Sleep duration and the risk of obesity – a cross-sectional study

Czas snu a ryzyko rozwoju otyłości – badanie przekrojowe

Edyta Suliga[1], Dorota Kozieł[2], Elżbieta Cieśla[3], Dorota Rębak[2], Stanisław Głuszek[2]

[1]Department of the Prevention of Alimentary Tract Diseases, Institute of Nursing and Midwifery, Faculty of Medicine and Health Sciences, Jan Kochanowski University, Kielce, Poland
Head of the Department: Prof. Grażyna Rydzewska-Wyszkowska MD, PhD
[2]Department of Surgery and Surgical Nursing with the Scientific Research Laboratory, Institute of Nursing and Midwifery, Faculty of Medicine and Health Sciences, Jan Kochanowski University, Kielce, Poland
Head of the Department: Prof. Stanisław Głuszek MD, PhD
[3]Department of Developmental Age Research, Institute of Public Health, Faculty of Medicine and Health Sciences, Jan Kochanowski University, Kielce, Poland
Head of the Department: Prof. JKU Grażyna Nowak-Starz PhD

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Słowa kluczowe: kobiety, mężczyźni, wskaźnik masy ciała, czas snu, procent tłuszczu w ciele.

Abstract

Introduction: So far, the association between a longer sleep duration, state of health, and the risk of obesity and the influence of gender on the association between sleep duration and the risk of obesity has not been fully explained.
Aim of the research: To examine the relationships between self-reported sleep duration, body mass index (BMI), and body fat percentage (%BF), and also to determine whether such associations are the same in men and in women.
Material and methods: This study included 10,367 participants aged 37 to 66 years. Logistic regression was applied for risk assessment of the prevalence of abnormal BMI values and %BF in groups of sleep duration. Sleep of 7–8 h per night was adopted as a reference level.
Results: In men, the risk of obesity was significantly greater only in the group sleeping ≤ 6 h (OR = 1.18, 95% CI: 1.08–1.28; $p < 0.05$); however, in women, only among those sleeping ≥ 9 h (OR = 1.14, 95% CI: 1.02–1.26; $p < 0.05$). The risk of obesity, determined on the basis of %BF, was higher only in individuals sleeping ≥ 9 h. In the adjusted model, it turned out to be significant in the general study population (OR = 1.28, 95% CI: 1.07–1.53; $p < 0.05$) and in women (OR = 1.14, 95% CI: 1.03–1.27; $p < 0.05$).
Conclusions: In women, a greater risk of obesity was related to a longer sleep duration (≥ 9 h), whereas in men, the tendency of obesity occurrence along with shorter sleep (≤ 6 h). Thus, the physiological consequences of sleep duration may be different in women than in men.

Streszczenie

Wprowadzenie: Dotychczas nie wyjaśniono w pełni zależności między dłuższym czasem snu a ryzykiem wystąpienia otyłości oraz wpływu płci na tę zależność.
Cel pracy: Zbadanie zależności między deklarowanym czasem snu a wskaźnikiem masy ciała (BMI) i procentową zawartością tłuszczu w ciele (%BF), a także ustalenie, czy relacje te są takie same u mężczyzn i u kobiet.
Materiał i metody: W badaniu wzięło udział 10 367 osób w wieku od 37 do 66 lat. Do oceny ryzyka (OR) wystąpienia nieprawidłowych wartości BMI oraz procentowej zawartości tłuszczu (%BF) w poszczególnych grupach czasu trwania snu zastosowano regresję logistyczną. Jako poziom referencyjny przyjęto sen trwający 7–8 godzin w ciągu nocy.
Wyniki: U mężczyzn ryzyko wystąpienia otyłości było istotnie większe tylko w grupie osób śpiących ≤ 6 godzin (OR = 1,18, 95% CI: 1,08–1,28; $p < 0,05$), natomiast u kobiet tylko wśród śpiących ≥ 9 godzin (OR = 1,14, 95% CI: 1,02–1,26; $p < 0,05$). Ryzyko rozwoju otyłości określanej na podstawie %BF było wyższe jedynie u osb śpiących ≥ 9 godzin. W modelu adiustowanym okazało się ono istotne u ogółu uczestników (OR = 1,28, 95% CI: 1,07–1,53; $p < 0,05$) oraz u kobiet (OR = 1,14, 95% CI: 1,03–1,27; $p < 0,05$).
Wnioski: U kobiet większe ryzyko otyłości wiązało się z dłuższym czasem snu (≥ 9 godzin), natomiast u mężczyzn stwierdzono tendencję do występowania otyłości w powiązaniu z krótszym snem (≤ 6 godzin). Fizjologiczne konsekwencje czasu trwania snu mogą się więc różnić u kobiet i u mężczyzn.

