Periodic Limb Movements During Sleep: Population Prevalence, Clinical Correlates, and Racial Differences

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Study Objective: There is growing interest in the study of periodic limb movements during sleep and their potential clinical correlates. The aim of the present analysis is to address the lack of population-based studies using polysomnographic (PSG) measures to determine the prevalence of period limb movements during sleep in specific racial groups as well as the general population.

Settings and participants: A community-based sample of 592 participants drawn from the general population of tricounty Detroit (mean age = 41.9 ± 12.6 years; 52.9% F; 31.5% African American). All individuals were assessed using objective and subjective measures in the sleep laboratory.

Measurements: Participants were evaluated during a 24-h laboratory assessment, including a polysomnogram and multiple sleep latency test. Periodic leg movements were scored using standard criteria. Reports of sleep disturbance and daytime sleepiness were also assessed using standardized measures including the Global Sleep Assessment Questionnaire (GSAQ) and the Epworth Sleepiness Scale (ESS).

Results: The overall prevalence of periodic limb movements during sleep (PLMSI >15) was 7.6%. African Americans had a lower prevalence of PLMSI >15 than Caucasians (4.3% vs. 9.3%; \( \chi^2 = 4.5, P < 0.05 \)). Regardless of race, symptoms of insomnia were significantly higher in individuals with PLMSI >15 than in those with PLMSI ≤15 (45% vs. 25%; \( \chi^2 = 6.84, P < 0.01 \)).

Keywords: Periodic limb movement, racial differences, excessive sleepiness, prevalence, restless leg syndrome

Conclusion: This is the first study to determine the prevalence of PLMS in a population-based sample using standardized objective criteria. A key finding of the present study is that racial differences in this PSG parameter do exist, with African Americans being less likely to have elevated PLMS.

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There has been a growing interest in ethnic and racial diversity in relation to sleep parameters. The study of differences in sleep between racial groups may lead to an increased understanding of genetic and environmental contributions to sleep physiology and its disorders. Numerous studies of sleep have examined differences in sleep parameters and sleep related symptoms by gender and age, but not nearly as many have focused on racial differences. Nonetheless, several studies have demonstrated racial differences in relation to sleep variables. Differences in sleep habits as well as a higher prevalence of sleep disordered breathing (SDB) in African Americans compared to Caucasians has been reported. The heterogeneity of restless leg syndrome (RLS) prevalence estimates (0.1% to 13%) across countries with varying ethnic and racial distributions has led to studies investigating potential racial differences in this disorder. In one population-based survey in the United States, the prevalence of RLS was estimated at approximately 4% in both African Americans and Caucasians. In a study of older hemodialysis patients, Kutner and Bliwise found a lower prevalence of restless leg symptoms in African American patients and in a follow-up analysis reported reduced periodic limb movements during sleep (PLMS) in the African American sample. Thus, the influence of racial differences in RLS and/or PLMS is not well defined.

Despite the wealth of data available on the prevalence of RLS among individuals of varying ethnic and racial backgrounds, few studies have examined potential racial differences in the closely related occurrence of PLMS. The term for periodic limb movements during sleep, originally called nocturnal myoclonus, was defined as a phenomenon characterized by repetitive flexions and extensions involving the toes, ankles, and occasionally the knee and hip. These frequent movements occur in one or both legs during sleep, and often produce brief arousals and, in some cases, full awakenings from sleep. Periodic limb movement disorder (PLMD) is defined by the International Classification of Sleep Disorders (ICSD) as periodic leg move-
dents >15/h accompanied by a clinical sleep disturbance or a complaint of daytime fatigue. Although results have been mixed as to whether PLMD causes significant sleep disturbance or excessive daytime sleepiness, recent studies have demonstrated that nearly all PLMS are accompanied by autonomic arousal. In addition, evidence is emerging that PLMS is associated with increases in blood pressure.

