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Wearable technology data-based sleep and chronic disease relationship

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ABSTRACT

Objective: The aim of the study was to examine the cross-sectional relationship between sleep duration and 12 chronic diseases (obesity risk, diabetes, asthma, renal failure, hypertensive diseases, chronic obstructive pulmonary disease, cardiovascular diseases, ischaemic heart disease, pulmonary heart disease, immunodeficiencies and immune system disorders) by transferring the data to the national electronic patient record system through wearable device technology.

Materials and Methods: The data of the study were obtained from the Ministry of Health "Turkey National Personal Health Record System" (The "e-Nabız"). Between 30.03.2023 and 28.05.2023, 315448 data from 27847 people (15167 male) were collected and analysed on the basis of province, rural status, age group, gender and presence of chronic diseases and average, minimum (min.), maximum (max.) sleep duration. Descriptive statistics, chi-square analysis, Independent Samples t-Test, One-way Analysis of Variance and Pearson's correlation coefficient were used.

Results: The max. and average sleep duration were significantly shorter in men. Max. sleep duration decreased while the average sleep duration increased with increasing age. Participants with asthma, chronic renal failure and cerebrovascular diseases had decreased average sleep duration. The frequency of those who slept for 7-8 hours, which is the ideal sleep duration, is lower in all chronic diseases.

Conclusion: Most of the common chronic diseases may affect the sleep duration times and quality, which may further affect the prognosis of these patients.

Keywords: Sleep duration, Wearable technology, Chronic diseases, Cross-sectional study

1. INTRODUCTION

Sleep is essential for life. We spend one third of our lives in sleeping. Moreover, sleep is a very important part of quality of life [1]. There is increasing research evidence of an association between sleep disorders and cognitive dysfunction, occupational and traffic accidents, as well as some chronic diseases, metabolic, cardiovascular and cerebrovascular complications and mortality [2-6]. These results are important both in clinical practice and in the planning and implementation of public health policies for health economics. Questionnaire-based population studies have suggested high prevalence rates of sleep disorders [7-10]. In Turkey in 2015, the prevalence rate of insomnia (men/females) was 15.3% (10.5%/20.2%; P <0.001), high sleep-related breathing disorders was 13.7% (11.1%/20.2%; P <0.001), excessive daytime sleepiness was 5.4% (5.0%/5.7%); P: 0.09), restless legs syndrome was reported as 5.2% (3.0%/7.3%; P <0.001) [11].

The interaction between sleep and diseases is reciprocal. Both sleep disorders cause diseases and diseases cause sleep disorders. The impairment of sleep duration and quality cause decreased cognitive abilities and increased risk of occurrence or the frequency of existing symptoms of many psychiatric (such as panic disorder, major depressive disorder), cardiovascular, neurological (such as frequent seizures in epileptic patients), metabolic (such as diabetes, obesity), rheumatological and infectious diseases [12-15]. Symptoms of diseases such as asthma, coronary artery disease and stroke may occur with sleep disorders. Sleep disorders related to the presence of medical and psychosocial diseases are more common than primary disorders of sleep [16-18].

Studies on sleep disorders are generally based on extensive "questionnaire survey" in the literature. However, with the development of wearable technology, vital data such as sleep,

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walking, respiration can be easily recorded and measured. Turkey National Personal Health Record System (The e-Nabız) was established in Turkey in 2015. Since then, "personal health records" are stored nationally. Patients can manage, share, safely store and process their own health records [19]. In very few countries, health records of the whole population can be kept with a similar system. Therefore, in this study, the data of the study were obtained by patients transferring their "personal health records" to the national database to the extent permitted by wearable technologies.