Introduction

The occurrence of obesity is determined by genetic, metabolic, and behavioural factors. The results of several epidemiological studies and meta-analyses, conducted in the last decade, have allowed us to identify a new risk factor of overweight and obesity, which is short duration of sleep [1–6]. In the opinion of the majority of authors, the lowest occurrence of excessive body mass in adults is related to sleep lasting at least 7 h [7–9]. However, so far, the association between longer sleep duration, the state of health, and the risk of obesity has not been fully explained [10–14]. Moreover, in studies conducted to date, a higher body mass index (BMI) has been adopted as an indicator of obesity. However, there have been few papers published in which the association between body composition and sleep duration was analysed, and their results are inconclusive [7, 15]. Likewise, the influence of gender on the association between sleep duration and the risk of obesity has not been fully explained [7, 16–18].

Aim of the research

The aim of the study is to examine relationships between self-reported sleep duration, BMI, and body fat percentage, and also to determine whether such associations are the same in men and in women.

Material and methods

Research material was collected within the framework of the PONS project (Polish-Norwegian Study), prospective research on the health condition of the inhabitants of the Świętokrzyskie Province in Poland. The study was approved by the Ethics Committee within the Cancer Centre and Institute of Oncology in Warsaw, and by the Committee on Bioethics at the Faculty of Health Sciences, Jan Kochanowski University in Kielce, Poland. The studies included a questionnaire interview, anthropometric measurements, blood pressure measurements, and analyses of collected fasting-blood samples, on the basis of which the concentration of cholesterol and triglycerides was determined. Detailed information regarding the project, research procedures, and group selection were described in previously published papers [19–21]. In brief: 13,172 individuals were examined (4447 men), aged between 37 and 66 years, permanently residing in the Kielecki Region in Poland. Individuals with incomplete data were excluded from the study ($n = 2609$), as well as people with a history of cardiovascular disease (coronary artery disease, angina pectoris, myocardial infarction), stroke, cancer, or diabetes ($n = 196$). In further analysis of the data, 10,367 participants were included.

Sleep duration

Sleep duration was assessed with the question: "On average, how many hours do you sleep each night?" Answers were recorded in whole hours. We created the following three categories of sleeping duration: ≤ 6 h, 7–8 h, and ≥ 9 h per night. We also refer to these three groups as short, normal, and long sleepers, respectively.

Anthropometric measurements

Anthropometric indices were measured by well-trained investigators, following a standard protocol. The measurements of body weight and percentage of body fat were done by means of the body composition analyser, Tanita SC 240 MA, with an accuracy of 0.1 kg and 0.1%. Body height measurements were done by means of the scales' stadiometer, with an accuracy of 0.1 cm. Body mass index was calculated as weight in kg divided by the square of height in metres. Obesity was defined as a body mass index ≥ 30 kg/m^2 and on the basis of sex-specific cutoffs for %BF at the level ≥ 25% for men and ≥ 35% for women [22].

Covariates

Covariates for model adjustment were selected according to known predictors of obesity and factors that have an influence on sleep duration [23, 24]. The socio-demographic variables included: sex (men; women), age, education (university; lower than university), place of residence (city; country), and marital status (married or in a stable relationship; single or a widow/widower). Physical activity (PA) was evaluated with the use of the International Physical Activity Questionnaire (IPAQ) – the long form [25]. The analysis included the most frequent forms of activity, i.e. walking PA and moderate PA. Due to the small number of participants declaring vigorous PA, we did not include it in our analysis. Walking PA during the last week involved walking for 10 min or more every day, in all domains subject to assessment: job-related PA, transportation PA, recreation, sport, and leisure-time PA. Moderate PA included the time devoted to activities of moderate intensity, related to the domains: job-related PA; housework, house maintenance and caring for family; sport, recreational and leisure time. The scores are presented as time in minutes/day. Sitting time (ST) during the preceding week was determined on the basis of time spent in a sitting position on working days and at weekends. Next, the average number of minutes spent sitting during the day was calculated. The data concerning coffee and alcohol consumption were collected by means of the Food Frequency Questionnaire (FFQ). Alcohol consumption was evaluated on the basis of the frequency of alcoholic drinks consumption during the preceding 30 days in the following categories: every day, 4–5 times a week, 2–3 times a week, once a week, 2–3 times in the last 30 days, once during the last 30 days, not at all in the last 30 days, I don't know, refusal to answer.

The answers relating to the consumption frequency of products from the questionnaire were transformed into daily consumption doses and then standardised by *z*-score. As far as coffee is concerned, a portion consisted of one cup (250 ml). The frequencies of consumption were classified as follows: 6 times a day or more, 4–5 times a day, 2–3 times a day, once a day, 5–6 times a week, 2–4 times a week, 1–3 times a month, once a week, less frequently than once a month or not at all, I don't know, I refuse to answer the question. The respondents who smoked cigarettes on a daily basis during the study were classified as current smokers, and those who had not smoked for longer than 6 months – as former smokers; the rest were regarded as non-smokers.