It has been demonstrated that RLS and PLMS are related to low iron stores as reflected by reduced serum ferritin levels. In fact, a recent study has demonstrated a distinct genetic sequence variant related to PLMS that also varies with serum ferritin levels, providing further evidence for the link between low iron stores and the development of PLMS. Given studies demonstrating higher iron stores in African Americans, these data provide a plausible rationale for racial differences in the prevalence of PLMS.

There are no PSG studies examining the prevalence of PLMS in the general population and even fewer examining the prevalence of PLMS in African Americans. The reason for this discrepancy is likely due to the practical difficulty inherent in assessing large population-based samples in the laboratory; PLMS is a sign-based finding utilizing polysomnographic measures, whereas RLS is a symptom-based disorder. In an attempt to circumvent this limitation, one population-based survey obtained respondent reports of PLMS and estimated the prevalence of PLMD at approximately 3.9%. While no racial differences were examined in this study, PLMD was found to be associated with shift work, daily caffeine intake, and stress.

The major limitation of this study was that PSG was not used to verify the presence of PLMS. Indeed, nearly all studies of PLMD have been carried out in self-selected clinical populations.

In one of the few laboratory studies investigating potential racial differences in PLMS, O’Brien and colleagues found that African American children 5–7 years of age had a lower prevalence of PLMS than Caucasian children, despite absence of differences in sleep architecture. Further support for this racial difference comes from a study of PLMS in hemodialysis patients, which found a lower prevalence of PLMS in African Americans.

It is important to determine the prevalence of PLMS in the general population, as well as to identify associated risk factors in order to determine possible pathophysiology and effective treatment. Selection bias inherent in clinical samples limits the ability to generalize previous findings. Thus, it is unclear if the racial distribution of adult PLMS varies, which is important in terms of allocation of health services and health promotion regarding PLMS. In addition, identification of a reduced or increased risk for PLMS in certain racial groups may inform future etiological hypotheses.

Because of limited data available regarding the prevalence and morbidity of PSG-defined PLMS as well as a lack of population-based data on the racial distribution of this important aspect of sleep, the purpose of the present analysis was to (1) estimate the prevalence of PLMS >15 in the general population, (2) determine if there is a relationship between PLMS and race, and (3) investigate the relationship between PLMS and an objective measure of daytime sleepiness.

METHODS

Subjects

The data used for this study were collected as part of a larger epidemiological study on daytime sleepiness in the general population of tri-county Detroit, Michigan. This area includes 84% of the population of Southeastern Michigan and is similar to the demographics of the United States as a whole, with the exception of a slightly skewed racial/ethnic distribution (i.e., larger African American population and a smaller Hispanic population). The research design was composed of 2 components: (1) a random digit dial computer assisted telephone survey, and (2) an overnight polysomnogram (PSG). To be eligible for this study, participants had to be between the ages of 18 to 65 years of age. A random probability selection procedure was used to determine the sex of the target adult. If 2 or 3 adults within a target gender were present in a household, random probability selection procedure (oldest/second, oldest/youngest) was used to determine the target respondent. If 4 or more adults with target gender were present in the household, the last birthday method was used to determine the target respondent. To maintain an unbiased sample, only individuals who could not answer the questionnaire due to sensory or mental impairment were excluded from sample. The overall response rate was 70.1%.

Of the 3,282 subjects, 623 were studied during a 24-h laboratory evaluation. One subject was excluded on the basis of age. The demographic details of the larger sample including race, age, and socioeconomic status have been published elsewhere and are nearly identical to the 2000 census data for the area. Of the 3,282 subjects, 403 were randomly selected. Because this study was a part of a larger study on daytime sleepiness, we also selected 220 individuals who scored high on the Daytime Sleepiness Scale (DSS). However, there were no differences in the periodic limb movement parameters between these samples (see results). Thus, combined data from both the random and enriched samples are presented here (Figure 1).

We excluded 23 participants (3.7%) from our data analysis because they had apnea hypopnea indexes (AHI) ≥15 per hour. Less than 5% of the laboratory participants were missing subjective or objective data caused by data loss or technical error. The final sample included 592 individuals (4 participants did not report race, and 4 individuals had missing PSG data due to technical error). Of those participants with complete laboratory data, 31.5% were African American. Individuals with missing data on a particular variable were excluded from the respective analyses. Individuals were paid for study participation. The Henry Ford Hospital institutional review board approved all procedures, and informed consent was obtained from all participants.