The aim of the study was to examine the cross-sectional relationship between sleep duration and 12 chronic diseases (obesity risk, diabetes, asthma, renal failure, hypertensive diseases, chronic obstructive pulmonary disease (COPD), cardiovascular diseases, ischaemic heart disease, pulmonary heart disease, immunodeficiencies and immune system disorders) by transferring the data to the national electronic patient record system through wearable device technology. In this study, the relationship between sleep duration and demographic data, province, urban/rural residence status was also investigated. In the literature, the relationship between chronic diseases and sleep has been frequently investigated while studies on rural/urban region distinction are rare.

2. MATERIALS and METHODS

This study was designed in an analytical and cross-sectional model to reveal the relationship between sleep duration and chronic diseases. The data of the study were obtained from the Ministry of Health the e-Nabız system with the permission letter numbered E-26216721-708.99-215526724 between 30.03.2023 and 28.05.2023 on the basis of province, rural status, age group, gender and presence of chronic diseases and average, minimum (min), maximum (max) sleep duration. In this study, 315448 data from 27847 people were collected and analysed. The data were analysed using IBM SPSS Statistics 22.0 package programme. While the outcome variable of the study was considered as sleep duration; gender, age group, region, rural area and chronic diseases were considered as independent variables. While 11 chronic diseases were grouped as "present" and "no", for obesity, the prevalence of the disease obtained from the Ministry of Health e-Nabız system on the basis of province, gender and age groups and calculated per 1000 people according to the population was used. Also, in this study, we focused on chronic disease of those who shared their sleep data. For the analyses, sleep duration was classified into 3 categories as 6 hours or less, 7-8 hours ideal and 9 hours or more excessive based on previous national and international studies [20].

Table I. *Mean sleep duration according to baseline characteristics of the participants*

	Number (n)	Percentage (%)	Min. Sleep Time (min) (mean±SD)	Max. Sleep Time (min) (mean±SD)	Average Sleep Time (min) (mean±SD)
Gender					
Women	12680	45.53	108.89±90.49	692.30±108.7	412.42±40.21
Male	15167	54.47	108.01±87.01	675.03±109.62	396.31±43.53
p			*0.407*	***<0.001***	***<0.001***
Age Groups					
<25 years	13201	47.41	95.12±72.03	703.11±98.80	403.08±34.28
25-39 years	10398	37.34	100.94±81.45	683.69±108.33	400.61±39.67
40-64 years	3984	14.31	162.34±119.41	622.83±117.64	412.85±64.22
>64 years	264	0.95	252.75±129.02	546.59±113.85	412.38±92.91
p			*0.407*	***<0.001***	***<0.001***
Region					
Mediterranean Region	2491	8.9	123.240±93.46	633.56±97.56	402.0±47.28
Eastern Anatolia Region	779	2.8	185.96±118.70	588.58±110.82	400.34±65.99
Aegean Region	4095	14.7	117.15±96.05	671.79±104.98	408.12±46.62
Southeastern Anatolia Region	997	3.6	136.57±97.51	601.34±110.62	385.74±61.24
Central Anatolia Region	5145	18.5	101.25±83.63	683.22±97.79	403.39±96.82
Black Sea Region	1775	6.4	168.81±108.70	593.28±106.99	399.09±62.13
Marmara Region	12565	45.1	89.97±71.57	721.13±98.24	404.71±33.28
p			***<0.001***	***<0.001***	***<0.001***
Ruralisation					
Rural	2549	9.15	172.72±116.02	583.28±109.99	397.40±65.49
Urban	25298	90.85	101.92±82.63	692.93±104.34	404.28±39.76
p			***<0.001***	***<0.001***	***<0.001***
Sleep Time					
≤6 hours	1988	7.14	135.67±75.86	474.23±145.18	304.3±65.11
7-8 hours	25099	90.13	98.74±75.05	700.73±87.55	408.00±20.91
≥9 hours	760	2.73	356.19±142.25	639.55±71.31	519.60±42.0
p			***<0.001***	***<0.001***	***<0.001***

Min: minimum, Max: maximum

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Table II. *Mean sleep duration of participants according to chronic diseases*

