

# Physical Activity and Sleep Differences Between Osteoarthritis, Rheumatoid Arthritis and Non-Arthritic Samples in China: Comparing Objective Measures versus Self-Reports

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## Research article

**Keywords:** physical activity, sleep, osteoarthritis, rheumatoid arthritis, Sensewear

**Posted Date:** January 7th, 2020

**DOI:** <https://doi.org/10.21203/rs.2.20151/v1>

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**Version of Record:** A version of this preprint was published at BMC Public Health on October 9th, 2021.  
See the published version at <https://doi.org/10.1186/s12889-021-11837-y>.

# Abstract

## Background and Objectives

Objectively-measured differences in physical activity (PA) and sleep have been documented in osteoarthritis (OA) or rheumatoid arthritis (RA) samples compared to non-arthritic controls. However, it is not clear whether (1) OA and RA subgroups also differ on these indexes or (2) the extent to which distinct arthritis subgroups versus controls can be accurately identified on the basis of objective PA and sleep indexes compared to self-report measures. This study addressed these gaps.

## Methods

Gender- and age-equated Chinese adults diagnosed with OA (29 women, 11 men) and RA (29 women, 11 men) as well as non-arthritic controls (29 women, 11 men) wore a Sensewear Armband (SWA) for 7 days to obtain objective PA and sleep data in addition to completing complementary, widely-used self-report measures.

## Results

There were no differences between the three groups on any of the 13 self-report PA and sleep indexes completed. Conversely, OA and RA subgroups displayed significantly lower PA levels and more sleep problems than controls did on a majority of SWA indexes, though arthritis subgroups were not differentiated from one another on these measures. Based on non-multicollinear SWA indexes (steps, moderate activity, vigorous activity, time awake after sleep onset), 75 - 82.5% of arthritis subgroup members were correctly identified while accuracy rates were attenuated for controls.

## Conclusions

Where possible, objective measures should be used to assess PA and sleep of OA and RA patients while particular self-report PA questionnaires should be avoided.

## Background

Deficits in physical activity (PA) and sleep are prevalent within arthritis populations [1,2,3,4,5,6], contribute to reduced quality of life [7,8,9] and predict poor health outcomes such as cardiovascular disease morbidity and mortality [10,11]. These data have been derived from objective measures of PA and sleep as well as complementary self-report instruments. Although questionnaires are inexpensive and convenient to use, PA and sleep estimates calculated from them correlate inconsistently with objective indexes [12,13,14], and appear to discriminate arthritis samples from controls less accurately than objective measures do [15,16].

Accelerometers have emerged as valid objective alternatives to questionnaires and assess PA in contexts of daily life [17]. Small, unobtrusive, comfortable to wear devices can track intensity, duration, and

frequency of PA in a manner that controls for potential biases in recall and social desirability. Some PA trackers such as the Sensewear Armband (SWA) have added advantages of differentiating sedentary activity from sleep and generating accurate data regarding sleep parameters [16].

Studies based on objective assessments have documented less frequent, less intense PA levels and/or more frequent sleep disturbances within various arthritis subgroups compared to non-arthritic controls [16,17,18,19]. To illustrate, Pioreschi et al. [17] used accelerometers to assess habitual PA of rheumatoid arthritis (RA) patients and non-arthritic controls. RA patients displayed significantly more sedentary activity than controls did. Higher PA levels were also related to better health-related quality of life. In other research, osteoarthritis (OA) patients and non-arthritic controls showed no significant differences in average daily energy expenditures but the former group displayed less PA based on average steps per day [18].

Despite evidence of arthritis versus control differences on objectively-assessed PA and sleep, the associated literature has important gaps. First, arthritis subgroup (e.g., OA vs. RA) comparisons of PA and sleep have received comparatively little attention. Studies have reported no differences between patients with RA versus fibromyalgia [5] or lupus [15] but may have been under-powered due to small sample N's. Evaluations within larger samples would provide more rigorous tests of arthritis subtype differences in PA and sleep. Such information could clarify whether matching PA or sleep targets with specific interventions has utility within particular arthritis subgroups. Furthermore, because evidence is based almost exclusively on samples from Western countries, it is not clear whether findings apply to groups in understudied yet highly populated low and middle income countries (LMICs). To illustrate, overall rates of OA and RA in China are comparable to or higher than those reported in higher income Western countries [20,21] but the relative paucity of well-trained, qualified treatment specialists [22,23] and low affordability of newer biological agents [24] are more pronounced barriers to care. Clarifying whether and how PA and sleep are affected by arthritis in understudied cultural contexts provides critical foundations for the development and use of informed guidelines to improve these facets of functioning.

