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Association between Duration of the Sleep and Body Weight

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Summary

Some studies have suggested that there could be an association between the duration of sleep in humans and development of the obesity. We have analyzed the group of the probands (n = 3970, 2038 males and 1932 females, aged 18-65 years), with permanent address in the Central or South Bohemia. We ascertained the relationship between the duration of their sleep (obtained per questionnaire) and body mass index, weight, height, the value of systolic and diastolic blood pressure, heart rate, waist and hip circumference, the values of total-, high density- and low density- cholesterol, thyroid hormone and body exercise performed. The optimal values of the body mass index (and optimal body weight) were associated with the duration of sleep 7 hours per night ($P < 0.001$). This association was found both in males and females and in both districts. Other anthropometrical and biochemical parameters were not associated with the sleep duration.

Key words

Obesity • Sleep • Hour • Body mass index

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Introduction

The prevalence of the obesity has increased dramatically both in developing and developed countries over the last several decades. In the research of obesity much attention has focused on decreasing food intake and increasing physical exercise, but these efforts are very often only short-term effective. And so, there is necessary to identify other new approaches that might also affect the development of; and could be used in prevention of obesity.

Nearby the abundant energy intake and low physical activity, there are many other factors, which could be behind the recent obesity pandemia (Keith *et al.* 2006).

The number of hours sleep per night is one of the recently discussed new parameters, which are intensively studied. It is proved that sleep serves a vital function, but there is still no consensus on all specific functions of sleep (Siegel 2005, Mignot 2008). Numerous studies on mammalians were performed and they found that „good“ sleepers were often predators or had a relatively secure sleep in comparison to „poor“ sleepers (Lesku *et al.* 2009). The results of these studies suggested that predators act as a selection pressure favoring the evolution of short – sleeping prey. How can we disclose the relationship to body weight?

For human adults 7-8 hours per night have been recommended as the optimal duration of sleep (Chaput *et al.* 2009, Xiang *et al.* 2009). Several epidemiologic studies have studied the association of sleep duration with obesity and diabetes. In a randomized crossover trial, the probands with sleep restriction to 4 hours showed decreased levels of the anorexigenic hormone leptin (it causes loss of appetite) and increased levels of orexigenic (appetite increasing) hormone ghrelin (Beihl *et al.* 2009). It has been also suggested that the hormones leptin and ghrelin, which influence energy homeostasis (and thus also weight gain), may play an important role in the association between

short sleep and diabetes (Beihl *et al.* 2009). Chaput *et al.* (2009) found that both too short and too long sleeping (7-8 hours per night are recommended) are associated with higher risk of developing type 2 diabetes mellitus. Finally, Taheri *et al.* (2004) and Najafian *et al.* (2008) have ascertained that extreme short sleep were nonetheless associated with higher body mass index.

We have analyzed the putative association between the duration of sleep and anthropometrical and biochemical parameters in a large group of middle European Caucasians.

Materials and Methods

Analyzed individuals

All 3970 probands (2038 male and 1932 female, aged 18-65 years) with their permanent address in the district of Central or South Bohemia were included in the study.

Anthropometrical and biochemical parameters

In all individuals, the following data were collected. Duration of the sleep, body exercise habits, smoking status, birth weight and dietary habits (including alcohol consumption) were collected per questionnaire. The body exercise should taken minimal 30 minutes (l session), the duration of sleep was mentioned in hours per night.

Biochemical parameters (fasting glucose, total- high density lipoprotein- and low density lipoprotein-cholesterol, triglycerides and thyroid hormone) were analyzed from blood samples using the commertionally available kits Roche-Hitachi.

Further, body weight, height, circumference of the waist and hip (waist and hip circumferences were measured in the middle between the arch of 10^{th} rib and the top of crista iliaca), systolic and diastolic blood pressure (measured with a standard mercury sphygmomanometer, on the right arm, three times, we calculated the average of these three measurements) and heart rate were measured by trained nurse according the standardized methods.

Body mass index (BMI) was calculated like weight (in kg) divided by square of height (in meters).

The examination of the probands were done after their signature of the inform consent.

