

Restless Legs Syndrome and Poor Sleep Quality in Obese Children and Adolescents

© Rıza Taner Baran¹, © Müge Atar², © Özgür Pirgön², © Serkan Filiz³, © Meral Filiz⁴

¹University of Health Sciences, Antalya Training and Research Hospital, Clinic of Pediatric Endocrinology and Diabetes, Antalya, Turkey

²Süleyman Demirel University Faculty of Medicine, Department of Pediatric Endocrinology and Diabetes, Isparta, Turkey

³University of Health Sciences, Antalya Training and Research Hospital, Department of Pediatric Allergy, Antalya, Turkey

⁴University of Health Sciences, Antalya Training and Research Hospital, Department of Physical Therapy and Rehabilitation, Antalya, Turkey

What is already known on this topic?

Restless Legs syndrome (RLS) is a sensory-motor disorder characterized by feelings of discomfort, causing the desire to move the legs. RLS is also common in the pediatric population affecting 2-4% of school-aged children and adolescents. Sleep disturbance has been shown to be a commonly associated feature of RLS in the pediatric population.

What this study adds?

This study demonstrated that the rate of Restless legs syndrome is higher in obese adolescents than in the general population. The rate is higher in patients with higher body mass index. Obese patients with RLS were found to have significantly more sleep-related symptoms.

Abstract

Objective: Adult epidemiological studies suggest that the rate of Restless Legs syndrome (RLS) in the general population may range from 5% to 15%. The aim of this study was to investigate the frequency of RLS in a community sample of obese adolescents aged 10-16 years and to assess the association with sleep quality and health-related glucose metabolism markers.

Methods: The study group comprised 144 obese and overweight children aged 10-16 years and the control group consisted of 66 age-matched healthy children. The RLS Questionnaire devised by the International RLS Study and the Pittsburgh Sleep Quality Index (PSQI), where a score >5 indicates poor sleep quality, was used to assess sleep quality.

Results: Mean body mass index (BMI) of the overweight/obese and control groups were 30.5 ± 0.5 and 18.7 ± 0.2 , respectively. The frequency of RLS was higher in the obese group (21.7%) than the overweight (3.4%) and control (1.5%) ($p < 0.001$) groups. The frequency of a poor PSQI score was significantly higher ($p < 0.001$) in the obese group (37.3%) than the control group (24.2%). The obese with RLS group also had poorer sleep quality scores than the non-RLS obese group. Many symptoms of sleep disruption were more common in obese patients with RLS and RLS was independently correlated with a high PSQI score [odds ratio (OR): 2.25, confidence interval (CI): 0.96-5.28, $p < 0.001$] and an increased BMI z-score (OR: 8.87, CI: 2.04-38.61, $p < 0.001$).

Conclusion: RLS is common in obese children and may be associated with altered sleep quality. Obese children with RLS need to be assessed since they may need support to improve their sleep quality.

Keywords: Obesity, restless legs syndrome, sleep quality, adolescent



Address for Correspondence: Müge Atar MD, Süleyman Demirel University Faculty of Medicine, Department of Pediatric Endocrinology and Diabetes, Isparta, Turkey
Phone: +90 246 211 93 02 **E-mail:** drmugeatar@gmail.com **ORCID ID:** orcid.org/0000-0002-9153-8580
This manuscript was presented Turkish Pediatric Congress (Türk Pediatri Kongresi, 2017).

©Copyright 2018 by Turkish Pediatric Endocrinology and Diabetes Society
The Journal of Clinical Research in Pediatric Endocrinology published by Galenos Publishing House.

Conflict of interest: None declared

Received: 08.08.2017

Accepted: 16.11.2018

Introduction

Childhood obesity is associated with various adverse outcomes, such as poor academic performance, reduced psychological well-being, life-long obesity and cardiovascular diseases, which can all impair overall quality of life (1). Obese individuals are significantly more likely to report sleep disturbances (2). Today, there is increasing evidence indicating that sleep duration may be associated with obesity since sleeping plays a vital role in hormonal release, metabolic changes and lifestyle, which may result in obesity (3).

Restless Legs syndrome (RLS) is a sensory-motor disorder characterized by feelings of discomfort, causing the desire to move the legs (4). It manifests as an urge to move or the presence of unpleasant sensations in the extremities, symptoms that are worse with inactivity (while resting, sitting or lying down), which partially or wholly ease while moving the legs or walking, and are most severe at night (5,6). Currently, the pathophysiology of RLS is thought to be related with genetic predisposition, brain dopamine dysfunction and deficiencies in iron metabolism, although these factors have to date offered only a partial explanation (7).