Statistical analysis

The normality of distribution of quantitative characteristics was evaluated: %BF, BMI, age, coffee and alcohol consumption, PA, and ST. Arithmetic means and standard deviations as well as medians and a quartile range were calculated (Q1–Q3) in the groups distinguished, based on the time devoted to sleep. A structure indicator was calculated for qualitative characteristics: place of residence, education, marital status, and smoking. The χ^2 test was used to test the structure indicator, whereas in case of quantitative variables, a one-way analysis of variance ANOVA or the median test and Kruskal-Wallis test were applied, depending on the type of distribution and the significance of variance (Table 1). The Scheffé post-hoc test was used to evaluate intergroup differences. Logistic regression was used for risk assessment (OR) of the occurrence of abnormal values of BMI and %BF in individual groups of sleep duration. Sleep of 7–8 h per night was adopted as a reference level. Two models were analysed: unadjusted and adjusted for socio-demographic variables (age, gender, place of residence, education, marital status); and health-related behaviour (smoking, coffee and alcohol consumption, sum of moderate and walking PA, sitting time). The *p*-values less than 0.05 were considered statistically significant. The statistical analysis was carried out with the use of the Statistica software, version 12.0.

Results

The characteristics of the study participants is presented in Table 1. Female participants of the study sleeping the longest had a higher BMI and more adipose tissue compared to other women. In men, no significant difference of %BF was observed depending on sleep duration, whereas the highest BMI was noted in men sleeping the shortest. The lowest average age of women was found in those sleeping 7–8 h, and the highest average age was noted in the group of men sleeping the longest. Shorter sleep duration was significantly more often found in men and women with better education, living in cities, compared to inhabitants of rural areas. The group of those with a short sleep duration included the greatest number of single women compared to those in stable relationships. No differences were noted in relation to the amount of coffee and alcohol consumption, and in the number of smokers, depending on sleep duration. Women who slept 7–8 h were most physically active, while the shortest sitting time was noted in those who slept less than 7 h per night. The risk of obesity, determined on the basis of the BMI indicator, was higher in the general subject population, both in the group of subjects sleeping the longest, as well as those sleeping the shortest, compared to individuals sleeping 7–8 h (Table 2). In men, the risk of obesity was significantly higher only in the group sleeping ≤6 h, whereas in women this was true only in those sleeping ≥ 9 h. The same scores were obtained in the models unadjusted and adjusted for all confounders. The risk of obesity determined on the basis of %BF was higher only in individuals sleeping ≥ 9 h. In the adjusted model, it turned out to be significant in the general study population and in women.

Discussion

The results of the conducted study confirmed that the risk of obesity (BMI ≥ 30 kg/m^2) was lowest in individuals declaring 7–8 h of sleep, i.e. the duration considered by most authors to be optimal for maintaining normal body mass [7, 26–28]. Chaput *et al.* [29] showed that a change of sleep duration from short (≤ 6 h per day) to one lasting 7–8 h was, in the period of a six-year-long observation, related to a decrease of adipose tissue gain. It was proven that shorter sleep can affect energy balance by an up-regulation of orexigenic hormones and a downregulation of anorexigenic hormones associated with increased hunger and caloric intake [30, 31]. Doo and Kim [32], in a study of the Korean population, confirmed that the association of short sleep duration with the risk of obesity was potentially changed by dietary fat and carbohydrate consumption. Lakerveld *et al.* [33] proved that shorter sleep duration can also lead to obesity due to the longer screen time related to it. The results of our own study revealed that men and women sleeping 7–8 h spent significantly more time doing moderate physical activity compared to other participants, which could be an additional factor decreasing the risk of excess body mass in this group of subjects.

Some papers did not confirm that sleep duration was significantly correlated with a greater risk of obesity [34, 35]. Grandner *et al.* [36] explain that the association between sleep duration and BMI is probably age-dependent. In young adults, this relationship is linear, and the longer the sleep, the lower the BMI. This association changes in middle-age, in which 7–8 h

Table 1. The characteristic of the study participants in three categories of sleep duration

