Accelerometer-Measured Physical Activity and Its Impact on Sleep Quality in Persons Suffering From Restless Legs Syndrome

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Abstract

Background: Main symptoms of the restless legs syndrome (RLS) are sleep onset insomnia and difficulty to maintain sleep. Previous studies showed that regular physical activity can reduce the risk of developing RLS. However, the relationships of physical activity on sleep quality parameters in subjects suffering from RLS have not been investigated by applying accelerometry. Thus, the present study investigates the impact of physical activity during the day (7-12 h, 12-18 h, 18-23 h) on sleep quality in subject suffering from idiopathic RLS as well as their intensity and extent of physical activity by applying a real-time approach.

Methods: In a sample of 47 participants suffering from idiopathic RLS, physical activity and sleep quality were captured over one week by using accelerometers. For data analysis physical activity levels and step counts during three periods of a day (morning, afternoon, evening) were correlated with sleep quality parameters of the following night.

Results: In this observational study, significant correlations of physical activity with the sleep parameters were rarely confirmed (exception: negative correlation of steps in the morning with periodic leg movements in sleep and negative correlation of physical activity in the evening and total sleep period). However, the physical activity levels of the participants were unexpectedly high compared to population-level data and variance in physical activity was low. The average activity was 13,817 (SD=4,086) steps and 347 (SD=117) minutes of moderate physical activity per day in females and 10,636 (SD=3,748) steps and 269 (SD=69) minutes of moderate physical activity in males, respectively. However, the participants conducted no vigorous physical activity.

Conclusions: To investigate the effects of daily physical activity and RLS symptoms interventional studies with different intensities of physical activities at different points of time during the day are needed.

Background

The restless legs syndrome (RLS) is a frequent neurological long-term disease with a prevalence of 2.4% to 10.8% in adults (1). The main characteristic is the longing to move the legs which is caused by unpleasant feelings in the legs that improves somewhat by moving them (2). The syndrome can manifest as idiopathic type without any known cause or symptomatic, e.g. due to diabetic or uremic polyneuropathy, in Parkinson’s disease and spinal cord diseases. In particular, the unpleasant feelings and/or pain in the legs occur in the evening or night during physical rest. Common complaints are difficult sleep onset and difficulties in maintaining sleep (3).

Moving the legs or walking around for a short time ameliorates the patients’ discomfort (4). Medical treatment usually includes levodopa and dopamine agonists. However, the efficacy of drug treatments more or less disappears as time goes by (5). Three prospective cohort studies (6-8) revealed that regular physical activity reduces the risk of developing a RLS. Giannaki et al. (9-11) and Sakkas et al. (12), Mortazavi et al. (13) as well as Song et al. (14) showed that exercise training ameliorates symptoms of RLS in persons suffering hemodialysis. DeMello et al. (15, 16) found that RLS symptoms during the night in paraplegic individuals are significantly reduced after physical exercise about twelve hours before sleeping. However, Daniele et al. (17) did not find any correlation between physical activity and RLS complaints in diabetic individuals. In a randomized controlled trial in subjects with idiopathic RLS, Aukerman et al. (18) found significant reliefs of RLS complaints after strength and endurance training twice a week over a period of twelve weeks. On the other hand, in another randomized trial Harrison et al. (19) did not find a significant effect of a program of so-called tension and trauma release exercises once a week over a period of six weeks (n = 9 participants in each group). Franco et al. (20) suggested that physical exercise is a favorable non-pharmacological treatment for sleep-related movements disorders including RLS. Therefore, the question arises whether individuals with idiopathic RLS also benefit from daily physical activity with regard to their sleep quality during the following night.

The potential relationship is hypothesized to occur on a short-term basis within a day period (21): physical activity during the previous day is assumed to affect the sleep quality during the following night. In previous studies in healthy individuals (21) or individuals suffering from RLS, (10, 14) physical activity and sleep quality were often averaged over multiple days. This ignores the day-to-day variations which are required to determine whether physical activity influences sleep quality on a micro-scale level (within 24 hours) (22). Thus, to investigate this relationship the day-to-day variations within individuals should be considered and physical activity and sleep quality parameters have to be observed on a daily basis.