Procedures

Initially, the participants completed a 20-min telephone interview which included questions related to sleep and health habits, along with general information regarding sleep disorders and medical and psychiatric status. Participants selected to come into the laboratory completed a 2-week sleep diary and reported to the laboratory at the end of the 2 weeks.
Periodic leg movements were scored using standard criteria from the *International Classification of Sleep Disorders, Second Edition (ICSD-2)* manual. Leg movements were scored by the following strict criteria: (1) duration between 0.5 to 5 sec; (2) amplitude ≥ 25% of calibration movement; (3) interval between 5 and 90 sec from leg movement onset; and (4) movements had to be part of a series of ≥ 4 consecutive movements meeting these criteria. Leg movements were also quantified based on whether they were associated with an arousal (PLMA), or a full awakening (> 15 sec of subsequent wakefulness [PLMW]).

Arousals were scored using standard criteria. The periodic leg movement in sleep index (PLMSI) was calculated by dividing the total number of leg movements occurring during sleep by total sleep time. Consistent with the ICSD-2 criteria, a PLMSI > 15 was used as the cutoff criterion for elevated PLMSI. The rationale for the use of this cutoff in the ICSD-2 is that normative values greater than the previously accepted cutoff of 5 have been found in studies when respiratory events may have been present, and that a partial overlap of PLMSI values has been found between symptomatic and asymptomatic individuals.

Reports of insomnia and daytime sleepiness were assessed using the Global Sleep Assessment Questionnaire (GSAQ) and the Epworth Sleepiness Scale (ESS). Possible responses to the questions from the GSAQ were: “never,” “sometimes,” “usually,” or “always.” Participants also needed to have responded with “usually” or “always” to either question 1 or 2 regarding insomnia on the GSAQ to meet symptom criteria. GSAQ question 1 was: “over the past 4 weeks did you have difficulty falling asleep, staying asleep, or feeling poorly rested in the morning?” and was used to assess symptoms of sleep disturbance. The GSAQ question 2 was: “over the past 4 weeks did you feel asleep unintentionally or have to fight to stay awake during the day?” and was used to assess daytime sleepiness. In addition, the Epworth Sleepiness Scale was used as an additional subjective measure of sleepiness. Reports of restless legs and periodic leg movements were collected using 2 questions from the GSAQ: question 7: “did you have restless or crawling feelings in your legs at night that went away if you moved your legs?” and question 8: “did you have repeated rhythmic leg jerks or leg twitches during your sleep?” Several questions regarding specific insomnia symptoms (i.e., sleep induction and maintenance) were also examined, using data collected during the phone interview.

In order to examine prevalence differences with respect to caffeine intake, habitual caffeine consumption averages were calculated. These were based on reported daily caffeine intake per day recorded in the 2-week sleep diary. Daily milligrams of caffeine intake was estimated based on the type of drink (coffee, soda, tea) and the number of drinks recorded per day. Similarly, average daily consumption of alcoholic drinks was calculated from data recorded in the 2-week sleep diary as recorded in drinks per week.

**Analysis**

All statistical analyses were performed using SPSS 10.0. Comparisons by race were first made for the standard PLMSI cutoff of >15/h to determine if African Americans had a lower prevalence of leg movements during sleep. Cross tabulations with chi-square analyses were used to compare the prevalence of PLMSI >15 in each racial group (African Americans, Caucasians, other). Sleep parameters and other continuous variables were compared for individuals with and without PLMSI >15, using separate analysis of variance (ANOVA). Finally, a logistic regression analysis using race as a predictor of PLMSI with insomnia or sleepiness while controlling for age, gender, caffeine, RLS, socioeconomic status, and body mass index (BMI) was performed.

