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Subjective Estimation of Physical Activity Using the IPAQ Varies by Fitness Level

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Abstract
Background: Subjective measures of moderate and vigorous physical activity (MVPA) rely on 'relative' intensity while objective measures capture 'absolute' intensity, thus fit individuals may perceive the same activity differently than unfit individuals. Methods: Adults (N=211) wore the SenseWear Armband (SWA) for ten consecutive days to objectively assess sedentary time and MVPA. On day eight participants completed the International Physical Activity Questionnaire (IPAQ) to subjectively assess sitting time and MVPA. Fitness was assessed via a maximal treadmill test, and participants were classified as 'unfit' if the result was in the bottom tertile of the study population by sex or 'fit' if in the upper two tertiles. Results: Overall, estimates of MVPA between the IPAQ and SWA were not significantly different (IPAQ minus SWA, 67.4±919.1 MVPA minutes/week, P=.29). However, unfit participants overestimated MVPA using the IPAQ by 37.3% (P=.02), but fit participants did not (P=.99). This between-group difference was due to overestimation using the IPAQ of moderate activity by 93.8 minutes/week among the unfit individuals, but underestimation of moderate activity among the fit participants by 149.4 minutes/week. Conclusion: Subjective measures of MVPA using the IPAQ varied by fitness category, with unfit participants overestimating their MVPA and fit participants accurately estimating their MVPA.

Keywords
Cardiorespiratory fitness, IPAQ, accelerometer, measurement

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Abstract

Background: Subjective measures of moderate and vigorous physical activity (MVPA) rely on ‘relative’ intensity while objective measures capture ‘absolute’ intensity, thus fit individuals may perceive the same activity differently than unfit individuals. **Methods**: Adults (N=211) wore the SenseWear Armband (SWA) for ten consecutive days to objectively assess sedentary time and MVPA. On day eight participants completed the International Physical Activity Questionnaire (IPAQ) to subjectively assess sitting time and MVPA. Fitness was assessed via a maximal treadmill test, and participants were classified as ’unfit’ if the result was in the bottom tertile of the study population by sex or ‘fit’ if in the upper two tertiles. **Results**: Overall, estimates of MVPA between the IPAQ and SWA were not significantly different (IPAQ minus SWA, 67.4±919.1 MVPA minutes/week, *P*=.29). However, unfit participants overestimated MVPA using the IPAQ by 37.3% (*P*=.02), but fit participants did not (*P*=.99). This between-group difference was due to overestimation using the IPAQ of moderate activity by 93.8 minutes/week among the unfit individuals, but underestimation of moderate activity among the fit participants by 149.4 minutes/week. **Conclusion**: Subjective measures of MVPA using the IPAQ varied by fitness category, with unfit participants overestimating their MVPA and fit participants accurately estimating their MVPA.

Keywords: Cardiorespiratory fitness, IPAQ, accelerometer, measurement

Background

Physical activity (PA) can be measured with reasonable accuracy through the use of subjective or objective instruments, though differences in validity exist between the two techniques. Numerous PA questionnaires have been developed but the International Physical Activity Questionnaire (IPAQ) is the most commonly used PA tool worldwide.[1,2] It has been used in a variety of populations [3-5] and to identify levels of PA associated with various disease outcomes.[6,7] Predictive utility is perhaps best demonstrated in a recent study documenting dose-response relationships between low PA levels assessed by the IPAQ and increased mortality and CVD event rates.[8] It has been shown to have good reliability when repeated over a short period of time (<10 days, r=0.80) but correlations with objective, accelerometry-based measures were relatively weak (r=0.30).[9] A separate validation study involving 1,751 adults reported a similar correlation between self-reported and accelerometer-measured PA (r=0.33)[10] and specific discrepancies in reported vs observed times spent in physical activity (underestimations observed for sedentary and moderate activity, and overestimations for vigorous activity). This pattern of overestimated vigorous PA is commonly observed with the IPAQ, and as high as three quarters of many populations end up meeting physical activity public health recommendation of 150 minutes of MVPA per week.[2,11-13]

The tendency for high estimates of reported MVPA is not unique to the IPAQ as it has been observed in numerous other studies including the NHANES. Discrepancies between objective and subjective measures can be attributed to the inherent differences in the two assessments as well as to the challenges of recalling and coding physical activity. A recent measurement error study reported larger discrepancies in a 24 hour PA recall for older and heavier individuals suggesting that differences in perception of the activities may be a key contributing factor in the discrepancies.[14] Other studies have reported differences by sex,[10] age,[10] weight status,[15] socio-economic,[9,10] and regional biases.[9] Social desirability (the tendency for participants to respond in a manner that will be viewed favorably by others) is also a known source of potential bias in self-reported physical activity[16] but this hasn't been shown to vary by personal or demographic variables.

