Title: 24-hour Activity and Sleep Profiles for Adults Living with Arthritis: Habits Matter

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ABSTRACT

Objectives: Identify 24-hour activity-sleep profiles in adults with arthritis and explore factors associated with profile membership.

Methods: Cross-sectional cohort, using baseline data from two randomized trials studying activity counselling for people with rheumatoid arthritis (RA), systemic lupus erythematosus (SLE) or knee osteoarthritis (OA). Participants wore activity monitors for 1-week and completed surveys for demographics, mood (Patient Health Questionnaire-9) and sitting and walking habits (Self-Reported Habit Index). 1440 minutes / day stratified into minutes off-body, sleeping, resting, non-ambulatory, and intermittent or purposeful ambulation. Latent class analysis determined cluster numbers; baseline-category multinomial logit regression identified factors associated with cluster membership.

Results: 172 people (RA: 51%, OA:30%, SLE: 19%). Clusters: *High Sitters*: 6.9 hours sleep, 1.6 hours rest, 13.2 hours non-ambulatory, 1.6 hours intermittent and 0.3 hours purposeful walking. *Low Sleepers*: 6.5 hours sleep, 1.2 hours rest, 12.2 hours non-ambulatory, 3.3 hours intermittent and 0.6 hours purposeful walking. *High Sleepers*: 8.4 hours sleep, 1.9 hours rest, 10.4 hours non-ambulatory, 2.5 hours intermittent and 0.3 hours purposeful walking. *Balanced Activity*: 7.4 hours sleep, 1.5 hours sleep, 9.4 hours non-ambulatory, 4.4 hours intermittent and 0.8 hours purposeful walking. Younger age [OR: 0.95 (95% CI: 0.91-0.99)], weaker occupational sitting habit [OR: 0.55 (95% CI: 0.41-0.76)] and stronger walking outside habit [OR: 1.43 (95% CI: (1.06-1.91)] were each associated with Balanced Activity relative to High Sitters.

Conclusions: Meaningful subgroups were identified based on 24-hour activity-sleep patterns. Suggesting tailoring interventions based on 24-hour activity-sleep profiles may be indicated, particularly in adults with stronger habitual sitting or weaker walking behaviors.

SIGNIFICANCE AND INNOVATIONS

- We used latent class analysis to evaluate data from research grade activity monitors in 172 adults with rheumatoid arthritis, systemic lupus erythematosus or knee osteoarthritis to identify distinct 24-hour activity-sleep profiles.
- We identified four activity-sleep profiles that were characterized primarily by differences in time in non-ambulatory activity (High Sitters: > 13 hours), time sleeping (High and Low Sleepers: > 8½ and < 6½ hours sleep) or time walking (Balanced Activity: > 5 hours walking, including > ½ hour of purposeful walking).
- Younger age, weaker usual occupational sitting and stronger walking outside habits were associated with a greater likelihood for membership in a Balanced Activity profile relative to a High Sitters profile.
- Findings suggest that targeting or tailoring activity interventions for adults with arthritis based on 24-hour activity-sleep profiles may be indicated, particularly in adults with stronger habitual sitting or weaker habitual walking behaviors.

Adults with arthritis may not be able spend much time in higher intensity physical activities due to activity limitations [1]. Consequently, they may not be able to meet the aerobic activity guideline of getting at least two and a half hours in moderate to vigorous physical activity (MVPA) every week [2-5]. Arthritis-related pain, fatigue, limited joint and muscle function or mood disruption may contribute to increased sedentary activity, less walking or impact sleep quality and quantity [1, 6-8]. Which in turn, may have implications for a person's overall health, as being physically inactive and having insufficient (< 6 hours) or excessive sleep (> 9 hours) are independently associated with higher risk of all-cause mortality [8-14], including in people with arthritis [15]. Whereas, supporting someone to be physically active, to limit sitting activities and get sufficient sleep have all been shown to be independently associated with better health outcomes [16-21].