**RESULTS**

There were no differences in the PLMSI between the random and selected samples (random PLMSI = 3.6 ± 9.1 and selected = 2.9 ± 9.0; P = 0.22). As both samples were drawn from the larger overall population-based random digit dialing protocol, data from both groups were combined for analyses. The overall prevalence of PLMSI >15/h was 7.6%. The demographic data
The overall prevalence of subjects having a PLMSI >15 combined with symptoms of insomnia or excessive sleepiness was 4.5%. Similar to the analysis of PLMSI, African Americans also had a lower prevalence of PLMSI >15 and symptoms than Caucasians (1.1% vs. 5.8%; P < 0.02). In 2 separate multiple logistic regression analyses (PLMSI and PLMSI + symptoms), these racial differences remained significant after controlling for body mass index (BMI), age, gender, socioeconomic status, AHI, and habitual alcohol and caffeine consumption (P < 0.05). Differences were found in daily caffeine intake between African Americans and Caucasians, with Caucasians consuming more caffeine (mean = 78 mg vs. mean = 142 mg; P < 0.05). However, no correlation was found between the amount of caffeine consumed and the PLMSI (r = 0.02, P = 0.62).

In individuals with PLMSI > 15, 56% reported symptoms of either sleepiness or sleep disturbance on the GSAQ, compared with only 29% in those participants with a PLMSI ≤ 15 (χ² = 11.18, P < 0.001). When each symptom was compared separately, 45% of individuals with a PLMSI > 15 reported sleep disturbance in the month previous to their laboratory visit, compared to 25% for those with a PLMSI ≤ 15 (χ² = 6.84, P < 0.01). For sleepiness, 12.5% of individuals with a PLMSI > 15 reported sleepiness on the GSAQ compared to 8.5% with a PLMSI ≤ 15 (P > 0.05; Figure 3). Different commonly used clinical cutoffs produced a similar pattern of results showing that individuals with elevated PLMSI (i.e., > 10; > 5), reported significantly more insomnia symptoms (P < 0.05 for both) but no significant difference in daytime sleepiness (P > 0.05). Overall, PLMSI was correlated with GSAQ insomnia complaints in Caucasians (r = 0.23, P < 0.05), but not in African Americans (r = 0.08, P > 0.05). When specific insomnia symptoms were examined, individuals with PLMSI > 15 reported significantly more difficulty falling asleep (P < 0.05) and more difficulty falling back to sleep after waking up (P < 0.05). In addition, the PLMSI was weakly but significantly associated with both symptoms—difficulty falling asleep (r = 0.12, P < 0.01) and difficulty falling back to sleep after waking up (r = 0.08, P < 0.05). No difference was found between high and low PLMSI groups for either mean MSLT or ESS scores (P > 0.05 for both; Table 1). Neither objective nor self-report measures of sleepiness were correlated with the PLMSI (MSLT, r = −0.08; ESS, r = 0.01; P > 0.05 for both).