	Number (n)	Percentage (%)	Min. Sleep Time (min) (mean±SD)	Max. Sleep Time (min) (mean±SD)	Average Sleep Time (min) (mean±SD)
Asthma					
No	25604	91.95	101.49±80.93	692.23±103.19	404.271±39.28
Present	2243	8.05	187.32±126.28	576.33±122.68	396.57±71.35
p			***<0.001***	***<0.001***	***<0.001***
Kidney failure					
No	27813	99.88	108.21±88.34	683.09±109.36	403.65±42.66
Present	34	0.12	270.14±143.46	516.05±126.21	400.08±110.90
p			***<0.001***	***<0.001***	*0.627*
Diabetes					
No	25295	90.84	100.33±80.13	693.02±103.04	403.76±38.67
Present	2552	9.16	188.47±122.41	582.48±120.76	402.55±71.95
p			***<0.001***	***<0.001***	*0.173*
Hypertensive diseases					
No	27733	99.59	107.72±87.710	683.54±108.93	403.62±42.369
Present	114	0.41	274.71±137.68	524.50±137.74	408.92±105.36
p			***<0.001***	***<0.001***	*0.187*
Hypertension					
No	23719	85.18	95.164±73.315	698.73±98.701	403.51±35.219
Present	4128	14.82	184.51±123.65	591.86±123.43	404.41±72.376
p			***<0.001***	***<0.001***	*0.217*
COPD					
No	27505	98.77	106.48±86.349	684.95±107.70	403.69±41.742
Present	342	1.23	263.67±123.91	517.36±127.57	400.42±95.575
p			***<0.001***	***<0.001***	*0.161*
Chronic renal failure					
No	27649	99.29	107.37±87.366	684.12±108.44	403.71±42.106
Present	198	0.71	253.44±131.87	510.67±123.67	394.71±100.91
p			***<0.001***	***<0.001***	***0.003***
Pulmonary heart diseases					
No	27790	99.80	108.07±88.253	683.22±109.22	403.65±42.647
Present	57	0.20	270.45±113.02	523.08±141.09	403.78±94.282
p			***<0.001***	***<0.001***	*0.981*
Cerebrovascular diseases					
No	27565	98.99	106.91±86.771	684.56±108.01	403.71±41.705
Present	282	1.01	254.46±133.96	519.30±131.88	397.29±104.80
p			***<0.001***	***<0.001***	***0.012***
Immune deficiencies and immune system disorders					
No	27819	99.90	108.24±88.409	683.05±109.42	403.64±42.764
Present	28	0.10	276.32±126.62	522.32±100.85	407.78±78.746
p			***<0.001***	***<0.001***	*0.609*
Ischaemic heart disease					
No	26263	94.31	102.51±82.148	689.25±104.90	403.55±39.420
Present	1584	5.69	206.14±126.64	577.49±129.26	405.25±80.372
p			***<0.001***	***<0.001***	*0.125*
Prevalence of obesity					
r			*-0.160*	*0.249*	*0.087*
p			***<0.001***	***<0.001***	***<0.001***

Min: minimum, Max: maximum; COPD: chronic obstructive pulmonary disease

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Statistical Analysis

The data were analysed using IBM SPSS Statistics 22.0 package programme. Descriptive statistics, chi-square analysis, Independent Samples t-Test, One-Way Analysis of Variance and Pearson's correlation coefficient were used to analyse the data. In order to determine whether the average, min. and max. sleep duration of the participants differed according to gender, age group, rurality, region and presence of chronic disease, Independent Samples t-Test was performed for variables with two groups and One-Way Analysis of Variance was performed for variables with three or more groups. Chi-square analysis was performed to determine the differences in sleep duration categories according to independent variables. Statistical significance level P<0.05 was accepted in the evaluations.