An un-examined influence on discrepancies between subjectively and objectively measured physical activity estimates is physical fitness. Subjective measures rely on 'relative' intensity while objective measures capture 'absolute' intensity. Fit individuals would logically perceive the same activity very differently than unfit individuals due to differences in the relative intensity. For example, if a fit (peak METs=17.0) and an unfit (peak METs=10 METs) individual[17] each 'briskly walked' at the same absolute intensity 3.5 mph (equivalent to 4.3 METS), their relative intensity would be different, 25.3% of max capacity for the fit individual and 43.0% for the unfit individual. The objective activity monitors would record the same absolute intensity, but the unfit individual may recall the intensity as 'moderate' while the fit individual may recall the intensity as 'light.' In other words, subjective measures are based on relative intensity.

Given the wide use of physical activity questionnaires in both clinical[18] and research[19] settings, it is important to better understand the impact of fitness on discrepancies between subjective and objective estimates of physical activity. The purpose of the present study is to compare physical activity and sedentary time estimates from the IPAQ (a self-administered subjective activity questionnaire), and the SenseWear® armband monitor (an objective measure of activity) in fit and unfit individuals.

Methods

Data for the present study were obtained from the Energy Balance Study, a large, longitudinal cohort study.[20] Briefly, participants were recruited from August 2011 – July 2012, and those diagnosed with/taking medications for a major chronic disease (E.g., hypertension, diabetes, cancer) or with unstable/undiagnosed health conditions were excluded. The study was approved by the University of South Carolina Institutional Review Board and informed consent was obtained from each participant.

Anthropometric and fitness assessment Height and body weight were calculated from the average of three measurements made with a traditional stadiometer and electronic scale. Fat mass and fat free mass were estimated using dual energy X-ray absorptiometery (DXA, Lunar DPX® system, version 3.6; Lunar Radiation Corp, Madison, WI). Each participant performed a graded exercise test to determine cardiorespiratory fitness (CRF) using the Modified Bruce protocol on a motorized Trackmaster treadmill (Full Vision, Inc., Newton, KS), with the use of a standard 12-lead ECG and with respiratory gases sampled using a TrueOne 2400 Metabolic Measurement Cart® (ParvoMedics, Salt Lake City, Utah). Participants were instructed to exercise to volitional fatigue. Criteria for a successful test were meeting one of the following: plateau of oxygen consumption or heart rate with increases in workload, respiratory exchange rate ≥1.15, or a rating of perceived exertion ≥17 on a 20 point scale.[21] Participants were categorized as 'unfit' if they were in the bottom 1/3 percentile for CRF (mL/kg/min) and 'fit' if they were in the upper 2/3 percentile for CRF (mL/kg/min) of the total sample by gender. This classification strategy was utilized given no widely accepted criteria for defining CRF levels currently exists. However, the values presented here closely correspond to the CRF values and nomenclature (E.g., 'unfit',

'fit') of the Aerobics Center Longitudinal Study, a widely cited database with maximal exercise duration on >13,000 individuals.[17]

Objective physical activity measurement The SenseWear armband ((SWA) - BodyMedia Inc. Pittsburgh, PA), is an arm-based activity monitor that estimates energy expenditure using a tri-axial accelerometer and physiologic sensors, including heat flux, skin temperature, near-body ambient temperature, and galvanic skin response. The SWA has been validated in a variety of populations (including active[22] and diseased cohorts[23]) and has been found to accurately estimate total energy expenditure[22-24] though estimations of energy expenditure during periods of physical activity is lower.[25-27] Data processed from the armband were pre-processed using the proprietary algorithm software (SenseWear Professional software V.7.0, algorithm V.2.2.4) to derive time and energy expenditure in 60 second epochs for sedentary, moderate, vigorous, and MVPA for each day of wear, which were then summed to create daily values. Time spent in physical activity was classified by intensity according to the estimated metabolic equivalent of task (MET) based on the following criteria: Sedentary, 1.0 to ≤1.5 METs; Light, >1.5 to <3.0 METs; Moderate, ≥3.0 to <6.0 METs; Vigorous, ≥6.0 METs (as the IPAQ does not assess light activity, the armband values of light activity are not presented here). Due to low amounts of time spent in vigorous activity among participants, all activity ≥3.0 METs was also summed to identify moderate – vigorous (MVPA) activity. Time spent in MVPA was also calculated using activity attained in ≥10 minutes bouts (with allowances for interruptions of 1 or 2 minutes below threshold),[28] given that IPAQ scoring guidelines are based on these criteria.