### Table 1—Subjective and Objective Data for the PLMSI Groups

<table>
<thead>
<tr>
<th>Sleep Variables</th>
<th>PLMSI ≤ 15 (N = 547)</th>
<th>PLMSI &gt; 15 (N = 45)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>40.6 ± 12.61</td>
<td>46.8 ± 13.3*</td>
</tr>
<tr>
<td>% Female</td>
<td>53.7%</td>
<td>42.2%</td>
</tr>
<tr>
<td><strong>Socioeconomic status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10,000-20,000</td>
<td>16.9%</td>
<td>18.2%</td>
</tr>
<tr>
<td>20,000-35,000</td>
<td>18.9%</td>
<td>27.3%</td>
</tr>
<tr>
<td>35,000-75,000+</td>
<td>64.2%</td>
<td>54.5%</td>
</tr>
<tr>
<td><strong>Objective sleep data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep efficiency</td>
<td>84.53 ± 11.94</td>
<td>81.72 ± 11.66</td>
</tr>
<tr>
<td>Sleep latency</td>
<td>16.16 ± 24.06</td>
<td>10.64 ± 9.20*</td>
</tr>
<tr>
<td>LPS</td>
<td>26.29 ± 33.38</td>
<td>22.72 ± 20.78</td>
</tr>
<tr>
<td>Stage 1 %</td>
<td>10.05 ± 6.90</td>
<td>12.09 ± 6.28</td>
</tr>
<tr>
<td>Stage 2 %</td>
<td>57.69 ± 23.00</td>
<td>57.90 ± 9.72</td>
</tr>
<tr>
<td>Stage 3/4 %</td>
<td>14.76 ± 9.87</td>
<td>12.15 ± 9.48</td>
</tr>
<tr>
<td>REM %</td>
<td>18.43 ± 6.72</td>
<td>17.86 ± 6.29</td>
</tr>
<tr>
<td>Average MSLT</td>
<td>10.28 ± 4.75</td>
<td>9.81 ± 4.73</td>
</tr>
<tr>
<td>BMI</td>
<td>27.68 ± 6.20</td>
<td>28.85 ± 5.34</td>
</tr>
<tr>
<td><strong>Subjective sleep data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epworth Sleepiness Scale</td>
<td>9.04 ± 4.43</td>
<td>9.07 ± 4.06</td>
</tr>
<tr>
<td>Caffeine mg/day</td>
<td>137.78 ± 167.95</td>
<td>130.57 ± 135.26</td>
</tr>
<tr>
<td>PLMS Index</td>
<td>1.18 ± 3.02</td>
<td>29.99 ± 14.33*</td>
</tr>
<tr>
<td>RLSQ1*</td>
<td>5.5%</td>
<td>22.5%</td>
</tr>
<tr>
<td>RLSQ2*</td>
<td>2.7%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Reported Hypertension %</td>
<td>26.1%</td>
<td>34.8%</td>
</tr>
</tbody>
</table>

*P < 0.05; P < 0.1; LPS = latency to persistent sleep; RLSQ1 = Answered “usually” or “always” to question 7 on the Global Sleep Assessment Questionnaire (GSAQ): Did you have restless “crawling” feelings in your legs at night that went away if you moved your legs?

RLSQ2 = Answered “usually” or “always” to question 8 on GSAQ: Did you have repeated rhythmic leg jerks or leg twitches during your sleep?

Along with objective PSG and subjective sleep measures in the 2 PLMS index groups (i.e., PLMSI ≤ 15 and PLMSI > 15) are shown in Table 1. Individuals with a PLMSI > 15 were slightly but significantly older (P < 0.05). No group differences were found for any of the PSG variables, with the exception that individuals with PLMSI >15 had a shorter latency to the first stage of sleep. Those with a PLMSI >15 also had a greater percentage of stage 1 sleep, but this did not reach statistical significance (P = 0.056). There were no between-group differences for self-reported sleep variables.

African Americans had a lower prevalence of PLMSI > 15 than Caucasians (4.3% vs. 9.3%; χ² = 4.5, P < 0.05). While the numbers of subjects in the “other” racial category (i.e., American Indian or Alaskan Native, Asian, and all other racial groups) were not sufficient to provide adequate statistical power for comparison, individuals in the “other” category had a similar prevalence of PLMSI >15 to that of Caucasians (8.1% vs. 9.3%; P > 0.05). Figure 2 shows that African Americans had a lower prevalence of PLMSI throughout the entire range of potential cutoff values.

The overall prevalence of subjects having a PLMSI >15 combined with symptoms of insomnia or excessive sleepiness was 4.5%. Similar to the analysis of PLMSI, African Americans also had a lower prevalence of PLMSI >15 and symptoms than Caucasians (1.1% vs. 5.8%; P < 0.02). In 2 separate multiple logistic regression analyses (PLMSI and PLMSI + symptoms), these racial differences remained significant after controlling for body mass index (BMI), age, gender, socioeconomic status, AHI, and habitual alcohol and caffeine consumption (P < 0.05). Differences were found in daily caffeine intake between African Americans and Caucasians, with Caucasians consuming more caffeine (mean = 78 mg vs. mean = 142 mg; P < 0.05). However, no correlation was found between the amount of caffeine consumed and the PLMSI (r = 0.02, P = 0.62).