RLS is usually associated with delayed sleep onset, difficulty in maintaining sleep, decreased total sleep time and reduced or absent slow-wave sleep (8). Sleep disturbance has been shown to be a commonly associated feature of pediatric RLS in population and clinic-based studies. Sleep disturbance is often the primary clinical complaint and more common in children with more severe RLS. Sleep disturbance is reported to be present in over 85% of pediatric patients with RLS (9,10,11). Six studies in adolescents reported that low sleep quality was negatively associated with body mass index (BMI) gain during the follow-up period (12).

The estimated prevalence of RLS has been reported to range between 4% and 29% in adults (13). RLS is less common in the pediatric population affecting 2-4% of school-aged children and adolescents (14,15). Some adult epidemiological studies have reported that BMI is associated with a higher likelihood of having RLS (16,17). However, unlike in adults, to date there have been no studies that have evaluated the prevalence of RLS and poor sleep quality in obese children.

The main focus of this present analysis was to determine the frequencies of RLS and poor sleep quality in obese pubertal children using the new International RLS Study Group (IRLSSG) criteria. The secondary objective was to assess the impact of RLS on sleep quality and the relationship between

glucose metabolism markers and lipids. It was hypothesized that the frequency of RLS would increase progressively as adiposity and insulin resistance (IR) increased, and that RLS would have a negative impact on sleep quality scores in children with obesity.

Methods

Subjects

A total of 115 obese and 29 overweight adolescents with a mean age of 13.1 ± 1.7 years (range, 10-16 years), mean BMI of 30.5 ± 0.5 were randomly recruited from among obese children who were admitted to the Pediatric Endocrinology Unit of Antalya Research Hospital between January and October 2017. The adolescents were grouped according to their BMI percentile values. Adolescents were excluded if they had a history of major illness, including type 1 or type 2 diabetes, were taking any medications, or had a condition known to influence body composition, insulin action, or insulin secretion (e.g. glucocorticoid therapy, hypothyroidism, Cushing's disease). All subjects were in good health and had normal thyroid function. The control group consisted of 40 girls and 26 boys (mean age: 12.9 ± 2.7 years, mean BMI of 18.7 ± 0.2) who attended the hospital for minor illnesses such as common cold, conjunctivitis, or other similar condition.

BMI was calculated as weight (in kilograms) divided by height (in meters squared). Patients with a BMI of $\geq 95^{\text{th}}$ percentile [BMI-standard deviation score (SDS) ≥ 1.64] according to reference curves for Turkish children were accepted as obese and BMI of 85-95th percentile (BMI-SDS = 1.04-1.64) as overweight (18). The pubertal development stages were assessed by a single pediatric endocrinologist using the criteria of Tanner stages. Staging for sexual maturation was > 2 in all girls and boys (Tanner stages II-V) and considered as pubertal. The girls with menarche were excluded from the study.

The study was approved by the Local Ethics Committee of the Antalya Research Hospital Institutional Review Board (approval number: 19.01.2017-2/17). Signed informed consent was obtained from each subject over age 12 years. Informed parental consent was obtained for all children regardless of age.

Plasma glucose, insulin levels and other parameters were determined in blood samples collected between 08.00 and 10.00 am, after fasting for 12 hours overnight. Glucose was determined by the glucose oxidase method. Serum insulin levels were measured with an immulite immunoassay system (Diagnostic Products, Los Angeles,

CA). The homeostasis model assessment (HOMA) of IR was calculated as fasting insulin concentration ($\mu\text{U/mL}$) \times fasting glucose concentration (mg/dL)/405. Iron and total iron binding capacity (TIBC) were studied using an Architect C8000 device (Abbott Laboratories, Abbott Park, IL, USA), ferritin on a Dxl 600 device (Beckman-Coulter Inc., Pasadena, CA, USA) and hemoglobin on a Cell-Dyn Ruby device (Abbott Laboratories), all in accordance with the manufacturers' instructions. Serum concentrations of total cholesterol, high-density lipoprotein cholesterol, and triglycerides were measured using routine enzymatic methods with an Olympus 2700 analyzer (Olympus Diagnostica GmbH, Hamburg, Germany). Low-density lipoprotein (LDL) cholesterol levels were calculated using the Friedewald equation.

International Restless Legs Syndrome Study Group Rating (Symptom Severity) Scale

Pediatric or physical medicine residents asked face-to-face questions about the RLS diagnosis and severity based on the IRLSSG 2012 criteria. Pediatric diagnostic criteria are used for 10-12-year-old children while adult diagnosis criteria are used for 13-16-year-old children. Children were given a positive diagnosis of RLS if they met the following four criteria: 1) an urge to move due to uncomfortable sensations in the legs, 2) uncomfortable sensations are relieved by movement, 3) symptoms worsen during rest or inactivity, and 4) symptoms worsen in the evening (11).

