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Self-reported and Objectively Measured Physical Activity in Adults with Systemic Lupus Erythematosus

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Abstract

Objective—Most estimates of physical activity (PA) patterns in systemic lupus erythematosus (SLE) are based on subjective self-report measures prone to error. The aims of this study were to obtain objective measurements of PA using an accelerometer and estimates of energy expenditure based on the self-reported International Physical Activity Questionnaire (IPAQ), and to describe their relationship.

Methods—The "Activity in Lupus To Energize and Renew" (ALTER) study, a cross-sectional study of PA, included 129 persons with SLE. Accelerometer measures over 7 days included total daily activity counts and minutes of moderate-vigorous physical activity (MVPA). Each person completed the IPAQ via telephone interview. Spearman correlations (r) and 95% confidence intervals (CIs) assessed associations between accelerometer and IPAQ.

Results—Daily PA means (SD) from accelerometer measures were total daily activity counts, 502,910 (118,755) and MVPA, 40 (30) minutes. The median (interquartile range) MET-min per day for IPAQ intensities were: total 400 (159–693); walking, 83 (26–184); and moderate-vigorous, 231 (77–514), and domains were: work 0 (0–73); active transportation 28 (0–85); domestic and garden 77 (26–231); and leisure 57 (0–213). Associations between accelerometer measures and IPAQ were: 1) total daily count vs. IPAQ total, r=0.21, 95% CI: (0.03, 0.37); and 2) MVPA vs. IPAQ moderate-vigorous, r=0.16, 95% CI: (-0.02, 0.33).

Conclusion—Accelerometer measures and IPAQ energy expenditure estimates were moderately correlated. IPAQ provided descriptive PA data whereas accelerometers captured all daily activities and can help assess guideline attainment. The choice of IPAQ versus accelerometer measure should consider the purpose for which PA is measured.

Introduction

Physical activity (PA) in persons with rheumatic diseases is thought to be limited due to the burden of disease. Only a few studies describe objective and self-reported PA measurements and PA guideline achievements in persons with osteoarthritis and rheumatoid arthritis (1–3). Previous studies of persons with systemic lupus erythematosus (SLE) have utilized self-

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report questionnaires to capture PA including the Medical Outcomes Study (MOS) Short Form 36 (SF-36) (4) with a simple self-assessed question, such as "How often per week, on average, have you been physically active at least 30 min/day at a 'high' exertion level, during the past six months?"(5, 6) and SF-36 with Multiethnic Study of Atherosclerosis (MESA) Typical Week Physical Activity Survey (7), adapted from the Cross-Cultural Activity Participation Study of women (6, 8). One self-reported measure, the International Physical Activity Questionnaire (IPAQ)(8), also has been utilized in SLE (9). While self-reported instruments generally require less time to complete, they can be prone to inaccuracies. Persons have been found to underestimate their daily walking distance (10) and overestimate their energy expenditure, with a tendency for greater overestimation in older and more obese individuals (11, 12). Different instruments have been used to capture aerobic capacity in persons with SLE, including measurement of maximal oxygen uptake (VO_2 max) with a cycle ergometer exercise test and peak oxygen consumption during the treadmill test, and show decreased aerobic capacity in SLE and low-to-moderate activity (5, 13). One of the critical limitations of these previous objective measures is the inability to capture continuous routine daily PA of individuals.

Accelerometers have been successfully used with adults having chronic conditions and in clinical situations to detect PA levels (1, 14–18). Accelerometers provide a reliable tool to accurately capture PA intensity, frequency, and duration (e.g., moderate-vigorous physical activity [MVPA] minutes/day), but this objective assessment can be expensive in large scale studies compared to self-reported measures. Current PA guidelines for adults, including those with arthritis, recommend 150 minutes each week of MVPA accumulated in bouts lasting at least 10 minutes (19–21). The importance of guideline attainment motivates research that can assess the metric of MVPA bouts or a surrogate of the measure. To date, no study has been published using objective PA monitors such as accelerometers to assess activity levels in the population with SLE; instead studies have relied on subjective responses to questionnaires. To address these measurement challenges, we obtained objective accelerometer and self-reported IPAQ PA measures in patients with SLE, and investigate the associations between these measures.

