; mean education=14.5 years; median income=\$40,000 to \$50,000). The sample overrepresented females, but was otherwise comparable to US Census 2000 estimates for the state of Hawaii. The sample size was selected to provide adequate statistical power for model tests with an expected loss to follow-up of 25%.¹⁵

Assessments occurred at baseline and at 6-month intervals for 2 years. A cohort of 497 participants who completed the measures 3 times or more was used for analysis; 468 completed 4 assessments and 394 completed all 5. Physical activity levels of the cohort were similar to the random sample and have been described elsewhere.¹⁶ Participant characteristics are

reported in Table 1. Physical activity levels according to Healthy People 2010 guidelines are shown in Table 2.

Procedures

The questionnaire was programmed into a computer assisted telephone interview system by a local survey firm. Prior to survey administration, the questionnaire was pilot tested for interpretability and ease of administration. Participants were recruited using random digit dialing procedures with a maximum of 3 call attempts per household including at least one week and one weekend day attempt. A total of 4,392 calls made by random digit dialing resulted in contact, of which 2,785 calls (63.41%) reached eligible households and 1,607 calls reached ineligible households (paggers, non-residents, non-English speakers). An adult household member 18 years or older whose birthday was closest to the date of the phone call was asked to participate. Trained interviewers informed potential participants that they would receive a \$10 incentive per interview, with \$25 for the last one, if they agreed to participate in 30-minute interviews regarding their physical activity over two years. The survey firm recruited 700 participants (a 25.13% recruitment rate= recruited/eligible households). Informed consent ensuring privacy and confidentiality was obtained from participants. The University of Hawaii Institutional Review Board approved all procedures. Simple random sampling was used without stratification, over-sampling, or weighting for minority representation. The low recruitment rate likely limits generalizability of the sample estimates. Nonetheless, the main goal of the study was to track physical activity in a cohort across time, more so than to provide population-wide estimates of physical activity among Hawaii residents.

Measures

Self-reported demographics included age, height, weight, formal education, household income, gender, race/ethnicity and marital status. Physical activity was assessed using the International Physical Activity Questionnaire (IPAQ) interview short form¹² and the Godin Leisure-Time Exercise Questionnaire (GLTEQ).¹³ The IPAQ records physical activity as hours and additional minutes of participation during the past 7 days in activities rated according to multiples of metabolic equivalents (METs) expressed as MET-min · wk⁻¹. It assesses frequency and duration (≥ 10 min each session) of walking (3.3 METs) and moderate (4 METs) and vigorous (8 METs) physical activity. The GLTEQ expresses physical activity as METs · wk⁻¹. It assesses the number of days a week spent doing mild (3 METs), moderate (5 METs), and strenuous (9 METs) activities. To be consistent with guidelines for moderate physical activity contemporary with the time the study was conducted, the time frame of the GLTEQ was modified for this study to be at least 30 minutes a day (rather than 15 minutes in the original version). Reliability and criterion validity judged against accelerometry for the IPAQ and the GLTEQ are comparable to other self-report measures of physical activity.^{12, 13, 17-20} See Appendix 1 for Interview Definitions. Meeting the guidelines was defined as follows: moderate - at least 30 min, accumulated in sessions of 10 or more min, 5 or more days per week; vigorous - at least 20 minutes, accumulated in sessions of 10 or more min, 3 or more days per week; moderate-or-vigorous – attaining either the moderate or vigorous recommendation or both. The GLTEQ includes brisk walking in the estimate of moderate physical activity. IPAQ provides separate estimates of moderate physical activity and walking, so we computed rates of meeting the moderate guideline and the regular, moderate-or-vigorous guideline for the IPAQ without or with walking included (i.e. at least 30 min of moderate activities or walking or both, accumulated in sessions of 10 or more min, 5 or more days per week). In our experience, asking people to rate their vigorous activity first, followed by moderate activity and walking using the IPAQ (its original ordering) results in apparent doubling of time spent in vigorous activities compared with a reversed ordering of response queries.²¹ So for this study we followed the ordering described in Appendix 1 (personal communication with Adrian Bauman, June, 2003).

Analysis

Latent transition analysis—Participants in the cohort were first classified according to not meeting or meeting the U.S. Healthy People 2010 recommendations for moderate (at least 30 minutes 5 or more days per week), vigorous (at least 20 minutes 3 or more days per week), or regular (i.e., moderate-or-vigorous) physical activity⁶ at each of the 5 time points using latent transition analysis (LTA) performed by *Mplus* 5.1.²² LTA provided Bayesian probability estimates of participants' movement between discrete latent classes of meeting or not meeting the recommendations. Missing data were replaced using full information maximum likelihood (FIML) estimation, which yields accurate fit indices and parameter estimates with up to 25% simulated missing data.²³ The cohort completed 2328 of 2485 possible assessments (99.7%); missing responses to the completed assessments were 24 of 11060 responses (0.2%).

