Journal of Food and Nutrition Sciences
2018; 6(1): 18-23
http://www.sciencepublishinggroup.com/j/jfns
doi: 10.11648/j.jfns.20180601.13
ISSN: 2330-7285 (Print); ISSN: 2330-7293 (Online)

Assessment of Obesity and Circadian Rhythm Irregularities of Disabled People

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To cite this article:
Müge Arslan, Müveddet Emel Alphan. Assessment of Obesity and Circadian Rhythm Irregularities of Disabled People. *Journal of Food and Nutrition Sciences*. Vol. 6, No. 1, 2018, pp. 18-23. doi: 10.11648/j.jfns.20180601.13

Received: November 8, 2017; **Accepted**: November 16, 2017; **Published**: December 20, 2017

Abstract: Circadian rhythm is responsible for regulation of metabolic systems. Irregularities of circadian rhythm is thought to be increasing risk factor for metabolic disorders like obesity. The aim of the current study is to examine this relationship and understand mediatory effects of daily dietary habits in this relationship for disabled people. 103 subjects (56 male, 47 female) from an Education and Rehabilitation Centre of Disabled People in Çorum in Turkey participated to the study. The subjects' sleep quality was assessed with Pittsburg Sleep Quality Inventory (PSQI). BMI levels was used for obesity diagnosis. Daily dietary habits and calorie intake of subjects were also measured by survey and daily food consumption recordings for 7 days. 28,2% of the subjects diagnosed with obesity according to BMI levels. 38,8% of the subjects are found to be having bad sleep quality. There is a positive significant relationship between obesity and bad sleep quality. Daily carbohydrate, protein and fat intake is also found to be positively related with bad sleep quality. As a result, findings of the current study indicates the effect of circadian rhythm on daily dietary habits which further leading to increased obesity risk for disabled people.

Keywords: Obesity, Circadian Rhythm, Dietary Habits, Disability

1. Introduction

In the last few decade, obesity has gained much attention as a public health hazard in most countries due to its extensive harm on human body. It is a disease associated with excessive fat accumulation in body [1, 2]. Diagnosis of obesity bases on body measurement. This measurement method called as body mass index (BMI) and is obtained by dividing the weight by the square of the height [3]. The criteria for obesity has changed in years due to definition of it and the population that is considered [4]. However, World Health Organization (WHO) standardized the criteria as it shown in the Table 1. According to these criteria <16 BMI is defined as extremely thin, <18 as thin and ≥25 as obese [5, 6, 7, 8]. However, these cut-offs may show slight changes according to age, sex and the country [9, 10]. For example, WHO identified 20-30BMI as normal and >33 obesity for women while the normal limit is 12-20 BMI and the obesity limit is>25 for men in later studies.

Table 1. *International classification for BMI.*

Classification	Cut-off (kg/m^2)	BMI (kg/m^2) (Additional cut-off)
Thin	<18,00	<18,5
Average weight	18,50–24,99	18,50–22,99
		23,00–24,99
Over weight	25,00–29,99	25,00–27,49
		27,50–29,99

Classification	Cut-off (kg/m^2)	BMI (kg/m^2) (Additional cut-off)
Obese	≥30,00	≥30,00
1. class	30,00–34,99	30,00–32,49
		32.,0–34,99
2. class	35,00–39,99	35,00–37,49
		37,50–39,99
3. class	≥40,00	≥40,00

Obesity is seen as a trigger of many chronic and fatal diseases such as diabetes and hypertension [11], and its prevalence increases every year. According to MONICA study of WHO which has lasted for 12 years, the prevalence of obesity increase 10-30% in only ten years. CDC (Center for Disease Control), on the other hand, present this increase rate as approximately 35% between 2003-2010 [12]. This increase bases on many factors, but the most important one may be the dietary habit of people. People consume more than 50 different nutrients according to their dietary habits. These nutrients can be grouped in 6 categories. These are carbohydrates, proteins, fat, vitamins, minerals and water [13]. Daily calorie need is met with carbohydrates in 45-65%, with proteins in 10-12% [14, 15] and with fat in 20-35% [15] in a normal dietary. Vitamins and minerals, on the other hand, contribute to the sustainability of human health and various diseases and developmental disorders emerge in the case of deficiency of them [14, 16, 17].