Materials and Methods

Study Population

All study participants in Activity in Lupus To Energize and Renew (ALTER) are enrolled in the Chicago Lupus Database (CLD), a registry established at Northwestern University in 1991. Currently, there are 728 patients registered in the CLD who fulfill 4 or more of the 1982/1997 revised American College of Rheumatology criteria for SLE (22, 23). Participants were recruited by letters of invitation, phone calls, and in-person during clinic visits from November 2011 to December 2012. Among 167 participants recruited, 19 declined due to scheduling conflicts, and the remaining 18 declined because of health issues or other personal reasons. One hundred thirty patients initially enrolled in ALTER. Accelerometer data were collected from 129 ALTER participants at baseline visit. One person was excluded after review of a skin biopsy that failed to conclusively document

malar or discoid skin lesions, therefore unable to fulfill eligibility classification criteria for SLE. The final study results reported herein include 129 study participants.

Physical Activity Accelerometer Measurement

PA was measured using a GT3X ActiGraph accelerometer (ActiGraph; Pensacola, FL), a small triaxial accelerometer that measures acceleration and deceleration in three planes (24). The accuracy (walking speed (25)) and test-retest reliability (26) of ActiGraph accelerometers under field conditions have been established in many populations including persons with rheumatic disease (27). The vector magnitude from the triaxial accelerometry was computed using a specific Freedson algorithm described by Sasaki et al (28).

Trained research personnel gave uniform scripted in-person instructions to wear the accelerometer on a belt at the natural waistline on the right hip in line with the right axilla upon arising in the morning and continuously until retiring at night, except during water activities, for seven consecutive days. Participants maintained a daily log to record time spent in water and also cycling activities, which may not be fully captured by accelerometers. Participants returned the accelerometers to the research center, where data were downloaded using the manufacturer's software, and checked for valid data recording.

Accelerometer output is an activity count, which is the weighted sum of the number of accelerations measured over a minute, where the weights are proportional to the magnitude of measured acceleration. Accelerometer data were analytically filtered using methodology validated in patients with rheumatic disease (29, 30). Non-wear periods were defined as ≥90 minutes with zero activity counts (allowing for two interrupted minutes with counts<100) (30). A valid day of monitoring was defined as 10 or more wear hours per day (31). To provide reliable PA estimates, we restricted analyses to participants with at least 4 valid days of accelerometer monitoring (31). We applied intensity thresholds used per Freedson algorithm (28) on a minute-by-minute basis to classify activity as MVPA (counts ≥2690). Average daily activity counts and time (minutes) spent in MVPA were estimated.

IPAQ

The IPAQ long questionnaire is a recall instrument designed to assess PA and inactivity in adults aged 18–65 years (32). This instrument was chosen for the study after considering the average age of adults with SLE. The IPAQ long form questionnaire assesses 7-days of PA across a comprehensive set of domains including leisure time, domestic and gardening (yard), work-related, and transport-related physical activities and can be conducted via telephone interview. Computation of the long form total scores sums the duration (in minutes) and frequency (days) for all types of activities in all domains and can be viewed as a continuous variable, and summarized by median minutes/week or median MET-minutes/week. METs are assigned to activities based on intensity levels (moderate = 4.0, walking = 3.3, vigorous = 8.0). The calculated IPAQ score has demonstrated reliability and validity; higher scores represent greater levels of activity (32).

Other Measurements

The Safety of Estrogens in Lupus Erythematosus – National Assessment-Systemic Lupus Erythematosus Disease Activity Index (SELENA-SLEDAI) was used to assess disease activity, with score range from 0 to 105, with <4 indicating inactive disease (33). The Systemic Lupus International Collaborating Clinics/American College of Rheumatology-Damage Index (SLICC/ACR-DI) was used to assess cumulative organ damage with maximum score of 46 (34). Current medication use was collected as part of the disease assessment.

Statistical Analysis

Our primary cross-sectional study (ALTER) was designed to enroll 130 participants to test our primary hypothesis that lower fatigue is associated with higher physical activity, and assumes at most 10–15% attrition (thus providing about 110 evaluable participants for analysis). For a (conservative) two-sided test using α=0.05 and β=0.10 (90% power), we required n=112 patients to detect a moderate correlation of 0.30 between our primary outcome, fatigue, measured by the Fatigue Severity Score (FSS) and our primary physical activity measure (average daily accelerometer activity count). With 80% power we can expect to detect correlations as small as 0.25 with n=123 evaluable patients. The current analysis was an ancillary study to the ALTER project where we compared accelerometer and IPAQ measures of physical activity.

Data are summarized using means and standard deviations (SDs) and medians and interquartile ranges (IQRs) for continuous variables, as appropriate, depending on whether the distributions are approximately Gaussian or not. In particular, IPAQ results are reported as medians (IQR) as recommended in the literature, and means (SD) were also recorded. Frequencies and percentages are used to summarize categorical variables. Spearman's rank correlation coefficients (r) and associated 95% confidence interval (CI), based on Fisher's z transformation of r, are used to estimate the associations between IPAQ physical activity measures and each of two accelerometer PA summary measures (average daily counts and average daily MVPA minutes). A Spearman correlation coefficient with 95% CI that excludes 0 is considered to be statistically significant (two-sided p value < 0.05). All analyses were performed using SAS statistical software version 9.2 (Cary, NC).

