School and Health 21, 2010, *Health Education: International Experiences*

THE ASSOCIATION BETWEEN SLEEP DURATION AND BODY WEIGHT IN ADULT

Zlata PISKÁČKOVÁ

Abstract: *Total sleep duration is still shorter in modern society, according to research to less than 7 hours per night. Conversely the number of obese individuals is increasing. Numerous epidemiological studies have confirmed an inverse association between sleep duration and BMI in adult population and in children. The paper presents results of survey involving 493 adults at the age of 18-65 years. In this group has not been shown statistically significant differences in duration of the sleep in relation to BMI. Although the sleep restriction is considered as a novel risk factor contributing to obesity, findings in this survey are probably influenced by other factors such as the presence of chronic diseases, genetic predisposition, dietary habits and lifestyle of the individual.*

Keywords: *sleep, sleep duration, body weight, BMI, obesity*

Introduction

Sleep is a natural physiological process, the need of which can differ individually; in average it ranges from 6 to 8 hours per night in the adult population. During the last 50 years material changes in the way of life took place in the developed countries. Pace of life in the modern society accelerates and sleep duration becomes shorter. In the USA 50 years ago the average sleep duration was 8 - 8.9 hours, but in 2008 the average sleep duration was only 6.7 hours per night (Van Cauter et al. 2008). Besides inadequate sleep duration, the modern population also suffers from another relatively frequent problem - sleeplessness, insomnia; according to carried our research 10 – 20 % population suffers from insomnia, depending on the age. The studies confirm that importance of the sleep does not consist only in compensation of psychical and physical fatigue, but sleep is important for activity of the body as a complex whole, in particular for correct function of the metabolic, endocrine, immunity and cardiovascular systems (Spiegel et al. 1999).

The studies concerning relationship between sleep duration and body weight can be broken down into the cross-sectional, long-time and laboratory studies. At the beginning the cross-sectional studies prevailed; they have proved either indirect relationship between sleep duration and BMI or, more frequently, relationship in the

form of the U-shaped curve on large population samples. These studies show that the individuals, sleeping in average 7 - 8 hours, have not only a lower risk of obesity development, but at the same time even a lower risk of development of hypertension and cardiovascular diseases (Buxton et al. 2010). The studies, monitoring long-time relationship between sleep duration and body weight, confirm in the majority of cases that it is not a random association. For instance in the known Nurses Health Study, incorporating the set of 68 183 women (21 – 64 years old), after 16 years of monitoring the scientists came to the conclusions that the risk of weight gain by 15 kg during 16 years is by 32 % higher in the women sleeping 5 hours and by 12 % higher in the women sleeping 6 hours, compared with the women sleeping the desirable 7 - 8 hours (Patel et al. 2006). The laboratory studies focused on clarification of the cause of this relationship refer mainly to disordered regulation of the hormones, secretion of which is subject to circadian rhythmicity and effect of which affects metabolism or food intake. The hormones leptin and ghrelin can serve as an example - both of them affect food intake (leptin – inhibits, ghrelin – stimulates food intake) and both of them at the same time show secretion in dependence on rotation of the sleeping and waking phases. Experiments in the healthy adults have proved that sleep deprivation leads to drop of leptin level by 18 % and to growth of ghrelin level by 28 % with a significantly higher hunger by 24 %, which fact results in a higher energy intake (Spiegel et al. 2004). These hypotheses indicate the way how lack of sleep can impair the basic physiological processes at the biological level. Besides the leptin and ghrelin hormones inadequate and poor-quality sleep can also contribute to glucose tolerance disorder and to development of diabetes mellitus (Spiegel et al. 2005).

Set and methodology

The set was represented by the volunteer respondents applied for, based on the advertised research intention in the printed mass media. The respondents were motivated by the objective to get to know certain information about themselves from the results of the study and by the possibility of short consultation with the professional staff. The individuals were included in the period 2005 – 2009. The exclusion criteria included gravidity, treatment by certain medicinal products (hormonal drugs, antidepressants or antipsychotics) and tumoral diseases in the medical history. The final set incorporated the respondents at the age ranging from 18 to 65 years.

