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Is There Any Effect of the Chronobiological Profile on Auditory Skills?

Kronobiyolojik Profilin İşitsel Beceriler Üzerinde Herhangi Bir Etkisi Var Mıdır?

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Abstract

Objective: This study aimed to investigate the peripheral and central auditory performance of circadian chronotypes at different times of the day.

Materials and Methods: The participants, whose chronotypes were determined using the morningness eveningness questionnaire, underwent acoustic immittance measurements, Otoacoustic Emission test, Pure Tone Audiometry test, Frequency Pattern test, Duration Pattern test (DPT), Turkish speech in noise (TSiNT) and Auditory Verbal Learning test (AVLT) both in the morning and evening. A total of 63 participants with normal hearing and montreal cognitive assessment score ≥21 were included.

Results: Morning types scored significantly higher on the A7 subtest of the AVLT during the morning session (p<0.05). Evening types achieved significantly higher scores on the TSiNT during the evening session (p<0.05). In the morning tests, morning types showed significantly better performance on the left ear DPT compared to intermediate types (p<0.05). Similarly, in the evening tests, morning types outperformed intermediate types on the TSiNT (p<0.05).

Conclusion: The results indicated that the central auditory performance of individuals with the same chronotype varies at different times of the day, influenced by their circadian profile.

Keywords: Auditory perception, chronotype, circadian rhythm, memory, hearing tests

Öz

Amaç: Bu çalışmanın amacı, sirkadiyen kronotiplerin günün farklı saatlerindeki periferik ve santral işitsel performanslarını araştırmaktır.

Gereç ve Yöntem: Sabahçılık akşamcılık anketi ile kronotipleri belirlenen katılımcılara sabah ve akşam saatlerinde akustik immitans ölçümleri, Otoakustik Emisyon testi, Saf Ses Odyometri testi, Frekans Patern testi, Süre Patern testi (SPT), Gürültüde Türkçe Konuşma testi (TKT) ve İşitsel Sözel Öğrenme testi (İSÖT) uygulandı. Normal işiten ve montreal kognitif değerlendirme skoru ≥21 olan toplam 63 katılımcı çalışmaya dahil edilmiştir.

Bulgular: Sabah tipleri İSÖT'nin A7 alt testinde sabah seansında anlamlı olarak daha yüksek puan aldı (p<0,05). Akşam tipleri akşam seansında TKT'de anlamlı derecede daha yüksek puan almıştır (p<0,05). Sabah testlerinde, sabah tiplerinin sol kulak SPT sonuçları ara tiplerden anlamlı derecede daha iyiydi (p<0,05). Akşam testlerinde, sabah tipleri TKT'de ara tiplerden anlamlı derecede daha iyi performans göstermiştir (p<0,05).

Sonuç: Sonuçlar, aynı kronotipin günün farklı saatlerindeki santral işitsel performansının sirkadiyen profilden etkilendiğini göstermiştir.

Anahtar Kelimeler: İşitsel algı, kronotip, sirkadiyen ritim, bellek, işitme testleri

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Introduction

Circadian rhythm is the repetition of biochemical, physical, and behavioral routines of an organism at certain intervals and within a certain frequency. The maintenance of the rhythm depends on both exogenous (environmental) and endogenous (biochemical) factors.[1] In this context, the circadian rhythm is part of a very primitive system, considering that the most important and probably most constant zeitgeber in evolutionary terms is the light-dark cycle.[2] The suprachiasmatic nucleus (SCN) is the region of the central nervous system that initiates and maintains the cycle.[3] The process organized by the SCN is supported by neurochemicals from many organs and tissues in the peripheral system: heart, liver, kidneys, lungs, intestine, skin, lymphocytes, esophagus, spleen, thymus, adrenal gland, prostate, olfactory bulb. The levels of neurotransmitters and more hormones required for a healthy circadian rhythm may vary depending on the zeitgebers.[4]