This study had two purposes. First, we assessed differences in objective versus questionnaire measures of PA and sleep between gender-matched samples with OA, RA, and non-arthritic controls. Based on related research [15], arthritis subgroups were expected to display comparatively less PA and more sleep disturbances than controls would, especially on objective indexes. Conversely, few OA vs. RA subgroup differences were expected. Second, we assessed the accuracy of significant objective and subjective measures of PA and sleep in identifying group membership of arthritis patients versus controls; objective indexes were expected to be more sensitive than self-reports.

## Method

### Participants

The sample comprised Chinese adults with OA (29 women, 11 men) and RA (29 women, 11 men), as well as gender-matched non-arthritic controls (CON) who did not report ongoing pain (29 women, 11 men). On

average, the sample was 57.22 years of age (SD = 16.64 years) with a majority reporting education of less than high school completion (82%) and a current committed relationship (78%). On average, participants had a body mass index (BMI) of 23.44 (SD = 3.13, range: 16.23 - 31.22). Majorities reported neither smoking (83%) nor consuming alcohol (83%) at present. For pain duration, subgroups with OA (M = 127.40 months, SD = 128.26) and RA (M = 139.85 months, SD = 117.22), did not differ,  $t = -0.453$ ,  $p = 0.652$ . Pain-related interference with daily activities during the past week, rated between 1 = *None* and 5 = *Extreme*, did not differ between arthritis subgroups (OA: M = 2.63, SD = 1.10 vs. RA: M = 3.03, SD = 1.21,  $t = 1.55$ ,  $p > .126$ ).

## Procedure

The study was approved by the Human Research Ethics Committee of Southwest University, Chongqing (534472715). Participants were recruited from local community settings affiliated with the university (i.e., large apartment complexes), two local hospitals, and extended social networks of students ( $n = 9$ ) assisting with data collection. Selection criteria included (1) age of at least 18 years, (2) either a physician-based diagnosis of OA, a diagnosis of RA based on 2010 American College of Rheumatology criteria [25] or the absence of ongoing chronic pain for three months or longer, (3) absence of neurological or psychiatric conditions that could interfere with comprehension, (4) ambulatory independence with minimal assistance (i.e., walking with or without a cane), and (5) absence of allergies to copper given the need to wear the armband for extended intervals.

Management from contacted settings provided permission to recruit volunteers via print advertisements and contacts from organization staff. Those who wished to be involved were given a general description of the research (i.e., a study on physical activity, sleep and health among adults with arthritis or an absence of ongoing pain), an informed consent detailing the voluntary, confidential nature of participation, estimated time involved (one week), and compensation (250 yuan), the self-report measures below and an SWA. Research personnel were on hand to ensure participants understood data collection procedures and to answer queries. Participants were asked to wear the SWA for seven consecutive days, except during water-based activities, for at least 21.5 hours per day in line with criteria of past work [26]. During the study, participants received a daily text message with reminders to continue wearing the SWA and finish the sleep diary. Sleep diaries were completed every day and the PA questionnaire was completed after SWA data had been collected. Upon completion, each participant was compensated and SWA data printouts were provided and discussed upon request.

Questionnaire measures had been back-translated previously into Mandarin or underwent Mandarin translation to English back-translation procedures by two fluently bilingual members of the research team. Discrepancies between translations and original scale versions were discussed with the corresponding author to most closely approximate intended item meaning.

## Objective Measures

**SenseWear Armband (SWA)** (model: MF-SW; Body Media, Pittsburgh, PA, USA). The SWA is worn over the left tricep and uses multiple sensors to assess heat flux (i.e., heat dissipated from body), galvanic skin response (estimate of skin conductivity) and skin temperature as well as a three-axis accelerometer that estimates energy expenditures at varying metabolic equivalents (METs) from sleeping peacefully to vigorous PA [27]. Aside from these indexes, we assessed sedentary (0–1.5 METs), moderate (3.0–6.0 METs), and vigorous (above 6.0 METs) activity levels, total PA equal to or greater than 3 METs, PA duration, (PAD), number of steps, and time lying down.