Pittsburgh Sleep Quality Index

This is a questionnaire assessing sleep quality as well as the presence and severity of sleep disorder. It includes seven components and 19 self-rated questions, assessing subjective sleep quality (e.g. "How would you rate your sleep quality overall?"), sleep latency (e.g. "How long does it usually take you to fall asleep at night?"), sleep duration (e.g., "How many hours of actual sleep do you get at night?"), habitual sleep efficiency (time asleep vs total time in bed), sleep disorder (e.g. "How often do you have trouble sleeping because you wake up in the middle of the night or in the early morning?"), use of sleeping medications and daytime dysfunction (e.g. "How often do you have trouble staying awake while driving, eating meals, or engaging in social activity?"). All questions were rated between 0 and 3 points; 0: not during the past month, 1: less than once a week, 2: once or twice a week, 3: three or more times a week. In addition, sleep quality is rated as follows; 0: very good, 1: fairly good, 2: fairly bad, 3: very bad. Component scores are totalled to obtain a global score ranging from 0-21 points. Higher global scores indicate worse sleep quality, where a score > 5 indicated poor sleep quality. The

diagnostic sensitivity and specificity of the scale are 89.6% and 86.5%, respectively (19). The Turkish validation and reliability study was performed by Agargun et al (20) in 1996.

Statistical Analysis

Mean and standard errors were used as descriptive statistics. Differences in the means of variables were tested using both parametric and non-parametric tests depending on the distribution of the variables. The Shapiro-Wilk W test was used to test for normality; $p < 0.05$ was considered evidence for non-normality. Categorical variables across groups were compared using the chi-square test or Fisher's exact test (if a cell number was five or less). Multivariable-adjusted logistic regression models were used to evaluate the association between the various risk factors and RLS and prevalent RLS. Odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) were calculated. In the model evaluating the association between risk factors and RLS, RLS status was the dependent variable and independent variables were the various risk factors such as obesity, Pittsburgh Sleep Quality Index (PSQI) score, hemoglobin, ferritin, plasma glucose, plasma insulin and HOMA. All tests were two-sided; the level of statistical significance was at $p < 0.05$. All analyses were performed with SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

The characteristics of the 210 adolescents in the study are shown in Table 1. No differences were found among the three groups with respect to mean age and gender. Obese and overweight subjects had slightly higher hemoglobin levels than control subjects and the obese group had elevated ferritin levels compared to the other two groups, although the ferritin and hemoglobin levels were within normal limits in all groups. There was no significant difference between the groups with respect to TIBC levels. Fasting glucose, fasting insulin, LDL cholesterol, triglycerides levels and HOMA values were increased in the obese group compared to the other two groups. The overweight group had higher fasting insulin and triglyceride levels than the control group but the other glucose metabolism markers such as HOMA values were similar.

Frequency of Restless Legs Syndrome in Obese Children

Overall, 12.8% of the cohort met the diagnostic criteria for RLS. Within the three study groups, the frequency of RLS was higher in the obese group (21.7%) than in the overweight (3.4%) and control groups (1.5%) ($p < 0.001$). When compared to obese children diagnosed as RLS and

non-RLS, BMI-SDS was higher in the obese children with RLS than the non-RLS obese children (3.04 ± 0.46 vs 2.86 ± 0.43 , $p < 0.05$) (Figure 1A).

Sleep Characteristics in Obese Subjects with Restless Legs Syndrome

Poor sleep quality was found in 32.8% of the adolescents of the study group. The PSQI score was found to be higher in the obese group (5.45 ± 0.2) than in the other two groups and the overweight group (4.21 ± 0.5) had a significantly higher score than the control group (3.91 ± 0.2) (Figure 1B).

These differences were statistically significant and the obese and overweight groups had higher scores than the control group. Therefore, the frequency of poor sleep quality (> 5 PSQI score) was higher in the obese group (37.3%) than in the control group (24.2%, $p < 0.001$). Gender difference was not statistically significant among the groups.