Each participant was provided with a monitor that was pre-programmed with their age, gender, height and weight. The participants were instructed to wear the armband for ten consecutive days, including while sleeping but excluding times if the SWA were to be in contact with water. Participants were also provided with a daily log to track any non-wear segments during their ten day wear period. Bouts of activity reported on the self-administered logs were manually entered into the software and non-specified segments were coded as 1.5 METs to ensure complete 24-hour records of activity for each armband wear report. Criteria for valid SWA wear time was set at ≥7 days including two weekend days with ≥18.4 hours/day of verifiable time.[20]

Subjective physical activity measurement The long form, self-administered version of the IPAQ was sent to the participants electronically on the eighth day of armband wear, and the participants used the questionnaire to self-report physical activity from the previous seven days. Two versions of the IPAQ have been developed, short (7 questions) and long (27 questions). The long form is more time consuming but is recommended for controlled trials due to its ability to categorize the domains in which the physical activity is performed.[9] The long form assesses self-reported time (minutes/day and days/week) spent in four domains of activity for at least 10 minutes: leisure time physical activity, domestic and gardening (yard) activities, work-related physical activity and transport-related physical activity, in addition to time spent sitting. MET-minutes per week were also calculated for sedentary activities, moderate activities, vigorous activities and MVPA using the following equation:

activity MET-minutes/week = MET value x minutes per day of activity x days performing activity where MET value of queried activity was selected from the Compendium of Physical Activities[29] during the IPAQ Reliability Study,[9] and is available in the 'Guidelines for data processing and analysis of the IPAQ' on the survey website.[30] The guidelines are extremely detailed and provide protocols for administration, rules for data processing, and summary algorithms.

Statistical analyses Due to a non-normal distribution of several of the variables examined, data analyses were performed with the data unadjusted and also transformed using a log scale. The results were not different between the two approaches and the data presented here are untransformed for easier interpretation. Additionally, results were analyzed for both minutes per week and MET-minutes per week. These results were not different between the minutes per week and MET-minutes per week variables and the data presented here are in minutes per week for consistency. Participant characteristics were based on demographic and physiological measurements using means and standard deviations for continuous variables and percentages for categorical variables. Statistical significance for comparison between groups was tested using t-tests for continuous variables and chi-square for categorical variables. Since the data was not normally distributed, nonparametric Spearman correlations were calculated to determine relationships between variables. Statistical significance was set at $P<.05$ (two-sided) for all analyses. All aforementioned analyses were performed using SAS 9.3 (Cary, N.C.). Due to differences in sample size between the groups, a post hoc power analysis was performed using G*Power 3 (Germany) which yielded a power of 0.92 to detect differences between group means based on an effect size of 0.5.

Results

Participant characteristics are presented in Table 1, both overall and by fitness category. Overall, participants were young adult (28.1±3.7 years) men and women (53.1% female) who had completed at least four years of college education (91.5%). Fit participants had a significantly higher CRF compared to unfit participants (42.6±7.6 vs. 29.7±6.6 mL/kg/min, *P*<.0001), and these values closely align with a widely cited fitness classification system for 'unfit' and 'fit' individuals.[17] Fit participants also had lower body weight (73.1±12.9 vs. 82.1±14.6 kg, *P*<.0001) and percent body fat (25.8±10.0 vs. 34.9±10.3 percent, *P*<.0001) compared to unfit participants, though differences in BMI did not reach statistical significance (24.8±3.5 vs. 28.2±4.2 kg/m^2, *P*=.0852).