The data were obtained, based on anthropometric measurements and on 7-day records of food intake, physical activity and sleep records. Physical activity was assessed objectively, using the pedometer attached on the body during the day. The anthropometric measurements, registration of medical history - diseases and drugs - clarification of correct filling-in of records and use of pedometers, were realized by a stable team of trained specialists. The records of food intake were assessed by the software NutriMaster (Abbott Laboratories).

Basic characteristics of the set can be found in the Tables 1 and 2 below.

Tab. 1 Set description: basic characteristics

Sex men women total	126 (25,6)1 367 (74,4)1 493 (100) 1
Age (years)	45 (18-65)2
Height (cm)	167,7 (8,9)3
Weight (kg)	91,4 (23,1)3
BMI (kg/m2)	32,5 (7,8)3
KT systolic (mm Hg)	131,7 (19,7)3
KT diastolic (mm Hg)	87,0 (12,7)3
Body fat percentage (%)	36,9 (10,8)3
Waist (cm)	101,2 (19,1)3
Primary energy demand (KJ)	7231,6 (1335,9)3

1 – n (%)
2 – median (range)
3 – average (SD)

Tab. 2 Set description: presence of disease and nicotinism

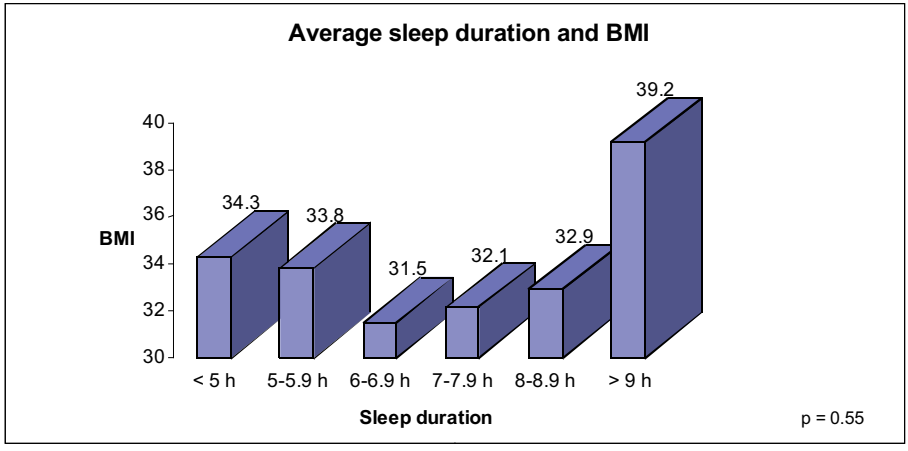
Disease	*n (%)* *of the total number of 493*
Esophageal reflux disease	11 (2,2)
cardiovascular system	16 (3,3)
Arthritis	24 (4,7)
Respiratory system	26 (5,3)
Diabetes mellitus	28 (5,7)
Thyroid gland diseases	173 (35)
Smoking Yes No	79 (16) 414 (84)

Statistics

The Kolmogorov-Smirnov test was applied for assessment of data distribution. In case of normal distribution the ANOVA test and the t-test were applied, otherwise the Kruskal-Wallis test was used. The level of significance $\alpha = 0,05$ was set for all rests. The data were analyzed, using the programme Statistica 9.1.

Results

Relation between the average sleep duration and BMI can be found on the graph 1, where indication of dependence in the form of the U-shaped curve can be seen; statistic significance has not been proved ($p = 0.55$). The lowest BMI (31.5) was established in the group sleeping in average 6 – 6.9 hours.



Graph 1: Relationship between sleep duration and BMI

Relationship between the average sleep duration and other indicators is contained in the Table 3. Statistic dependence was proved only for the number of steps during the working days (p = 0.03), where significantly most step were established for the respondents sleeping in average 6 – 6.9 hours; this group made the maximum steps even during the weekend and therefore it is most probably not a coincidence that this group has at the same time the lowest BMI, irrespective of sleep duration.