The Canadian Society for Exercise Physiology (CSEP) has identified 24-hour movement guidelines for children and youth including recommendations for time spent sleeping, being physically active, participating in structured and unstructured walking activities and sitting for recreational screen activities [22]. Whereas, similar 24-hour movement guidelines for adults have not been established. Despite the lack of guidelines informing 24-hour movement in adults, research grade activity trackers worn for 24-hours over a period of days still offer an opportunity to understand different patterns of sleep and activity behavior [23-25]. Understanding activity and sleep patterns over 24-hours is informative in a way that is different than measuring different intensities of activity or sleep in isolation. For example, not meeting the MVPA guidelines does not equate to a person spending more time sleeping or sitting. Rather they could be spending extended periods of time walking around more slowly and getting an appropriate amount of sleep; both of which could reflect a more balanced activity and sleep lifestyle. It is also important to consider individual characteristics or clinical factors associated with different patterns of activity and sleep over 24-hours in adults with arthritis as these factors can inform future research or clinical interventions supporting individuals with arthritis to modify their activity or sleep behaviors [26-28].

To date there are a limited number of studies outlining variations in patterns of 24-hour activity and sleep within defined adult health populations using objective measures [29-32]. To our knowledge no previous study has examined how objectively measured 24-hour activity and sleep profiles may vary in adults with arthritis. As such, the purpose of this study was two-fold. First, we sought to identify and describe the characteristics of distinct 24-hour activity-sleep profiles in adults with rheumatoid arthritis (RA), systemic lupus erythematosus (SLE) or knee osteoarthritis (OA) using objectively measured activity. Secondly, we explored individual demographic or clinical factors associated with 24-hour activity-sleep profile allocation.

PARTICIPANTS AND METHODS

We conducted a cross-sectional cohort study using baseline data from two randomized clinical trials studying the effect of physical activity counselling for people with knee OA (SuPRA study) or RA or SLE (OPAM-IA study) [33,34]. Participants were eligible if they had a physician diagnosis of RA, SLE or knee OA, or in the case of undiagnosed knee OA were 50 years or older and experienced pain or discomfort in or around the knee during the previous year lasting 28 or more days [35]. Participants had to be able to participate in physical activities without health professional supervision, have no prior experience with using wearable activity monitors and have email and internet access [33,34]. Participants were recruited from facilities offering arthritis care in two large metropolitan health care authorities in British Columbia, Canada. Recruitment information was also posted on research websites, Facebook, Twitter, Kajiji and Craigslist [33,34].

24-hour activity was measured by research grade SenseWear Mini^{TM} activity monitors (BodyMedia, Inc., Pittsburgh, PA). The activity monitors were worn for 1-week on the upper arm over the triceps on the non-dominant arm and were removed only for showering or other water-based activities. Sensewear monitors are multi-sensor devices that integrate tri-axial accelerometry data with personal demographic and physiologic data. Sensewear monitors provide reliable and valid estimates of activity in people living with arthritis if worn for 4 or more days [36-38]. Sensewear monitors have an excellent ability to differentiate between sedentary and light intensity activities (Positive Predictive Value: 0.81) [39]. Sensewear monitors demonstrate high wake / sleep agreement (80%) and high sensitivity for sleep estimation (89%) compared to polysomnography and provide equivalent measures for time sleeping compared to sleep diaires in free-living conditions [40,41]. Sensewear monitors also automatically turn off when not in contact with skin, providing accurate estimates of time off-body (i.e. activity unknown).

Activity data were included for individuals with four to six days with data from mid-night to mid-night, with at least 20 hours of wear. We used the average value across all days of wear for outcome analyses for each participant. The downloaded data from the device were processed using Sensewear professional software $_{v7.0}$, with the minute-by-minute data exported and processed further using MATLAB software (R2016a, The MathWorks, Inc., Natick, Massachusetts, United States). Minute-by-minute files include data for a number of outcomes (e.g. tri-axial acclerometry metrics, galvanic skin response, skin and near body temperature, step count, intensity of activity and energy expenditure, and identifiers for lying down, sleeping or off-body). We used off-body, step count, lying down and sleep identifiers to stratify each of the 1440 minutes in a participant's day into one of six activity-sleep categories: 1) off-body (off body identifier), 2) sleeping (lying down + sleep identifiers), 3) resting (lying down – sleep identifiers), 4) non-ambulatory activity (non-lying down, no step count), 5) intermittent walking (non-lying down, < 50 steps/min step count), and 6) purposeful walking (non-lying down, ≥ 50 steps/min step count). We used a 50 steps / minute cut-point to define intermittent verses purposeful walking based on an exploration of step cadence data (unpublished) which is comparable to Tudor-Locke and others for defining sporadic verses purposeful walking cadence with cut-points varying from 40 to 60 steps / minute [42].