Classification Agreement—Agreement between the two measures for classifying people as meeting vs. not meeting the recommendations for moderate or vigorous physical activity was estimated by kappa statistics, which compute the intra-class correlation for binary data and permit weighting to minimize false negatives or false positives.²⁴ Commonly used values of kappa for judging the qualitative strength of agreement are: slight = .00 to .20; fair = .21 to .40; moderate = .41 to .60; substantial = .61 to .80; nearly perfect > .80.²⁵ For this study, weights of zero or one were used to put emphasis on avoiding false positives (i.e., lack of agreement for meeting the guideline) or false negatives (i.e., lack of agreement for not meeting the guideline), respectively.²⁴ A weight of one-half (i.e., Cohen's kappa) placed equal emphasis on avoiding false positives and false negatives.

Multinomial logistic regression analysis—Multinomial logistic regression analysis using maximum likelihood estimation was performed with SPSS 15.0 to determine whether agreement for meeting the guideline for regular participation in moderate-or-vigorous physical activity differed at each 6-month transition, while adjusting for demographic variables that might be associated with classification accuracy. Statistical significance of likelihood ratios and goodness of model fit were tested by χ^2 tests.²⁶ Strength of association was estimated using pseudo R^2 .²⁷

Based on results of the LTA, participants were placed in 1 of 4 discrete classes at each 6-month transition (e.g., from baseline to 6-month assessment, from 6-month to 12-month, etc.): 1) not meeting-to-not meeting; 2) meeting-to-not meeting; 3) not meeting-to-meeting; 4) meeting-to-meeting). The meeting-to-meeting classification (i.e., those who remained active) was the reference for all odds-ratios.

The following variables were included as covariates in tests of the logistic models: gender, age (< 50 ≥ years); race (Hawaiian/Pacific Islander vs. White; Asian vs. White; multi-ethnic vs. White); education (<15 ≥ years); median annual household income (≤\$40,000-50,000>); marital status (married or living with partner vs. widowed, separated/divorced, or never married); body mass index (bmi) (<25 ≥). Reported logistic models were adjusted for gender and other significant ($p < .05$) covariates.

Results

Latent Transition Analysis: Meeting Recommended Levels of Physical Activity

When physical activity was measured by the IPAQ, 4.4%, 13.5%, and 17.7% of the cohort met the recommendation for moderate, vigorous, and regular moderate-or-vigorous physical activity, respectively, at all 6-month assessments, while 41.9%, 33.8%, and 23.9% never met recommended levels. The corresponding rates were, conversely, 8.7%, 17.1%, 23.5% for always meeting the recommendations and 24.1%, 31.8%, and 14.7% for never meeting them,

when physical activity was measured using the GLTEQ. When IPAQ walking was included, 33.2% met the moderate level and 41% met the regular moderate-or-vigorous level at all times and only 9.7% and 7% never met those recommendations.

Moderate Activity

IPAQ: Twenty-four to 30 percent of the cohort met the recommended level of moderate physical activity at each 6-month assessment. See Figure 1. The rate was 62% to 66% when walking was included. Probabilities ranged from 45% to 61% that people would meet the guideline at the 6-month transition if they had met it at the preceding assessment and from 17% to 22% that they would meet the guideline the next time if they had not met it the last time. Those probabilities were 73% to 81% and 30% to 41% when walking was included. The probability that participants would transition from meeting the moderate activity guideline to not meeting it (48%) was higher than the probability that they would transition from not meeting the guideline to meeting it (19%), $z = 9.6$, $p < .001$.

GLTEQ: Thirty-three to 40 percent of the cohort met the recommended level of moderate physical activity each time. See Figure 1. Probabilities ranged from 55% to 63% that people would meet the guideline next time if they had met it last time and from 21% to 33% that they would meet the guideline the next time if they had not met it the last time. The probability that participants would transition from meeting the guideline to not meeting it (43%) was higher than the probability that they would transition from not meeting the guideline to meeting it (29%), $z = 4.5$, $p < .001$.

Vigorous Activity

IPAQ: Thirty-three to 42 percent of the cohort met the recommended level of vigorous physical activity each time. See Figure 1. There was a 67% to 71% probability that people would meet the guideline at each 6-month transition if they had met it at the prior assessment and a 20% to 23% chance of meeting the guideline if they had not met it the preceding time. The probability that participants would transition from meeting the guideline to not meeting it (30%) was higher than the probability that they would transition from not meeting the guideline to meeting it (21%), $z = 3.2$, $p < .001$.

GLTEQ: Thirty-seven to 44 percent of the cohort met the recommended level of vigorous physical activity at each 6-month assessment. See Figure 1. Probabilities ranged from 61% to 78% that people would meet the guideline at the 6-month transition if they had met it at the preceding assessment and were about 20% that they would meet the guideline the next time if they had not met it the last time. The probability that participants would transition from meeting the guideline to not meeting it (32%) was higher than the probability that they would transition from not meeting the guideline to meeting it (24%), $z = 2.74$, $p = .003$.