Tab. 3 Relationship between sleep duration and certain parameters

	Sleep duration – average (median)						
	< 5 (4.8)	5-5.9 (5.4)	6-6.9 (6.7)	7-7.9 (7.6)	8-8.9 (8.4)	9 > (9.5)	p
Number of persons (%)	11 (2.3)	38 (7.7)	147 (29.8)	199 (40.3)	85 (17.3)	13 (2.6)	
Age (years)	51.0 (7.5)	45.3 (9.3)	45.6 (11.5)	43.6 (12.9)	43.1 (14.9)	44.8 (14.2)	0.29
BMI (kg/m2)	34.4 (5.7)	33.8 (7.4)	31.5 (6.9)	32.1 (7.4)	32.9 (9.6)	39.2 (9.3)	0.55
% of fat	42.4 (3.4)	38.3 (9.6)	36.5 (10.4)	36.3 (10.9)	36.7 (11.9)	44.4 (11.6)	0.45
Waist (cm)	108.4 (19.6)	104.9 (18.1)	100.0 (17.4)	99.6 (19.1)	100.7 (20.7)	120.3 (20.1)	0.40
Primary energy demand	7 156.9 (1 869.3)	7 250.5 (1 211.6)	7 126.3 (1 350.0)	7 297.2 (1 344.2)	7 188.3 (1 272.2)	7 711.6 (1 395.6)	0.78
Blood pressure systolic	136.6 (11.7)	133.2 (19.9)	132.4 (21.4)	130.9 (18.4)	130.7 (21.2)	134.3 (19.2)	0.20
Blood pressure diastolic	89.2 (11.3)	89.0 (12.7)	87.8 (12.8)	85.9 (12.0)	86.0 (14.2)	89.0 (12.2)	0.14
Pedometer working days	7 628.4 (2 650.8)	7 520.3 (2 884.9)	8 124.3 (3 163.1)	7 733.2 (3 087.1)	6 808.4 (3 200.2)	6 483.5 (3 592.3)	0.03
Pedometer weekend	5 780.1 (2 634.6)	5 691.1 (2 997.5)	7 190.5 (4 006.3)	6 754.0 (3 714.6)	5 933.8 (3 107.5)	5 258.7 (3 617.1)	0.20

The values are reflected as the average (SD)

Other parameters only indicate possible relationship. As far as dependence of sleep and age is concerned, there is an explicit negative correlation: Age of respondents drops with reducing sleep duration ($p = 0.29$). Percentage of body fat and waist copy BMI values in a similar way without any statistic dependence. The primary energy demand also does not show a closer association with sleep. Blood pressure values indicate low dependence on sleep; the lowest systolic and diastolic pressure values were measured in the respondents sleeping 7 – 8.9 hours ($p = 0.20$ and/or $p = 0.14$).

Discussion

Relationship between sleep duration and body mass index (BMI) has not been proved statistically in this investigation ($p = 0.55$). One of the main reasons of the failure to prove the relationship between sleep and body weight can consist in composition of the research set itself which is not representative adequately. Women prevailed in the set (74.4 %), middle age generation (median of 45 years) and individuals with obesity according to BMI (average BMI - 32.5). Though the sample was not randomized and chosen randomly, we can speak about the population mean, because according to the statistics it is valid that there are 52 % adult individuals in the Czech population in the zone of excessive weight (Životní styl a obezita/Lifestyle and Obesity, 2005).

Size of the set can be another possible factor. Epidemiological cross-sectional studies, monitoring relationship between sleep and BMI comprised much more greater sets: Vorona et al. (2005) examined 924 individuals (at the age ranging from 18 to 91 years), Taheri et al. (2004) monitored 1024 individuals (at the age ranging from 30 to 60 years), Buxton et al. (2010) in the National Study in the USA analyzed the set of 56 507 individuals (at the age ranging from 18 to 85 years), in the Czech study Adámková et al. (2009) examined 3970 individuals (at the age ranging from 18 to 65 years); Buscemi et al. (2007) is the sole exception, because he has proved statistical significance in the mixed set of 200 individuals (at the age ranging from 18 to 49 years), but only in women. In our set less frequently represented were mainly the extreme groups sleeping < 5 hr and > 9 hr. Nevertheless, a similarly irregular representation with the highest number of respondents sleeping in average 7 – 8 hours could be found in the majority of large studies (Adámková et al. 2009, Patel et al. 2006, Bjorvatn et al. 2007), where in addition to it, the statistical significance was proved even with smaller BMI differences than in our set. In our case we can most probably find rather the relationship of obesity and physical activity, because the individuals with the lowest BMI (31.5) from the category of sleep duration of 6 – 6.9 hours have shown statistically significantly the most walked steps during the working days ($p = 0.03$) as well as during the weekends ($p = 0.14$).