Online surveys collected demographic (age, sex, and usual occupation), mood (depression), and sitting and walking habit strength data from both studies. Participants selected the best fit for usual occupation from employed (full-, part- or self-employed), retired, household work, student, volunteer or other. Depression was measured using the Patient Health Questionnaire-9 (PHQ-9), a nine-item questionnaire rated on a 7-point Likert scale [Score: 0-27] with higher scores indicating greater severity of clinical depression [43]. Habit strength was measured using the Self-Reported Habit Index (SRHI) questionnaire, a 12-item questionnaire examining the frequency (how often), automaticity (done without conscious thought) and self-identity (how a person identifies with the behaviour) for defined behaviors occurring within a specified context

[45,46]. The questions are rated on a 7-point Likert scale [Score: 1-7] with a score of 1 indicating weaker and 7 representing stronger perceived habits [44, 45]. Participants rated their strength of habit for three daily activity-related behaviors: 1) sitting during leisure time at home, 2) sitting during usual occupational activities, and 3) walking outside for ten minutes or more.

We conducted a Latent Class Analysis (LCA) using time spent in the six activity-sleep categories over 24-hours and Akaike's and Bayesian Information Criterion (AIC/BIC) model comparison analyses to determine the number of clusters. Descriptive statistics (mean and standard deviations of continuous variables and percentages for categorical variables) were computed for the cohort as a whole, and within each activity cluster, for the following characteristics: age, body mass index (BMI), sex, usual occupation, total daily steps, number of days of wear, average steps / minute during intermittent and purposeful walking, depression score, sitting and walking habit strength scores and number of minutes spent in each of the six activity-sleep categories. Baseline-category multinomial logit regression with backward elimination was used to identify factors associated with likelihood for cluster allocation relative to the reference cluster with the highest daily non-ambulatory time. Factors included in the model were age, BMI, sex, arthritis diagnosis, employment status, depression, occupational sitting habit score, home leisure sitting habit score and walking outside habit score. The effect of factors remaining in the final model were reported as Odds Ratio (OR) point estimates with the Wald 95% confidence intervals (95% CI) relative to the reference cluster (OR: 1.0). All statistical analyses were conducted using SAS v9.4 software (SAS Institute Inc., North Carolina, USA).

Both studies were carried out in compliance with the Helsinki declaration for conducting research with humans and received ethical approval from the University of British Columbia, Vancouver, Canada (SuPRA study: H15-02038. OPAM-IA study: H15-01843) [33,34].

RESULTS

Cohort Characteristics: Of the 172 participants in the cohort, 51% (n=88) had RA, 30% (n=52) had knee OA and 19% (n=32) had SLE. Average age was 58.1 years (SD: 13.5), average BMI was 28.3 kg/m^2 (SD:7.8) with 86% (n=148) being female. Forty three percent (n=74) reported their usual occupation as employed, 26% (n=45) reported they were retired, 18% (n=31) reported household work as their usual occupation and the remaining 13% (n=22) reported their usual occupation as student, volunteer or other (Table 1). Average daily steps was 5990 (SD:3234). Average days of wear was 5.9 (SD:0.4) indicating that the monitors were consistently worn across weekend and weekdays. Average number of steps per minute during intermittent and purposeful walking activities were 16.8 (SD:2.1) and 76.8 (SD:10.7) steps / minute respectively. Average depression score was 7.0 (SD:5.6) / 27. Average scores for usual occupational sitting, home leisure sitting and walking outside habit scores were 4.8 / 7 (SD:1.3), 4.6 / 7 (SD:1.7) and 4.1 / 7 (SD:1.8) respectively (Table 2). Participants spent on average 7.3 hours (SD:1.2) sleeping, 1.5 hours (SD:0.8) resting, 11.3 hours (SD:0.3) in non-ambulatory activities, 3.0 hours (SD:1.2) in intermittent and 0.5 hours (SD:0.4) in purposeful walking and 0.4 hours (SD:0.3) with the monitor off-body (Table 3 and Figure 1).