Moderate-or-Vigorous Activity

IPAQ: Forty to 50 percent of the cohort met the recommended level of regular moderate-or-vigorous physical activity at each assessment. See Figure 1. The rate was 69% to 74% when walking was included. There was a 61% to 73% probability that people would meet the guideline at each 6-month transition if they had met it 6 months earlier and a 24% to 32% chance of meeting the guideline 6 months later if they had not met it last time. Those probabilities were 78% to 85% and 38% to 46% when walking was included. The probability that participants would transition from meeting the moderate-or vigorous guideline to not meeting it (32%) was similar to the probability that they would transition from not meeting the guideline to meeting it (29%), $z = 0.96$, $p = .338$.

GLTEQ: Forty-nine to 60 percent of the cohort met the recommended level of regular moderate-or-vigorous physical activity each time. See Figure 1. There was a 68% to 74% probability that people would meet the guideline next time if they had met it at the preceding 6-month assessment and a 27% to 40% chance of meeting the guideline next time if they had not met it 6 months ago. The probability that participants would transition from meeting the guideline to not meeting it (mean = 28%) was lower than the probability that they would transition from not meeting the guideline to meeting it (mean = 35%), $z = 2.3$, $p = .011$.

Classification Agreement: Cross-sectional Comparisons: Agreement for classifying people who either met or did not meet the guideline each time was fair-to-moderate for moderate physical activity ($\kappa \sim .36-.52$), moderate-to-substantial for vigorous physical activity ($\kappa \sim .55 - .74$), and moderate for regular moderate-or-vigorous physical activity ($\kappa \sim .43 - .66$) (see Table 3). The difference between weighted kappa (0) and kappa (1) coefficients indicates that the accuracy of classifying people who met the recommendation was lower for moderate and moderate-or-vigorous physical activity than for vigorous physical activity. This is explainable by the higher point-prevalence of meeting the moderate and moderate-or-vigorous guidelines estimated by the GLTEQ (see Figure 1), yielding poorer agreement for meeting the guideline than for not meeting the guideline (Kraemer, 2006).

Agreement was worse when walking was included in the IPAQ estimate of meeting the guideline for moderate activity ($\kappa \sim .25-.35$) or for regular moderate-or-vigorous activity ($\kappa \sim .35-.49$). High kappa (0) coefficients ($\sim .47 - .70$, mean = .62) indicated the much higher prevalence of meeting the guidelines for moderate (62%-66%) and for moderate-or-vigorous (69%-74%) activity estimated by IPAQ when walking was included, when compared to estimates by IPAQ with walking excluded (see Figure 2) and by GLTEQ (see Figure 3).

Classification Agreement: Longitudinal Transitions

Classification Agreement: Longitudinal Transitions: Moderate Activity: Kappa values indicated moderate or fair-to-moderate agreement, respectively, for classifying stable classes of people who either met (κ (1/2) ranged from .42 to .53, mean = .48) or did not meet (κ (1/2) ranged from .35 to .43, mean = .38) the guideline each time and slight-to-fair agreement for classifying those who transitioned negatively (i.e., from meeting to not meeting the guideline) (κ (1/2) ranged from .13 to .27, mean = .21) or positively (i.e., from not meeting to meeting the guideline) (κ (1/2) ranged from .28 to .31, mean = .29).

When walking was included in the IPAQ estimate of meeting the guideline, kappa values were lower for classifying people who either met the guideline each time (κ (1/2) ranged from .28 - .33, mean = .30), failed to meet the guideline each time (κ (1/2) ranged from .30 - .40, mean = .33), or transitioned negatively between meeting and not meeting the guideline (κ (1/2) ranged from .04-.22, mean = .13) or positively between not meeting to meeting the guideline (κ (1/2) ranged from .13 - .20, mean = .16).

Vigorous Activity: Kappa values indicated substantial agreement for classifying stable classes of people who either met (κ (1/2) ranged from .65 to .74, mean = .70) or did not meet (κ (1/2) ranged from .60 to .71, mean = .65) the guideline each time and moderate agreement for classifying those who transitioned negatively (κ (1/2) ranged from .34 to .55, mean = .44) or positively (κ (1/2) ranged from .38 to .56, mean = .45).

Moderate-or-Vigorous Activity: Kappa values indicated moderate agreement for classifying stable classes of people who either met (κ (1/2) ranged from .47 to .64, mean = .57) or did not meet (κ (1/2) ranged from .48 to .59, mean = .52) the guideline each time and fair agreement for classifying those who transitioned negatively (κ (1/2) ranged from .18 to .38, mean = .30) or positively (κ (1/2) ranged from .35 to .41, mean = .38). See Table 4.

When walking was included in the IPAQ estimate of meeting the guideline, kappa values were lower for classifying people who either met the guideline each time (kappa ($\frac{1}{2}$) ranged from $\sim .43$ - .49, mean = .46), failed to meet the guideline each time (kappa ($\frac{1}{2}$) ranged from .39 - .50, mean = .43), or transitioned negatively between meeting to not meeting the guideline (kappa ($\frac{1}{2}$) ranged from .10-.40, mean = .24) or positively between not meeting to meeting the guideline (kappa ($\frac{1}{2}$) ranged from .22 - .29, mean = .26).