Statistical analysis

Shapiro – Wilk test were used to determine whether the outcome variables were normally distributed. Variables were reported as means ± S.D. If variables were normally distributed, ANOVA test ant t-test were used. If variables were not normally distributed, Mann-Whitney test was used. Spearman and Pearson correlation coefficients were computed to determine the bivariate relationship between all variables. Statistical analyses were performed using the SPSS System software package.

Table 1. Basic parameters of the analyzed individuals.

Parameter	Value
weight (kg)	78.19 ± 16.51
height (cm)	174.09 ± 9.48
BMI (kg/m²)	26.15 ± 4.70
waist circumference (cm), male	86.70 ± 14.06
waist circumference (cm), female	81.56 ± 13.27
hip circumference (cm), male	96.78 ± 11.47
hip circumference (cm), female	98.62 ± 10.27
sleep (hours per night)	7.05 ± 0.68
fast glucose (mmol/l)	5.39 ± 1.43
total cholesterol (mmol/l)	4.75 ± 0.91
triglycerides (mmol/l)	1.65 ± 1.03
high density cholesterol (mmol/l)	1.33 ± 0.40
low density cholesterol (mmol/l)	2.74 ± 0.84
SBP (mm Hg) male	128.23 ± 7.11
SBP (mm Hg) female	126.28 ± 7.22
DBP (mm Hg) male	79.91 ± 3.56
DBP (mm Hg) female	79.26 ± 3.69
heart rate/min	70.45 ± 9.72
thyroid hormone (μmol/l)	2.61 ± 1.67

BMI - body mass index; mmol/l - milimol per liter; μmol/l - micromol per liter; SBD - systolic blood pressure; DBP - diastolic blood pressure.

Results

The basic data of the probands included in the study are summarized in the Table 1.

In the entire sample we have detected the significant correlation between the duration of sleep and weight ($P < 0.05$) and BMI ($P < 0.001$), irrespective of the permanent address and of the gender of the volunteers.

Other analyzed parameters (fasting glucose, total- high density lipoprotein- and low density

lipoprotein- cholesterol, triglycerides, thyroid hormone, body weight, and height, circumference of the waist and hip, waist-hip ratio, hearth rate and systolic and diastolic blood pressure were not significantly associated with sleep duration (Table 2).

No significant difference was ascertained in the duration of sleep according to the grade of the education (both gender).

The highest body mass index (28.48±4.49 kg/m² male, 27.29±5.72 kg/m² female, $P < 0.05$) was measured in the group of the primary education at comparison with the higher grade of the education (middle education 25.42±4.385, resp. university education 25.49±4.107 kg/m²).

The optimal BMI values were associated with the sleep at least 7 hours per night (Table 4). The minimal duration of sleep was 4-5 hours per night (N = 191 individuals, 138 females) and maximal BMI in this group has been 34.56±3.623 kg/m². The duration of sleep 10 hours or longer per night, was reported by 232 probands (169 males) and maximal BMI in this group has been 32.61±1.736 kg/m² (average BMI was measured 30.81±1.746 kg/m²).

Table 2. The correlation between sleep and the other parameters.

Parameter	n	Corpair correlation	P
height	3970	-0.0329	n.s.
weight	3970	-0.1034	< 0.05
waist - circumference	3970	-0.0931	n.s.
hip - circumference	3970	-0.0856	n.s.
BMI	3970	-0.1097	< 0.05
systolic blood pressure	3970	-0.0197	n.s.
diastolic blood pressure	3970	-0.0197	n.s.
heart rate	3970	0.0643	n.s.
triglycerides	2379	0.0097	n.s.
glycaemia	3970	-0.0830	n.s.
thyroid hormon	1990	-0.0722	n.s.
total cholesterol	3970	-0.0196	n.s.
HDL cholesterol	2297	-0.0437	n.s.
LDL cholesterol	2297	0.0200	n.s.

n.s. - non significant; HDL - high density lipoprotein; LDL - low density lipoprotein.

Further, the highest duration of sleep was ascertained in the volunteers exercised twice weekly ($P < 0.01$) in comparison to the other groups irrespective of the permanent address (Table 3).

Discussion

Chronic partial sleep deprivation as a consequence of voluntary bedtime restriction is commonly observed in modern society (Chaput *et al.* 2009), but the final consequences of the sleep restriction are poorly understood.