The unfit and fit participants spent equal relative amounts of time in the various domains of physical activity (unfit vs. fit: occupational, 28.8% vs. 31.0%, *P*=.63; transport, 11.0% vs. 13.9%, *P*=.37; household, 20.0 vs. 24.6%, *P*=.19) except for leisure-time (40.6% vs. 31.5%, *P*=.03) as reported using the IPAQ. Compliance with the SWA was excellent, with 23.0±1.1 hours of daily wear time overall and no difference between unfit and fit participants (22.8±1.6 vs. 23.1±0.8 hours/day, *P*=.1117). Table 2 displays time spent in activity by intensity level, both overall and by fitness category, according to the two assessment techniques. According to IPAQ, fit participants spent less time in sedentary activity and more time in vigorous, but differences in moderate and MVPA were not statistically significant. Time spent in MVPA is presented using the cumulative min/day (MVPA- cumulative) technique and using the ≥10 minute continuous bout (MVPA- bouts) technique. By comparison to IPAQ results, SWA data indicate that fit participants spent less time in sedentary activity and more time in moderate, vigorous, and MVPA (both cumulative and bouts) activity compared to unfit participants.

Table 3 displays differences between the two measures (IPAQ minus SWA) and tests for differences between methods for all participants and for each fitness group. Overall, statistically significant differences between the IPAQ and SWA were observed for time spent in sedentary activity (4717.0±1248.9 min/week, *P*<.0001), vigorous activity (138.4±242.2 min/week, *P*<.0001), and MVPA- bouts (456.2±926.4 min/week, *P*<.0001). When examined by fitness group, the only intensity not different by method for unfit participants was moderate activity (93.8±683.6 min/week, *P*=.2619), while the only intensity not different by method for fit participants was MVPA- cumulative (0.3±996.2 min/week, *P*=.9983). When separated by sex, there were no differences in the patterns of results by CRF group for any of the variables previously described, except for MVPA (cumulative) among unfit adults (males; -144.1±811.4 minutes/week, *P*=.3228; females, -265.5±628.0 minutes/week, *P*=.0158, Supplementary Tables 1 & 2). Likewise, the differences by method (IPAQ – SWA) for each level of fitness were similar between males and females (Supplemental Table 3).

Bland-Altman 95% limits of agreement (± 1.96 SD) plots were used to evaluate the bias of the results for each category of activity by fitness group, and are displayed in Figure 1. The estimation of MVPA- cumulative produced a mean value close to zero (0.3161 minutes/week), indicating large bias for all other activity intensities. For each activity intensity and fitness group, the 95% agreement limits between IPAQ and SWA were extremely large (E.g., MVPA- bouts= -899.1 to 1936 minutes/week) indicating poor agreement between the techniques.

Correlation coefficients between the two methods are displayed in Table 4. Overall, time spent in activity intensity as measured by the IPAQ was significantly correlated with SWA, though the strength of the association varied from moderate (vigorous r=.47, *P*<.0001) to weak (MVPA- bouts r=.21, *P*=.0496). Correlations between the two measurements varied considerably by fitness group (e.g., vigorous unfit, r=.1498; moderate fit, r=.4380) with statistically significant associations for all intensities except vigorous intensity activity for unfit participants, while only vigorous intensity activity was significantly associated for fit participants.

Discussion

The primary finding of the current study was that agreement between the IPAQ and the SWA varied considerably by fitness level. Specifically, unfit individuals were found to overestimate MVPA while good agreement was observed for fit individuals. This finding is novel and adds CRF level to the previously cited confounders in the assessment of physical activity including social desirability, socio-economic status, weight status, sex, and age. Overall, the IPAQ underestimated time spent in sedentary activity and overestimated time spent in vigorous and MVPA- bouts compared to the SWA, with agreement between the measures only occurring for moderate and MVPA- cumulative intensity levels. When examined by fitness level the IPAQ overestimated MVPA- cumulative by 208 minutes/week among unfit individuals, but by <1 minute/week for fit individuals. Specifically, whereas the IPAQ underestimated moderate-intensity activity for all participants, it overestimated moderate-intensity activity for unfit participants but underestimated it by fit participants. These differences between unfit and fit individuals are likely due to differences in both the perception of the intensity of a given activity and actual differences in the intensity of a given activity. The differential reporting of MVPA by unfit and fit individuals presented here suggest participant fitness level should be taken into account when subjective estimations of physical activity are employed.