Activity Cluster - Identification: We identified four 24-hour activity-sleep profiles (clusters) using LCA and best model fit from AIC and BIC analyses (Figure 2). The four clusters were primarily differentiated by time sleeping and resting (High and Low Sleepers), time in non-ambulatory activity (High Sitters) or time in ambulatory activity (Balanced Activity). We defined the profile with the highest non-ambulatoray activity as 'High Sitters', noting that non-ambulatory activities most likely included passive and active sitting activities with some time potentially spent in standing activities [46]. We defined the 'Balanced Activity' profile as approaching recommended daily activity and sleep benchmarks for middle-aged to older adults [19-24]. This included spending approximately 7½ hours sleeping and 1½ hours of resting, having less than 9½ hours in non-ambulatory activities and more than 5 hours walking, including at least a ½ hour in purposeful walking activities.

Activity-Sleep Clusters - Time in Different Activity (Table 3): There was very little difference in the time off-body across the clusters, varying from 0.4 to 0.5 hours (SD:0.2 - 0.3). Time spent in the remaining five activity or sleep categories across the clusters were as follows (Figure 1):

1. *Balanced Activity*: Individuals in this cluster (n=40) spent on average 7.4 hours (SD:1.2) sleeping, 1.5 hours (SD:0.8) resting, 9.4 hours (SD:1.0) in non-ambulatory activity, 4.4 hours (SD:0.9) in intermittent walking, and 0.8 hours (SD:0.5) in purposeful walking.
2. *High Sleepers*: Individuals in this cluster (n=45) spent on average 8.4 hours (SD:1.0) sleeping, 1.9 hours (SD:1.0) resting, 10.4 hours (SD:1.2) in non-ambulatory activity, 2.5 hours (SD:0.6) in intermittent walking, and 0.3 hours (SD:0.2) in purposeful walking.
3. *Low Sleepers*: Individuals in this cluster (n=52) spent on average 6.5 hours (SD:0.9) sleeping, 1.1 hours (SD:0.4) resting, 12.2 hours (SD:1.1) in non-ambulatory activity, 3.3 hours (SD:0.6) in intermittent walking, and 0.6 hours (SD:0.4) in purposeful walking.
4. *High Sitters*: Individuals in this cluster (n=35) spent on average 6.9 hours (SD:0.8) sleeping, 1.6 hours (SD:0.6) resting, 13.2 hours (SD:0.9) in non-ambulatory activity, 1.6 hours (SD:0.5) in intermittent walking, and 0.3 hours (SD:0.3) in purposeful walking.

Activity-Sleep Clusters – Participant Demographics (Table 1): Individuals in the Low Sleepers and High Sitters clusters tended to be slightly older on average (61 years) than those in the other two clusters (55 years). Individuals in the Balanced Activity and Low Sleeper clusters tended to have a slightly low BMI (~ 27 kg/m^2) than those in the other two clusters (~ 30 kg / m^2). Males represented 23% of the the High Sitters, 12-13% of the Balance Activity and High Sleepers and 8% of Low Sleepers. Relative to the distribution of types of arthritis across the cohort, participants with RA were slightly more likely to be represented in the High Sleepers, SLE in the High Sitters, and knee OA in the Balanced Activity clusters. Fifty-two percent of Balanced Activity, 48% of the Low Sleepers and 37-38% of High Sleepers and High Sitters were employed. Retired individuals represented 40% of High Sitters and 20-25% of individuals in the other three clusters. Twenty-five percent of individuals in the Balanced Activity cluster and 13-18% of participants in the other three clusters reporting household work as their usual occupation.