Multinomial Logistic Regression: Moderate-or-Vigorous Activity: The logistic models for the 4 transition periods (e.g., baseline to 6-month assessment; 6-month to 12-month assessment, etc.) were all significant (χ^2 (9-15) ≥ 220.8 , $p < .001$) and had acceptable fit (χ^2 (9-30) ≥ 11.8 , $p \geq .065$) ($R^2 \geq .40$). Agreement of the models ranged from 62% to 68%. Only gender and education contributed to the models ($p < .05$). Agreement for the meeting-to-meeting class was higher in men than women at the 6-month (70% vs. 56%, $z = 1.8$ $p = .036$) and 18-month (76% vs. 62%, $z = 1.9$ $p = .029$) transitions and was lower in people with 15 or more years of education at the 18-month transition (60% vs. 76%, $z = 2.3$, $p = .01$). Agreement in the not meeting-to-not meeting class at the 24-month transition was higher in people with ≥ 15 years of education (88% vs. 66%, $z = 3.0$, $p = .002$).

Discussion

As far as we know, this is the first study to describe within-person variation in meeting a public policy recommendation for participation in physical activity in a population-based cohort of adults using different measures. We found considerable variation. Approximately 25% to 30% of the cohort had roughly equal odds ($\sim 30\%$) of transitioning either positively or negatively between meeting and not meeting the guideline for moderate-or-vigorous physical activity at each 6-month follow-up. About 18% to 24% of the cohort met that recommendation each time, while 14% to 24% never met it.

Agreement between the IPAQ and GLTEQ for the cross-sectional, point-estimates of meeting the guideline for regular participation in moderate-or-vigorous activity was moderately high and was better than agreement between the IPAQ and the Behavioral Risk Factor Surveillance System (BRFSS) reported in a nationwide cross-sectional survey (kappa ranged from .34 to .49 in that study).²⁸ However, agreement was merely fair for classifying people who transitioned negatively from meeting to not meeting the guideline and positively from not meeting to meeting the guideline. Thus, prevalence and incidence rates of meeting the recommended level of either moderate or vigorous physical activity vary across time and are estimated differently by the IPAQ and the GLTEQ. This finding illustrates a mainly unexplored problem for public health promotion, namely accurate classification of longitudinal change within people.

Surveillance systems that estimate point-prevalence of physical activity in successive years monitor group trends in a population, but they do not provide measures of change within people or how patterns of change differ between people. Measurement of change is a pre-requisite to quantifying exposure in outcome studies, identifying environmental and inter-personal determinants of meeting physical activity guidelines, and evaluating whether public health interventions can be successful in helping people sustain increases in their rate of meeting physical activity guidelines.¹⁰

Kappa statistics are influenced when the prevalence of the underlying binary trait (i.e., meeting a physical activity recommendation) differs substantially from 50% and when tests differ in their proportions of positive results (i.e., binary classes of meeting a recommendation).²⁹ Estimates of meeting the vigorous recommendation were similar between the measures, but the GLTEQ was more likely to classify people as meeting the moderate activity guideline. The point-estimates of meeting the guideline for moderate-or-vigorous activity ranged from 40%

to 50% when physical activity was measured by the IPAQ and 50% to 60% when it was measured by the GLTEQ. These rates are similar to point-estimates of the U.S. adult population (i.e., 48-49%) based on recent BRFSS surveys^{3,28} The rates are higher than a recent estimate from the National Health Interview Survey (i.e., 30%).⁵ At each 6-month transition, incidence estimates by IPAQ were lower (~14%) than GLTEQ (~23%) for meeting the moderate guideline both times and were higher (~62% vs. ~47%) for not meeting the moderate guideline each time. Agreement did not differ according to socio-economic characteristics other than gender and education level, which were not strong modifiers. A limitation of the study was that the cohort was predominantly comprised of middle-aged people who had attended at least some college and had a middle-class income. Two-thirds of the cohort were women. Because prevalence rates of sufficient physical activity in the US population differ according to those factors,⁷ it is possible that socio-economic factors may be associated with agreement in other longitudinal cohorts that include a more representative range of diversity than obtained in the present cohort.

An expanded IPAQ definition of moderate physical activity that included walking resulted in kappa values for agreement with the GLTEQ that were worse than obtained when walking was excluded from the moderate category assessed by IPAQ. With walking included, 62% to 66% of participants in this study cohort met the moderate activity guideline at each 6-month assessment compared to prevalence rates of 24 to 30% and 33% to 42% using the moderate classifications provided the IPAQ and GLTEQ, respectively. The accurate measurement of walking by recall is as yet an unresolved dilemma for population surveillance of physical activity that depends on context.³⁰⁻³⁴ We excluded mild exercise (which includes easy walking) assessed by the GLTEQ in the comparisons with the IPAQ. The American College of Sports Medicine and the American Heart Association,³⁵ regard moderate intensity to be between 3-5.9 METS. The scientific advisory committee of the Physical Activity Guidelines for Americans,³⁶ defines moderate intensity to be 40%-45% of aerobic capacity, which depending on fitness level, corresponds to roughly 3.8 to 7.5 METS in people who are middle-aged or younger. The GLTEQ defines fast walking as moderate exercise (rated as 5 METS) and easy walking as mild exercise (rated as 3 METS) without reference to context. The IPAQ does not specify walking pace and includes walking at work and for transportation, as well as for exercise and leisure. Fast walking is usually gauged to be between 3-4 mph (3.3 to 5 METS), and easy walking is usually gauged to be less than 3 mph (2.0 to 3.0) METS.^{35,37} The IPAQ assigns 3.3 METS to walking, even though walking for transportation is usually gauged to be less than 3.0 mph.³⁷ Easy or slow walking would be moderately intense only for elderly or people with disability or very low fitness.³⁸ The comparisons between the IPAQ and GLTEQ we made in this report were based on time, so they were not affected by the different MET values assigned to moderate activity by the 2 measures. Nonetheless, subjective interpretations of the intensity of physical activities like walking likely contributed to classification errors between the IPAQ and the GLTEQ for moderate physical activity.³² Also, different interpretations by respondents of walking for leisure-time exercise and for utilitarian purposes (e.g., transportation and activity at work) are likely to lower agreement between the measures.