Variables	Gender	I ≤ 6 h of sleep	II 7–8 h of sleep	III ≥ 9 h of sleep	*P*-value
BMI *x* ± SD; M (Q1–Q3)	Women	27.81 ±4.91;[B] 27.05 (24.18–30.80)	27.67 ±4.83;[C] 26.96 (24.26–30.32)	28.56 ±5.10; 28.21 (24.81–31.44)	< 0.001
	Men	28.63 ±4.21;[A,B] 28.37 (25.69–31.05)	28.25 ±3.82; 27.96 (25.71–30.34)	28.46 ±3.99; 28.99 (25.51–31.14)	0.039
%BF *x* ± SD; M (Q1–Q3)	Women	35.53 ±7.05;[B] 36.20 (31.00–40.40)	35.71 ±6.61;[C] 36.20 (31.60–40.20)	36.98 ±6.41; 37.65 (33.20–41.40)	< 0.001
	Men	27.02 ±6.71; 26.30 (22.30–30.90)	26.86 ±6.38; 26.40 (22.70–30.40)	28.05 ±6.41; 27.15 (24.00–31.50)	0.053
Age *x* ± SD; M (Q1–Q3)	Women	55.67 ±5.16;[B] 56.00 (52.00–60.00)	54.84 ±5.34;[C] 55.00 (51.00–59.00)	55.63 ±5.54; 56.00 (51.00–60.00)	< 0.001
	Men	55.25 ±5.36;[B] 56.00 (51.00–60.00)	55.45 ±5.45;[C] 56.00 (51.00–60.00)	57.62 ±5.24; 59.00 (53.00–62.00)	< 0.001
Place of living: city, *n* (%)	Women	1178 (68.69)	2826 (61.66)	315 (59.43)	< 0.001
	Men	580 (66.13)	1474 (59.75)	108 (56.84)	0.002
Education: university, *n* (%)	Women	495 (28.80)	1340 (29.24)	110 (20.75)	0.001
	Men	242 (27.59)	602 (24.40)	35 (18.42)	0.018
Marital status: single, *n* (%)	Women	486 (28.34)	1093 (23.85)	112 (21.13)	< 0.001
	Men	111 (12.66)	243 (9.85)	22 (11.58)	0.062
Former smokers, *n* (%)	Women	494 (28.80)	1313 (28.65)	158 (29.81)	0.096
Curent smokers, *n* (%)	Women	368 (21.46)	880 (19.20)	88 (16.60)	
Former smokers, *n* (%)	Men	369 (42.08)	1030 (41.75)	87 (45.79)	0.058
Current smokers, *n* (%)	Men	219 (24.97)	519 (21.04)	41 (21.58)	
Coffee [servings/day] *x* ± SD; Me (Q1–Q3)	Women	1.32 (1.03); 1.00 (0.79–2.50)	1.30 (0.94); 1.00 (1.00–2.50)	1.21 (0.98); 1.00 (0.43–2.50)	0.115
	Men	1.24 (1.20); 1.00 (0.07–2.50)	1.16 (1.08); 1.00 (0.14–2.50)	1.17 (1.10); 1.00 (0.07–2.50)	0.791
Alcohol [servings/day] *x* ± SD; Me (Q1–Q3)	Women	0.05 ±0.08; 0.03 (0.00–0.08)	0.06 ±0.08; 0.03 (0.00–0.08)	0.05 ±0.08; 0.03 (0.00–0.08)	0.159
	Men	0.16 ±0.21; 0.08 (0.03–0.14)	0.16 ±0.22; 0.08 (0.03–0.14)	0.17 ±0.25; 0.08 (0.03–0.14)	0.446
ST [min/day] *x* ± SD; Me (Q1–Q3)	Women	1879.89 ±1385.38;[B] 1680.00 (1200.00–2100.00)	2067.11 ±1496.49;[C] 1800.00 (1260.00–2520.00)	2061.46 ±1432.71; 1800.00 (1260.00–2520.00)	< 0.001
	Men	2089.42 ±1410.11; 1860.00 (1260.00–2520.00)	2147.4 ±2846.6; 1800.00 (1260.00–2520.00)	1996.0 ±1045.0; 1680.0 (1260.00–2400.00)	0.756
PA [min/day] *x* ± SD; Me (Q1–Q3)	Women	232.09 ±125.31;[A] 210.00 (140.00–300.00)	242.74 ±128.21; 230.00 (150.00–320.00)	237.33 ±123.61; 220.00 (150.00–315.00)	0.018
	Men	211.37 ±142.072; 180.00 (10.00–540.00)	217.09 ±140.68; 190.00 (10.00–540.00)	191.98 ±123.69; 172.50 (20.00–540.00)	0.060

BMI – body mass index, %BF – body fat percentage, x – arithmetic mean, SD – standard deviation, Me – median, Q – quartile, ST – sitting time, PA – physical activity, NS – non significant, [A]significant difference between: I and II, [B]I and III, [C]II and III.