SWA reliability and validity have been satisfactory in general samples [28] as well as those with arthritis [27,29]. In this study, SWA estimates from two days evaluated device reliability [28]. The SWA produced reliable estimates of PA in the OA sample (i.e., reliabilities of individual parameters ranged from  $r = .72$  to  $.93$ , with an average of  $r = .88$ ), RA sample (individual parameter reliabilities ranged from  $r = .82$  to  $.91$  with a mean of  $r = .90$ ) and control group (parameter reliabilities ranged from  $r = .75$  to  $.95$  and averaged  $r = .89$ )

Because the SWA differentiates sedentary activity from sleep and is reliable and valid in assessing sleep parameters in various populations [16,30,31], data were also collected during the 7 consecutive nights of use. Following Oudegeest-Sander et al. [32], we assessed (1) sleep onset latency (SOL) based on the interval between “lights out” and the beginning of “sleep onset”, (2) waking after sleep onset time (WASO) as duration of “awake” epochs (in minutes) that occurred after sleep onset and before final awakening, (3) total sleep time (TST) as number of minutes sleeping, and sleep efficiency (SE) as total sleep time divided by total lying down time  $\times 100$ . In this study, intra-class correlations were acceptable across subgroups, with the exception of SOLs in the control group: TST (OA =  $.90$ , RA =  $.82$ , CON =  $.86$ ), WASO (OA =  $.71$ , RA =  $.86$ , CON =  $.82$ ), SOL (OA =  $.76$ , RA =  $.70$ , CON =  $.59$ ), and SE (OA =  $.90$ , RA =  $.87$ , CON =  $.87$ ).

## Self-Report Measures

**International Physical Activity Questionnaire Short Form-Chinese (IPAQ-SF-C)** [33]. The IPAQ-SF is a standardized PA questionnaire that has been used cross-culturally in populations 18-65 years of age [34]. The scale consists of seven items requiring PA estimates during the previous week, including number of days and amount of time spent walking, sitting, or participating in moderate PA (e.g., carrying light loads, bicycling at regular pace, doubles tennis) and vigorous PA (heavy lifting, digging, aerobics, fast bicycling). Acceptable psychometrics have been reported in various population subgroups [33,34]. Alphas for OA ( $\alpha = .74$ ) and RA ( $\alpha = .76$ ) subgroups in this study were satisfactory while that of the CON subgroup ( $\alpha = .68$ ) approached the conventional threshold of acceptability ( $\alpha = .70$ ).

**Pittsburgh Sleep Diary (PSD)** [35]. The “waketime” PSD assess several self-reported sleep parameters: (1) SOL in estimated minutes, (2) total time in bed (TIB) based on to bed and wake up times in minutes, (3) frequency of nightly awakenings (FNA) between *0 = not at all* and *5 or more = number of awakenings per night*, (4) TST from 0 minutes to TIB, (5) WASO measured as awake minutes after sleep onset before lights on and ranging from 0 minutes to TIB - SOL - TST, and (6) sleep efficiency percentage (SE) based

on the formula,  $SE = TST/TIB$ . We also assessed (7) sleep quality (SQ), ranging from  $0 = not\ at\ all\ refreshed$  to  $10 = completely\ refreshed$  and (8) alertness on final waking, ranging from  $0 = not\ at\ all\ alert$  to  $10 = completely\ alert$ . Nearly all PSD indexes had acceptable alphas (OA:  $\alpha = .85$  to  $\alpha = .98$ , RA:  $\alpha = .66$  to  $\alpha = .97$  CON:  $\alpha = .79$  to  $\alpha = .96$ ).

**Demographics.** Sex, age, height, weight, marital status (no /yes to married or dating), personal education level (from primary school or lower to post-secondary education), and status as a smoker and consumer of alcohol (no versus yes) were assessed. Pain duration and current pain severity were also assessed in arthritis subgroups.