Self-reports of physical activity overestimate physical activity levels when compared to objective monitoring by accelerometry.^{39,40} Hence, it is likely that the classification accuracy of the IPAQ and GLTEQ for estimating whether people meet recommended physical activity levels determined by objective methods such as accelerometry or heart rate monitoring will be lower than their agreement with each other.⁴¹ This requires further examination in both cross-sectional analysis of point-estimates and longitudinal analysis of change.

We used the revised Healthy People 2010 recommendation <http://www.healthypeople.gov/data/midcourse/pdf/fa22.pdf> for regular participation in either moderate or vigorous physical activity and used one measure that specified sessions of at least

10 minutes (i.e., the IPAQ) and another measure that specified a 30-minute duration (i.e., the GLTEQ). The 30-minute context used for the GLTEQ might underestimate the rate of meeting the guideline for vigorous physical activity (i.e., people might have failed to report sufficient time even though they spent ≥ 20 min per session, but less than 30 min). Nonetheless, the agreement between the IPAQ and GLTEQ was substantially higher for meeting the vigorous guideline than for meeting the moderate guideline. Likewise, the 30-min context of the GLTEQ might underestimate moderate activity in people who interpret the question to mean a single session rather than to also consider the total accumulation of physical activity during the day. Conversely, excluding walking from moderate activity assessed by the IPAQ will underestimate moderate activity in people who walk briskly (e.g., 3 mph or faster). The newly released Physical Activity Guidelines for Americans recommends 75 min each week in vigorous physical activity,¹ which would fall between the total time frames of 60 min for the IPAQ and 90 min for the GLTEQ used in this study. Those guidelines and the joint recommendations by the American College of Sports Medicine and American Heart Association³⁵ published since Healthy People 2010 are more explicit about recommending regular physical activity using different combinations of moderate activity, e.g., 30 min of moderate activity 5 days per week or 50 min of moderate activity 3 days per week¹ or varying combinations of moderate and vigorous activity (e.g., walking for 30 minutes twice a week plus jogging for 20 min twice a week.³⁵

Because of its prominence in U.S. public health policy,^{1,35, 42-44} binary classification of physical activity participation merits continued investigation using prospective cohort designs and methods such as latent transition analysis that model intra- and inter-personal patterns of change. The minimal amount of physical activity needed to increase health and well-being is not yet known,³⁶ so further research is needed to examine whether self-report measures such as the IPAQ and the GLTEQ, or objective measures such as accelerometers, pedometers, or heart rate monitoring can accurately classify longitudinal transitions between physical inactivity or light activity and moderate or vigorous activity levels that are below currently recommended levels. Until it becomes feasible to use objective measures of physical activity to assess within-person change, it will continue to be important to corroborate whether currently validated self-reports of physical activity can be used to track individual changes in physical activity.

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Appendix 1

Interview definition of participation in regular physical activity according to IPAQ:

“I am going to ask you about the time you spent being physically active in the last 7 days. Please answer each question even if you do not consider yourself to be an active person. Think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.”

Now think about the time you spent walking in the last 7 days.

“This includes walking at work and at home, walking to travel from place to place, and any other walking that you did solely for recreation, sport, exercise or leisure.”

During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

How much time in total did you usually spend walking on one of those days?

What is the **total** amount of time you spent **walking** over the last 7 days?

Now think about other activities which take **moderate physical effort** that you did *in the last 7 days*.

“Moderate physical activities make you breathe somewhat harder than normal and may include carrying light loads, bicycling at a regular pace, or doubles tennis. Do not include walking. Again, think about *only* those physical activities that you did for at least 10 minutes at a time. Vigorous activities make you breathe much harder than normal and may include heavy lifting, digging, aerobics, or fast bicycling. Think about *only* those physical activities that you did for at least 10 minutes at a time.

During the last 7 days, on how many days did you do **moderate** physical activities?

How much time in total did you *usually* spend *on one* of those days doing **moderate** physical activities?

Now, think about all the **vigorous** activities which take **hard physical effort** that you did in the last 7 days.

“Vigorous activities make you breathe much harder than normal and may include heavy lifting, digging, aerobics, or fast bicycling. Think about *only* those physical activities that you did for at least 10 minutes at a time.”