Activity-Sleep Clusters - Clinical Characteristics (Table 2): Individuals in the High Sitters and High Sleepers clusters acquired an average number of daily steps varying from 3317 (SD:1729) to 4229 (SD:1423) steps. Low Sleepers aquired an average of 6706 (SD:2618) daily steps and individuals in the Balanced Activity cluster acquired on average 9379 (SD:3086) daily steps. Across all clusters the average number of days of wear varied from 5.8 (SD:0.5) to 5.9 (SD:0.4) / 6. Average steps / minute for intermittent and purposeful ambulation varied from 15.3 (2.0) to 18.7 (SD:1.8) and 74.7 (SD:9.7) to 78.3 (SD:10.3) steps respectively. The average depression score varied from 6.3 (SD:6.0) to 8.5 (SD:5.9) / 27. High Sitters reported average usual occupational and home leisure sitting habit scores of 5.3 (SD:1.0-1.4) / 7, whereas, High and Low Sleepers and Balanced Activity clusters reported average usual occupational and home leisure sitting habit scores varying from 3.8 (SD:1.8) to 4.7 (SD:1.8) / 7. Individuals in the Balanced Activity and Low Sleepers clusters reported walking outside habit scores varying from 4.4 (SD:1.6) to 4.5 (SD:1.9) / 7 on average. Whereas, High Sitters and High Sleepers reported outside walking habits varying from 3.6 (SD:1.6) to 3.7 (SD:1.8) / 7 on average.

Activity-Sleep Clusters - Profile Allocation Factors (Table 4): Age and usual occupational sitting and walking outside for more than 10 minutes habit strength were factors associated with cluster allocation, whereas, BMI, arthritis diagnosis, sex, employment status, mood and perceived home leisure sitting habit strength were not. Relative to High Sitters, individuals in the other three clusters were slightly younger (OR varying from 0.95 to 0.98). These findings indicate that relative to High Sitters, for every year increase in age individuals in the cohort were less likely to be members of the Balanced Activity (5% less likely), High Sleepers (4% less likely) or Low Sleepers (2% less likely) clusters. Whereas, relative to High Sitters individuals in the other three clusters reported notably weaker usual occupational sitting habits (OR varying from 0.55 to 0.74). These findings indicate that relative to High Sitters, for every 1-unit increase in reported usual occupational sitting habit strength individuals in the cohort were less likely to be members of the Balanced Activity (45% less likely), Low Sleepers (26% less likely) or High Sleepers (26% less likely) clusters. Conversly, relative to High Sitters individuals in the other three clusters reported notably stronger walking outside habits (OR varying from 1.09 to 1.43). These findings indicating that relative to High Sitters, for every 1-unit increase in reported walking outside habit strength participants in the cohort were more likely to be members of the Balanced Activity (43% more likely), Low Sleepers (37% more likely) or High Sleepers (9% more likely) clusters.

DISCUSSION

We used objectively measured physical activity to identify and describe distinct 24-hour activity-sleep profiles in 172 adults diagnosed with RA, SLE or knee OA. In addition, we explored individual and clinical characteristics associated with profile allocation. Four distinct 24-hour activity-sleep profiles were identified with the differences across the profiles characterized by variations in the time participants spent in sleeping (High and Low Sleepers), non-ambulatory activities (High Sitters) and ambulatory activities (Balanced Activity). We also found that an individuals' age and their perception of the strength of their usual occupation sitting and walking outside for more than 10 minutes habits were associated with profile membership. These findings reinforce that people with arthritis are likely to present with distinct variations in their patterns of sleep and daily activity across 24-hours and that existing habitual sitting or walking behaviours may influence 24-hour activity-sleep patterns.

There are a limited number of previous studies examining profiles or phenotypes of activity in adult populations using latent class analyses of objectively measured activity data. Prior studies have examined variations in activity during waking hours [29-31], or activity-sleep over 24-hours [32]. All identifying distinct activity profiles (3 to 6 profiles) for time spent in different types or intensity when awake, with one identifying a distinct profile of poor sleepers. Similarly, we found that adults with arthritis presented with distinctly different patterns of sleep and activity over 24-hours. However, our findings suggests that adults with arthritis may present with different patterns of sleep and activity over 24-hours than those previously reported.

Our findings also indicate that it may be appropriate to consider different strategies to target for activity-related behavior change in adults with arthritis based on a person's 24-hour activity-sleep profile. As an example, almost a quarter of individuals in our study cohort presented with a more balanced 24-hour activity-sleep profile suggesting that they were likely limiting time spent in non-ambulatory activities such as sitting, spending reasonable amounts of time in walking activities, including purposeful walking activities for at least a ½ hour and also getting adequate sleep and rest [16-21]. Highlighting the value of monitoring, acknowledging and supporting individuals with arthritis in their ongoing efforts to maintain a balance of sleep, walking and sitting activities despite the challenges of living with arthritis and a potential an inability to meet MVPA guidelines [2-5].