## Data Analysis

Group differences in age BMI, relationship status, education, smoking status and alcohol use status were assessed with univariate analyses of variance (ANOVAs) and chi-square tests. Multivariate analyses of variance (MANOVAs) evaluated overall group differences on (1) SWA versus (2) questionnaire-assessed PA and sleep. For each set of comparisons, univariate F's were presented to illustrate group differences on specific indexes; Bonferroni-adjusted post-hoc tests examined specific subgroup differences on measures having significant univariate F values. Finally, standard multiple logistic regression analyses (LGA) assessed accuracies in correctly identifying participant group membership (OA or RA versus control) from responses on non-multicollinear SWA or self-report indexes on which significant subgroup differences were found in preceding analyses.

## Results

### Sample Differences on Demographics

The three groups did not differ on age, BMI, current relationship status or education level. Furthermore, no differences were found for smoking or alcohol consumption status (see Table 1).

### Sample Differences on Objective Indexes of Physical Activity and Sleep

A significant multivariate effect was observed for SWA indexes,  $F(1, 118) = 2.212, p = 0.001$ . Table 2 indicates control group members had significantly less sedentary activity as well as more moderate PA, vigorous PA, overall PA, and active energy expenditures, longer PA durations, and higher average daily step counts than did cohorts with OA and RA. Arthritis subgroups did not differ from one another on any PA indexes. On sleep measures, groups did not differ on SOLs or TST. However, controls spent less time awake after sleep onset than either arthritis subgroup did and displayed marginally better sleep efficiency than OA subgroup members did ( $p = .053$ ).

### Sample Differences on Self-Report Measures of Physical Activity and Sleep

For questionnaire measures of PA and sleep, the multivariate F value was not significant,  $F(1, 118) = 1.088, p = 0.359$ . Furthermore, arthritis subgroups and controls did not differ on any of the individual PA

or sleep indexes (Table 3).

## Accuracy of Sensewear Indexes in Identifying Group Membership

Questionnaire indexes were excluded from LGA due to the absence of group differences in self-reported PA and sleep. Prior to running LGAs, bivariate correlation coefficients were calculated on (1) SWA indexes that differentiated between groups (Table 2) to identify multicollinear indexes ( $r > .70$ ). Redundant measures were excluded to reduce total predictors in analyses. Correlation analyses (Table 4) indicated sedentary behavior had correlations  $>.70$  with moderate activity, active energy expenditure, METs, and physical activity duration, all of which were excluded from LGA. Thereafter, 4 SWA indexes remained: sedentary activity, vigorous activity, steps, and WASO time. To ensure chance alone probabilities were held constant (50%) for each subgroup in analyses, separate classification models were generated to evaluate accuracies in identifying (1) OA vs control and (2) RA vs control condition membership from surviving SWA indexes. Because arthritis subgroups did not differ on SWA indexes, no OA versus RA model was generated

Overall models were highly significant ( $p$ 's  $< .001$ ) and indicated individual responses on included SWA indexes generated overall classification accuracies that exceeded chance levels, particularly for the identification of arthritis subgroup membership (see Table 5). In the initial model, more than 80% of RA patients were correctly identified from the 4 SWA indexes. Step counts had a significant, unique impact within the classification model. In the second LGA, 75% of OA patients were correctly identified from SWA index responses. Both steps and WASO made significant, unique contributions to the model. Conversely, within each LGA, classification accuracies were attenuated for control group members ( $\leq 65\%$ ), albeit modestly higher than chance levels (Table 5).

## Discussion

Overall results underscored the superiority of objective measures rather than questionnaires in discriminating PA levels and sleep disturbances of patients with RA and OA compared to non-arthritic controls. First, with the exception of overall energy expenditures and lying down time, OA and RA patients displayed significantly less PA than did controls on objective indexes tapping sedentary, moderate, and vigorous activity levels, active energy expenditures, overall activity levels  $\geq 3$  METS, and PA durations. In contrast, estimates of time sitting down, walking, moderate activity, and vigorous activity based IPAQ-C responses did not differ between groups. The most glaring discrepancy was in relation vigorous activity. SWA data aligned with the hypothesis that non-arthritic controls would display elevations compared to each arthritis subgroup while. questionnaire results indicated OA patients reported over 5 hours more of vigorous activity than controls did.

The pattern of group difference results dovetails with evidence of weaker validity of questionnaires than objective measures in differentiating PA levels of arthritis patients versus controls in Western samples [15,16,18]. Comparatively low average education levels may have contributed to the lack of group differences on IPAQ-C PA indexes. However, other researchers have argued biases in recall and social

desirability as well as difficulties in mentally quantifying unstructured PA by frequency, intensity and duration also contribute to poor discriminant validity of PA questionnaires across studies [36].