Fitness level may affect self-report recall of physical activity due to differences in recall as well as to the subjective wording of the questionnaire items which are dependent on the individual's relative level of peak fitness. However, objective measures of physical activity such as the SWA measure absolute levels of physical activity and assign intensity levels based on predetermined (e.g. not individually based) criteria that are independent of an individual's level of fitness. In the current study, moderate intensity activity is defined as ≥3.0 METs and

<6.0 METs. Based on the CRF levels of the unfit and fit groups, this represents activity occurring at 35.3-69.4% and 24.6-48.4% of maximal effort, respectively. Likewise, vigorous activity would occur at ≥70.6% for unfit individuals and ≥49.2% for fit individuals. When compared to the common criteria for prescribing moderate (50-69% of maximum heart rate) and vigorous activity (70-85% of maximal heart rate), it becomes clear that the application of absolute cut points will result in differences in estimations of physical activity across ranges of CRF levels. Unfit individuals would be more likely to perceive and report a traditionally defined "Light" activity as "Moderate" or a "Moderate" activity as "Vigorous".

Practically, the use of absolute cut points across a range of fitness levels would manifest itself in the form of overestimation of MVPA among unfit individuals, and previous studies have reported higher levels of subjective MVPA compared to objective MVPA.[10,31,32] Two recent studies have explored this relationship closely. Canning et al. described feelings associated with 'light,' 'moderate' and 'vigorous' intensity exercise as designated by the Canadian Physical Activity Guidelines.[33] When the participants were asked to walk at a moderate or vigorous pace, only 24% achieved the designated MET values used to categorize these intensities - the majority actually walked at light intensity. A large cross-sectional study (n=1347) compared estimates from a 24hour recall to corresponding estimates from the SWA.[14] The authors reported over-estimations of MVPA of 14.6 minutes per day and differential amounts of error based on age and BMI but contributions of fitness were not examined. The present study demonstrated considerable overestimation by unfit participants but highly accurate results in the fit individuals. It is possible that the extremely close means in the fit group can occur by chance but the results clearly show differences in discrepancies by level of fitness.

The IPAQ is a well-recognized tool used to assess physical activity and which has been found to be a valid and reliable questionnaire that is commonly used[9] when compared to other self-report measures.[34] Originally developed in 1996 by an international consensus group of researchers, it has been extensively tested and found overall to be reliable (long form, ρ= 0.33, 95% CI 0.26-0.39) and valid (long form, ρ = 0.81, 95% CI 0.79-0.82) in a variety of populations including developed countries and urban settings in developing countries.[9] A recent validity study involving 1751 adults across a wide age range have confirmed an association between the IPAQ and accelerometery of ρ= 0.32 (P<.0001);[10] for comparison, a review of seven other subjective measures of physical activity reported a median validity correlation of about 0.30.[34] Our findings suggest a much lower level of validity for MVPA using both the cumulative (ρ= 0.2184, P<.05) and bout (ρ= 0.1354, P<.05) techniques. The correlation between IPAQ and accelerometery appears to be modest for estimating moderate activity (ρ=.41) in some populations, such as young adult men,[15] but not others, such as middle aged men and women (ρ=.21).[35]

Although not designed to do so, the IPAQ has been used to estimate CRF level of respondents based on self-report of physical activity with generally mixed results and correlations ranging from r=.31[35] to r=.41.[15] For example, Fogelholm et al. noted that the most active 20% of participants did not possess the highest CRF levels of the entire sample.[36] Additionally, 10% of participants had a 'poor' CRF level yet reported very high levels of physical activity. While several factors may explain these findings, they are consistent with other studies which have found the IPAQ to overestimate physical activity.[37,38] For example, a comparison of three widely used PA questionnaires found the prevalence of PA via the IPAQ to be 26% higher compared to other surveys.[39]

The strengths of the present study include a large sample size with exceptional SWA wear time. Additionally, the IPAQ was administered during SWA wear period, resulting in simultaneous assessment of physical activity using objective and subjective methods and extending our internal validity. Additionally, our participants included a wide range of activity and CRF levels, extending our external validity. However, despite this wide range of activity and CRF levels, our participants overall would be considered more active and fit than the general US population. As a result, the differences in validity observed here by fitness level may not commonly be observed in populations with homogeneous levels of low CRF and physical activity. It has been suggested that the activity monitors inaccurately estimate the metabolic cost of non-leisure-time physical activity due to the intermittent nature of free-living activities such as housekeeping, which would result in the over- or under- estimation of self-reported MVPA if these activities occurred in high amounts.[40] However, time spent in the various non-leisure time domains of physical activity (e.g. household physical activity) was not different between unfit and fit participants.