When the obese patients with RLS and non-RLS were compared, the scores of subjective sleep quality ($p = 0.004$), sleep latency ($p < 0.001$) and sleep disorders ($p < 0.001$) were significantly higher in the RLS obese subjects than in the non-RLS obese subjects, as reflected by the PSQI. The total PSQI score was significantly higher in obese subjects with RLS than in the non-RLS obese subjects (8.1 ± 0.7 vs 4.5 ± 0.2 , $p < 0.001$) (Table 2). When the poor and good scores for total PSQI scores were compared in all obese subjects, poor sleep quality subjects were found to have higher BMI and BMI-SDS values than those with good sleep

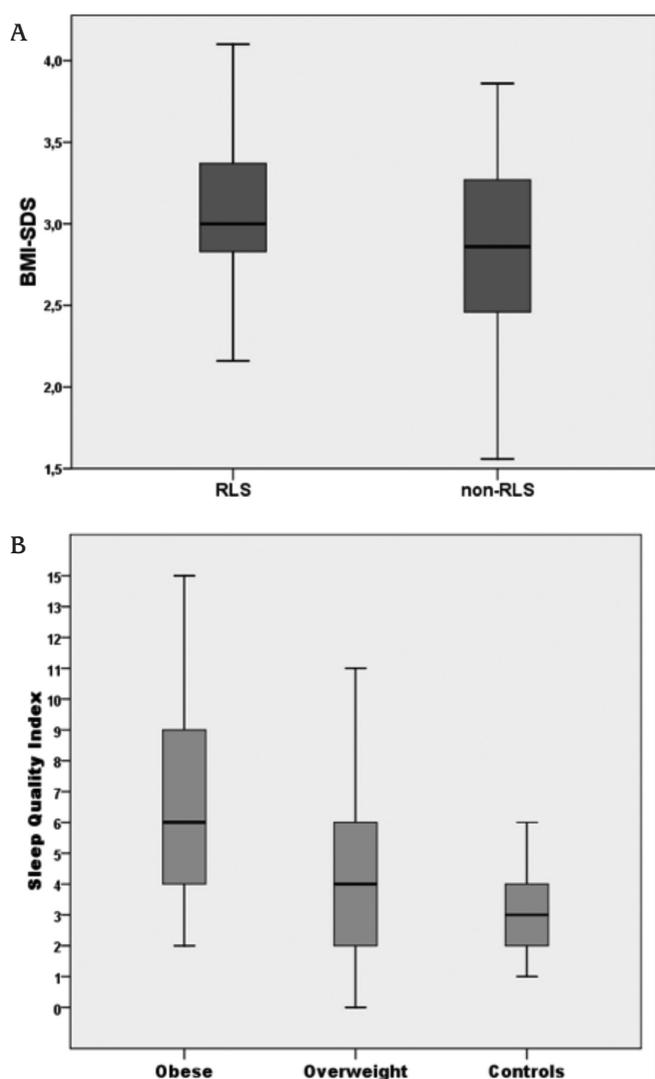


Figure 1. A) Boxplot for the distribution of body mass index - standard deviation score in obese children with restless legs syndrome and non- restless legs syndrome. B) Boxplot for the distribution of scores obtained through the Pittsburgh Sleep Quality Index used in children and adolescents according to their body mass index - standard deviation score

BMI: body mass index, SDS: standard deviation score, RLS: restless legs syndrome

Table 1. Characteristics of the study groups according to body mass index

	Obese	Overweight	Control
n	115	29	66
BMI	32.1 ± 0.3	$26.7 \pm 0.5^*$	$18.7 \pm 0.2^{§}$
BMI-SDS	2.9 ± 0.45	$1.39 \pm 0.27^*$	$-0.29 \pm 0.85^{§}$
Age (years)	13.5 ± 2.7	12.8 ± 2.2	12.9 ± 2.7
Gender (F/M)	70/45	20/9	40/26
Sleep disorders			
PSQI score	5.45 ± 0.2	$4.21 \pm 0.5^*$	$3.91 \pm 0.2^{§}$
Poor PSQI (%)	43 (37.3)	10 (34.4)	16 (24.2) [#]
RLS (%)	25 (21.7)	1 (3.4) [*]	1 (1.5) [#]
Laboratory values			
Hemoglobin (g/dL)	13.3 ± 1.2	13.2 ± 0.8	$12.9 \pm 0.1^{§}$
Ferritin (ng/mL)	31.04 ± 3.8	21.4 ± 2.1	$24.9 \pm 3.8^{#}$
TIBC % (mcg/dL)	433 ± 40.1	376 ± 14.9	387 ± 6.2
Fasting glucose (mg/dL)	87.6 ± 1.03	85.3 ± 2.3	$82.1 \pm 3.5^{#}$
Fasting insulin (mIU/mL)	18.9 ± 1.5	10.8 ± 5.3	$4.3 \pm 2.5^{§}$
HOMA	3.1 ± 0.3	2.1 ± 0.1	$1.7 \pm 1.2^{#}$
LDL-cholesterol (mg/dL)	96.3 ± 3.4	89 ± 14.2	$88 \pm 12.4^{#}$
HDL-cholesterol (mg/dL)	45.7 ± 1.2	42.6 ± 2.6	42.3 ± 4.5
Triglycerides (mg/dL)	120 ± 5.4	129 ± 20.2	$94 \pm 12.3^{§}$

$p < 0.01$ for *: obese and overweight, #: obese and control, §: overweight and control, BMI: body mass index, SDS: standard deviation score, F: female, M: male, PSQI: Pittsburgh Sleep Quality Index, RLS: restless legs syndrome, TIBC: total iron binding capacity (%), HOMA: homeostatic model assessment of insulin resistance, LDL: low-density lipoprotein, HDL: high-density lipoprotein

quality ($p = 0.04$). No significant differences with respect of concentrations of hemoglobin, plasma glucose, plasma insulin and HOMA values were found between obese subjects with poor (> 5) and good PSQI (< 5) (Table 3).