Table 2. The risk of obesity prevalence depending on sleep duration

BMI, %BF	Model	Gender	≤ 6 h of sleep	7–8 h of sleep	≥ 9 h of sleep
BMI ≥ 30 kg/m^2	Unadjusted	Total	**1.17 (1.07–1.29)**	1.0	**1.39 (1.19–1.62)**
		Men	**1.17 (1.08–1.26)**	1.0	1.08 (0.93–1.26)
		Women	1.04 (0.98–1.10)	1.0	**1.21 (1.11–1.33)**
	Adjusted	Total	**1.19 (1.07–1.33)**	1.0	**1.23 (1.03–1.48)**
		Men	**1.18 (1.08–1.28)**	1.0	1.05 (0.88–1.24)
		Women	1.03 (0.96–1.10)	1.0	**1.14 (1.02–1.26)**
%BF: ≥ 25% for men, ≥ 35% for women	Unadjusted	Total	0.98 (0.91–1.09)	1.0	**1.48 (1.34–1.47)**
		Men	1.02 (0.94–1.10)	1.0	**1.19 (1.02–1.39)**
		Women	0.99 (0.94–1.04)	1.0	**1.23 (1.13–1.35)**
	Adjusted	Total	1.04 (0.94–1.14)	1.0	**1.28 (1.07–1.53)**
		Men	1.05 (0.97–1.14)	1.0	1.12 (0.95–1.33)
		Women	0.99 (0.93–1.06)	1.0	**1.14 (1.03–1.27)**

*BMI – body mass index, %BF – body fat percentage, numbers in **bold** indicate statistically significant results.*

of sleep is connected with the lowest BMI, and both shorter and longer sleep are related to a higher BMI. In older individuals, correlations between these variables become weaker. Our subject age group (37–66 years) included mainly middle-aged participants and confirmed a U-shaped association between sleep duration and BMI characteristic for this time of life.

The results of the analyses of relationships between body composition and sleep duration are unambiguous. Chaput *et al.* [7] found lower percentage of body fat in men and women who reported sleeping 7–8 h/night compared to those reporting 5–6 h of sleep per night. However, the authors calculated body fat percentage based on the measurements of skinfold thicknesses. St-Onge *et al.* [15] did not find any significant correlation between adiposity and sleep duration in adults. However, Wirth *et al.* [37] noted that both elevated BMI as well as body fat percentage were observed for shorter sleep duration, whereas in both papers body fat percentage was measured by dual X-ray absorptiometry. Xiao *et al.* found that a short sleep duration (< 6 h) was associated with higher measures of body size and fat composition, although the effects were attenuated after snoring was adjusted [38].

The lack of relationship between short sleep duration and %BF, noted in this study, may result from the fact that a significant percentage of participants with BMI < 30 kg/m^2 had excessive adipose tissue, which was confirmed by previously conducted analyses [39] and studies by other authors [40]. Correlations obtained in the analysis of each criterion of obesity are different because sex-specific cutoffs for %BF at a level ≥ 25% for men and ≥ 35% for women were, in the subject population, more comparable with the value of BMI ≥ 25 kg/m^2 than ≥ 30 kg/m^2.

The associations between long sleep duration and the risk of excessive body mass are relatively seldom described in literature. However, several authors confirmed that longer sleep duration is related to a greater risk of overweight and/or obesity and a greater mass gain [17, 41, 42]. Tu *et al.* [43] noted that participants who had higher measurements for BMI and waist circumference were less likely to have short sleep duration and more likely to have long sleep duration. However, Nagai *et al.* [44], in long-term studies, found that longer sleep was connected with long-term weight gain, but only in the obese. A reliable explanation may involve a reduced energy expenditure related to longer time spent in bed [18, 41, 42]. Moreover, longer sleep can result in the subjects having less time for physical activity in the day. We need to consider the possibility that self-reported long-duration sleepers are spending a lot of time in bed but not getting a lot of sleep, i.e. they might have poor sleep quality due to sleep disorders or other health issues [41]. Xiao *et al.* [38] observed that poor sleep quality was associated with higher adiposity. The association between long sleep duration and the risk of obesity was not confirmed by Kobayashi *et al.* [4], which could result from the fact that ≥ 8 h was adopted as cut-off of long sleep duration.

The analysis of scores conducted separately for both sexes revealed that in women a greater risk of obesity was related to longer sleep duration, whereas in men, shorter sleep duration. Moreover, this relationship in men occurred only when BMI was adopted as a criterion of obesity. The results obtained by other authors are inconclusive. Most papers showed that associations between sleep duration and BMI are stronger, or occur only in women, not in men [16, 17, 42, 45, 46]. St-Onge *et al.* [15] also state that the relationship be-

tween self-reported sleep duration and body composition may be stronger in women than in men. Other studies did not reveal any differences based on sex [4, 18]. However, a few papers showed that such associations were present only among men [7, 47]. Spaeth *et al.* [48] found that men exhibited a greater increase in daily caloric intake during sleep restriction as a result of consuming more calories during late-night hours than women did. Population studies showed that sleep duration was inversely associated with BMI in men only, whereas poor sleep quality was positively associated with BMI in women only [49, 50].