In conclusion, the primary finding of the present study was differential self-reporting of MVPA based on fitness level. Unfit individuals over estimated time spent in MVPA as measured using the IPAQ compared to the SWA, resulting from accurate estimation of moderate intensity activity but overestimation of vigorous activity. Conversely, fit individuals accurately reported time spent in MVPA, but underestimated moderate activity and overestimated vigorous activity separately. By identifying sources of bias among participants, such as CRF, users of the IPAQ may improve the subjective assessment of physical activity.

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Author's contributions:

The author's contributions are as follows: RPS, NCG, GAH, and SNB designed the research project; AEP conducted the research; RPS analyzed the data; RPS and NCG wrote the manuscript; all authors read and approved the final manuscript.

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"Subjective Estimation of Physical Activity Using the IPAQ Varies by Fitness Level" by Shook RP et al.
Journal of Physical Activity & Health

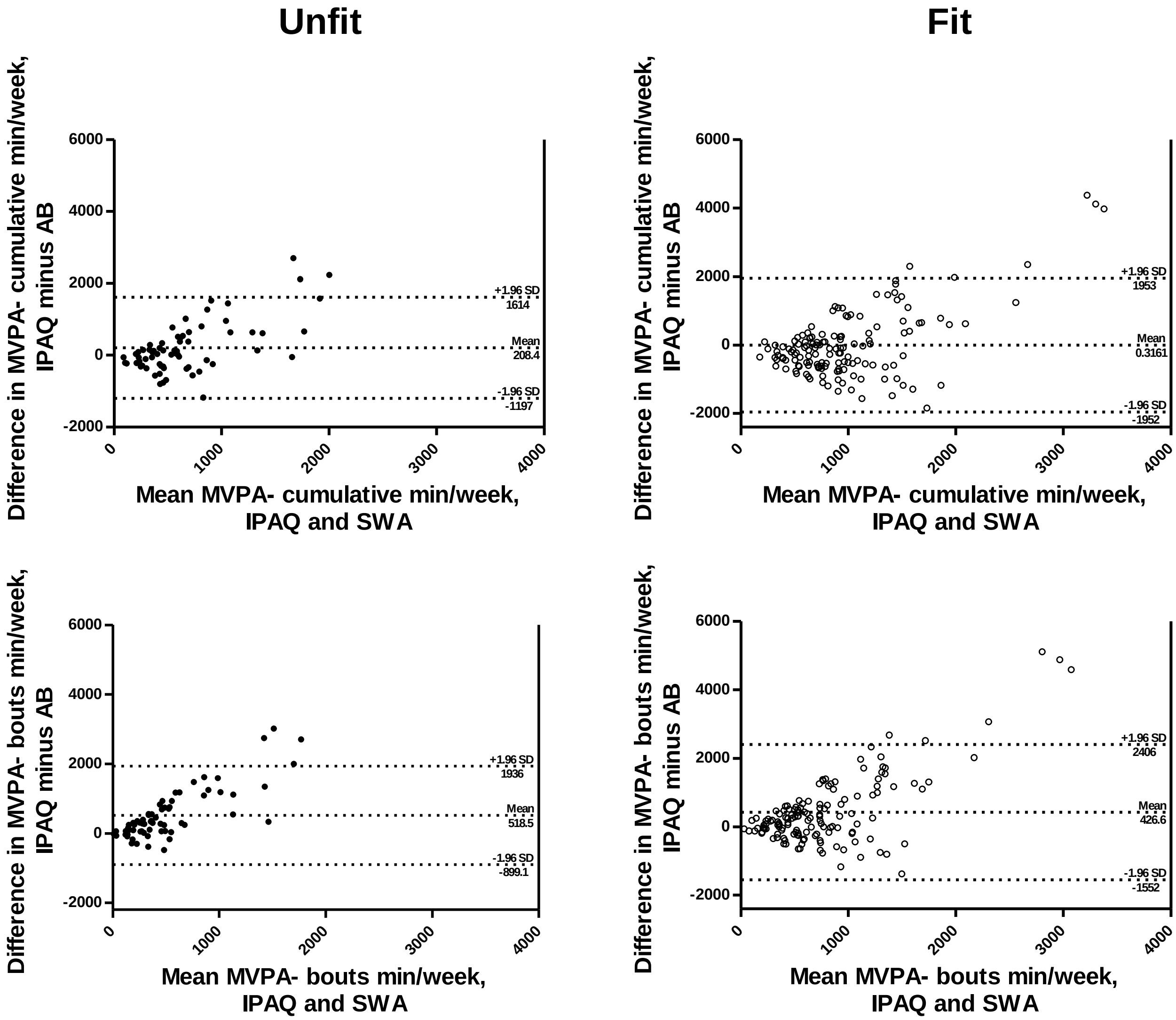

Figure. Bland-Altman plots displaying mean and 95% confidence levels (1.96 SD) for minutes of MVPA by fitness group (Unfit, left column; Fit, right column).