The remaining individuals in our cohort were fairly evenly distributed across three other less-balanced 24-hour activity-sleep profiles that could be selectively targeted for different behavior change initiatives. As an example, individuals in the High Sitters profile did meet recommended guidelines for sleep, whereas, they typically spent more than 13 hours in non-ambulatory activity and less than two hours walking around when they were awake. Suggesting that supporting High Sitters to identify opportunities to replace non-ambulatory activities with walking activities may be an appropriate strategy, while also acknowledging and supporting their ongoing efforts to maintain adequate sleep.

In comparison, individuals in the High and Low Sleeper profiles not only differed by having more or less sleep than recommended, they also differed in how they spent their time in different activities when awake. The High sleepers spent less than three hours walking around when they were awake, whereas, the Low Sleepers spent more than 12 hours in non-ambulatory activity. Suggesting that in addition to exploring why sleep may be disrupted in these individuals, it may also be appropriate to support High Sleepers to identify opportunities to increase their walking activities (i.e. a ‘move more’ focus) and support Low Sleepers to identify opportunities to reduce their non-ambulatory activities (i.e. a ‘sit less’ focus). Moreover, supporting Low and High sleepers to by more physical active when awake may have an additional secondary benefit associated with improved sleep. Although inconclusive, there is emerging evidence in older adult populations indicating that increasing physical activity participation can be associated with better sleep duration and sleep quality [47,48].

We found that younger age was associated with a greater likelihood for allocation to a Balanced Activity profile. However, despite being a statistically significant factor age was only marginally associated with profile allocation. In contrast, our findings indicated that a persons' perception of their a strength of habit for sitting during their usual occupation activities or walking outside for more than 10 minutes had a marked influence on the likelihood of someone being allocated to Balanced Activity profile. Suggesting that a person’s perceived sitting and walking habit strength matter. Habit is a low-level or sub-consious thought process, where a contextual stimulus or cue in the environment generates an impulse towards an action, or a series of actions [49]. The resulting habitual behavior(s) will occur if the impulse is not over-ridden by a more conscious thought to act differently [50]. These finding support further explorations of the influence of strong or weak activity-related habits on activity-related health behavior change interventions in future investigations.

This study has limitations. This was an exploratory analyses of secondary data in a small cohort (< 200 people) of adults with mixed diagnoses of arthritis who were recruited from two large metropolitan areas in Canada into two randomized clinical trials promoting physical activity. As such, the clinical and demographic characteristics described for the cohort as a whole, or in the comparisons across the four profiles, may not represent the diversity across adult populations with arthritis. As well, findings from our study can not be generalized to individuals with arthritis who live in more remote or rural settings or to individuals not likely to consent to participate in clinical trials promoting physical activity. In addition, our suggestions for selective targeting of different activity or sleep behaviors based on 24-hour activity and sleep profiles are speculative.

We were only able to explore selected demographic and clinical factors in our analyses; including only those factors collected commonly across both studies. As such, we were not able to explore a number of factors that may also have influenced activity-sleep patterns across 24-hours in adults with arthritis. Some examples of key demographic, clinical or social factors that should be explored in future studies include measures of arthritis disease duration, indicators of disease activity, functional ability, co-morbidity and quality of life, as well as, an examination of income, education and ethnicity.

This study provides preliminary evidence that there are likely to be distinctly different profiles for 24-hour activity and sleep in adults with arthritis that are potentially definable in terms of individual or clinical characteristics associated with profile membership. Findings also suggest that targeting or tailoring activity interventions for individuals with arthritis based on 24-hour sleep activity and sleep profiles may be indicated, particularly in adults with stronger habitual sitting or weaker habitual walking behaviors. Together these findings support further larger-scale prospective cohort investigations examining variations in, and characteritics of, 24-hour activity-sleep profiles in adults with arthritis.