Risk Factors for Restless Legs Syndrome

Multivariable logistic regression analysis revealed that increasing BMI was significantly associated with RLS when controlled for

confounding factors. In this analysis, BMI-SDS (BMI-SDS > 1.64 ; OR: 8.87, 95% CI: 2.04-38.61, $p < 0.001$), and total PSQI scores (> 5 score; OR: 2.25, CI: 0.96-5.28, $p < 0.001$) were also independent significant risk factors for the incidence of RLS in adolescents. As was true for the full cohort, RLS in the obese group was independently and positively associated with age (OR: 0.83, CI: 0.35-1.98, $p = 0.02$) and plasma glucose (OR: 3.68, CI: 0.86-15.72, $p < 0.001$) but not with hemoglobin (OR: 1.98, CI: 0.25-15.8, $p = 0.87$), ferritin (OR: 1.42, CI: 0.57-3.56, $p = 0.615$), plasma insulin (OR: 1.29, CI: 0.51-3.27, $p = 0.343$) and the HOMA value (OR: 3.02, CI: 1.32-6.90, $p = 0.086$) (Table 4).

Table 2. Comparison of sleep quality scores (Pittsburgh Sleep Quality Index) in obese children with restless legs syndrome and non- Restless Legs syndrome

	Obese patients		p value
	RLS n = 25	Non-RLS n = 90	
Subjective sleep quality scale	1.76 ± 0.2	1.09 ± 0.1	0.004
Sleep latency	1.92 ± 0.3	0.66 ± 0.08	< 0.001
Sleep duration	0.44 ± 0.1	0.37 ± 0.06	0.616
Habitual sleep efficiency	0.44 ± 0.1	0.36 ± 0.05	0.525
Sleep disorders	1.32 ± 0.1	0.89 ± 0.04	< 0.001
Use of sleeping medication	0.14 ± 0.02	0.12 ± 0.05	0.219
Daytime dysfunction	1 ± 0.1	1.45 ± 0.1	0.234
Total PSQI score	8.1 ± 0.7	4.5 ± 0.2	< 0.001

PSQI: Pittsburgh Sleep Quality Index, RLS: Restless Legs syndrome

Table 3. Sleep quality Index in obese children with Restless Legs syndrome (cut-off score for poor sleep quality was over 5 according to Pittsburgh Sleep Quality Index)

Factors	Sleep Quality Index (PSQI) scores		p value
	Poor > 5	Good < 5	
BMI	32.9 ± 4.1	30.3 ± 3.8	0.04
BMI-SDS	2.9 ± 0.46	2.3 ± 0.42	0.04
Hemoglobin	13.5 ± 1.3	13.2 ± 1.1	0.20
Fasting insulin	19.4 ± 2.1	18.1 ± 2	0.67
Fasting glucose	87 ± 9.1	88.4 ± 10	0.50
HOMA	3.4 ± 0.4	2.7 ± 0.4	0.27

PSQI: Pittsburgh Sleep Quality Index, BMI: body mass index, SDS: standard deviation score, HOMA: homeostasis model assessment

Table 4. Relationships between risk factors and Restless Legs syndrome

		RLS	Non-RLS	Adjusted OR 95% CI	p value
Age	> 12	18	129	0.83 (0.35-1.98)	0.02
	< 12	9	54		
BMI-SDS	> 1.64	25	107	8.87 (2.04-38.61)	< 0.001
	< 1.64	2	76		
PSQI score	> 5	18	86	2.25 (0.96-5.28)	< 0.001
	< 5	9	97		
Hemoglobin	> 11	26	170	1.98 (0.25-15.8)	0.87
	< 11	1	13		
Ferritin	> 15	20	122	1.42 (0.57-3.56)	0.615
	< 15	7	61		
Fasting glucose	> 100	3	6	3.68 (0.86-15.72)	< 0.001
	< 100	24	177		
Fasting insulin	> 20	7	39	1.29 (0.51-3.27)	0.343
	< 20	20	144		
HOMA	> 2.5	14	48	3.02 (1.32-6.90)	0.086
	< 2.5	13	135		

RLS: restless legs syndrome, OR: odds ratio, CI: confidence interval, BMI: body mass index, SDS: standard deviation score, PSQI: Pittsburgh Sleep Quality Index, HOMA: homeostasis model assessment

Discussion

Firstly, the present study demonstrated that there is a significantly higher frequency of RLS in obese adolescents than in age-matched healthy control subjects (21.7% vs 1.5%). Secondly, obese patients with RLS were found to have many more sleep-related symptoms than those without RLS and RLS was found to be an independent predictor of poor sleep quality as reflected by the PSQI scores (OR: 2.25). RLS can be considered to be a common and clinically relevant sleep disorder in adolescents with obesity.