During the last 7 days, on how many days did you do **vigorous** physical activities?

How much time in total did you *usually* spend *on one* of those days doing **vigorous** physical activities?”

Interview definition of participation in regular physical activity according to GLTEQ:

“How many days in a week do you do **moderate activity** for at least 30 minutes a day total?”

Moderate activity is activity that doesn't make you tired, and makes you sweat just a little.

Some examples would be fast walking, slow bicycling, easy swimming, weight lifting, baseball, softball, tennis, volleyball, hula, or dancing.

“How many days in a week do you do **strenuous activity** for at least 30 minutes a day total?”

Strenuous activity is activity that makes your heart beat quickly, and makes you sweat. Some examples would be running, jogging, fast bicycling, aerobic dance, roller blading, paddling, fast swimming, soccer, basketball, football or martial arts.”

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Figure 1.

Point prevalence $\pm$ 95% CI at baseline and 6-month assessment of meeting the U.S. Healthy People 2010 guidelines for participation in moderate, vigorous, or regular (moderate or vigorous) physical activity measured by the International Physical Activity Questionnaire (IPAQ) and the Godin Leisure-Time Exercise Questionnaire (GLTEQ). Prevalence of moderate and regular is also estimated by the IPAQ including walking.

Figure 2.

Cumulative prevalence of insufficient physical activity, walking, moderate physical activity, and vigorous physical estimated by the IPAQ at 6-month intervals across 2 years.

Figure 3.
Cumulative prevalence of insufficient physical activity, moderate physical activity, and vigorous physical estimated by the GLTEQ at 6-month intervals across 2 years.

Figure 4.

Prevalence $\pm$ 95% CI of transition classes of meeting or not meeting the U.S. Healthy People 2010 guidelines for participation in moderate, vigorous, or regular (moderate or vigorous) physical activity at each 6-month transition measured by the International Physical Activity Questionnaire (IPAQ) and the Godin Leisure-Time Exercise Questionnaire (GLTEQ).

Walking is excluded from IPAQ to increase agreement. Transitions are: 1=baseline to 6 mo; 2= 6 mo to 12 mo; 3= 12 mo to 18 mo; 4=18 mo to 24 mo. Classes are: 1=stable not meeting; 2=meeting-to-not meeting; 3=not meeting-to-meeting; 4= stable meeting.

Table 1

Participant characteristics at baseline.

Characteristic	Sample (N=700)	Cohort (N=497)
	Mean (SD)	Mean (SD)
Age	47.0 (17.1)	49.7 (16.7)
BMI	25.9 (5.6)	25.9 (5.8)
Education (years)	14.6 (2.8)	15.0 (2.9)
Median household income	\$40-50,000/year	\$40-50,000/year
	Frequency (%)	Frequency (%) Gender
Male	256 (36.6)	177 (35.6)
Female	438 (62.6)	316 (63.6)
Missing	6 (0.9)	4 (0.8)
Race/Ethnicity		
White	261 (37.3)	198 (39.8)
Pacific Islanders	155 (22.1)	96 (19.3)
Asian	218 (31.1)	158 (31.8)
Other	60 (8.6)	40 (8.0)
Missing	6 (0.9)	5 (1.0)
Hispanic/Latino	71 (10.1)	41 (8.2)
Marital status		
Married	360 (51.4)	263 (52.9)
Never married	156 (22.3)	94 (18.9)
Widowed	45 (6.4)	40 (8.0)
Divorced/separated	103 (14.7)	72 (14.5)
Living with partner	34 (4.9)	26 (5.2)
Missing	2 (0.2)	2 (0.4)

Table 2

Physical activity according to not meeting or meeting the U.S. Healthy People 2010 recommendations for participation in moderate or for vigorous physical activity in a cohort (N=497) of adults living in Hawaii assessed at baseline and 6-month intervals for 2 years.

Measure of Physical Activity Guideline Time of assessment	Met the Guideline	Did Not Meet the Guideline
IPAQ METx min · wk ⁻¹	Mean (SD)	Mean (SD)
Moderate activity baseline	2413 (1489) n = 136	575 (653) n = 355
6 months	2193 (1462) n = 113	474 (578) n = 345
12 months	2439 (1484) n = 141	503 (574) n = 303
18 months	2339 (1553) n = 114	524 (616) n = 302
24 months	2327 (1520) n = 117	539 (650) n = 277
Moderate activity (including walking) baseline	3041 (2164) n = 359	698 (699) n = 135
6 months	2670 (1918) n = 312	716 (682) n = 144
12 months	3143 (2198) n = 314	617 (588) n = 131
18 months	3049 (2215) n = 290	565 (530) n = 126
24 months	2962 (2175) n = 289	688 (752) n = 105
Vigorous activity baseline	2943 (2370) n = 191	367 (671) n = 303
6 months	2718 (2307) n = 156	280 (526) n = 304
12 months	2429 (2123) n = 172	306 (539) n = 273
18 months	2650 (2203) n = 160	271 (482) n = 256
24 months	2936 (2594) n = 157	316 (534) n = 237
GLTEQ MET · wk ⁻¹		
Moderate activity baseline	30.6 (4.7) n = 193	10.2 (7.1) n = 298
6 months	30.3 (4.8) n = 158	9.8 (7.4) n = 300
12 months	30.1 (4.7) n = 184	10.0 (7.0) n = 261
18 months	30.4 (4.7) n = 170	10.2 (7.4) n = 246
24 months	31.0 (4.6) n = 167	10.3 (7.0) n = 227
Vigorous activity baseline	40.5 (12.8) n = 206	5.7 (7.5) n = 289
6 months	38.9 (13.3) n = 172	4.9 (7.0) n = 288
12 months	39.1 (12.9) n = 175	5.1 (7.2) n = 270
18 months	36.6 (11.3) n = 161	5.4 (7.4) n = 255
24 months	40.6 (13.0) n = 168	5.7 (7.4) n = 226