Second, despite the absence of subgroup differences across SWA and questionnaire indexes of sleep onset, total sleep time and sleep efficiency, a notable discrepancy emerged for wake after sleep onset time (WASO). SWA data collected during sleep indicated arthritis subgroups, especially those with OA, displayed significantly more WASO than controls did. In contrast, self-reported estimates of WASO minutes collected following each nightly sleep were lowest among OA patients and nearly 33% lower than estimates from controls. In related work, Roehrs et al. [5] identified more WASO time among patients with fibromyalgia and RA than pain-free controls during a nocturnal polysomnogram while subgroup differences were not evident on self-report sleep indexes. In tandem, these findings suggest WASO may be a key objective measure distinguishing sleep disturbances of various arthritis subgroups from controls while complementary questionnaire indexes have poor discriminant validity.

The utility of objective indexes in discriminating PA levels and sleep disturbances of arthritis subgroups versus controls was reinforced further by classification analysis results. Specifically, arthritis subgroup members, particularly those with RA, could be distinguished from controls at levels well above chance based on a subset of four SWA indexes. Although questionnaire indexes were excluded from subgroup classification analyses due to the complete absence of subgroup differences, objective assessments indicated RA and OA are characterized by specific deficits in PA and/or sleep compared to controls. Comparatively weaker classification accuracy levels of controls may have been a partial reflection of their generally greater variability in PA levels and sleep disruptions. This point is underlined by the typically larger standard deviations and wider individual differences on SWA indexes for controls illustrated in Table 2. Although chronic pain was an exclusion criterion in the selection of controls, per the general population, group members may have shown greater heterogeneity in health, illness, and functioning than did cohorts experiencing limitations from arthritis.

The emergence of steps as the only PA index to discriminate both arthritis subgroups from controls in classification analyses is consistent with results from other arthritis research [18]. Indeed, decreased sedentary activity and increased light intensity activity – not just bouts of moderate to vigorous activity bouts – confer health benefits for arthritis groups [11]. Practically, then, step counts monitored via pedometers or simple phone apps offer useful, inexpensive, objective PA measures for arthritis patients in China and abroad that are preferable to the IPAQ-C or other questionnaires susceptible to biases in reporting and recall.

Finally, in contrast to arthritis versus control differences on SWA indexes, no arthritis subgroup differences were found. This finding aligns with results of smaller N studies comparing different patient subgroups on objective measures of PA [15] and sleep [5]. The current sample was at least double the size of those from these studies so null effects were less likely to be a function of reduced statistical power. Even though OA and RA differ in prevalence, causes, courses, prognoses, and treatment [37,38,39,40], the lack of arthritis subgroup differences in reported interference from pain was at least

partially attributable to the absence of corresponding differences on objective PA and sleep indexes. Furthermore, because ambulatory independence was a necessary selection criterion and groups did not differ on age or pain duration, RA subgroup members may have been higher functioning than the population from which they were drawn.

Notwithstanding its implications, select limitations of this study warrant mention. First, samples were non-randomly selected Chinese community dwellers so caution is warranted in generalizing results to inpatients and those incapable of independent ambulation, other arthritis subtypes or groups in other countries. Moreover, even though the IPAQ-C and PSD discriminated poorly between the groups under study, this conclusion does not necessarily extend to other questionnaire measures of PA and sleep.

In conclusion, this study indicated objective measures are preferable to specific questionnaires in discriminating experiences of PA and sleep among ambulatory Chinese adults with RA or OA compared to non-arthritic controls. However, converging with smaller N studies, arthritis subtype differences in objectively-assessed PA and sleep were not observed. Finally, classification analysis results underscored step counts as an easily available, cost-efficient and useful objective alternative to questionnaires in discriminating PA of arthritis subgroups versus controls.