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Table 1: Participant Demographics: Cohort vs Activity-Sleep Profiles

	All (n=172)	Balanced Activity (n=40)	High Sleepers (n=45)	Low Sleepers (n=52)	High Sitters (n=35)
Age - Years [Mean (SD)]	58.1 (13.5)	54.9 (12.7)	55.2 (14.2)	60.5 (11.6)	61.8 (15.0)
Body Mass Index – kg/m^2 [Mean (SD)]	28.3 (7.8)	27.2 (6.7)	30.0 (8.5)	26.9 (6.0)	29.8 (9.9)
Sex - Male (%)	13.4	12.5	13.3	7.7	22.9
Osteoarthritis – Knee (%)	29.7	37.5	24.4	28.9	28.6
Rheumatoid Arthritis (%)	51.2	47.5	55.6	51.9	48.6
Systemic Lupus Erythematosus (%)	19.2	15	20	19.2	22.9
Employed [Full- / Part- / Self-] (%)	43.6	47.5	37.8	50	37.2
Retired (%)	25	20	24.4	19.2	40
Household Work (%)	17.4	25	17.8	13.5	14.3
Student / Volunteer / Other (%)	14	7.5	20	17	8.6

Table 2: Clinical Characteristics [Mean, SD]: Cohort vs Activity-Sleep Profiles

	All (n=172)	Balanced Activity (n=40)	High Sleepers (n=45)	Low Sleepers (n=52)	High Sitters (n=35)
Total Steps (Steps / day)	5989.9 (3233.8)	9378.5 (3085.9)	4229.1 (1422.7)	6706.0 (2618.1)	3317.3 (1738.9)
Days of wear (#)	5.9 (0.4)	5.9 (0.3)	5.9 (0.4)	5.8 (0.5)	5.9 (0.4)
Intermittent Walking (mean steps / min)	16.8 (2.1)	18.7 (1.8)	15.9 (1.4)	17.1 (1.8)	15.3 (2.0)
Purposeful Walking (mean steps / min)	76.8 (10.7)	76.5 (11.5)	74.7 (9.7)	78.3 (10.3)	77.7 (11.6)
Depression *	7.0 (5.6)	6.3 (6.0)	8.5 (5.9)	6.6 (4.9)	6.4 (5.2)
Habit ** - Home Leisure Sitting	4.8 (1.3)	4.3 (1.5)	4.8 (1.3)	4.7 (1.3)	5.3 (1.0)
Habit **- Occupational Sitting	4.6 (1.7)	3.8 (1.8)	4.7 (1.8)	4.6 (1.6)	5.3 (1.4)
Habit **- Walking Outside	4.1 (1.8)	4.5 (1.9)	3.7 (1.8)	4.4 (1.6)	3.6 (1.6)

* Patient Health Questionnaire - 9 [Score: 0-27. Higher = Greater clinical depression] [43]

** Self-Reported Habit Index [Score: 1-7. 1 = weak and 7 = strong habit] [44]

Table 3: Hours in Different Activity [Mean, SD]: Cohort vs Activity-Sleep Profiles.

	All (n=172)	Balanced Activity (n=40)	High Sleepers (n=45)	Low Sleepers (n=52)	High Sitters (n=35)
Off Body	0.4 (0.3)	0.4 (0.3)	0.5 (0.4)	0.4 (0.3)	0.4 (0.2)
Sleep	7.3 (1.2)	7.4 (1.2)	8.4 (1.0)	6.5 (0.9)	6.9 (0.8)
Rest	1.5 (0.8)	1.5 (0.8)	1.9 (1.0)	1.1 (0.4)	1.6 (0.6)
Non-Ambulatory	11.3 (0.3)	9.4 (1.0)	10.4 (1.2)	12.2 (1.1)	13.2 (0.9)
Ambulatory - Intermittent	3.0 (1.2)	4.4 (0.9)	2.5 (0.6)	3.3 (0.6)	1.6 (0.5)
Ambulatory - Purposeful	0.5 (0.4)	0.8 (0.5)	0.3 (0.2)	0.6 (0.4)	0.3 (0.3)

Table 4: Prediction Factors* [Odds Ratio, Wald 95% Confidence Interval] x Activity-Sleep Profile

	Balanced Activity (n=40)	High Sleepers (n=45)	Low Sleeper (n=52)	High Sitters ** (n=35)
Age	0.95 (0.91 - 0.99)	0.96 (0.92 - 0.99)	0.98 (0.95 - 1.02)	1
Occupational Sitting Habit	0.55 (0.41 - 0.76)	0.74 (0.55 - 1.01)	0.74 (0.55 -1.00)	1
Walking Outside Habit	1.43 (1.06 - 1.91)	1.09 (0.83 -1.43)	1.37 (1.04 -1.79)	1