Due to the cross-sectional nature of the study, a causal connection between sleep duration and the risk of obesity cannot be fully explained. However, experimental studies have shown that sleep reduction may have a significant metabolic effect on body mass homeostasis [51]. A limitation of this study involves also the fact that sleep duration was not measured but obtained from a questionnaire. However, Taheri *et al.* [52] found that self-reported sleep duration and polysomnographic measurement are both stable and highly correlated. Moreover, the study did not include the quality of sleep, which, similar to too short sleep, can activate the same mechanisms of energy uptake regulation and cause greater adiposity [53, 54].

A strong aspect of the study involves the large number of subjects and the fact that it was a homogeneous group in relation to age and ethnic origin. The analysis also included a large number of confounders, such as physical activity, sitting time, coffee consumption, and socio-demographic variables.

Conclusions

The conducted study confirmed the existence in the general study population of a U-shaped relationship between sleep duration and the risk of obesity defined as BMI ≥ 30 kg/m^2. A greater risk of obesity, defined on the basis of %BF, occurred only in connection with longer sleep duration. The analysis of results conducted separately for both sexes revealed that in women, a greater risk of obesity was related to a longer sleep duration (≥ 9 h), whereas in men a tendency to the prevalence of obesity in connection with shorter sleep was observed (≤ 6 h). In order to test the differences in associations between sleep duration and the risk of obesity depending on sex, it is necessary to conduct further, preferably long-term studies with the use of objective methods of measurement of sleep duration.

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Conflict of interest

The authors declare no conflict of interest.

References

1. Cappuccio FP, Taggart FM, Kandala NB, Currie A, Peile E, Stranges S, Miller Ma. Meta-analysis of short sleep duration and obesity in children and adults. Sleep 2008; 31: 619-26.
2. Park SE, Kim HM, Kim DH, Kim J, Cha BS, Kim DJ. The association between sleep duration and general and abdominal obesity in Koreans: data from the Korean National Health and Nutrition Examination Survey, 2001 and 2005. Obesity (Silver Spring) 2009; 17: 767-71.
3. Anic GM, Titus-Ernstoff L, Newcomb PA, Trentham-Dietz A, Egan KM. Sleep duration and obesity in a population-based study. Sleep Med 2010; 11: 447-51.
4. Kobayashi D, Takahashi O, Deshpande GA, Shimbo T, Fukui T. Association between weight gain, obesity, and sleep duration: a large-scale 3-year cohort study. Sleep Breath 2012; 16: 829-33.
5. Ford ES, Chaoyang Li, Wheaton AG, Chapman DP, Perry GS, Croft JF. Sleep duration and body mass index and waist circumference among US Adults. Obesity (Silver Spring) 2014; 22: 598-607.
6. Roda C, Charreire H, Feuillet T, Mackenbach JD, Compernolle S, Glonti K, Bárdos H, Rutter H, McKee M, Brug J, Bourdeaudhuij ID, Lakerveld J, Oppert JM. Lifestyle correlates of overweight in adults: a hierarchical approach (the SPOTLIGHT project). IJBNPA 2016; 13: 114.
7. Chaput JP, Lord C, Aubertin-Leheudre M, Dionne IJ, Khalil A, Tremblay A. Is overweight/obesity associated with short sleep duration in older women? Aging Clin Exp Res 2007; 19: 290-4.
8. Jean-Louis G, Williams NJ, Sarpong D, Pandey A, Youngstedt S, Zizi F, Ogedegbe G. Associations between inadequate sleep and obesity in the US adult population: analysis of the National Health Interview Survey, 1977–2009. BMC Public Health 2014; 14: 290.
9. Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, Dinges DF, Gangwisch J, Grandner MA, Kushida C, Malhotra RK, Martin JL, Patel SR, Quan SF, Tasali E. Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult: methodology and discussion. SLEEP 2015; 38: 1161-83.
10. Gangwisch JE, Malaspina D, Boden-Albala B, Heymsfield SB. Inadequate sleep as a risk factor for obesity: analyses of the NHANES I. Sleep 2005; 28: 1289-96.