The present observational study aimed to investigate if there is a relationship between actual physical activity during the day and insomnia and periodic leg movements in sleep (PLMS) (as an objective (measurable) manifestation of RLS symptoms), in individuals suffering from idiopathic RLS by applying a real-time approach considering day-to-day variations. One the one hand, it aimed to analyze the effects of physical activity during different daytimes of the previous day on sleep quality. On the other hand, the effects of the levels and different intensities of physical activity during the previous day and the sleep quality were analyzed. Finally, the overall level of physical activity in subjects with idiopathic RLS were analyzed and compared with epidemiological data from the German population.
Methods

Study design and recruitment

As physical activity varies substantially over the course of a week (23, 24), an observational study was considered as an appropriate study design to investigate the relationship of physical activity and sleep quality in individuals suffering from RLS on a daily basis. Based on the natural variability of physical activity within the participants differences in sleep quality during the nights following days with different levels of physical activity should be analyzed. Thus, an observational study was conducted based on a sample of persons suffering from idiopathic RLS and data collection took part between August 2017 and December 2018. The participants were recruited from three neurological practices in northern Germany (Bremen, Hamburg, and Pinneberg). Inclusion criteria were an age of at least 18 years, the established diagnosis of idiopathic RLS according the Restless Legs Syndrome Diagnosis Index (RLS-DI) ≥11, and provision of informed consent. Exclusion criteria were pregnancy, symptomatic RLS including metabolic abnormalities, e.g. renal insufficiency, diabetes mellitus, iron deficiency (ferritin concentration <50 μg/l) as well as diseases that limit physical activities during daily life. No preselection of the participants with regard to their physical activity was made. The physical activity level of the participants was unknown when they were included in the examination.

The study was approved by the ethic committees of the Georg-August-University Göttingen (no. 17/2/2016) and Medical association of Thuringia (59838/2017/142) and were conducted according to the Declaration of Helsinki. All participants of the study gave their written informed consent to participate and were informed in detail about the study and data management by the neurologist of the practices where they were recruited.

Data collection

Data collection took part over a period of eight days. Initially, the participants were instructed and informed about the study aims and data collection procedure by their neurologist in the neurological practice they attend regularly. The participants were informed that the scientific study aims to identify any relationships between physical activity during the day and the quality of sleep (sleep onset latency, weakening periods, sleep efficacy). Additionally, the participants were asked not to change their medication throughout the data collection period. Due to partly severe RLS complaints a break of medication did not seem appropriate.

Leg-worn actigraphy is an alternative method of measuring PLMS (25). During the informed consent discussions, the participants received three ActiGraph Link wearable sensors. The ActiGraph Link (ActiGraph Corporation, Pensacola, FL, USA) is a small commercially available tri-axial wearable inertial measurement unit. One accelerometer that was provided to capture physical activity levels was equipped with a wristband. Two accelerometers that were provided to capture PLMS during the nights had no belt or band. The participants were instructed how and when to wear the accelerometers during the following eight consecutive days. Furthermore, they were instructed to document their sleep quality during the eight days data collection period (first day: handing out the accelerometers; eighth day: return of the accelerometers). Participation was voluntary and anonymous and participants were informed about data security regulations prior to the investigation. The participants were instructed verbally and in written form how to use the accelerometers during the data collection period.

Measures

Objectively measured actual physical activity. Assessments of physical activity were obtained using an accelerometer that was worn on the wrist of the dominant hand. A 1s-interval was used to capture “activity counts” of the respective participant. Activity counts were converted to average minutes spent in resting or light (<3 metabolic equivalents (METs)), moderate (3–6 METs), vigorous (6–9 METs), and very vigorous (>9 METs) physical activity. Cut-offs for the different intensity levels of physical activity were set according to the recommendations of Sasaki et al.(26): light activity 0 – 2,690 counts per minute (cpm), moderate activity 2,691 – 6,166 cpm, intensive activity 6,167 – 9,642 cpm, and very intensive activity >9,643 cpm. The minutes spent in each level were calculated for three separate time periods over each day (morning: 6 AM -12 noon., afternoon: 12 noon – 6 PM, and evening: 6 PM – 11 PM) and for every time period a variable was built accounting for the minutes spent in light, moderate, and vigorous physical activity. Furthermore, steps were counted and number of steps during every time period of a day were calculated.