Studies show that circadian rhythm is one of the factors that pose high risk for obesity in daily routine [18, 19]. Circadian rhythm is a 24-hour endogenous biological rhythm. All biological oscillation of the body like hormone releases are set to it [7, 8, 20]. Therefore, changes in circadian rhythm cause irregularities in hormone releases and associative diseases [21-23]. One of them is leptin hormone that regulates appetite. Studies indicate that leptin hormone level decreases due to circadian rhythm irregularities and led to increased appetite and weight gain [18, 19]. Also, increase in ghrelin hormone is found to be related with decrease in leptin hormone in further studies. Ghrelin hormone also causes increase in appetite and hunger which further increase the weight gain [24, 25].

Many of these studies based on examining the circadian rhythm and obesity relationship through sleep irregularities. It is because one of the significant indicator of the circadian rhythm irregularities is sleep irregularities and disorders. According to findings, short sleep is associated with high BMI and type-2 diabetes [26, 27]. Especially, BMI is find to have negative relationship with sleep duration [28]. Therefore, people with sleep disorder are defined as under high risk of developing obesity [29, 30].

Circadian rhythm irregularities also effect dietary habits. Findings show that effect of energy expenditure on metabolism changes according to biological time of the body. People who work at night or with disorders like night eating syndrome are found to have tendency to increased BMI and to develop obesity due to continuing calorie intake during a time they should be sleeping [28, 31, 32, 33]. On the other hand, type of nutrients in daily dietary is found to be related with gene expressions that join into metabolism and regulation of circadian rhythm [34, 35]. In Kohsaka and his colleagues study, high-fat diet is found to changing locomotor activities of rodents and increasing their calorie intake during both day and night times [36]. Thus, the relationship between dietary habit and circadian rhythm may be interpreted as bi-directional. In terms of studies on this relationship, there is lack of research on people with disabilities. The current study focus on disabled people to understand this relationship. During the study, daily dietary habits and calorie intake of subjects are also assessed to understand possible effect of them on this relationship.

2. Subjects and Method

2.1. Subjects

This study is conducted with disabled people from an Education and Rehabilitation Centre of Disabled People in Çorum in Turkey. Ethical approval of the current study was given by the ethical committee of Okan University Institute of Health Sciences according to research protocol number 75 in 30.03.2016. Data was collected between April and June in 2016. Only people who does not have any mental or psychological disorder and whose families consent for participation to study are recruited. The total number of subjects is 103 (Male = 56, Female = 47). Their age is ranged between 18 to 74 (M = 32,17, Std = 10,43).

2.2. Measurement

Circadian rhythm of the subjects was measured through their sleeping cycle in this study. Evaluation of the subjects' sleep cycle was done by using Turkish version of Pittsburgh Sleep Quality Index (PSQI) [37]. Usage of this index requires both the subjects and one of their first degree relatives' answers. The index consists of sub-factors as sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medications and daytime dysfunction factors. Total score of 5 or below considered as having "good" sleep, while total score of higher than 5 considered as having "bad" sleep for this index. "Bad" sleep quality refers to high sleep disturbance in at least two sub-factors, or it may refer to mild sleep disturbance in more than three sub-factors in the index according to answers of subject.

In this study, obesity was measured through BMI. For this purpose, anthropometric measurements were used. Weight of

the subjects was measured by Fakir Herculus Body Analyzing Bascule (sensitive to 100 g) for who can stand themselves. Those subjects' height was measured with tape measure in standing position. On the other hand, weight of subjects who cannot stand themselves was measured using a chair. Ekoter B5 Electronic Weight Scale (with 150 kg weighing capacity) was used for weight measurement and tare of the chair was excluded from the total weight. Their height was measured while they were lying on their backs. Daily dietary habits and calorie intake was assessed with a survey consisting of 36 questions and daily food consumption recordings of each subject for 7 days.

3. Results

The data of the study was analyzed with SPSS v.22 program. Normal distribution of the data was controlled with Kolmogorov-Smirnov Z test. In all analyses 5% significance value was used to evaluate results.

According to BMI measurements, 28,2% of the subjects are diagnosed with obesity in Table 2 Distribution of anthropometric measurements and BMI according to age and sex are presented in Table 3. No significant difference between male and female subjects was found for BMI levels, $P>0,05$.