Although the pathophysiology of RLS is not yet fully understood, evidence exists for both iron/transferrin and dopaminergic abnormalities being factors in its etiology (10). Serum ferritin below 50 mcg/L was associated with increased severity of RLS in three adult studies (21,22,23). Recent pediatric case reports have also shown an improvement in RLS symptoms with oral iron therapy. However, iron deficiency is not common in all RLS sufferers and iron supplementation has shown variable success in RLS treatment (13,24,25). In this study, no relationships were found between RLS and serum levels of ferritin or hemoglobin, both of which have been reported to be related to the occurrence of RLS. However, it is possible that as the ferritin and TIBC levels were found within normal limits in all subjects, these were not detected as risk factors for RLS in the logistic analysis applied. In short, our findings suggest that low ferritin or iron deficiency has minimum or no impact on the development of RLS and that some undefined anemic condition might be required to increase the risk of the disorder. In most previous studies, anemia has been reported to be associated with increased risk for RLS, although approximately 70% of anemic adults do not develop RLS, and most patients with RLS do not have evidence of iron deficiency (7,26).

The diagnosis of idiopathic RLS is based on patient history as there are no physical characteristics or markers for the disorder. The disorder can be confirmed or ruled out on the basis of essential criteria defined by the IRLSSG. Two retrospective studies in adults have found the onset of RLS symptoms before the age of 20 years in approximately 40% of affected individuals (27,28). A large population-based prevalence study found RLS in 1.9% of children and 2% of adolescents in the United States and in the United Kingdom, respectively (29). More recently, a cross-sectional study carried out in Turkey estimated that the prevalence of RLS in non-obese children and adolescents was 2.9% (30). In the present study, the rate of RLS in the control group (1.5%) was found to be similar to the rate reported in previous studies on adolescents, while the frequency of RLS in obese

patients was found to be significantly higher than that of the normal population (21.7%). Per et al (30) also reported that mean BMI value in adolescents was significantly higher in a group with RLS compared to those without RLS. These findings emphasize the importance of raising awareness of RLS among obese adolescents.

An association between obesity and a higher RLS prevalence has been observed in several adult studies (16,31,32). In a cross-sectional study including 1,803 men and women aged 18 years or older, each increase of 5 kg/m² BMI was associated with a 31% increased likelihood of having RLS (16). Several studies also suggest that RLS may be linked to key components of the metabolic syndrome, including diabetes, obesity and dyslipidemia. In an adult study, participants suffering from RLS were 4.7 times more likely to have impaired glucose tolerance and 8.5 times more likely to have elevated glycemia (fasting blood glucose > 100 mg/dL) than the control group. Sleep disorders may have an association with decreased insulin sensitivity, independent of the association with adiposity (33,34). In the present study, obese patients had slightly elevated blood glucose levels but risk for RLS among the obese patients with elevated glucose levels or hyperinsulinemia was low. No correlation has been found among RLS and non-RLS adolescents for metabolic impairments such as glucose and insulin levels and HOMA, an IR marker.

A European primary-care study found that adult individuals whose RLS had a "high" negative impact on health had a significantly greater frequency of sleep disturbances (35). In another study by Picchiatti et al (29), the sleep disorder rate was reported as 69.4% in adult patients with RLS. The excessive movements during sleep reported by obese patients with RLS may be secondary to the presence of periodic limb movements. In adults, leg movements are associated with 10-20% increases in heart rate and large elevations in blood pressure which begin at the time of leg movement onset and continue for 10-15 seconds afterwards (36). In the present study, RLS had a negative impact on sleep quality (OR: 2.25) in adolescents with obesity.

PSQI is a questionnaire which is useful in the evaluation of the quality and amount of sleep and the presence and severity of sleep disorders. In the present study, obese RLS patients were found to have elevated PSQI scores indicating poor sleep quality, especially in sleep latency, compared to non-RLS obese adolescents. There is also increasing evidence of an association between shortened sleep duration and/or poor sleep quality and obesity. In the current study, obesity was found to be significantly associated with an increased risk of developing RLS and poor sleep quality.