Besides the active leisure/physical activity presence or absence of chronic diseases seems to be an important factor: presence of one or more diagnoses was connected positively with a shorter sleep (< 6.9 hr) ($p = 0.041$). A higher frequency of chronic diseases linked with a shorter sleep has also been proved by Buscemi et al. 2007 (patients with cardiovascular diseases had a shorter sleep duration compared with the patients that did not suffer from cardiovascular diseases), Singh et al. 2005 (sleep < 7 hr represented a higher risk for development of diabetes mellitus) and for instance Buxton et al. (2010) has proved that a very short sleep (< 7 hr) as well as a very long sleep (> 8

hr) are connected positively with the risk for development of not only obesity, but also diabetes, hypertension and cardiovascular diseases. Gangwish et al. (2006) has proved in his research that sleep deprivation is an independent risk factor for development of hypertension; in our research we have revealed a similar coincidence - the highest blood pressure values were measured in the individuals sleeping < 6.9 hours as well as in the individuals sleeping more than 9 hours, but without any statistical significance.

The issue of chronic diseases consists mainly in the fact that these diseases can mutually affect both the body weight and sleep duration and vice versa which fact can be supported by the laboratory studies, where lack of sleep for instance led to impairment of the glucose tolerance. In the studies with the cross-sectional design, which is the case of our research, it is not possible to establish what is the reason and what the consequence, whether the sleep, obesity or chronic disease. In this case a long-time monitoring of the set of respondents would be more advantageous.

In this set we have failed to prove statistically relationship between sleep duration and body weight; a certain role could be played here by minor, but not less significant factors. It is necessary to consider subjective answers of the respondents, seasonal differences in the course of data collection, because the season affects materially the dietary habits, physical activity, daily rhythm and well-being of the people. The following has not been for instance considered among the analysed data: socioeconomic background, marital status, overuse of legal stimulants (coffee, alcoholic beverages); the level of stress, mainly with respect to quality of sleep, plays nowadays a very important role. Kohatsu et al. (2006) has proved negative correlation between sleep duration and degree of depression, Stranges et al. (2008) and Lopéz-García et al. (2008) alike.

Genetic predisposition also plays a considerable role; literature sources show that genetic predisposition participates by 60 - 70 % in development of obesity, the remaining part is affected by the lifestyle of the individual. Sleep duration also has its genetic background, which fact can be supported by individual necessity of sleep duration within a wide range of 6 - 8 hours. Despite the genetic predisposition the scientific researches confirm that the lifestyle of the individual is decisive for mutual relation of sleep and obesity, where adequate weight and sufficient physical activity support high-quality sleep and, vice versa, high-quality and adequate sleep is the preventive factor reducing the risk for development of obesity, hypertension, diabetes mellitus, cardiovascular diseases and mortality.

Conclusion

Our own research investigation has failed to prove a statistically significant relationship between sleep duration and BMI ($p = 0.55$). Nevertheless even without statistical significance the relationship between these variables was very close to the U-shaped curve; the lowest BMI could be found in the individuals sleeping in average 6 – 6.9 hr, who at the same time have walked statistically significantly most steps during the working days ($p = 0.03$). Sleep duration in the examined set was connected closely with presence of chronic diseases; in presence of one and more diagnoses the respondents had more frequently sleep duration shorter than 6.9 hours ($p = 0.041$).

Body weight and sleep duration could be affected even by other factors, for in-

stance socioeconomic background, marital status, seasonal differences in the course of data collection, overuse of legal stimulants (coffee, alcoholic beverages), the level of stress that have not been considered during the research. The results could also be distorted by the bias caused by subjective answers or by incorrectly done records by the respondents. Last, but not least, the set might be neither representative adequately nor large enough for safe proof of statistical differences.

Though the causal link between sleep and obesity has not been clarified fully yet, conclusions of many studies agree that a very short sleep (< 7 hr) represents the risk factor for development of not only obesity, but also hypertension, diabetes mellitus and metabolic syndrome. Therefore sleep and correct sleep hygiene can be considered protective factor of the same importance like healthy dietary habits and adequate physical activity in preventing development of obesity and other chronic diseases.