Results

Of the 129 study participants in ALTER, 127 (98%) completed IPAQ, and 120 (93%) had at least 4 valid days of accelerometer monitoring. Demographic characteristics of the final ALTER study participants are given in Table 1. Women comprised a majority of the participants, who were predominantly Caucasian with the mean (SD) age of 45.4 (10.9) years. The average BMI was 27.9 (8.0) kg/m^2. Most participants had low disease activity with a mean SELENA-SLEDAI at 2.4 (2.8), had minimal damage with a mean SLICC/ACR-DI of 1.7 (2.2), and only 47% (n=61) were taking immunosuppressive medications at the time of their study participation.

ALTER participants did not differ significantly compared to other persons in the Chicago Lupus Database in race/ethnicity (e.g. Caucasian 53% ALTER vs. 60% others; African Americans 27% vs. 25%; Hispanic 9% vs. 10% with p=0.1) or BMI (27.9 ± 8.0 kg/m^2 vs. 26.6 ± 6.6 kg/m^2). However, ALTER participants were older (45 years vs. 36 years with p<0.0001), less likely to have smoked (24% vs. 31% with p=0.1), had longer mean disease duration (15 years vs. 11 years with p=0.0003), and used more anti-malarials (85% vs. 45% with p<0.0001), mycopheolate mofetil (18% vs. 6% with p<0.0001), and tacrolimus (1% vs. 0 with p=0.2).

Average accelerometer wear time was 866.4 min/day (95% CI: 852, 882) and 6.41 days/week (95% CI: 6.26–6.57). Objective daily PA measured by triaxial accelerometry showed that adults with SLE spent 39.6 minutes in MVPA on average (Table 2). IPAQ data indicated that SLE adults engaged most of their PA time in domestic and garden domain (median 77.1 MET-min per day), followed by leisure (56.6 MET-minutes per day) and active transportation (28.3 MET-min per day) (Table 3). In contrast to the objective data, in Table 3, self-reported IPAQ showed that SLE adults spent more time in MVPA (median 231.4 MET-min per day) compared to walking (median 82.5 MET-min per day) activity.

The correlations between self-reported and objective PA measures in SLE adults were modest (Table 4). Association between accelerometers and IPAQ [Spearman correlation r (95% CI)] were: MVPA min/day and IPAQ moderate-vigorous MET-min/day r=0.16 (−0.02, 0.33) and accelerometer total counts to IPAQ Total MET-min/day 0.21 (0.03. 0.37). The correlation between accelerometer MVPA min/day and IPAQ Total MET-min/day was 0.26 (0.08, 0.42). There were no significant differences between the correlations when stratified by age, gender, and disease status (data not shown).

We also looked at the impact of weight and corticosteroid use on PA. When the ALTER data were adjusted for BMI, the objectively measured PA differed significantly between those with normal (BMI < 25 kg/m2) versus overweight/obese (BMI ≥ 25 kg/m2) BMI only in total activity, and the difference was not statistically significant for objective MVPA or self-reported measures (data not shown). The correlations between the objective and subjective assessments were stronger between objective MVPA and subjective measures in those of normal weight, but the correlations were less and not significant for those overweight/obese (data not shown). When PA was stratified by the prednisone use, there were no significant differences between those who used corticosteroids and those who did not, in all the PA measures. The correlations between objective and subjective PA were stronger in those who did not use corticosteroids with some significance in the IPAQ total score correlations to the accelerometers, but no significance was found in others (data not shown).

Discussion

To our knowledge, our study is the first to evaluate and compare subjective and objective measures of PA in SLE adults with the IPAQ long self-report questionnaire and the ActiGraph GT3X accelerometer. The IPAQ provided useful descriptive information, reflecting times engaged in different domains of work, active transportation, domestic and

garden, and leisure, in addition to intensity levels of PA shown by the IPAQ and accelerometry. Most adults self-reported more time on domestic and garden activities and leisure-time activities and the least time in the “active” category of active transportation. Accelerometers provided objective information about time per day spent in different PA levels.