Study Limitations

There are limitations to our study. Firstly, the number of cases with RLS was relatively small. Secondly, while the questionnaire was based on criteria established by the IRLSSG for children, these questionnaires are not fully validated in the pediatric population and can lead to misclassification. Despite these limitations, the present study has established that RLS is common in obese children and adolescents and is a significant cause of sleep-related symptoms.

Conclusion

The results of this study demonstrated that the rate of RLS was higher in obese adolescents than in the general population and the rate increased as BMI values increased. It was also found that presence of RLS and a high BMI z-score, but not IR, have a significant impact on subjective sleep disturbances in obese patients. There is a clear need for further, randomized controlled RLS studies to better understand the metabolic response characteristics of the obese adolescent population.

Ethics

Ethics Committee Approval: The study was approved by the Ethics Committee of Antalya Training and Research Hospital (approval number: 19.01.2017-2/17).

Informed Consent: Consent form was obtained from patients and their families.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Rıza Taner Baran, Meral Filiz, Serkan Filiz, Concept: Özgür Pirgon, Rıza Taner Baran, Design: Rıza Taner Baran, Müge Atar, Meral Filiz, Serkan Filiz, Data Collection or Processing: Rıza Taner Baran, Meral Filiz, Serkan Filiz, Analysis or Interpretation: Meral Filiz, Serkan Filiz, Müge Atar, Literature Search: Müge Atar, Rıza Taner Baran, Writing: Rıza Taner Baran, Müge Atar, Rıza Taner Baran.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Orio F, Tafuri D, Ascione A, Marciano F, Savastano S, Colarieti G, Orio M, Colao A, Palomba S, Muscogiuri G. Life style changes in the management of adulthood and childhood obesity. *Minerva Endocrinol* 2016;41:509-515.
2. Pearson NJ, Johnson LL, Nahin RL. Insomnia, trouble sleep-ing, and complementary and alternative medicine: Analysis of the 2002 national health interview survey data. *Arch Intern Med* 2006;166:1775-1782.
3. Bayon V, Leger D, Gomez-Merino D, Vecchierini MF, Chennaoui M. Sleep debt and obesity. *Ann Med* 2014;46:264-272. Epub 2014 Jul 11
4. Cogen JD, Loghmanee DA. Sleep-related movement disorders. In: Sheldon SH, Ferber R, Kryger MH, Gozal D (eds). *Principles and practice of pediatric sleep medicine*. Philadelphia, Saunders/Elsevier, 2014;333-336.
5. Picchietti DL, Picchietti MA. Restless legs syndrome. In: Kothare SV, Kotagal S (eds). *Sleep in childhood neurological disorders*. New York, Demos Medical, 2011;57-70.
6. Khatwa U, Kothare SV. Restless legs syndrome and periodic limb movements disorder in the pediatric population *Curr Op Pulm Med* 2010;16:559-567.
7. Allen RP, Earley CJ. The role of iron in restless legs syndrome. *Mov Disord* 2007;22:440-448.
8. Stiasny K, Wetter TC, Trenkwalder C, Oertel WH. Restless legs syndrome and its treatment by dopamine agonists. *Parkinsonism Relat Disord* 2000;7:21-25.
9. Picchietti DL, Rajendran RR, Wilson MP, Picchietti MA. Pediatric restless legs syndrome and periodic limb movement disorder: parent-child-pairs. *Sleep Med* 2009;10:925-931. Epub 2009 Mar 21
10. Picchietti D, Stevens HE. Early manifestations of restless legs syndrome in childhood and adolescence. *SleepMed* 2008;9:770-781. Epub 2007 Nov 19
11. Picchietti DL, Bruni O, de Weerd A, Durmer JS, Kotagal S, Owens JA, Simakajornboon N; International Restless Legs Syndrome Study Group (IRLSSG). Pediatric restless legs syndrome diagnostic criteria: an update by the International Restless Legs Syndrome Study Group. *Sleep Med* 2013;14:1253-1259. Epub 2013 Sep 4
12. Li L, Zhang S, Huang Y, Chen K. Sleep duration and obesity in children: A systematic review and meta-analysis of prospective cohort studies *J Paediatr Child Health* 2017;4:378-385. Epub 2017 Jan 10
13. Innes KE, Selfe TK, Agarwal P. Prevalence of restless legs syndrome in North American and Western European populations: a systematic review. *Sleep Med* 2011;12:623-634. Epub 2011 Jul 12
14. Turkdogan D, Bekiroglu N, Zaimoglu S. A prevalence study of restless legs syndrome in Turkish children and adolescents. *Sleep Med* 2011;12:315-321. Epub 2011 Feb 19
15. Yilmaz K, Kilincaslan A, Aydin N, Kor D. Prevalence and correlates of restless legs syndrome in adolescents. *Dev Med Child Neurol* 2011;53:40-47. Epub 2010 Sep 28
16. Phillips B, Young T, Finn L, Asher K, Hening WA, Purvis C. Epidemiology of restless legs symptoms in adults. *Arch Intern Med* 2000;160:2137-2141.
17. Gao X, Schwarzschild MA, Wang H, Ascherio A. Obesity and restless legs syndrome in men and women. *Neurology* 2009;72:1255-1261.
18. Ozturk A, Mazicioglu MM, Hatipoglu N, Budak N, Keskin G, Yazlak Z, Balci N, Yildiz H, Yildiz K, Ustunbas HB, Kurtoglu S. Reference body mass index curves for Turkish children 6 to 18 years of age. *J Pediatr Endocrinol Metab* 2008;21:827-836.
19. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193-213.
20. Agargun MY, Kara H, Anlar O. The validity and reliability of the Pittsburgh Sleep Quality Index. *Turk Psikiyatri Derg* 1996;7:107-115.
21. O'Keefe ST, Gavin K, Lavan JN. Iron status and restless legs syndrome in the elderly. *Age Ageing* 1994;23:200-203.
22. Sun ER, Chen CA, Ho G, Earley CJ, Allen RP. Iron and the restless legs syndrome. *Sleep* 1998;21:371-377.