Literature

ADÁMKOVÁ, V. aj. Association between duration of the sleep and body weight. *Physiological Research* 2009, roč. 58 (supp. 1), s. 27-31.

BJORVATN, B**.** aj. The association between sleep duration, body mass index and metabolic measures in the Hordaland Health Study. *J Sleep Res* 2007, roč. 16, s. 66-67.

BUSCEMI, D. aj. Short sleep times predict obesity in internal medicine clinic patients. *J Clin Sleep Med* 2007, roč. 3, s. 681-687.

BUXTON, M. aj. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. *Social Science and Medicine* 2010, roč. 71, s. 1027-1036.

GANGWISCH, F. E. aj. Short sleep duration as risk factor for hypertension. *Hypertension* 2006, roč. 47, s. 833-839.

KOHATSU, N. D. aj. Sleep duration and body mass index in a rural population. *Arch Intern Med* 2006, roč. 166, s. 1701-1705.

LÓPEZ-GARCÍA, E. aj. Sleep duration, general and abdominal obesity, and weight change among the older adult population of Spain. *American Journal of Clinical Nutrition* 2008, roč. 87, s. 310-316.

PATEL, S. R. aj. Association between reduced sleep and weight in women. *American Journal of Epidemiology* 2006, roč. 164, s. 947-954.

SINGH, M. aj. The association between obesity and short sleep duration: a population-based study. *Journal of Clinical Sleep Medicine* 2005, roč. 1, č. 4, s. 357-363.

SPIEGEL, K. aj. Impact of sleep debt on metabolic and endocrine function. *Lancet* 1999, roč. 354, s. 1435-1439.

SPIEGEL, K. aj. Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels and increased hunger and appetite. *Annals of Internal Medicine 2004,* roč. 141, s. 846-850. (a)

SPIEGEL, K. aj. Sleep loss: a novel risk factor for insulin resistance and Type 2 diabetes. *J Appl Physiol* 2005, roč. 99, s. 2008-2019.

STRANGES S, aj. Cross-sectional versus prospective associations of sleep duration

with changes in relative weight and body fat distribution. *American Journal of Epidemiology* 2008, roč. 167, č. 3, s. 321-329.
TAHERI, **S**. aj. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. *Plos Medicine* 2004, roč. 1, č. 3, s. 210-217.
Van CAUTER, E. aj. Metabolic consequences of sleep and sleep loss, *Sleep Medicine* 2008, roč. 9 (Suppl. 1), s. 23-28.
VORONA, R. D. aj. Overweight and obese patients in a primary care population report less sleep than patients with a normal body mass index. *Arch Intern Med* 2005, roč. 165, s. 25-30.
Životní styl a obezita (2005), STEM/MARK, a. s. Výzkum pro MZ ČR a Českou obezitologickou společnost projekt Zdraví 21, cit. 28. 8. 2010. Dostupné na World Wide Web: http://www.zdravi21msk.cz/03_plneni/files/obezita_dospeli.pdf.

VZTAH MEZI DÉLKOU SPÁNKU A TĚLESNOU HMOTNOSTÍ U DOSPĚLÝCH

Abstrakt: Celková doba spánku se v moderní společnosti neustále zkracuje, podle výzkumů na méně než 7 hodin za noc. Naopak počet obézních jedinců stále narůstá. Nepřímý vztah mezi délkou spánku a BMI v dospělé populaci i u dětí prokázala řada epidemiologických studií. V příspěvku jsou prezentovány výsledky šetření zahrnující 493 dospělých jedinců ve věku 18-65 let. V tomto souboru nebyly prokázány statisticky významné rozdíly v délce spánku ve vztahu k BMI. Ačkoliv je zkrácený spánek nově považován za rizikový faktor přispívající k obezitě, v provedeném průzkumu jsou závěry pravděpodobně ovlivněny i jinými faktory jako jsou například přítomnost chronických onemocnění, genetické dispozice, stravovací návyky a životní styl jedince.

Klíčová slova: spánek, délka spánku, tělesná hmotnost, BMI, obezita