Objectively measured sleep quality. Sleep quality was assessed using two accelerometers that were worn at the arches of both feet during sleep hours and the accelerometer worn on the wristband. According to the manufacturer’s description [Actilife 6 User’s Manual] two accelerometers were placed at the arches before sleep time and were secured by using medical tapes that were provided by the neurologists together with the accelerometers. The parameters that were recorded were the number of interruptions of sleep (accelerometer at the wrist) and PLMS per hour, total sleep period and sleep efficacy (duration of sleep divided by the duration of lying in bed) (accelerometer at the arches).
Statistical analyses

To identify significant between group differences (between males and females) an independent t-test was performed. The statistical evaluation did not include the first and last day of the data collection period as recording of these both days did not cover a whole day. Therefore, six days could be considered for statistical analyses. For each participant the mean and median values and corresponding measures of dispersion of the steps and duration in each physical activity intensity category (light, moderate, intensive, and very intensive) in minutes per day were calculated.

Considering each day of the data collection period (not the total investigational period) the Pearson-Bravais correlation coefficients $r$ between the number of steps and the minutes of physical activity levels on the one hand and the sleep parameters (sleep onset latency, duration of weakening periods, sleep efficacy) were calculated. Afterwards these correlation coefficients were z-transformed. Due to the fact that not all participants documented six complete investigational days the z values have been weighted by the number of days for which data was available. Thereby the mean values of the z values of all participants have been calculated and finally re-transformed into correlation coefficients.

Two-by-two-table tests were performed by using Fisher’s exact test. The correlation coefficients between school education and the mean daily steps and moderate physical activity resp. were calculated by using Spearman’s rank correlation coefficient. A level of 0.05 was set as a threshold to determine statistical significance.

Results

Descriptive results

Sixty-two persons suffering from RLS initially expressed interest in participating in the study. Five of them withdrew their interest during their discussion with their neurologists even before checking the inclusion and exclusion criteria. Of the remaining 57 potential study participants (40 women and 17 men) six women and four men had to be excluded due to different reasons: indications for a secondary RLS such as iron deficiency, vitamin B12 deficiency, or diabetes mellitus; failure to appear for handing out the accelerometers; abandonment of study, e.g. due to another acute disease; provision of invalid accelerometric data. Thus, at least usable data were delivered by 34 female and 13 male participants (N=47). Descriptive data of these participants is presented in Table 1. Except for one individual each participant received drugs during the data collection period in order to ameliorate the RLS complaints and confirmed not having changed treatment throughout the data collection.

Female participants were significantly older than the males ($p = 0.035$). Nine participants had completed the compulsory basic secondary school, 13 female and two male probands the secondary school, two females successfully passed the high school, and ten female and two male participants obtained a university degree. 19 participants (40%) were employed and 28 participants were pensioners (60%).

No participant performed physical activity equivalent to accelerometric criteria of intensive or very intensive activity (>6,166 cpm). The number of daily steps significantly correlated with the duration of moderate physical activity ($r = 0.88, p < 0.001$). The participants’ body mass indexes neither correlated significantly to the daily footsteps (women: $r = -0.28$, men: $r = -0.05$) nor the moderate physical activity (women: $r = 0.02$; men: $r = 0.30$). Both, the mean number of weekly footsteps ($p = 0.003$) and the mean duration of weekly moderate activity ($p = 0.012$) were significantly higher in female participants compared to their male counterparts. The participants’ age did not correlate with the mean daily footsteps (women: $r = -0.11$, men: $r = 0.07$) and the mean duration of moderate physical activity (women: $r = -0.03$, men: $r = -0.45$). The mean number of footsteps did not correlate with education (women: $r = 0.27$, men: $r = 0.12$). The mean objectively assessed total sleeping period was 361 minutes (SD=10 minutes; median value: 342 minutes; 1st and 3rd quartile: 284 and 430 minutes, resp.). Complete sleep recordings using the accelerometer were available from 40 participants regarding PLMS and 45 participants regarding awakenings, total sleep period, and sleep efficacy.

Impact of physical activity on RLS symptoms

From a subjective perspective, twenty-five participants (17 women, 8 men) reported that they did not make the experience that their physical activity had any impact on their RLS complaints, 13 participants (11 women, 2 men) made varying experiences or were not sure regarding the possible impact and 8 participants (5 women, 3 men) reported that physical activity ameliorates their complaints, whereas one female participant reported a negative impact of physical activity on her RLS complaints.