Focusing of the sleep duration continuum, several studies have shown an increased risk of diabetes mellitus associated with long sleep duration (Beihl *et al.* 2009). We cannot confirm this result because we have ascertained no relationship between the duration of sleep and fasting glucose, like a marker for disclosing of diabetes in population. But our sample is compiling rather young individuals and these associations could be more expressed in elderly individuals.

Sahlin *et al.* (2009) has written, that hypertension is associated especially with the duration of sleep < 6 hours a night, but we have not confirm this result, because we have not ascertained any relationship between the duration of sleep and the value of systolic and diastolic blood pressure.

In our study we have detected significant association between the duration of sleep and both BMI ($P < 0.001$) and body weight ($P < 0.05$). This association was found both in males and females and was not age dependent.

Behind the reducing of the physical activity and high energy intake, there are many other risk factors which are responsible for the recent obesity pandemia (Keith *et al.* 2006, Adámková *et al.* 2007, Hubáček 2009). By our results we have to claim that the relationship between BMI and body exercise is not so clear, because the minimal BMI of our probands was calculated in the group exercised twice weekly. How is their lifestyle? In our opinion, these individuals in majority do not use the elevators, prefer going for a walk instead using of cars of public transportation etc. Some studies confirm this complicated situation (Valentine *et al.* 2009).

The sleep deprivation seems to be the most important one, unluckily also for the children. It was found that short sleep duration is positively associated with obesity in children, too (McKenzie *et al.* 2008, Jiang

Table 3. Relationship between duration of sleep and body exercise.

Exercise	Never	1x weekly	2x weekly	3x weekly	Daily
sleep (h) CB	6.96 ± 1.51	7.21 ± 1.39	7.37 ± 1.04	7.31 ± 1.03	7.21 ± 1.16
sleep (h) SB	7.28 ± 1.20	7.52 ± 1.44	7.71 ± 1.27	7.39 ± 1.24	7.58 ± 1.44
			p<0.01		

h - hours per night; CB - Central Bohemia; SB - South Bohemia.

Table 4. Relationship between the duration of sleep and body mass index.

Sleep (h)	4 – 6 n = 386	7 n = 2911	8 – 11 n = 566	p<
BMI (kg/m²)	27.46 ± 4.919	25.40 ± 4.201	25.18 ± 4.868	0.001

h - hours per night, BMI - body mass index.

et al. 2009).

We know that the deprivation of sleep produces hyperphagia (as a possible mechanism leading to the obesity) not just in animals; but also in humans has recently been shown to induce similar effects (revised by Keith *et al.* 2006). There is known, that sleep time less than five hours per day compared with longer time of sleep increased the relative risk for abdominal obesity and in people less than 60 years (for both male and female). The relationship between the duration of sleep and waist circumference was found (Najafian *et al.* 2008), unfortunately we have not confirmed this results.

The pathway for explaining the influence of the deprivation of sleep and the increasing of BMI in the countries has not been clear, yet. There is a general consensus that sleep participates in the regulation of many physiological functions and sleep deprivation is a common phenomenon in modern society on the whole world. Maybe, the deprivation of sleep is like a strong stress for the organism, because it was ascertained that plasma cortisol concentrations decline a few hours after onset of sleep and for example the level of cortisol increased in young, healthy adult males more when sleep was restricted to 4 hours period, than when the sleep period was extended to more than 8 hours periods (Wu *et al.* 2008).

Adamantis and de Lecea (2009) have published that energy homeostasis, feeding, locomotor activity, reward and motivation are regulating the sleep-wake cycles.

As we have detected, our probands slept 4-11 hours per night (with majority n=1983, 52.3 % - sleeping for less than recommended 7 hours). It is in agreement with some other studies (Beihl *et al.* 2009, Thomas *et al.* 2009) showing that the average daily sleep decreased during pas several decades from over 9 to just about 7 hours per night among adults and this increase inversely correlate with BMI values through the same time period.

We have confirmed, that behind the low physical activity which is not accompanied with adequate lowering of energy intake, there could be many other factors responsible for recent increase of obesity prevalence and the sleeping deprivation is definitely one of them.

Conflict of Interest

There is no conflict of interest.

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