In individuals with PLMSI > 15, 56% reported symptoms of either sleepiness or sleep disturbance on the GSAQ, compared with only 29% in those participants with a PLMSI ≤ 15 (χ² = 11.18, P < 0.001). When each symptom was compared separately, 45% of individuals with a PLMSI > 15 reported sleep disturbance in the month previous to their laboratory visit, compared to 25% for those with a PLMSI ≤ 15 (χ² = 6.84, P < 0.01). For sleepiness, 12.5% of individuals with a PLMSI > 15 reported sleepiness on the GSAQ compared to 8.5% with a PLMSI ≤ 15 (P > 0.05; Figure 3). Different commonly used clinical cutoffs produced a similar pattern of results showing that individuals with elevated PLMSI (i.e., > 10; > 5), reported significantly more insomnia symptoms (P < 0.05 for both) but no significant difference in daytime sleepiness (P > 0.05). Overall, PLMSI was correlated with GSAQ insomnia complaints in Caucasians (r = 0.23, P < 0.05), but not in African Americans (r = 0.08, P > 0.05). When specific insomnia symptoms were examined, individuals with PLMSI > 15 reported significantly more difficulty falling asleep (P < 0.05) and more difficulty falling back to sleep after waking up (P < 0.05). In addition, the PLMSI was weakly but significantly associated with both symptoms—difficulty falling asleep (r = 0.12, P < 0.01) and difficulty falling back to sleep after waking up (r = 0.08, P < 0.05). No difference was found between high and low PLMSI groups for either mean MSLT or ESS scores (P > 0.05 for both; Table 1). Neither objective nor self-report measures of sleepiness were correlated with the PLMSI (MSLT, r = −0.08; ESS, r = 0.01; P > 0.05 for both).
We also found that subjects with a PLMSI > 15 were approximately 4 times as likely to have reported either “restless or crawling feelings in their legs at night” and almost 4 times as likely to have “repeated leg jerks or twitches during sleep” as those subjects with a PLMSI ≤ 15 (P < 0.05). However, there were no significant differences found between the racial groups for either question (P > 0.05). Only a small number of subjects (n = 5) had a significant number of leg movements (> 15/h) associated with arousals from sleep (i.e., PLMAI), and an even smaller number of subjects (n = 1) had frequent leg movements associated with full awakenings from sleep (i.e., > 15/h). No correlation was found between the PLMSI and PLMAI (P > 0.05).

**DISCUSSION**

This is the first study to determine the prevalence of PLMSI > 15 in a population-based sample using standardized PSG criteria. The prevalence rate found (7.6%) is consistent with previous findings using subjective criteria. Another major finding of the present study is that racial differences in PLMS exist, with African Americans being less likely to have a PLMSI > 15. Racial differences in PLMS have been shown in children 5-7 years of age, with few differences in sleep architecture. Our results are consistent with these findings and extend those results to the adult population. Interestingly, the relative risk for PLMS in African Americans compared to Caucasians in our adult sample was similar to that found in a study by Lee and colleagues. Taken together, these findings suggest that the racial differences found in adults may be present from an early age, pointing to potential genetic differences. Indeed, a recent study has implicated a common genetic variant in an intron of BTBD9 on chromosome 6p21.2 with an odds ratio for PLMS similar to that found in the present study. Further research is needed to determine if the present findings can be attributed to genetic components.

Evidence suggests that the dopaminergic neurotransmitter system is involved in the pathology of PLMS and RLS. In addition, current research has shown that low ferritin levels (reduced iron stores) are a significant factor in predicting a high prevalence of PLMS and RLS. One study showed that when patients were prescribed iron sulfate, their PLMS improved. Another study examining ferritin levels in the elderly with RLS showed that, when treated with ferrous sulfate for 2 months, the severity of RLS improved. Most importantly, additional research comparing ferritin levels in serum has shown that African Americans have a higher capacity to store iron than Caucasians, leading to a lower rate of RLS and PLMS and providing further support for the findings of this study. The lower prevalence of PLMS in African Americans than Caucasians should be studied further to determine the potential contributions of factors such as medication use (e.g., SSRIs), substance use, upper airway resistance syndrome, and genetics.