The statistical data analyses revealed low but significant negative correlations between the number of steps as well as moderate physical activity in the evening and the total sleep period (the more steps resulting in a shorter sleep period) and between the number of steps in the morning and PLMS in the night (the more steps, the less PLMS). No further significant correlations were found between the number of daily
steps or moderate physical activity during any of the three observational periods (6 AM – 12 noon, 12 noon – 6 PM, 6 PM – 11 PM) and any of the objectively measured sleep parameters (total sleep period, number of weakening periods, sleep efficacy, number of periodic leg movements in sleep) (Table 2 and Table 3).

Discussion

In the present study, the physical activity of subjects suffering from idiopathic RLS and their impact on RLS-related sleep quality was examined over one week by considering within-day relationships. Therefore, participants wore accelerometers to capture their daily steps and physical activity during three periods over each day and during night to capture their sleep quality over a time span of one week.

This study did not ascertain statistical correlations between the number of steps and moderate physical activity at various times of day on one hand and any parameter of sleep quality on the other hand except less PLMS after many steps in the morning and a shortened total sleep period after increased physical activity in the evening. In total, the present study does not reveal an obvious correlation between daytime physical activity and sleep quality in idiopathic RLS.

However, it is notable that the level of moderate physical activity was extremely high in the study population compared to epidemiological data from similar age groups and varied only slightly between participants (inter-individual) and also between different observation days within the individuals (intra-individual). In the current study, the mean of daily steps was almost 14,000 steps in females and around 10,600 steps in males, respectively. In comparison worldwide data comprising 68 days and over 700,000 people (27) showed that the mean number of daily steps in each of 111 nations included was around 4,000 to 6,000 steps – except for Hongkong where the population walked about 7,000 steps per day. With regard to the recommended level of steps per day (28), daily steps of 10,000 to 12,499 are considered as active and above 12,500 as highly active.

With regard to the physical activity recommendations postulated by the World Health Organization (29) at least 150 minutes of moderate physical activity are required for adults. Among women in Germany nationwide representative data revealed that only 15.5% are physically active at least 150 minutes per week, whereas the corresponding percentage in men is 25.4% (30).

In contrast, in the present study physical activity levels of all participants, especially the female ones, considerably exceeded the recommended levels of physical activity and the majority of the participants walked more the 10,000 steps per day which are considered as the benchmark for an active lifestyle (28, 31). On average the female participants reached more than twice and the males 1.5 as much as the recommended levels of physical activity. Similarly, in the study sample the average number of daily steps was approximately double as high compared to epidemiological data from previous studies focusing on the general populations (27, 32). Furthermore, in the current study the female participants were more active and cumulated more daily steps than the males. This might be due to the fact that they were on average almost ten years older than the males and, therefore, more often unemployed and potentially had more time to invest for physical activity. However, other studies monitoring the physical activity of general populations in Germany and worldwide consistently revealed that the levels of physical activity or step counts decrease with increasing age in elderly people from the age of 50 or 60, respectively (30, 32, 33). Thus, the higher levels of physical activity in the female participants (with older average ages) compared to the males seems to be a specificity of the study population. It may be conceivable that the participants having made the experience that moderate physical activity is particularly beneficial, developed a daily routine in conducting high levels of moderate physical activity each day. The experience of beneficial effects of moderate physical activity reported by the participants is in line with the results of studies showing a positive impact of physical activity on RLS symptoms (4, 15, 16, 34).

Furthermore, in the current study none of the participants performed vigorous physical activity even though their levels of moderate physical activity were remarkably high. One possible explanation could be that the participants avoided highly intensive physical activity willingly or unconsciously because they may expect negative consequences with regard to their RLS symptoms due to vigorous physical activity. Another explanation is the high cut-offs that were chosen for the definition of vigorous physical activity in the present study. However, the cut-off of 6,166 cpm applied in this study is based on existing evidence and were suggested for future studies (26). Nevertheless, in other studies lower cut-offs (6,000 cpm or 5,725, respectively) were suggested (35, 36). Particularly regarding higher ages there is no consensus on the most appropriate cut-off points for the classification of intensity levels (37).