3. RESULTS

The distribution of the participants according to their basic characteristics is shown in Table I. 54.4% of the participants were male, 47.4% were younger than 25 years of age, 45.1% lived in the Marmara region and 90.8% lived in non-rural settlements. When the distribution of the average sleep duration of the participants was analysed, it was determined that 90.1% of them slept for 7-8 hours. It was found that the max. and average sleep duration of males were less while the max. sleep duration decreased and the average sleep duration increased with increasing age. The average sleep duration was the highest in the Aegean and Marmara regions, and the average sleep duration of those who did not live in rural areas was higher.

Figure 1 shows the provinces with the lowest and highest average sleep duration in Turkey. The provinces with the lowest mean sleep duration were Kilis and Erzincan, while the provinces with the highest mean sleep duration were Uşak and Ardahan. In the provinces with the lowest mean sleep duration, the share of those with chronic diseases was higher and their mean sleep duration was shorter.

Table II shows the min., max. and average sleep duration according to chronic diseases. In the presence of asthma, chronic renal failure and cerebrovascular diseases, average sleep duration decreased, max. sleep duration decreased and min. sleep duration increased in all diseases. In parallel, the relationship between the prevalence of obesity and sleep duration showed a low-level positive relationship for average and max. sleep duration and a low-level negative relationship with min. sleep duration.

Table III shows the distribution of sleep duration according to the basic characteristics of the participants. Among women, those younger than 25 years of age, those living in Central Anatolia and Marmara regions, and those who do not live in rural areas, there are more people who sleep at ideal sleep duration.

Table IV shows the distribution of sleep duration of the participants according to their chronic diseases. The frequency of those who slept for 7-8 hours, which is the ideal sleep duration, is lower in all chronic diseases. Especially among those with renal failure, hypertensive diseases, COPD, chronic renal failure and cerebrovascular disease, the number of people who deviate from the ideal sleep time and sleep less is higher.

Table III. *Distribution of sleep duration according to the basic characteristics of the participants*

	SLEEP TIME			
	≤6 hours	**7-8 hours**	**≥9 hours**	**P**
Gender				
Female (n-%)	659 (5.2%)	11610 (91.6%)	411 (3.2%)	***<0.001***
Male (n-%)	1329 (8.8%)	13489 (88.9%)	349 (2.3%)	
Age Groups				
<25 years (n-%)	774 (5.9%)	12230 (92.6%)	197 (1.5%)	***<0.001***
25-39 years (n-%)	695 (6.7%)	9532 (91.7%)	171 (1.6%)	
40-64 years (n-%)	457 (11.5%)	3186 (80%)	341 (8.6%)	
>64 years (n-%)	62 (23.5%)	151 (57.2%)	51 (19.3%)	
Region				
Mediterranean Region (n-%)	229(9.2%)	2183(87.6%)	79(3.2%)	***<0.001***
Eastern Anatolia Region (n-%)	141(18.1%)	592(76%)	46(5.9%)	
Aegean Region (n-%)	299(7.3%)	3648(89.1%)	148(3.6%)	
Southeastern Anatolia Region (n-%)	228(22.9%)	734(73.6%)	35(3.5%)	
Central Anatolia Region (n-%)	307(6%)	4710(91.5%)	128(2.5%)	
Black Sea Region (n-%)	347(19.5%)	1322(74.5%)	106(6%)	
Marmara Region (n-%)	437(3.5%)	11910(94.8%)	218(1.7%)	
Ruralisation				
Rural (n-%)	474(18.6%)	1921 (75.4%)	154 (6%)	***<0.001***
Urban (n-%)	1514 (6%)	23178(91.6%)	606(2.4%)	

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Table IV. *Distribution of sleep duration of participants according to chronic diseases*