Table 2. *BMI of the subjects.*

BMI (kg/m^2)	Thin (≤ 18,5)	12	11,7
	Average weight (18,5 - 24,99)	42	40,8
	Over weight (25 - 29,99)	20	19,4
	Obese (30 - 39,99)	29	28,2

Table 3. *Distribution of anthropometric measurements.*

	SEX					
	MALE			**FEMALE**		
Features	**Min-Max**	**Median**	**M±Std**	**Min-Max**	**Median**	**M±Std**
Age (year)	19-74	29,5	31,46±10,63	18-59	31	33,02±10,24
Weight (kg)	42-120	68	71,43±18,2	30-113	60	63,6±16,86
Height (cm)	147-188	168,5	167,84±9,33	120-177	160	158,04±14,02
Waist Circumference (cm)	62-120	92,5	92,25±16,63	60-129	86	87,02±16,4
BMI (kg/m^2)	20,9-45,7	24,9	25,55±6,71	21,2-46,8	24,6	25,78±6,91

PSQI scores of the participants are found to be ranging between 0 to 13 (M=5,15; SD=03). According to these scores, 38,8% (N=40) of the subjects have bad sleep quality in Table 4. When the scores are evaluated according to sex, it is found that 32,1% of male subjects and 46,8% of female subjects have bad sleep quality in Table 4. However, there is no significant difference between two groups, $P>0,05$.

Table 4. *Distribution of sleep quality criteria (N=103).*

Sleep Quality Criteria	**PSQI score**							
	0		**1**		**2**		**3**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
PSQI- Sleep Quality	26	25,2	66	64,1	6	5,8	5	4,9
PSQI- Sleep Latency	43	41,7	21	20,4	33	32,0	6	5,8
PSQI- Sleep Duration	71	68,9	13	12,6	17	16,5	2	1,9
PSQI- Habitual Sleep Efficiency	70	68,0	18	17,5	7	6,8	8	7,8
PSQI- Sleep Disturbances	14	13,6	83	80,6	6	5,8	0	0
PSQI- Use of Sleeping Medications	49	47,6	48	46,6	1	1,0	5	4,9
PSQI- Daytime Dysfunction	44	42,7	55	53,4	3	2,9	1	1,0
				n			%	
PSQI total score	Min-Max.			0-13				
	M±Std			5,15±2,99				
Sleep Quality	Good			63			61,2	
	Bad			40			38,8	

The relationship between BMI measurements and sleep quality scores is analyzed based on the one of the aims of this study. Pearson Chi-Square (Fisher's Exact) Test was used considering both male and female subjects. A significant relationship between BMI and sleep quality is found in total, $P<0,01$. This significant relationship is also significant for both male ($P<0,01$) and female ($P<0,05$) subjects. Results showed that subjects with obesity diagnosis have bad sleep quality in Table 5.

Table 5. *Correlation between sleep quality and BMI levels (N=103).*

		Body Mass Index (BMI) levels									
		Thin		Average Weight		Over Weight		Obese			
Sex	**Sleep Quality**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	X^2	**P**
Male	Good	7	18,4	12	31,6	12	31,6	7	18,4	-	*0,008***
	Bad	2	11,1	7	38,9	0	0	9	50,0		
Female	Good	2	8,0	13	52	7	28,0	3	12,0	-	*0,022**
	Bad	1	4,5	10	45,5	1	4,5	10	45,5		
Total	Good	9	14,3	25	39,7	19	30,2	10	15,9	9,003	*0,029**
	Bad	3	7,5	17	42,5	1	2,5	19	47,5		

X^2=Pearson Chi-Square (Fisher's Exact)Test; *p<0,05 **p<0,01

Daily carbohydrate, protein and fat intake of the subjects and their distribution according to sleep quality are presented in Table 6. When PSQI scores considered, a significant relationship is found between PSQI scores and carbohydrate, (r = 0,490; *P* = 0,000), PSQI scores and protein intake (r = 0,319; *P* < 0,01), and PSQI scores and fat intake (r = 0,198; *P* < 0,05). These results indicate that daily carbohydrate, protein and fat intake increases as PSQI scores increases.