Strength and limitations

This study has some strengths that should be taken into account: First to the best of our knowledge, this is the first study investigating the relationship between physical activity and sleep quality in persons suffering from RLS by applying a real-time approach and objective measures. By capturing levels of physical activity and sleep quality in real time and considering day-to-day variations the short term effects could be analyzed which has not been investigated before. Secondly, this study is based on an objective measurement of physical activity...
and a sensor has been applied that has been shown to be a valid tool to measure both, sleep and physical activity simultaneously (38). Even though, the measures on sleep quality may be less accurate than polysomnography which can be considered as a gold standard (39, 40), accelerometry is a cost-efficient alternative to polysomnography with regard to sleep disturbances (41) and PLMS (39, 40, 42, 43). Additionally, accelerometers can be used to capture sleep quality parameters in a real-life home environment. Third, different time spans over the day have been taken into account when analyzing the relationships of physical activity and sleep quality.

However, also some limitations have to be considered: Firstly, the impact of the medication intake of the participants on the results cannot be assessed or quantified. The medication may cause mild disease with a rather low amount of PLMS, which might have hindered the identification of a relationship between physical activity and sleep quality. Secondly, the participants in this study showed very similar physical activity patterns during the data collection with only small variations from day to day. Thus, the inter-individual and intra-individual variance of physical activity in the sample was low and this could rule out to draw conclusions on the relationship of physical activity on sleep quality. Thirdly, we only tested for linear relationships between physical activity and sleep quality without taking other relationships like, for example, a U-shaped relationship into account. During the personal contact with the participants some reported that they experienced such a relationship. Fourthly, the power of our study could be too low for revealing statistical significant results.

Thus, to investigate the effects of daily physical activity on RLS symptoms interventional studies with different intensities of physical activities at different points of time during the day are needed.

**Conclusion**

To our best knowledge, the present study is the first study that examined the effects of physical activity on sleep quality in persons with idiopathic RLS and reported their physical activity levels using a real-time approach based on accelerometry. No association between physical activity and quality of sleep has been found. This could potentially be explained by the low variance in physical activity levels and step counts within the sample. It is striking that the participants of the study sample were extremely active (with a moderate intensity) in comparison to the activity levels of the general population. Finally, in the case that further studies will reveal a benefit of physical activity on RLS symptoms, this disease might be an interesting model for patients treating themselves by regularly being physically active.

**Declarations**

_Ethics approval and consent to participate_

The study was approved by the ethic committees of the Georg-August-University Göttingen (no. 17/2/2016) and Medical association of Thuringia (59838/2017/142) and were conducted according to the Declaration of Helsinki. All participants of the study gave their written informed consent to participate and were informed in detail about the study and data management by the neurologist of the practices where they were recruited.

_Availability of data and materials_

The datasets used and/or analyzed during the current study not publicly available due to privacy reasons of patients, but are available from the corresponding author on reasonable request.

_Competing interests_

The authors declare that they have no competing interests or personal relationships that could have appeared to influence the work reported in this article.

_Funding_

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_Authors’ contributions_

AKR and CDR planned and designed the study and drafted the manuscript. AKR finalized the manuscript and prepared the accelerometers and analyzed the accelerometer data. VH, HJB, CDR recruited and instructed the participants. GK analyzed the data. All authors read and approved the final manuscript.

_Acknowledgments_
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### Tables