	SLEEP TIME			
	≤6 hours	**7-8 hours**	**≥9 hours**	**P**
Asthma				
No (n-%)	1516(5.9%)	23497(91.8%)	591(2.3%)	***<0.001***
Present (n-%)	472(21%)	1602(71.4%)	169(7.5%)	
Kidney failure				
No (n-%)	1980(7.1%)	25079(90.2%)	754(2.7%)	***<0.001***
Present (n-%)	8(23.5%)	20(58.8%)	6(17.6%)	
Diabetes				
No (n-%)	1578(6.2%)	23176(91.6%)	541(2.1%)	***<0.001***
Present (n-%)	410(16.1%)	1923(75.4%)	219(8.6%)	
Hypertensive diseases				
No (n-%)	1961(7.1%)	25038(90.3%)	734(2.6%)	***<0.001***
Present (n-%)	27(23.7%)	61(53.5%)	26(22.8%)	
Hypertension				
No (n-%)	1290(5.4%)	22049(93%)	380(1.6%)	***<0.001***
Present (n-%)	698(16.9%)	3050(73.9%)	380(9.2%)	
COPD				
No (n-%)	1896(6.9%)	24899(90.5%)	710(2.6%)	***<0.001***
Present (n-%)	92(26.9%)	200(58.5%)	50(14.6%)	
Chronic renal failure				
No (n-%)	1926(7%)	24995(90.4%)	728(2.6%)	***<0.001***
Present (n-%)	62(31.3%)	104(52.5%)	32(16.2%)	
Pulmonary heart diseases				
No (n-%)	1976(7.1%)	25062(90.2%)	752(2.7%)	***<0.001***
Present (n-%)	12(21.1%)	37(64.9%)	8(14%)	
Cerebrovascular diseases				
No (n-%)	1916(7%)	24944(90.5%)	705(2.6%)	***<0.001***
Present (n-%)	72(25.5%)	155(55%)	55(19.5%)	
Immune deficiencies and immune system disorders				
No (n-%)	1982(7.1%)	25079(90.2%)	758(2.7%)	***<0.001***
Present (n-%)	6(21.4%)	20(71.4%)	2(7.1%)	
Ischaemic heart disease				
No (n-%)	1702(6.5%)	23995(91.4%)	566(2.2%)	***<0.001***
Present (n-%)	286(18.1%)	1104(69.7%)	194(12.2%)	
Prevalence of obesity (mean ±SD)	4.09±2.71	5.32±2.49	4.64±2.86	***<0.001***

COPD: chronic obstructive pulmonary disease

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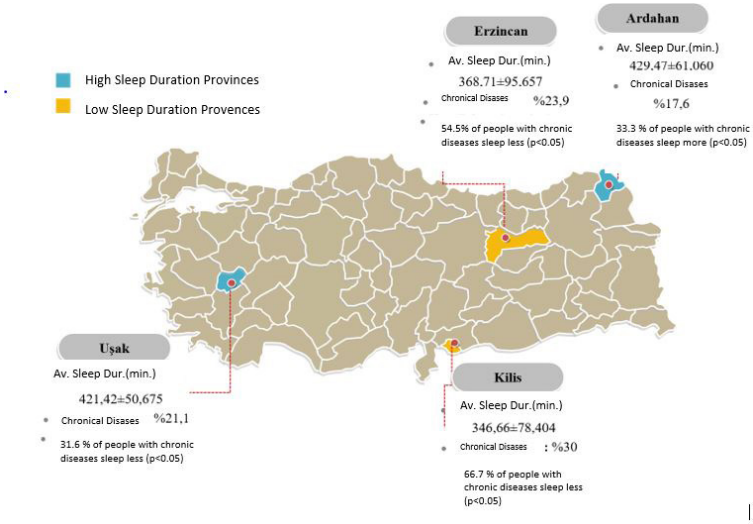

Figure 1. *Provinces with the lowest and highest average sleep duration in Turkey*

4. DISCUSSION

Sleep is one of the basic needs of human beings with physical, social, intellectual and spiritual needs, which must be met in a balanced way in order to be healthy [21].