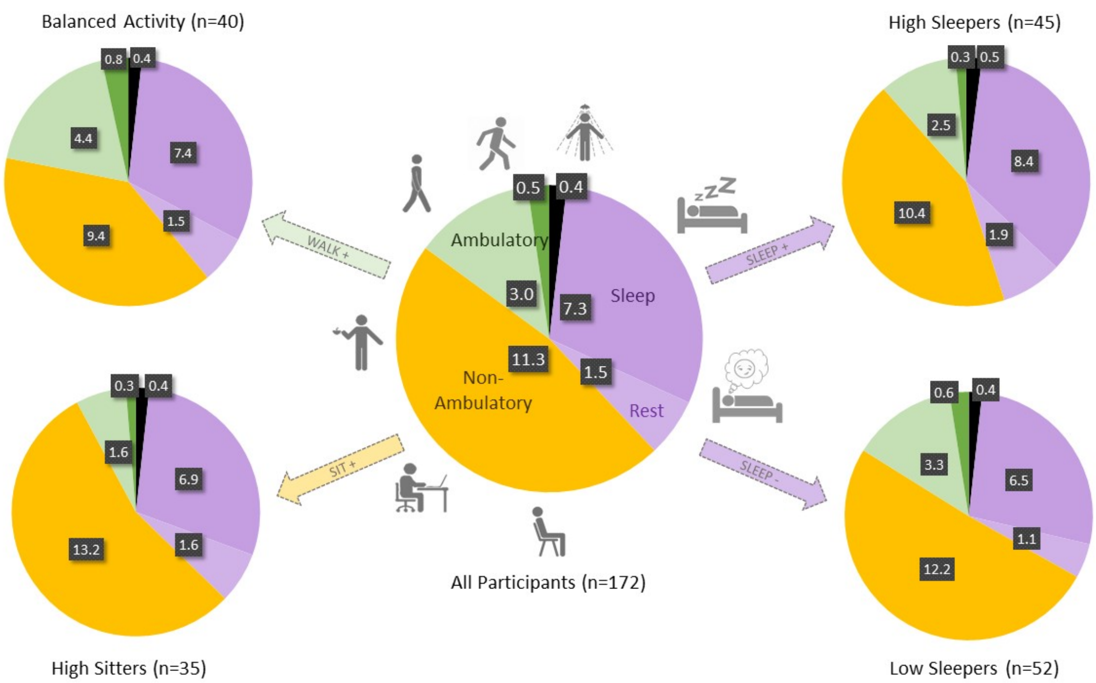
* Baseline-category multinomial logit regression with backward elimination

** Reference Cluster

FIGURE LEGENDS

Figure 1: Graphic comparison (Pie Charts) showing hours spent each day: 1) with the monitor off-body, 2) sleeping, 3) resting, 4) in non-ambulatory activities, 5) in intermittent ambulatory activities, and 6) in purposeful ambulatory activities. Comparing the cohort (N=172) in the centre relative to the Balanced Activity (n=40), High Sleepers (n=45), Low Sleepers (n=52) and High Sitters (n=35) activity-sleep profiles in the periphery.

Figure 2: Plot showing results of the Akaike's and Bayesian Information Criterion (AIC/BIC) model comparison analyses indicating four clusters to be the best model fit.



Balanced Activity (n=40)
0.8
0.4
4.4
7.4
1.5
9.4
WALK +
High Sleepers (n=45)
0.3
0.5
2.5
8.4
10.4
1.9
SLEEP +
0.5
0.4
Ambulatory
3.0
7.3
Sleep
11.3
1.5
Non-
Ambulatory
Rest
All Participants (n=172)
SIT +
SLEEP -
High Sitters (n=35)
0.3
0.4
1.6
6.9
1.6
13.2
Low Sleepers (n=52)
0.6
0.4
3.3
6.5
1.1
12.2

Cluster Number - Model Fit
590
580
570
560
550
540
530
520
510
500
2 Clusters
3 Clusters
4 Clusters
5 Clusters
AIC
BIC