**Table 1. Biometrical, behavioral, and sleep data of all participants**
<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Duration of disease (years)</th>
<th>BMI (kg/m²)</th>
<th>Steps (8-23 h)</th>
<th>Steps: Individual variance* [%]</th>
<th>Moderate physical activity (8-23 h) [min.]</th>
<th>Moderate physical activity: Individual variance* [%]</th>
<th>Number of interruptions of sleep</th>
<th>Total sleep period [h]</th>
<th>Sleep efficacy [%]</th>
<th>PLMS / h</th>
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</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
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<td>N= 34</td>
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<tr>
<td>M (SD)</td>
<td>65.4 (10.0)</td>
<td>11.8 (12.0)</td>
<td>26.9 (4.8)</td>
<td>13,817 (4,086)</td>
<td>15 (7)</td>
<td>347 (117)</td>
<td>18 (9)</td>
<td>17.8 (7.2)</td>
<td>5.9 (2.0)</td>
<td>81.2 (15.7)</td>
</tr>
<tr>
<td>Median</td>
<td>64.6</td>
<td>8</td>
<td>25.7</td>
<td>13,370</td>
<td>14</td>
<td>332</td>
<td>15</td>
<td>17.0</td>
<td>5.7</td>
<td>81.0</td>
</tr>
<tr>
<td>1st and 3rd quartile</td>
<td>56.3 – 74.8</td>
<td>3 – 15</td>
<td>23.5 – 29.8</td>
<td>10,565 – 16,794</td>
<td>11 – 19</td>
<td>257 – 419</td>
<td>12 – 21</td>
<td>12.3 – 22.0</td>
<td>4.6 – 7.2</td>
<td>73.7 – 86.8</td>
</tr>
<tr>
<td><strong>Men</strong></td>
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<td>N=13</td>
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</tr>
<tr>
<td>M (SD)</td>
<td>55.3 (14.7)</td>
<td>15.8 (15.6)</td>
<td>28.5 (4.9)</td>
<td>10,636 (3,748)</td>
<td>28 (15)</td>
<td>269 (96)</td>
<td>25 (6)</td>
<td>16.1 (7.5)</td>
<td>6.2 (2.0)</td>
<td>79.4 (11.2)</td>
</tr>
<tr>
<td>Median</td>
<td>55.3</td>
<td>10</td>
<td>29.9</td>
<td>9,924</td>
<td>24</td>
<td>245</td>
<td>25</td>
<td>17.0</td>
<td>5.7</td>
<td>81.5</td>
</tr>
<tr>
<td>1st and 3rd quartile</td>
<td>40.3 – 66.7</td>
<td>5 – 19</td>
<td>24.3 – 31.3</td>
<td>8,034 – 12,843</td>
<td>18 – 30</td>
<td>197 – 321</td>
<td>21 – 30</td>
<td>12.0 – 22.0</td>
<td>5.0 – 6.9</td>
<td>72.9 – 88.0</td>
</tr>
</tbody>
</table>

Note: h= hour (time of the day); M= mean value; min= minutes; N= sample size; PLMS= periodic leg movements; SD= standard deviation; *individual variance = intraindividual variance of physical activity from day to day

**Table 2: Correlation between steps and sleep quality parameters**
<table>
<thead>
<tr>
<th>Number of interruptions of sleep</th>
<th>Total sleep period</th>
<th>Sleep efficacy</th>
<th>PLMS / h</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>R</td>
<td>p</td>
<td>N</td>
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<tr>
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</tr>
<tr>
<td><strong>Steps</strong></td>
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<tr>
<td><strong>6 AM -12 noon</strong></td>
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</tr>
<tr>
<td>All</td>
<td>45</td>
<td>-0.0040 (95% CI: -0.1809 – 0.1731)</td>
<td>0.9648</td>
</tr>
<tr>
<td>Males</td>
<td>12</td>
<td>-0.1684 (95% CI: -0.4933 – 0.1977)</td>
<td>0.3682</td>
</tr>
<tr>
<td>Females</td>
<td>33</td>
<td>0.0465 (95% CI: -0.1566 – 0.2457)</td>
<td>0.6556</td>
</tr>
<tr>
<td><strong>Steps</strong></td>
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<tr>
<td><strong>12 noon -6 PM</strong></td>
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<tr>
<td>All</td>
<td>44</td>
<td>-0.0928 (95% CI: -0.2676 – 0.0879)</td>
<td>0.3140</td>
</tr>
<tr>
<td>Males</td>
<td>11</td>
<td>-0.3259 (95% CI: -0.6185 – 0.0462)</td>
<td>0.0846</td>
</tr>
<tr>
<td>Females</td>
<td>33</td>
<td>-0.0231 (95% CI: -0.2246 – 0.1804)</td>
<td>0.8258</td>
</tr>
<tr>
<td><strong>Steps</strong></td>
<td></td>
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<tr>
<td><strong>6 PM -11 PM</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>45</td>
<td>-0.1116 (95% CI: -0.2817 – 0.0653)</td>
<td>0.2158</td>
</tr>
<tr>
<td>Males</td>
<td>12</td>
<td>0.0386 (95% CI: -0.3088 – 0.3769)</td>
<td>0.8326</td>
</tr>
<tr>
<td>Females</td>
<td>33</td>
<td>-0.1599 (95% CI: -0.3501 – 0.0431)</td>
<td>0.1221</td>
</tr>
<tr>
<td><strong>Steps</strong></td>
<td></td>
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<tr>
<td><strong>6 AM -11 PM</strong></td>
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</tr>
<tr>
<td>All</td>
<td>44</td>
<td>-0.1411 (95% CI: -0.3124 – 0.0391)</td>
<td>0.1245</td>
</tr>
<tr>
<td>Males</td>
<td>11</td>
<td>-0.0322 (95% CI: -0.6156 – 0.0509)</td>
<td>0.0891</td>
</tr>
<tr>
<td>Females</td>
<td>33</td>
<td>-0.0871 (95% CI: -0.2847 – 0.1176)</td>
<td>0.4048</td>
</tr>
</tbody>
</table>