Table 1. Participant characteristics overall and by fitness level.

	All (N=211) (mean±SD)	**Unfit** (n=68) (mean±SD)	**Fit** (n=143) (mean±SD)	Between group differences (*P* value)
Female (%)	53.1	52.9	53.2	.9777
Age (years)	28.1±3.7	28.3±3.9	27.9±3.6	.4562
Height (cm)	171.2±9.3	170.4±9.1	171.5±9.5	.4191
Weight (kg)	76.0±14.1	82.1±14.6	73.1±12.9	<.0001
Body Mass Index (kg/m^2)	25.9±4.0	28.2±4.2	24.8±3.5	.0852
Body fat (%)	28.7±11.0	34.9±10.3	25.8±10.0	<.0001
Education				.4281
<4 years college (%)	8.5	5.9	9.8	
≥4 years college (%)	91.5	94.1	90.2	
Cardiorespiratory fitness (mL/kg/min)	38.5±9.5	29.7±6.6	42.6±7.6	<.0001

Table 2. Physical activity levels (mean±SD) between groups by assessment technique

	All N=211	**Unfit** n=68	**Fit** n=143	Between group differences, *P* value
IPAQ (min/week)				
Sedentary	2985.7±1253.2	3284.5±1405.7	2843.6±1152.0	.0166
Moderate	726.3±805.4	633.9±687.3	770.3±854.6	.2160
Vigorous	188.7±263.0	133.2±214.4	215.1±280.1	.0203
MVPA	915.0±895.0	767.0±740.9	985.4±954.0	.0710
SWA (min/week)				
Sedentary	4852.9±722.2	5314.9±714.9	4633.1±615.9	<.0001
Moderate	797.3±448.0	540.1±338.7	919.7±442.6	<.0001
Vigorous	50.3±72.1	18.6±28.2	65.4±81.2	<.0001
MVPA- cumulative	847.7±481.6	558.7±348.3	985.1±476.1	<.0001
MVPA- bouts	458.8±389.2	248.6±244.6	558.8±405.7	<.0001

Sedentary= IPAQ: time spent sitting; SWA= minutes spent at 1.0 to ≤1.5 METs.

Moderate= IPAQ: sum of time spent in moderate activity for each domain (at work + yard chores + inside chores + leisure + cycling for transport + vigorous yard chores); SWA: minutes spent at ≥3.0 to < 6.0 METs

Vigorous= IPAQ: sum of time spent in vigorous activity (at work + in leisure); SWA: minutes spent at ≥6.0 METs

MVPA= sum of minutes spent in moderate and vigorous activity from IPAQ.

MVPA- cumulative= sum of minutes spent in moderate and vigorous activity from SWA.

MVPA- bouts= sum of minutes spent in moderate and vigorous activity from SWA attained in ≥10 minutes bouts.

Table 3. Differences (mean±SD and percent) between measures (IPAQ minus SWA) overall and by fitness group

	All N=211 (% difference)	**Unfit** n=68 (% difference)	**Fit** n=143 (% difference)	Between method differences- overall, *P* value	Between method differences- unfit, *P* value	Between method differences- fit, *P* value
Sedentary	-1867.2±1232.4 (-38.5)	-2030.5±1295.8 (-38.2%)	-1789.5±1198.0 (-38.6%)	<.0001	<.0001	<.0001
Moderate	-71.0±855.3 (-8.9%)	93.8±683.6 (17.4%)	-149.4±917.8 (-16.2%)	.2285	.2619	.0533
Vigorous	138.4±242.2 (275.2%)	114.6±212.0 (616.1%)	149.7±255.1 (228.9%)	<.0001	<.0001	<.0001
MVPA- cumulative	67.4±919.1 (-8.0%)	208.4±717.2 (37.3%)	0.3±996.2 (0.0%)	.2889	.0194	.9983
MVPA- bouts	456.2±926.4 (99.4%)	518.5±87.7 (208.6%)	426.6±84.4 (76.3%)	<.0001	<.0001	<.0001