The degree to which the central pacemaker is necessary for maintaining the circadian rhythmicity of various cells, tissues, physiological functions, and behaviors differs across species and tissue types. To ensure synchronization between central pacemaker cells, they are linked by neurotransmitters and neuromodulators.[5]

In particular, serotonin and melatonin are important circadian synchronisers. The decrease in melatonin and increase in serotonin controlled by the SCN are activated by sunlight.[6] Cortisol, another neurochemical, is secreted in the presence of light and causes a decrease in melatonin levels.[7]

Studies have identified the roles of the SCN and the inferior colliculus in the central system, as well as the cochlea in the peripheral system, in regulating circadian rhythms.[3] The majority of studies have aimed to evaluate the effects of noise or ototoxic trauma when applied in the evening and morning. It has been concluded that the startle reflex of rats to sudden and high-intensity acoustic stimuli and their sensitivity to antibiotic-induced ototoxicity are different in light and darkness. Furthermore, the acoustic startle reflex response of mice exposed to a brief acoustic stimulus of 120 dB sound pressure level in the morning was 15% higher than the same sound in the evening.[8-10] Given that mice are nocturnal mammals that hunt at night, it can be inferred that this behavior leads to a reduced startle response during their active periods and an increased startle response during their rest periods. Therefore, it can be hypothesized that humans, as mammals, may be more vulnerable to noise during the day, considering the nocturnal nature of mammals.[2] However, it is important to keep in mind that primates have undergone evolutionary adaptations to be active in daylight, so the biochemical factors in each person vary throughout the day, leading to chronotype bias.[11] In addition to peripheral hearing, studies measuring central auditory processing capacity have shown that the same tests given to the same person at different times of the day produce different results. This difference is thought to be related to age, memory and circadian rhythm.[12] In addition, many studies examining language comprehension and selective attention have found a connection with the time of the test, revealing that individual performance varies based on the person's circadian characteristics.[13] Despite this, little is known about the relationship between the auditory system and circadian rhythms, or how they influence each other.

In the literature, there are experimental studies on animals that investigate the auditory system in relation to circadian rhythms.[14] However, no study has been found that evaluates the human auditory system in detail in relation to circadian rhythms. In addition, although the studies in the literature show comparative results between chronotypes (morning, intermediate and evening types), there is also a need for comparative results between individuals of the same chronotype at different times of the day. Therefore, this study aimed to investigate and compare the auditory performance of circadian chronotypes at different times of the day. In this context, our research is considered a potential pilot study.

Materials and Methods

This study was conducted between February and June 2023 with the approval of the Non-Interventional Research Ethics Committee of Üsküdar University (approval number: 61351342, date: 30.12.2022).

Participants

In this study, G*Power 3.1.9.4 was used to calculate the sample size. According to the program, the minimum sample size was 19, with a significance level of 0.05 and a power of 0.80, assuming a moderate effect. This study included 63 participants, 46 female and 17 male, aged 19-27 years (M: 22.77±1.84). Participants were between the ages of 18-35, had normal hearing, scored within normal limits on the Montreal Cognitive Assessment Scale (MoCA), and were native Turkish speakers. Participants with diagnosed psychological and/or neurological problems, exposure to noise as a hobby and/or occupation, tinnitus, active ear infection, and ototoxicity were excluded. All participants signed an informed consent form.

Participants were determined to have normal hearing using Acoustic Immittance Measurements, Otoacoustic Emission test and Pure Tone Audiometry test. An otoscopic examination was performed prior to Acoustic Immittance Measurements. Tympanometry And Acoustic Reflex testing were performed using the Interacoustics® Titan Handheld (Denmark). Bilateral type A tympanogram (0.3-1.6 cc compliance; ±100 daPa) and bilateral ipsilateral and contralateral reflexes between 500-4000 Hz were considered normal. Otodynamics ILOV6 (UK) equipment was used for the transient evoked Otoacoustic Emission test. A signal-to-noise ratio of 3 dB or more at least three frequencies was considered normal. Participants' air conduction thresholds at frequencies of 500-4000 Hz, were measured with supraaural headphones using an Interacoustics® AC40 clinical audiometer (Denmark). The average of 500-4000 Hz was used for the pure tone average (PTA). Normal hearing was accepted as PTA ≤25 dB HL. Speech tests were performed with speech recognition threshold using a list of 3-syllable phonetically balanced words and speech discrimination (SD) score using 25 monosyllabic phonetically balanced words.[15] The time of day for initial hearing assessments was randomized and completed at the beginning of sessions.