IPAQ = International Physical Activity Questionnaire; GLTEQ = Godin Leisure-Time Exercise Questionnaire; MET = metabolic equivalent;

Table 3

Classification agreement for point estimates of meeting the U.S. Healthy People 2010 recommendations for moderate, vigorous, or regular, moderate-or-vigorous physical activity measured by the International Physical Activity Questionnaire (IPAQ) or the Godin Leisure Time Exercise Questionnaire (GLTEQ) at baseline and at each subsequent 6-month interval (N=497).

<u>Baseline</u>				
	<u>GLTEQ</u>			
<u>IPAQ</u>	<u>Not met Guideline</u>	<u>Met Guideline</u>		<u>Intraclass Kappa (k) (95% CI)</u>
Moderate				
Not met guideline	265	94		k (1/2) = .42 (.34, .50)
Met	37	101	138	k (0) = .56 (.48, .64)
		195		k (1) = .33 (.25, .41)
Vigorous				
Not met guideline	244	61		k (1/2) = .55 (.48, .63)
Met	46	146	192	k (0) = .59 (.52, .66)
		207		k (1) = .52 (.45, .60)
Moderate-or-Vigorous				
Not met guideline	177	91		k (1/2) = .47 (.39, .55)
Met	42	187	229	k (0) = .58 (.51, .66)
		278		k (1) = .39 (.32, .47)
<u>6 months</u>				
Moderate				
Not met guideline	303	76		k (1/2) = .47 (.38, .55)
Met	32	86	118	k (0) = .60 (.51, .68)
	335	162		k (1) = .39 (.30, .47)
Vigorous				
Not met guideline	291	42		k (1/2) = .70 (.64, .77)
Met	25	139	164	k (0) = .76 (.69, .83)
		181		k (1) = .65 (.59, .72)
Moderate-or-Vigorous				
Not met guideline	223	73		k (1/2) = .59 (.52, .66)
Met	29	172	201	k (0) = .72 (.65, .79)
		245		k (1) = .50 (.43, .57)
<u>12 months</u>				
Moderate				
Not met guideline	270	80		k (1/2) = .52 (.44, .59)
Met	30	117	147	k (0) = .66 (.59, .74)
		197		k (1) = .42 (.35, .50)
Vigorous				
Not met guideline	275	30		k (1/2) = .74 (.68, .80)
Met	31	161	192	k (0) = .74 (.68, .80)

Baseline				
	GLTEQ			
IPAQ	Not met Guideline	Met Guideline		Intraclass Kappa (k) (95% CI)
		191		k (1) = .74 (.68, .81)
Moderate-or-Vigorous				
Not met guideline	190	60		k (1/2) = .66 (.59, .72)
Met	25	222	245	k (0) = .77 (.70, .83)
		282		k (1) = .58 (.51, .64)
18 months				
Moderate				
Not met guideline	270	107		k (1/2) = .37 (.29, .45)
Met	32	88	120	k (0) = .56 (.48, .64)
		195		k (1) = .28 (.19, .36)
Vigorous				
Not met guideline	270	38		k (1/2) = .69 (.63, .76)
Met	34	155	189	k (0) = .71 (.64, .77)
		193		k (1) = .68 (.62, .75)
Moderate-or-Vigorous				
Not met guideline	169	98		k (1/2) = .49 (.42, .57)
Met	30	200	230	k (0) = .67 (.60, .75)
		298		k (1) = .39 (.32, .46)
24 months				
Moderate				
Not met guideline	250	111		k (1/2) = .36 (.28, .44)
Met	37	99	136	k (0) = .53 (.45, .61)
		210		k (1) = .27 (.19, .36)
Vigorous				
Not met guideline	232	58		k (1/2) = .56 (.49, .64)
Met	48	159	207	k (0) = .59 (.52, .66)
		217		k (1) = .54 (.47, .61)
Moderate-or-Vigorous				
Not met guideline	155	93		k (1/2) = .43 (.35, .51)
Met	49	200	249	k (0) = .52 (.44, .60)
		293		k (1) = .36 (.29, .44)

CI = confidence interval; k (1/2) = kappa agreement with equal weighting for misclassification by IPAQ and GLTEQ; k (0) kappa agreement with zero weighting for “false positives” by IPAQ; k (1) kappa agreement with zero weighting for “false positives” by GLTEQ.