23. Frauscher B, Gschliesser V, Brandauer E, El-Demerdash E, Kaneider M, Rücker L, Poewe W, Högl B. The severity range of restless legs syndrome (RLS) and augmentation in a prospective patient cohort: association with ferritin levels. *Sleep Med* 2009;10:611-615. Epub 2009 Feb 5
24. Banno K, Koike S, Yamamoto K. Restless legs syndrome in a 5-year-old boy with low body stores of iron. *Sleep Biol Rhythms* 2009;7:52-54.
25. Starn AL, Udall JN Jr. Iron deficiency anemia, pica, and restless legs syndrome in a teenage girl. *Clin Pediatr (Phila)* 2008;47:83-85. Epub 2007 Jul 19
26. Earley CJ, Allen RP, Beard JL, Connor JR. Insight into the pathophysiology of restless legs syndrome. *J Neurosci Res* 2000;62:623-628.
27. Walters AS, Hickey K, Maltzman J, Verrico T, Joseph D, Hening W, Wilson V, Chokroverty S. A questionnaire study of 138 patients with restless legs syndrome: the 'Night-Walkers'survey. *Neurology* 1996;46:92-95.
28. Montplaisir J, Boucher S, Poirier G, Lavigne G, Lapierre O, Lespérance P. Clinical, polysomnographic, and genetic characteristics of restless legs syndrome: a study of 133 patients diagnosed with new Standard criteria. *Mov Disord* 1997;12:61-65.
29. Picchiatti D, Allen RP, Walters AS, Davidson JE, Myers A, Ferini-Strambi L. Restless legs syndrome: prevalence and impact in children and adolescents--the Peds REST study. *Pediatrics* 2007;120:253-266.
30. Per H, Gunay N, Ismailogullari S, Oztop DB, Gunay O. Determination of restless legs syndrome prevalence in children aged 13-16 years in the provincial center of Kayseri. *Brain Dev* 2017;39:154-160. Epub 2016 Sep 22
31. Ohayon MM, Roth T. Prevalence of restless legs syndrome and periodic limb movement disorder in the general population. *J Psychosom Res* 2002;53:547-554.
32. Kim J, Choi C, Shin K, Yi H, Park M, Cho N, Kimm K, Shin C. Prevalence of restless legs syndrome and associated factors in the Korean adult population: the Korean Health and Genome Study. *Psychiatry Clin Neurosci* 2005;59:350-353.
33. Brown MA, Goodwin JL, Silva GE, Behari A, Newman AB, Punjabi NM, Resnick HE, Robbins JA, Quan SF. The impact of sleep-disordered breathing on body mass index (BMI): the Sleep Heart Health Study (SHHS). *Southwest J Pulm Crit Care* 2011;3:159-168.
34. Pillar G, Shehadeh N. Abdominal fat and sleep apnea: the chicken or the egg? *Diabetes Care* 2008;31(Suppl 2):303-309.
35. Allen RP, Stillman P, Myers AJ. Physician-diagnosed restless legs syndrome in a large sample of primary medical care patients in western Europe: prevalence and characteristics. *Sleep Med* 2010;11:31-37. Epub 2009 May 22
36. Winkelman JW. The evoked heart rate response to periodic leg movements of sleep. *Sleep* 1999;22:575-580.