Table 6. *Sleep quality mean scores and carbohydrate, protein and fat levels (N=103).*

		Sleep Quality					
		Good			Bad		
		Min-Max	**Median**	**M±Std**	**Min-Max**	**Median**	**M±Std**
Male (n=56)	Carbohydrate%	26-58	43,5	44,13±6,39	37-59	50,5	48,94±5,02
	Protein%	10-25	19	18,84±3,13	15-21	18	17,56±1,65
	Fat%	27-49	36,5	36,95±5,10	25-43	34	33,72±4,56
Female (n=47)	Carbohydrate%	31-53	43	42,72±6,85	32-55	49	46,64±6,87
	Protein%	15-27	17	18,32±3,34	14-23	18,5	18,18±2,28
	Fat%	32-49	39	39,24±4,98	28-47	34	35,59±6,07
Total	Carbohydrate%	26-58	43	43,57±6,56	32-59	50	47,68±6,15
	Protein%	10-27	18	18,63±3,20	14-23	18	17,90±2,02
	Fat%	27-49	38	37,86±5,14	25-47	34	34,75±5,46

Daily energy intake of the subjects is also analyzed according to sleep quality. Independent sample t-test was used to compare energy intake of the subjects who have bad sleep quality and who have good sleep quality. Results showed that the subjects with bad sleep quality (*M* = 2210; *Std* = 569) have higher energy intake than the subjects with good sleep quality (*M* = 1370; *Std* = 500), (*P* = 0,000).

4. Discussion

The findings of the study revealed a relationship between sleep irregularity and obesity. Due to its importance as an indicator for circadian rhythm, irregularity in sleep cycle is interpreted as an irregularity in circadian rhythm in this study. Thus, the findings of the study present a relationship between circadian rhythm disturbance and obesity. This finding is also supported by previous studies of Bidulescu and his collegues of Hung and his colleagues and of Tamakoshi and his collegues and of Varana and his colleagues. In their study, Bidulescu, Hung, Tamakoshi, Varana and their colleagues reported a higher obesity risk for people who have bad sleep quality [21, 38, 39, 40] On the other hands, the findings of Yan's study revealed any relationship between sleep irregularity and obesity. [41]

The findings of the study revealed a relationship between sleep irregularity and consumption of carbohydrate and fat. As the consumption of carbohydrates and fats increases, sleep quality decreases. This finding is also supported by previous studies of Chaput, Katagiri, Yoneyama and of Öçal and his collegues. İn their study, Chaput, Katagiri and Yonema reported as consumption of carbonhydrates increases, sleep quality decreases. [42, 43, 44] Öçal reported as consumption of fat increases sleep quality decreases. [37]

5. Conclusion

Disabled people have limited mobility according to type and degree of their disability. This situation effects their life quality and body health diversely. However, there are lack of researches on disabled people in literature. Thus, the current study focuses on BMI levels and sleep quality of disabled people. Half of the subjects found to be having high BMI level, in our study while almost 30% of the subjects are in level of obesity. Although, this results may be resulted from restricted movements of body, bad sleep quality is also found to be related with obesity in the current study. Sleep quality is considered as an indicator of circadian rhythm [18, 28]. Previous studies show that circadian rhythm has many effects on metabolic system of body [7, 8]. Therefore, obesity rate in the subjects can be interpreted as not a result of limited body movement, but as a result of circadian rhythm irregularities.

Due to its effects on metabolism, circadian rhythm is associated with irregular dietary and increased energy intake [34-36]. To assess the effect of circadian rhythm on obesity, daily dietary habits and energy intake is also evaluated. The results showed that daily carbohydrate, fat and protein intake is positively increases as PSQI scores increases which is

associated with bad sleep quality. Daily calorie intake is also found to be positively correlated with bad sleep quality. These finding are in parallel with several studies that present comorbidity of sleep disorders with other disorders such as night eating syndrome which finally leads to increased risk of obesity and diabetes [28, 45, 46, 47]. When all of these results considered, increased risk of obesity of disabled people can be interpreted as a result of circadian rhythm irregularities rather than limited body movements due to its increasing effect on daily energy intake.

Funding Source

There was no funding or financial grants received for this study.

Conflict of Interest

There are no conflicts of interest in the publication of this study.

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