## Abbreviations

**ANOVAs:** analyses of variance

**BMI:** body mass index

**CON:** controls

**FNA:** frequency of nightly awakenings

**IPAQ-SF-C:** International Physical Activity Questionnaire Short Form-Chinese

**LGA:** logistic regression analyses

**LMICs:** low and middle income countries

**METs:** metabolic equivalents

**MANOVAs:** Multivariate analyses of variance

**OA:** osteoarthritis

**TIB:** total time in bed

**PAD:** physical activity duration

**PA:** physical activity

**PSD:** Pittsburgh Sleep Diary

**RA:** rheumatoid arthritis

**SWA:** Sensewear Armband

**SE:** sleep efficiency

**SOL:** sleep onset latency

**SQ:** sleep quality

**TST:** total sleep time

**WASO:** waking after sleep onset

## **Declarations**

### **Acknowledgements**

The author would like to thank all the researchers in the pain laboratory of Southwest university for their encouragement and support, and all the doctors in the ninth people's hospital of Chongqing for their strong support for this experiment.

### **Author information**

Ting Xu is first author, Todd Jackson is Corresponding author and other authors contributed equally to this work.

### **Authors' contributions**

Ting Xu and Todd Jackson drafted the manuscript; Ting Xu performed the statistical calculations; Xiaojun Jia, Shuanghong Chen, Yingying Xie collected data; and all authors read the manuscript, discussed the results, and approved the final version of the manuscript.

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## **Funding**

This study was supported by the National Natural Science Foundation of China (#31671142) and a Chongqing 100 Persons Fellowship to the corresponding author.

## **Ethics approval and consent to participate**

The study was approved by the Human Research Ethics Committee of Southwest University, Chongqing (534472715). Consent to participate: Not applicable

## **Consent for publication**

Not applicable

## **Availability of data and materials**

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

## **Competing interests**

The authors declare no conflict of interest in the conduct or presentation of this research.

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## Tables

**Table 1.** Sample differences on demographic measures (N = 120).

Measure	Group			Post-hoc	
	Osteoarthritis (N= 40)	Rheumatoid Arthritis (N = 40)	Control (N = 40)	F / c <sup>2</sup>	comparisons
Age	57.90(17.51)	59.35(16.52)	54.40(15.87)	0.94	no differences
Body mass index	23.73(3.90)	24.03(2.59)	22.54(2.58)	2.62	no differences
Current Relationship (Yes)	33(83%)	27(68%)	34(85%)	4.22	no differences
Education status				4.03	no differences
Primary school	13(32%)	13(33%)	14(35%)		
Middle school	15(38%)	15(37%)	18(45%)		
High school	4(10%)	4(10%)	2(5%)		
Post-Secondary	8(20%)	4(20%)	4(15%)		
Cigarette Smoking status					
Non-smoker	33(83%)	35(88%)	31(78%)	1.39	no differences
Smoker	7(17%)	5(12%)	9(22%)		
Current Alcohol Use					
Non-drinker	33(83%)	32(80%)	35(88%)	0.84	no differences
Drinker	7(17%)	8(20%)	5(12%)		

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

**Table 2** Sample differences on objective measures of physical activity and sleep.

	Group			F	Post-Hoc Comparisons
	Osteoarthritis (OA)	Rheumatoid Arthritis (RA)	Control (CON)		
Sensewear Index	M (SD) / Median (IQR)	M (SD) / Median (IQR)	M (SD) / Median (IQR)		
Physical Activity Index					
Sedentary activity (min/day)	1274.23 (90.91)	1283.10 (93.76)	1207.08 [130.21]	6.10**	CON < OA, RA
Moderate activity (min/day)	148.58 (85.38)	144.43 (93.76)	199.83 [130.21]	3.98*	CON > OA, RA
Vigorous activity (min/day)	3.98 (5.87)	1.95 (3.15)	13.53 (28.81)	5.24**	CON > OA, RA
Total energy expenditure (calories/day)	9485.68 (1808.17)	9426.08 (1728.19)	9918.49 (2520.88)	0.69	no differences
Active energy expenditure (calories/day)	2544.35 (1578.87)	2439.86 (1660.48)	3854.25 (3226.22)	4.76**	CON > OA, RA
Physical activity level (METs)	1.54 (.24)	1.51 (.27)	1.75 (.32)	8.68***	CON > OA, RA
Physical activity duration (min/day)	152.76 (91.15)	146.74 (97.19)	214.98 (121.37)	5.27**	CON > OA, RA
Steps (No./day)	7767.68 (4002.25)	7230.98 (3861.86)	11215.54 (4571.00)	10.83***	CON > OA, RA
Lying down (min/day)	534.35 (124.87)	519.59 (104.79)	514.50 (86.26)	0.38	no differences
Sleep Index					
Sleep onset latency (min/night)	19.63 (13.90)	15.55 (9.46)	14.20 (12.14)	2.23	no differences
Total sleep time (min/night)	418.50 (78.37)	407.01 (78.20)	405.95 (71.11)	0.34	no differences
Wake after sleep onset time (min/night)	128.23 (63.99)	116.52 (49.41)	91.76 (51.91)	4.51*	CON < OA, RA
Sleep efficiency (%)	75% (9%)	76% (8%)	80% (9%)	3.02	no differences