Participants answered the 19-question Morningness-Eveningness Questionnaire (MEQ), validated in Turkish by Pündük et al.[16] to determine which type they were according to their circadian rhythms. According to the score obtained from the questionnaire, participants were classified as "evening type" (16-41 points), "intermediate type" (42-58 points) and "morning type" (59-86 points). Since the same tests would be administered in both sessions, participants were divided into three groups (group 1: morning types, group 2: intermediate types, and group 3: evening types) to eliminate the experience effect; the first session of individuals in each divided group was randomly scheduled to take place in the morning or evening. According to the MEQ, 30.2% (n=19) of the participants were classified as morning type, 36.5% (n=23) as evening type, and 33.3% as intermediate type (n=21).

MoCA test was performed in the morning for morning types and in the evening for evening types. If the first session for evening types took place in the morning, the MoCA was administered during the second session, i.e., in the evening. In cases where the desired score was not achieved on the MoCA during the second session, the participant was excluded from the study, even though all tests had been conducted in the first session. As a result, two participants were excluded. For intermediate types, there was no restriction on the session in which the MoCA was administered, and it was conducted randomly across sessions.

Data Collection Tools

All evaluations were performed at the Audiology Laboratory of Üsküdar University. Frequency Pattern test (FPT), Duration Pattern test (DPT), and Turkish Speech in Noise test (TSiNT) were administered to assess central auditory processing skills; the Auditory Verbal Learning test (AVLT) was administered to assess cognitive skills and attention performance.

The tests were administered to each participant at 7:30 a.m. and 5:30 p.m. The assessments for all participants were completed within two hours (9:30 a.m. and 7:30 p.m., respectively).

The FPT contains two tones at frequencies of 880 Hz and 1122 Hz on a CD.[17] The duration of each tone is 200 ms and the interval between tones is 150 ms. There are 60 patterns of these sounds in groups of three for each ear. The stimuli were presented to the participant through supra-aural headphones at 50 dB SL in regard to hearing thresholds at 1000 Hz. The participant was asked to identify the sounds in the pattern in terms of high frequency and low frequency according to the order of arrival (e.g. low-low-high). The first 10 patterns presented to each ear were used for trial purposes and were not included in the scoring. The test score was calculated as the percentage of correctly identified patterns.

DPT[17] contains two tones on a CD with durations of 250 ms and 500 ms and a frequency of 1000 Hz. There are 66 patterns of these tones in groups of three for each ear. The stimuli were delivered to participants through supra-aural headphones at 50 dB SL, and participants were instructed to identify the sounds in the pattern based on their length (long versus short) and their order of presentation (e.g., short-short-long). The first 16 patterns presented for each ear were for trial purposes and were not counted. The test score is the percentage of patterns correctly identified.

For the TSiNT, participants were seated at a zero-degree angle to the loudspeaker and a distance of 1 meter from the loudspeaker. This test consisted of 25 isophonic monosyllabic words[15] inserted into multi-speaker babble noise (signal-to-noise ratio = 0 dB). The monosyllabic words spoken by a native Turkish speaker are recorded on a CD and presented through loudspeakers.

The Montreal Cognitive Assessment Scale, validated in Turkish by Selekler et al.[18] assesses cognitive functions such as attention and concentration, executive function, memory, language, visual structuring, abstract reasoning, calculation, and orientation. The maximum score that can be achieved on the test is 30. A score above 21 is considered normal.