11. Marshall NS, Glozier N, Grunstein RR. Is sleep duration related to obesity? A critical review of the epidemiological evidence. Sleep Med Rev 2008; 12: 289-98.
12. Theorell-Haglöw J, Berglund L, Janson C, Lindberg E. Sleep duration and central obesity in women – differences between short sleepers and long sleepers. Sleep Med 2012; 13: 1079-85.
13. Theorell-Haglow J, Berglund L, Berne C, Lindberg E. Both habitual short sleepers and long sleepers are at greater risk of obesity: a population-based 10-year follow-up in women. Sleep Med 2014; 15: 1204-11.
14. Watson NF, Badr MS, Belenky G, Bliwise DL, Buxton OM, Buysse D, Dinges DF, Gangwisch J, Grandner MA, Kushida C, Malhotra RK, Martin JL, Patel SR, Quan SF, Tasali E. Recommended amount of sleep for a healthy adult: a joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. J Clin Sleep Med 2015; 11: 591-2.
15. St-Onge MP, Perumean-Chaney S, Desmond R, Lewis CE, Yan LL, Person SD, Allison DB. Gender differences in the association between sleep duration and body composition: the Cardia Study. Int J Endocrinol 2010; 2010: 726071.
16. Cournot M, Ruidavets JB, Marquie JC, Esquirol Y, Baracat B, Ferrieres J. Environmental factors associated with body mass index in a population of Southern France. EACPR 2004; 11: 291-7.
17. Lopez-Garcıa E, Faubel R, Leon-Munoz, L, Zuluaga MC, Banegas JR, Rodrıguez-Artalejo F. Sleep duration, general and abdominal obesity, a weight change among the older adult population of Spain. Am J Clin Nutr 2008; 87: 310-6.
18. Watanabe M, Kikuchi H, Tanaka K, Takahashi M. Association of short sleep duration with weight gain and obesity at 1-year follow-up: a large-scale prospective study. Sleep 2010; 33: 161-7.
19. Zatonski WA, Manczuk M. Kielce PONS team. POlish-Norwegian Study (PONS): research on chronic non-communicablediseases in European high risk countries – study design. Ann Agric Environ Med 2011; 18: 203-6.
20. Suliga E, Koziel D, Ciesla E, Gluszek S. Association between dietary patterns and metabolic syndrome in individuals with normal weight: a cross-sectional study. Nutr J 2015; 14: 55.
21. Suliga E, Kozieł D, Cieśla E, Rębak D, Głuszek S. Coffee consumption and the occurrence and intensity of metabolic syndrome: a cross-sectional study. Int J Food Sci Nutrition 2016; 68: 507-13.
22. AACE/ACE Obesity Task Force. AACE/ACE Position Statement on the Prevention, Diagnosis, and Treatment of Obesity. Endocr Pract 1998; 4: 297-350.
23. Stranges S, Dorn JM, Shipley MJ, Kandala NB, Trevisan M, Miller MA, Donahue RP, Hovey KM, Ferrie JE, Marmot MG, Cappuccio FP. Correlates of short and long sleep duration: a cross-cultural comparison between the United Kingdom and the United States. Am J Epidemiol 2008; 168: 1353-64.
24. Wang S, Li B, Wu Y, Ungvari GS, Ng CH, Fu Y, Kou C, Yu Y, Sun HQ, Xiang YT. Relationship of sleep duration with sociodemographic characteristics, lifestyle, mental health, and chronic diseases in a large Chinese adult population. J Clin Sleep Med 2017; 13: 377-84.
25. International Physical Activity Questionnaire (IPAQ). IPAQ Scoring Protocol. Available online: https://sites.google.com/site/theipaq/
26. Buxton OM, Marcelli E. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. Soc Sci Med 2010; 71: 1027-36.
27. Gutiérrez-Repiso C, Soriguer F, Rubio-Martín E, Esteva de Antonio I, Ruiz de Adana MS, Almaraz MC, Olveira-Fuster G, Morcillo S, Valdés S, Lago-Sampedro AM, García Fuentes E, Rojo-Martínez G. Night-time sleep duration and the incidence of obesity and type 2 diabetes. Findings from the prospective Pizarra study. Sleep Med 2014; 15: 1398-404.
28. Jean-Louis G, Youngstedt S, Grandner M, Williams NJ, Sarpong D, Zizi F, Ogedegbe G. Unequal burden of sleep related obesity among black and white Americans. Sleep Health 2015; 1: 169-76.
29. Chaput JP, Tremblay A. Sleeping habits predict the magnitude of fat loss in adults exposed to moderate caloric restriction. Obes Facts 2012; 5: 561-6.
30. Morselli L, Leproult R, Balbo M, Spiegel K. Role of sleep duration in the regulation of glucose metabolism and appetite. Best Pract Res Clin Endocr Metab 2010; 24: 687-702.
31. St-Onge MP. The role of sleep duration in the regulation of energy balance: effects on energy intakes and expenditure. J Clin Sleep Med 2013; 9: 73-80.
32. Doo M, Kim Y. Association between sleep duration and obesity is modified by dietary macronutrients intake in Korean. Obes Res Clin Pract 2016; 10: 424-31.
33. Lakerveld J, Mackenbach JD, Horvath E, Rutters F, Compernolle S, Bárdos H, De Bourdeaudhuij I, Charreire H, Rutter H, Oppert JM, McKee M, Brug J. The relation between sleep duration and sedentary behaviours in European adults. Obes Rev 2016; 17: 62-7.
34. Nielsen LS, Danielsen KV, Sorensen TI. Short sleep duration as a possible cause of obesity: critical analysis of the epidemiological evidence. Obes Rev 2011; 12: 78-92.
35. Kowall B, Lehnich AT, Erbel R, Moebus S, Jöckel KH, Stang A. Associations between sleep characteristics and weight gain in an older population: results of the Heinz Nixdorf Recall Study. Nutrition Diabetes 2016; 6: e225.
36. Grandner MA, Schopfer EA, Sands-Lincoln M, Jackson N, Malhotra A. The relationship between sleep duration and body mass index depends on age. Obesity (Silver Spring) 2015; 23: 2491-8.
37. Wirth MD, Hébert JR, Hand GA, Youngstedt SD, Hurley TG, Shook RP, Paluch AE, Sui X, James SL, Blair SN. Association between actigraphic sleep metrics and body composition. Ann Epidemiol 2015; 25: 773-8.
38. Xiao Q, Fangyi G, Caporaso N, Matthews CE. Relationship between sleep characteristics and measures of body size and composition in a nationally-representative sample. BMC Obesity 2016; 3: 48.
39. Suliga E, Kozieł D, Cieśla E, Rębak D, Głuszek S. The relationship between dietary patterns and the risk of metabolic syndrome in obese adults. In press.
40. Peterson MD, Al Snih S, Stoddard J, Shekar A, Hurvitz EA. Obesity misclassification and the metabolic syndrome in adults with functional mobility impairments: Nutrition Examination Survey 2003-2006. Prev Med 2014; 60: 71-6.
41. Chaput JP, Despres JP, Bouchard C, Tremblay A. The association between sleep duration and weight gain in adults: a 6-year prospective study from the Quebec Family Study. Sleep 2008; 31: 517-23.