Activity accelerometers have been utilized to objectively measure PA since the 1980’s. Most of the monitors were uniaxial devices that measured activity in a vertical plane only. In 2009, the ActiGraph released a newer model, the GT3X that allowed triaxial data collection (vertical, anterior-posterior, and mediolateral). The triaxial accelerometer was developed to capture more activities using 3 planes of axis due to concerns of uniaxial accelerometer’s inability to capture side-to-side motion and sliding motion during slow walking speeds. The majority of previous research studies were conducted using uniaxial accelerometers, but Kaminsky et al. compared standardized walking speeds and free-living conditions, and recommended that it is reasonable to compare data derived from the uniaxial and triaxial models (35).

The amount of time per day spent in MVPA and total PA as measured with the accelerometer in this study of adults with SLE was comparable to the amount of PA in adults within the general population, although data from triaxial reports of PA are limited in adults. In a PA study utilizing ActiGraph GT3X triaxial accelerometers in healthy older men and women with mean age of 66 years, average (SD) movement counts/min were 321.7 (138.4) and MVPA min/day were 36.9 (25.7) (36). These values for total counts and MVPA min/day were similar to our study with ALTER participants (349.2 counts/minute (502,910 counts/day divided by 1440 minutes/day) and MVPA of 36.9 min/day). Although this study showed SLE adults having average of 39.6 min/day in MVPA, only 12.6 min/day were in MVPA accumulated in bouts lasting at least 10 minutes (data not shown), therefore not meeting the current PA guidelines for general adult population.

The performance of the IPAQ in this study was comparable to other reports. In a study by Vasheghani-Farahani with healthy older adults, the mean total IPAQ score was 719.1 MET-min/day; higher scores which would be expected in a healthy population as compared to our ALTER participants with SLE (mean total score of 531.9 MET-min/day) (37). In the Vasheghani-Farahani study, the most commonly activity reported was in the work domain which is in contrast to our results where domestic and garden were the most commonly reported activity domains. This may reflect that individuals who are chronically ill may have a higher unemployment rate and be engaged in less energetic activities. In another study, Rosemann et al used the IPAQ in an osteoarthritis population to show mean total IPAQ score of 392.4–404.4 MET-min/day (38), which interestingly, was lower than IPAQ mean total score from our study (531.9 MET-min/day). While it is not possible to determine why the values differ, it is possible that physiologic disability stemming from hip or knee joint damage may have limited participants from engaging in activities.

Our study also evaluated the correlation between two measures of PA: self-reported IPAQ and objectively measured average daily activity counts, and time spent in MVPA in SLE adults. The IPAQ total MET-min/day correlated modestly with accelerometer average daily

total counts and accelerometer MVPA min/day in the ALTER study participants. The correlations obtained between the IPAQ long questionnaire and accelerometer data are similar to those published in other studies (32). These very modest associations support the thought that the types of PA captured in a PA questionnaire reflect a different domain of PA (self-reported type and intensity) than PA measured using an objective monitor worn on the body. Differences aside, both subjective questionnaire data and objective monitor data provide useful feedback about a person's type, duration, and intensity of PA.

IPAQ data were expressed as the MET-min/day for MVPA and total daily activity. Accelerometer data were expressed as daily activity counts, and time spent in MVPA. Accelerometer measures showed a mean (median) of 39.6 (31.9) min/day of MVPA and the IPAQ estimated a median of 231.4 MET-min/day of MVPA. Although IPAQ and accelerometer assessments both provided useful PA measures, the IPAQ provided considerably higher PA scores for time spent in MVPA than the ActiGraph accelerometer. This finding is consistent with results from studies comparing the IPAQ and accelerometers (36). Both questionnaires and accelerometers have value for use in longitudinal and intervention studies because they have been documented to show changes in PA over time. For example, one study utilized an internet intervention as a way of effectively increasing self-reported and objective PA in persons with multiple sclerosis. These investigators paired IPAQ and accelerometer measures for each study participant to measure PA. They found that the change in objectively measured PA was more strongly correlated with the internet intervention over a 3-month period compared to the self-reported PA (39).

While the study showed that data from the IPAQ long questionnaire and the ActiGraph GT3X accelerometers could be obtained in SLE patients, there were some limitations to our study that should be noted. First, accelerometers used in the study did not capture water activities and may have underestimated time spent bicycling or in other activities that do not cause body deflections. These omissions could systematically underestimate PA. However, diary information indicated that the time these participants spent in water and cycling activities was minimal and likely did not lower the correlation between the IPAQ and accelerometers. Second, higher BMI may interfere with accurate accelerometer measures due to the interference of abdominal adiposity in accurate monitor placement (40). A recent study by Feito et al., found that BMI did not have a statistically significant effect on accelerometer recorded activity counts (41). The ALTER study, which has a majority of normal weight participants, mitigated this concern by individualized instruction on correct accelerometer placement for each participant. Because the triaxial accelerometer has been developed more recently, there are ongoing studies to test validity and reliability of different PA level cutpoints with these devices, and this may be another limitation to the study While the Freedson triaxial cutpoints of MVPA used in this study have been validated (28), other cutpoints using triaxial devices (such as light activity and non-sedentary activity) have yet to be validated. As such, these lower-intensity activities were not included in this study. Lastly, the subgroup of SLE adults in our study represents those with long disease duration (average duration of 14.5 years, data not shown) with low disease activity (Table 1), and this may not accurately describe general SLE population.