The AVLT, validated in Turkish by Genç-Açıkgöz and Karakaş[19], is designed for the comprehensive assessment of verbal learning as well as short- and long-term memory (LTM), based on free recall and recognition functions. The test material consists of A and B lists of 15 different concrete words and a recognition list of 50 words. After the 15 words in List A were read at 1-second intervals, the participants were asked to recall and recite the words they remembered from these 15 words in no particular order. This step of the test was repeated five times with 20-second intervals starting from the last word that the individual recalled (A1-A2-A3-A4-A5-A6-A7 trials). Afterwards, the words in the B list were presented at 20-second intervals, and the individual was asked to repeat what he/she remembered from this list (B1 trial). For list B, the individual was asked to recall the words in list A without reading list A 20 seconds after the last word that the individual recalled (A6 trial). Participants were asked to recall the words from list A (A7 trial) after a 20-minute waiting period. AVLT assesses verbal learning with the A1-A5 average of information processing about verbal materials, verbal learning with the A6 based on free recall, and LTM based on free recall with the A7. The maximum score that can be obtained from the AVLT is 15 for the A list, 15 for the B list, and 30 for the recognition list.[20] In our study, A1-5, A6, A7, and recognition scores were calculated on the AVLT.

Statistical Analysis

First, it was assessed whether the numerical data obtained were normally distributed. Kurtosis and skewness values between ±1.0 are considered perfect, but values between ±2.0 are also acceptable in many cases depending on specific applications.[21] In this study, data were considered to be normally distributed when skewness and kurtosis values were between -2 and +2.

SPSS v.24 was used for statistical analysis. In pairwise comparisons of tests administered to the same group, the Paired Sample t-test was used for data with a normal distribution, while the Wilcoxon Signed Ranks test was applied for data without a normal distribution. For three-group comparisons, the One-Way ANOVA Test was used when the data were normally distributed, and the Kruskal-Wallis test was used when the data were not normally distributed. Tukey's test was used for post-hoc analyses where appropriate.[21] The significance level was accepted as $p<0.05$.

Results

This study included 63 participants, 46 female and 17 male, aged 19-27 years (M: 22.77±1.84). Since their distribution was not equal, gender differences could not be analyzed. The results and significance values of the tests applied to all three groups in the morning and evening are shown in Table 1 and Figure 1. For morning types, when the results of the morning and evening tests were compared, a significant difference was found only in the A7 subgroup of the AVLT, which assesses LTM ($p<0.05$). Those with the morning type showed higher performance on the AVLT A7 test taken in the morning. No significance was observed between the morning and evening test results of the intermediate-type group ($p>0.05$). The results of the tests administered to this group at both times of day were similar. The results of the morning and evening tests of the evening group were significant only for the TSiNT and MoCA ($p<0.05$); with better performance observed in the tests conducted in the evening (Table 1 and Figure 1).
In the morning and evening sessions, the performances of the morning, evening, and intermediate types were compared, and the significance values obtained are shown in Table 2.
When the performance of the groups was compared in the morning tests, a significant difference was observed only in the DPT-Left side ($p<0.05$). Post-hoc analysis showed that the morning type performed significantly better than the intermediate type. In the other tests performed in the morning, the performance of the groups was similar. A comparison of the performance of the groups in the evening tests revealed a significant difference only in the TSiNT ($p<0.05$). Post-hoc analysis showed that the morning type performed significantly better than the intermediate type. In the other tests performed in the evening, the performance of the groups was similar (Table 2). The data and materials will be available from the corresponding author. This study was not preregistered.