42. Lyytikäinen P, Rahkonen O, Lahelma E, Lallukka T. Association of sleep duration with weight and weight gain: a prospective follow-up study. J Sleep Res 2011; 20: 298-302.
43. Tu X, Cai H, Gao YT, Wu X, Ji BT, Yang G, Zheng W, Shu XO. Sleep duration and its correlates in middle-aged and elderly Chinese women: the Shanghai Women's Health Study. Sleep Med 2012; 13: 1138-45.
44. Nagai M, Tomata Y, Watanabe T, Kakizaki M, Tsuji I. Association between sleep duration, weight gain, and obesity for long period. Sleep Med 2013; 14: 206-10.
45. Mezick EJ, Wing RR, McCaffery JM. Associations of self--reported and actigraphy-assessed sleep characteristics with body mass index and waist circumference in adults: moderation by gender. Sleep Med 2014; 15: 64-70.
46. Yan LX, Chen XR, Chen B, Bai YM, Li JH, Zhang XW, Dong Z, Wang H, Mi SQ, Zhao WH. Gender-specific association of sleep duration with body mass index, waist circumference, and body fat in Chinese adults. Biomed Environ Sci 2017; 30: 157-69.
47. Berg JF, Knvistingh NA, Tulen JH, Hofman A, Witteman JC, Miedema HM, Tiemeier H. Actigraphic sleep duration and fragmentation are related to obesity in the elderly: the Rotterdam Study. Int J Obes (Lond) 2008; 32: 1083-90.
48. Spaeth AM, Dinges DF, Goel N. Sex and race differences in caloric intake during sleep restriction in healthy adults. Am J Clin Nutr 2014; 100: 559-66.
49. Meyer KA, Wall MM, Larson NI, Laska MN, Neumark Sztainer D. Sleep duration and BMI in a sample of young adults. Obesity (Silver Spring) 2012; 20: 1279-87.
50. Yang TC, Matthews SA, Chen VY. Stochastic variability in stress, sleep duration, and sleep quality across the distribution of body mass index: insights from quantile regression. Int J Behav Med 2014; 21: 282-91.
51. Broussard JL, Kilkus JM, Delebecque F, Abraham V, Day A, Whitmore HR, Tasali E. Elevated ghrelin predicts food intake during experimental sleep restriction. Obesity (Silver Spring) 2016; 24: 132-8.
52. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med 2004; 1: e62.
53. Kilkus JM, Booth JN, Bromley LE, Darukhanavala AP, Imperial JG, Penev PD. Sleep and eating behavior in adults at risk for type 2 diabetes. Obesity (Silver Spring) 2012; 20: 112-7.
54. Gonnissen HK, Hursel R, Rutters F, Martens EA, Westerterp-Plantenga MS. Effects of sleep fragmentation on appetite and related hormone concentrations over 24 h in healthy men. Br J Nutr 2013; 109: 748-56.

Address for correspondence:

Dorota Rębak MD, PhD
Department of Surgery and Surgical Nursing
with the Scientific Research Laboratory
Institute of Nursing and Midwifery
Faculty of Medicine and Health Sciences
Jan Kochanowski University
al. IX Wieków Kielc 19, 25-317 Kielce, Poland
Phone: +48 501 321 304
Fax: +48 413 496 916
E-mail: dorotar@ujk.edu.pl