Other factors were examined in our study to determine possible differences that may have existed between individuals in each index group. Our study found that caffeine consumption, including coffee and all caffeinated beverages, was higher in Caucasians than in African Americans. However, unlike Ohayon’s study, which showed individuals who drank at least 3 cups of coffee per day were more likely to have symptoms of PLMD, our study showed no relationship between the amount of caffeine consumed and the number of periodic leg movements measured by PSG. Our data are consistent with a study showing no relationship between PLMI and caffeine consumption, using actigraphic measurement of leg movements. More studies are needed to determine what role, if any, caffeine has on periodic limb movements and how their consumption differs among the races possibly contributing to a difference in prevalence.

Another important result of this study was that 7.6% of individuals from the general population experience a significant number of periodic leg movements (> 15/h) during sleep. These individuals did not report significantly more daytime sleepiness but did report more sleep disturbance than individuals without a significant number of leg movements. By examining the symptoms associated with PLMD, we were able to determine which symptoms, if any, were associated with a PLMSI > 15. The analysis of MSLT and ESS results are in agreement with these findings and those of previous studies showing that even a high number of PLMS is not usually accompanied by excessive sleepiness (mean sleep onset latency on MSLT < 5; ESS score > 10). Our data are also consistent with another population-based study of PLMS, in which ESS scores were not associated with leg movements during sleep. The current study also extends those findings using the gold standard measure of sleepiness, the MSLT. However, data from clinical samples may show a differentially higher rate of sleepiness in individuals with PLMD, as excessive sleepiness is often a symptom which prompts initial clinical evaluation.

Interestingly, those with a PLMSI > 15 were much more likely to report symptoms of RLS or Insomnia on the GSAQ. While subjects with PLMSI > 15 had significantly elevated reports of insomnia symptoms including difficulty with sleep induction and maintenance, the PSG data did not indicate any significant sleep disturbance beyond a reduced sleep latency and a trend for increased stage 1 sleep in this group. This is consistent with studies of insomnia showing discrepancies between PSG and self-report data (e.g., no PSG sleep disturbance) despite the presence of other objective abnormalities. Although speculative, the trend...
towards an increase in stage I sleep suggests the reduced latency in the PLMSI group may reflect a slight increase in sleep pressure caused by sleep fragmentation that was not identified using standard PSG measures. Additional population-based studies are needed with diagnostic evaluations for sleep disorders to determine the possible relevance of the current findings for the assessment of periodic limb movement disorder.

Several limitations of the current study should be addressed. In previous studies the number of PLMS has been shown to vary from night to night, particularly in individuals with less severe sleep complaints. Because our study included only one night of PSG, it is possible that some individuals with elevated PLMS were not identified during the single overnight visit. It is also possible that a first night effect in the laboratory caused a disruption in sleep or a delay in sleep onset, resulting in fewer PLMS than otherwise might have been detected. The use of bed partner reports/interviews may have aided in this regard. Although one night of PSG is typically used in evaluations, further studies are warranted using multiple nights in order to confirm the prevalence rates found in the present study. In addition, the assessment of sleep disordered breathing was made using nasal thermistors and not nasal pressure recordings. Although there is a chance that some hypopneas may have been missed and counted as leg movements, the low PLMS arousal rates and lack of correlation between BMI and PLMS (r = 0.08, P = ns) argue against this possibility. Finally, the absence of differences in the prevalence of RLS symptoms in our sample is inconsistent with some studies, but in large epidemiological samples, using a standardized assessment, no racial differences in RLS were noted. These inconsistencies are likely due to the nature of the samples assessed.

The present findings show that the prevalence of PLMSI >15 is relatively high in the general population, and that African Americans have a significantly lower prevalence than Caucasians, based on polysomnography. More studies are needed to determine the potential genetic significance of periodic limb movements in relation to the racial differences found in the present study.

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