\*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$

Table 3 Sample differences on self-report indexes of physical activity and sleep.

Measure	Group			F
	Osteoarthritis (OA)	Rheumatoid Arthritis (RA)	Control (CON)	
	M (SD) / Median	M (SD) / Median	M (SD) / Median	
Physical Activity (IPAQ-SF) <sup>1</sup>				
Sitting (min/week)	264	236	214	1.02
Walking (min/week)	1636	1463	1681	0.23
Moderate (min/week)	1445	1744	2338	0.94
Vigorous (min/week)	1624	1117	1320	0.18
Total (min/week)	4705	4323	5339	0.32
Sleep (PSD)				
Sleep onset latency (min/night)	30.54±24.22	30.66±28.50	20.50±14.51	2.53
Total time in bed (min/night)	480.76±57.63	499.87±87.35	467.65±59.23	2.18
Frequency of nightly awaking	1.89±0.91	1.99±1.10	1.70±1.17	0.77
Total sleep time (min/night)	428.54±59.60	429.86±92.75	412.75±59.22	0.69
Wake after sleep onset time (min/night)	21.68±37.85	39.36±44.88	32.15±23.81	2.36
Sleep efficiency (%)	89.65±8.82	86.38±11.46	88.5±5.45	1.39
Sleep quality (0-10)	7.62±1.57	7.36±1.79	7.61±1.60	0.31
Alertness (0-10)	4.68±2.46	5.12±3.19	4.50±2.48	0.55

<sup>1</sup> Based on median minutes; \* $p < 0.05$ ; \*\* $p < 0.01$ ; \*\*\* $p < 0.001$

Table 4. Intercorrelations of sensewear armband (SWA) physical activity and sleep indexes within entire sample.

<b>SWA Index</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
1. Sedentary activity	∅						
2. Moderate activity	-0.97*	∅					
3. Vigorous activity	-0.49	0.33	∅				
4. Active energy expenditure	-0.73*	0.72*	0.46	∅			
5. Physical activity level (METs)	-0.93*	0.90*	0.54	0.70*	∅		
6. Physical activity duration	-0.99*	0.98*	0.47	0.75*	0.93*	∅	
7. Steps	-0.49	0.48	0.15	0.34	0.52	0.49	∅
8. Wake after sleep onset time	0.14	-0.14	-0.09	-0.16	-0.18	-0.13	-0.28

\*  $p < 0.001$ ; based on two-tailed significance tests.

**Table 5. Accuracy of Sensewear Armband physical activity and sleep indexes in identifying arthritis subgroups versus non-arthritic controls.**

**Group Classification Model**

<b>Sensewear Index</b>	Rheumatoid Arthritis vs. Control		Osteoarthritis vs. Control	
	Wald	p	Wald	p
Vigorous activity	1.438	0.23	1.1	0.967
Sedentary activity	0.211	0.646	0.002	0.294
Steps (Mean number per day)	7.956	0.005	4.974	0.026
Wake after sleep onset time	0.666	0.414	4.37	0.037

  

Group	Rheumatoid arthritis Control		Osteoarthritis Control	
	Group	Group	Group	Group
Arthritis subgroup (N = 40)	33 / 40 (82.5%) (17.5%)	7 / 40	30 / 40 (75.0%) (25.0%)	10 / 40
Control (N = 40)	14 / 40 (35.0%) (65.0%)	26 / 40	13 / 40 (32.5%) (67.5%)	27 / 40
Overall Model:	$\chi^2 (4) = 24.188, p < 0.001$		$\chi^2 (4) = 20.510, p < 0.001$	
	Total Correctly Classified: 73.8% (59 / 80)		Total Correctly Classified: 71.3% (57 / 80)	