Table 4

Classification agreement (95% CI) between transitions in meeting or not meeting the U.S. Healthy People 2010 recommendations for participation in moderate-or-vigorous physical activity measured at successive 6-month intervals by the International Physical Activity Questionnaire (IPAQ) and the Godin Leisure Time Exercise Questionnaire (GLTEQ) (N=497).

Physical activity guideline: baseline to 6-month				
Moderate-or-Vigorous				
	GLTEQ			Intraclass Kappa (k) (95% CI)
IPAQ				
	Not met-to-Not met			
Not met-to-Not met	125	40	165	k (1/2) = .48 (.40, .56)
	83		249	k (0) = .40 (.32, .48)
	208			k (1) = .58 (.50, .66)
	Met-to-Not met			
Met-to-Not met	37	50	87	k (1/2) = .30 (.19, .41)
	51		359	k (0) = .30 (.19, .40)
	88			k (1) = .30 (.20, .41)
	Not met-to Met			
Not met-to-Met	24	30	54	k (1/2) = .35 (.22, .47)
	36		407	k (0) = .33 (.20, .45)
	60			k (1) = .37 (.24, .49)
	Met-to-Met			
Met-to-Met	117	74	191	k (1/2) = .56 (.49, .64)
	24		282	k (0) = .72 (.65, .80)
	141			k (1) = .46 (.38, .54)
Physical activity guideline: 6 months to 12 months				
Moderate-or-Vigorous				
	GLTEQ			
IPAQ				Intraclass Kappa (k) (95% CI)
	Not met-to-Not met			
Not met-to-Not met	133	27	160	k (1/2) = .59 (.52, .66)

Physical activity guideline: baseline to 6-month									
Moderate-or- Vigorous									
	GLTEQ								Intraclass Kappa (k) (95% CI)
IPAQ									
	68			269					k (0) = .50 (.43, .57)
	201								k (1) = .72 (.64, .79)
	Met-to-Not met								
Met-to-Not met	22		33	55					k (1/2) = .36 (.23, .48)
	27		415						k (0) = .38 (.25, .51)
	49								k (1) = .33 (.21, .46)
	Not met-to Met								
Not met-to-Met	49		43	92					k (1/2) = .41 (.31, .52)
	46		359						k (0) = .41 (.30, .51)
	95								k (1) = .42 (.32, .52)
	Met-to-Met								
Met-to-Met	130		60	190					k (1/2) = .64 (.57, .71)
	22		285						k (0) = .77 (.70, .84)
	152								k (1) = .55 (.47, .62)
Physical activity guideline: 12 months to 18 months									
Moderate-or- Vigorous									
	GLTEQ								Intraclass Kappa (k) (95% CI)
IPAQ									
	Not met-to-Not met								
Not met-to-Not met	116		23	139					k (1/2) = .54 (.46, .62)
	81		277						k (0) = .43 (.35, .51)
	197								k (1) = .73 (.65, .80)
	Met-to-Not met								
Met-to-Not met	30		30	60					k (1/2) = .38 (.26, .500)
	40		397						k (0) = .35 (.23, .47)
	70								k (1) = .42 (.30, .54)
	Not met-to Met								

Physical activity guideline: baseline to 6-month					
Moderate-or- Vigorous					
	GLTEQ				Intraclass Kappa (k) (95% CI)
IPAQ					
Not met-to-Met	31	45	76		k (1/2) = .41 (.29, .52)
	22		399		k (0) = .51 (.39, .63)
	53				k (1) = .34 (.22, .46)
	Met-to-Met				
Met-to-Met	151	71	222		k (1/2) = .60 (.53, .67)
	26		249		k (0) = .74 (.67, .81)
	177				k (1) = .50 (.43, .57)
Physical activity guideline: 18 months to 24 months					
Moderate-or- Vigorous					
	GLTEQ				Intraclass Kappa (k) (95% CI)
IPAQ					
Not met-to-Not met	112	33	145		k (1/2) = .47 (.39, .55)
	89		263		k (0) = .38 (.29, .46)
	201				k (1) = .62 (.54, .70)
	Met-to-Not met				
Met-to-Not met	14	45	59		k (1/2) = .18 (.06, .30)
	33		405		k (0) = .20 (.08, .32)
	47				k (1) = .16 (.04, .28)
	Not met-to Met				
Not met-to-Met	25	29	54		k (1/2) = .34 (.22, .46)
	41		402		k (0) = .30 (.18, .42)
	66				k (1) = .38 (.26, .50)
	Met-to-Met				
Met-to-Met	146	93	239		k (1/2) = .47 (.39, .55)
	37		221		k (0) = .61 (.53, .69)

Physical activity guideline: baseline to 6-month				
Moderate-or-Vigorous				
		GLTEQ		
IPAQ				Intraclass Kappa (k) (95% CI)
	183			k (1) = .38 (.31, .46)

CI = confidence interval; k (1/2) = kappa agreement with equal weighting for misclassification by IPAQ and GLTEQ; k (0) kappa agreement with zero weighting for “false positives” by IPAQ; k (1) kappa agreement with zero weighting for “false positives” by GLTEQ.