Sedentary= IPAQ: time spent sitting; SWA= minutes spent at 1.0 to ≤1.5 METs.
Moderate= IPAQ: sum of time spent in moderate activity for each domain (at work + yard chores + inside chores + leisure + cycling for transport + vigorous yard chores); SWA: minutes spent at ≥3.0 to <6.0
Vigorous= IPAQ: sum of time spent in vigorous activity (at work + in leisure); SWA: minutes spent at ≥6.0 METs
MVPA= sum of minutes spent in moderate and vigorous activity from IPAQ.
MVPA- cumulative= sum of minutes spent in moderate and vigorous activity from SWA.
MVPA- bouts= sum of minutes spent in moderate and vigorous activity from SWA attained in ≥10 minutes bouts.

Table 4. Spearman correlation coefficients between IPAQ and SWA for each level of physical activity, both overall and by fitness level

Subjective	All	Unfit	Fit
Sedentary	.2784**	.4021*	.1911
Moderate	.1664*	.2575*	.1109
Vigorous	.4764**	.1498	.4380**
MVPA- cumulative	.2472*	.3020*	.1589
MVPA- bouts	.2144*	.2365*	.0711

* IPAQ significantly correlated with SWA, $P<.05$
** IPAQ Significantly correlated with SWA, $P<.0001$
Sedentary= IPAQ: time spent sitting; SWA= minutes spent at 1.0 to ≤1.5 METs.
Moderate= IPAQ: sum of time spent in moderate activity for each domain (at work + yard chores + inside chores + leisure + cycling for transport + vigorous yard chores); SWA: minutes spent at ≥3.0 to <6.0 METs.
Vigorous= IPAQ: sum of time spent in vigorous activity (at work + in leisure); SWA: minutes spent at ≥6.0 METs.
MVPA= sum of minutes spent in moderate and vigorous activity from IPAQ.
MVPA- cumulative= sum of minutes spent in moderate and vigorous activity from SWA.
MVPA- bouts= sum of minutes spent in moderate and vigorous activity from SWA attained in ≥10 minutes bouts.

Supplemental Table 1. Differences (mean±SD) between measures (IPAQ minus SWA) overall and by fitness group, males only

	All N=99	**Unfit** n=32	**Fit** n=67	Between method differences- overall, *P* value	Between method differences- unfit, *P* value	Between method differences- fit, *P* value
Sedentary	-2091.1±1255.4	-2197.4±1418.7	-2040.3±1170.0	<.0001	<.0001	<.0001
Moderate	84.2±1029.6	-37.2±777.0	142.2±1131.3	.4176	.7885	.3072
Vigorous	-168.9±270.1	-106.9±176.3	-198.4±301.7	<.0001	.0017	<.0001
MVPA- cumulative	-84.6±1117.8	-144.1±811.4	-56.2±1242.4	.4531	.3228	.7123
MVPA- bouts	-503.9±1142.6	-483.0±820.2	-514.0±1273.7	<.0001	.0022	.0015

Supplemental Table 2. Differences (mean±SD) between measures (IPAQ minus SWA) overall and by fitness group, females only

	All N=112	**Unfit** n=36	**Fit** n=76	Between method differences- overall, *P* value	Between method differences- unfit, *P* value	Between method differences- fit, *P* value
Sedentary	-1669.2±1182.1	-1882.0±1176.0	-1568.4±1179.6	<.0001	<.0001	<.0001
Moderate	59.5±669.2	-144.1±595.1	156.0±684.2	.3487	.1551	.0506
Vigorous	-111.4±212.1	-121.3±241.8	-106.8±198.0	<.0001	.0048	<.0001
MVPA- cumulative	-51.9±703.2	-265.5±628.0	49.2±718.0	.4362	.0158	.5519
MVPA- bouts	-414.1±683.4	-550.0±635.0	-349.7±700.0	<.0001	<.0001	<.0001

Supplemental Table 3. Are the differences by method (IPAQ minus SWA) for each level of fitness different by sex?

	Unfit	**Fit**
	P value	*P* value
Sedentary	.0982	.7102
Moderate	.9997	.9552
Vigorous	.1069	.9947
MVPA- cumulative	.9028	.9482
MVPA- bouts	.7173	.9909