In conclusion, the self-reported IPAQ and objective measures of PA were obtained and compared in adult SLE patients. The IPAQ provided useful descriptive PA data, which showed modest correlations with accelerometer measurements. The IPAQ long questionnaire can be a valuable tool to complement accelerometry because it can identify the types of activities performed and describe changes in the frequency and types of PA in patients with SLE in future intervention studies.

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Significance and Innovations

- The self-reported International Physical Activity Questionnaire (IPAQ) showed a moderate association with accelerometer measures in adults with SLE.
- The self-reported IPAQ and objective accelerometer data may be useful for different purposes in future research studies. The IPAQ provides descriptive data on the types of PA performed while accelerometer data may be useful when a change in PA is the outcome of interest in intervention studies.

Table 1

Demographic and Clinical Characteristics of Study Sample (n=129)

Variable	% (n)or Mean (±SD)
Sex: Men	6.2% (8)
Women	93.8% (121)
Caucasian race	52.7% (68)
Age, years	45.4 ± 10.9
BMI, kg/m^2	27.9 ± 8.0
Weight: Normal (BMI < 25 kg/m^2)	42.6%(55)
Overweight (BMI 25.0–29.9 kg/m^2)	27.1% (35)
Obese (BMI ≥ 30 kg/m^2)	30.2%(39)
SELENA-SLEDAI	2.4 ± 2.8
SLICC/ACR	1.7 ± 2.2
Medications	
Anti-malarials	84.5% (109)
Steroids (mean dose 10.6mg)	47.3% (61)
Immunosuppressives[a]	
Mycophenolate Mofetil	17.8% (23)
Azathioprine	10.9% (14)
Methotrexate	10.9% (14)
Cyclosporin	0.8% (1)
Leflunomide	0.8% (1)
Tacrolimus	0.8% (1)

SD: Standard deviation; BMI: Body Mass Index; SELENA-SLEDAI: Safety of Estrogen in Lupus Erythematosus National Assessment-SLE Disease Activity Index; SLICC: Systemic Lupus International Collaborative Clinics/ACR Damage Index; IPAQ: International Physical Activity Questionnaire

[a]No patients were on Cyclophosphamide

Table 2

Objective Daily Physical Activity Measures(n=120[a])

Accelerometer Daily Average	Mean (±SD) Median (IQR)
Total counts	502910 ± 118755 479218 (367264–586640)
MVPA minutes per day [b]	39.6 ± 29.9 31.9 (19.7–51.7)

SD: Standard deviation; IQR: Interquartile range

[a] excludes 9 participants with <4 days of valid accelerometer monitoring

[b] Moderate-to-Vigorous Physical Activity (MVPA) = count per minute≥2690

Table 3

Self-report Daily Physical Activity Measures from the International Physical Activity Questionnaire (IPAQ) (n=127[a])

IPAQ		Mean (SD) MET-min per day	Median (IQR) MET-min per day
Domains	Work	146.4 (338.7)	0.0 (0–72.9)
	Active Transportation	79.3 (180.8)	28.3 (0–84.9)
	Domestic and Garden	177.8 (227.8)	77.1 (25.7–231.4)
	Leisure	128.5 (162.4)	56.6 (0–212.8)
Intensities	Walking	172.5 (266.0)	82.5 (25.9–183.9)
	Moderate-to-Vigorous	359.4 (374.2)	231.4 (77.1–514.3)
	Total	531.9 (477.3)	400.1 (159.0–693.1)

[a] excludes 2 participants with missing IPAQ

Table 4

Associations between IPAQ and Accelerometer-based Measures: Spearman correlation(r) and 95% CI (n=118[a])

	Accelerometer Total	Accelerometer MVPA
IPAQ Total	0.21[b] (0.03, 0.37)	0.26 [b] (0.08, 0.42)
IPAQ Moderate-Vigorous	0.15 (−0.03, 0.32)	0.16 (−0.02, 0.33)

IPAQ: International Physical Activity Questionnaire; CI: confidence interval

[a] excludes 9 participants with <4 days of valid accelerometer monitoring and 2 participants with missing IPAQ

[b] p<0.05