Recent guidelines have shown promising progress in reducing morbidity and mortality in patients with cardiovascular disease. The importance of lifestyle changes such as balanced diet, physical activity and management of obstructive sleep apnea has been emphasised in the published guidelines [22-24]. However, the importance of having adequate sleep duration has not yet been included in guidelines, whereas this may help patients especially in the prevention of further cardiovascular disease. Indeed, according to national electronic patient registries, statistically significant associations were found between cerebrovascular disease, hypertensive diseases, ischaemic heart disease and min. sleep duration.

In a consensus published in 2015, the American Academy of Sleep Medicine (AASM) and the Sleep Research Society (SRS) defined normal sleep duration as 7 or more hours of sleep per night. However, this consensus also stated that sleeping more than 9 hours per night poses a health risk, but this applies to young adults, individuals who are trying to pay off sleep debt, and those who do not belong to any of the individuals with disease [25]. Among the sampled individuals aged 40-64 years (8.6%), women (5.6%) had a sleep duration of 9 hours or more. The detected individuals should be directed to normal sleep patterns through wearable technologies and warned to increase mobility.

The relationship between obesity prevalence and sleep duration was determined as a low positive relationship for average and max. sleep duration and a low negative relationship with min. sleep duration. In 2020, a study conducted in China found a strong association between excessive sleep duration and short sleep duration [26], while a meta-analysis suggested that short sleep duration was associated with obesity risk, but no such association was found for long sleep duration [27]. Among our findings, the number of people who slept far below the ideal sleep duration was higher among patients with renal failure. While the study by Lu et al. [26], supported our findings, in the study by Chen et al. [27], in 2022, sleep metrics predicted decreased renal function only in individuals with chronic kidney disease at baseline. Among this group, equations for glomerular filtration rate (eGFR) decline was associated with decreased stage N3 sleep (0.32 mL/min/1.73 m2/y per 10% decrease in N3; increased actigraphy napping frequency (beta: – 0.20 [-0.30, – 0.07]); and actigraphy sleep midpoint trajectory in early morning (ref: midnight, beta: – 0.84 [-1.19, – 0.50]). Urinary albumin-to-creatinine ratio increase was associated with high wake bouts trajectory (ref: low, beta: 0.97 [0.28, 1.67]) and increased sleep-related hypoxemia (oxygen saturation time<90% [≥5%], beta: 2.17 [1.26, 3.08]). Sleep metrics—N3 sleep, naps, and midpoint trajectory significantly modified associations between haemoglobin A1C and eGFR decline. According to the study, decreased deep sleep, daytime sleepiness, increased waking bouts, delayed sleep rhythms, and hypoxaemia during the night are associated with longitudinal renal function decline, and the effects are most prominent in individuals with chronic kidney disease [28]. The share of those who sleep 7-8 hours, which is the ideal sleep time, is less among those with all chronic diseases obtained in our study. Among those with hypertensive diseases, COPD and cerebrovascular disease, the number of people who deviated from the ideal sleep time and slept less is higher. Many studies in the literature support our findings [12-17]. In addition, regular sleep has been considered within the scope of preventive health services. The evaluation of regular sleep within the scope of health policies is one of the important conditions to be taken

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into consideration today. The provinces with the lowest mean sleep duration were Kilis and Erzincan, while the provinces with the highest mean sleep duration were Uşak and Ardahan. In the provinces with the lowest mean sleep duration, the share of those with chronic diseases was higher and their mean sleep duration was shorter. Health service providers should evaluate the sleep parameter in disease management with regard to both extremes of too little sleep and too much sleep. Multidisciplinary studies should be carried out to improve the quality of life by contributing to health planning in individuals with chronic diseases who experience sleep deficiency or excess.

Compliance with Ethical Standards

Approval: The data were obtained from the e-Nabız database of the Ministry of Health with the permission letter numbered E-26216721-708.99-215526724.

Conflicts of Interest: The author declares that he has no conflict of interest relevant to this article.

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Author Contribution: SB was responsible from the design, statistical analysis, and drafting of the article. He critically revised the manuscript.

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