Note: MPA = moderate physical activity; significant correlations are shown in bold.
Table 3: Correlation between moderate physical activity (MPA) and sleep quality parameters
<table>
<thead>
<tr>
<th></th>
<th>Number of interruptions of sleep</th>
<th></th>
<th>Total sleep period</th>
<th></th>
<th>Sleep efficacy</th>
<th>PLMS / h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>R</td>
<td>p</td>
<td>N</td>
<td>R</td>
<td>p</td>
</tr>
<tr>
<td><strong>MPA 6 AM - 12 noon</strong></td>
<td>All</td>
<td>45</td>
<td>-0.0040 (95% CI: -0.1809 – 0.1731)</td>
<td>0.9648</td>
<td>45</td>
<td>-0.0977 (95% CI: -0.2701 – 0.0807)</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>12</td>
<td>-0.1684 (95% CI: -0.4933 – 0.1977)</td>
<td>0.3682</td>
<td>12</td>
<td>-0.1531 (95% CI: -0.4813 – 0.2128)</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>33</td>
<td>0.0465 (95% CI: -0.1566 – 0.2457)</td>
<td>0.6556</td>
<td>33</td>
<td>-0.0088 (95% CI: -0.2778 – 0.1228)</td>
</tr>
<tr>
<td><strong>MPA 12 noon – 6 PM</strong></td>
<td>All</td>
<td>44</td>
<td>-0.0928 (95% CI: -0.2676 – 0.0879)</td>
<td>0.3140</td>
<td>45</td>
<td>-0.0146 (95% CI: -0.1912 – 0.1628)</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>11</td>
<td>-0.3259 (95% CI: -0.6185 – 0.0462)</td>
<td>0.0846</td>
<td>12</td>
<td>-0.0891 (95% CI: -0.4246 – 0.2679)</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>33</td>
<td>-0.0231 (95% CI: -0.2246 – 0.1804)</td>
<td>0.8258</td>
<td>33</td>
<td>0.0092 (95% CI: -0.1938 – 0.2114)</td>
</tr>
<tr>
<td><strong>MPA 6 PM – 11 PM</strong></td>
<td>All</td>
<td>45</td>
<td>-0.1116 (95% CI: -0.2817 – 0.0653)</td>
<td>0.2158</td>
<td>45</td>
<td>-0.2485 (95% CI: -0.4064 – -0.0762)</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>12</td>
<td>0.0386 (95% CI: -0.3088 – 0.3769)</td>
<td>0.8326</td>
<td>12</td>
<td>-0.2741 (95% CI: -0.5643 – 0.0764)</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>33</td>
<td>-0.1599 (95% CI: -0.3501 – 0.0431)</td>
<td>0.1221</td>
<td>33</td>
<td>-0.2401 (95% CI: -0.4213 – -0.0405)</td>
</tr>
<tr>
<td><strong>MPA 6 AM – 11 PM</strong></td>
<td>All</td>
<td>44</td>
<td>-0.1411 (95% CI: -0.3124 – 0.0391)</td>
<td>0.1245</td>
<td>45</td>
<td>-0.0805 (95% CI: -0.2553 – 0.0995)</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>11</td>
<td>-0.0322 (95% CI: -0.6156 – 0.0509)</td>
<td>0.0891</td>
<td>12</td>
<td>-0.1255 (95% CI: -0.4647 – 0.2459)</td>
</tr>
<tr>
<td>Females</td>
<td>33</td>
<td>-0.0871 (95% CI: -0.2847 – 0.1176)</td>
<td>0.4048</td>
<td>33</td>
<td>-0.0670 (95% CI: -0.2660 – 0.1375)</td>
<td>0.5220</td>
</tr>
</tbody>
</table>

Note: MPA = moderate physical activity; significant correlations are shown in bold.