Discussion

Chrono-psychologists refer to the circadian rhythm as the time of the day when a person feels most active, depending on day and night changes. This activity can be observed in various physiological processes, including body temperature, blood pressure, hormone secretion, glucose metabolism, sleep-wake cycles, and the release of neurotransmitters, as well as in mental and physical activities such as attention and short-term memory.[22] All of these factors are directly or indirectly related to the functioning of the auditory system and the overall activity of the nervous system. The above factors can influence processes ranging from the micromechanics of the cochlea-regulated by an adequate blood supply and nutrients essential for the proper functioning of sensory hair cells-to binaural auditory processing, which involves both ipsilateral and contralateral ascending auditory pathways, as well as the functions of the corpus callosum.[23] Although the changes of circadian rhythm in physiological processes are known, there are very few studies on its effect on hearing physiology with behavioral and electrophysiological measurements in audiology. In this study, we aimed to evaluate the effect of circadian chronotype on peripheral and central hearing systems and cognitive skills.

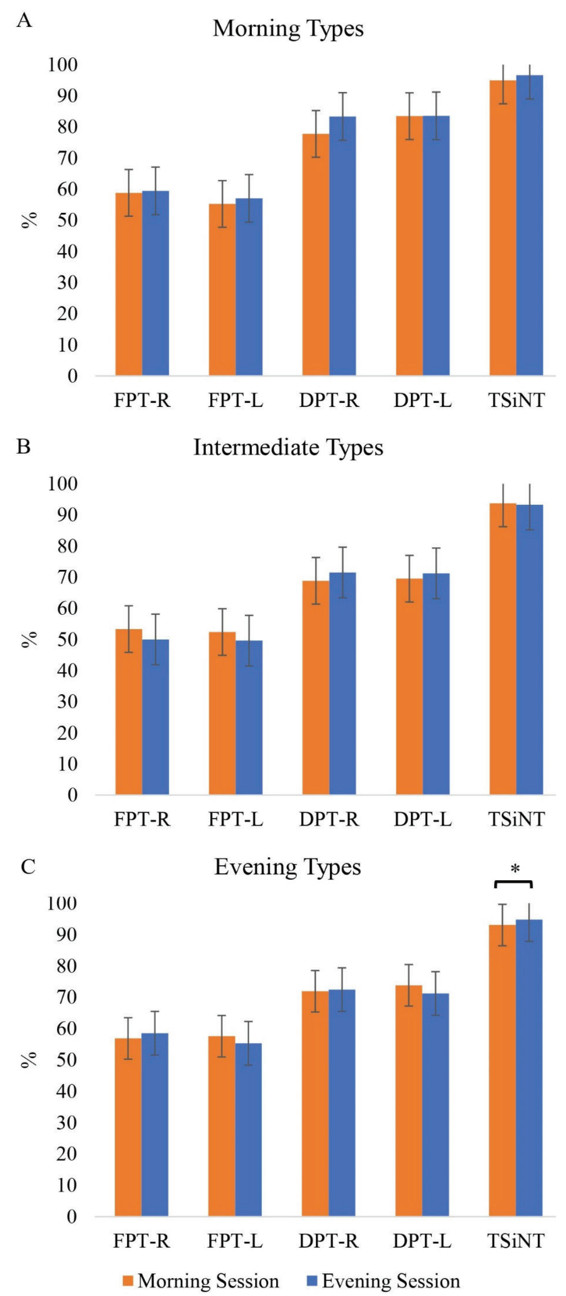

Figure 1. Results of the tests applied to the types in the morning and evening session.
*$p<0.05$: Statistically significant.
FPT-R: Right ear frequency pattern test, FPT-L: Left ear frequency pattern test, DPT-R: Right ear duration pattern test, DPT-L: Left ear duration pattern test, TSiNT: Turkish speech in noise test

Inhibitory controls and the ability to remove irrelevant information from consciousness are necessary for healthy cognitive processes. The inhibitory effect is also thought to be effective on systems such as speech comprehension, selective attention, and working memory.[24] A healthy peripheral and central auditory system is a prerequisite for the proper functioning of these mechanisms. Because of this close relationship between the hearing system and other cognitive systems, we included MoCA in our method. Consequently, the necessity for MoCA results to be within the normal range is paramount, despite the fact that normal hearing findings are included as criteria for inclusion in our study. SD performance in noise, as measured by tests such as TSiNT, necessitates the ability to disregard distracting noises and focus on the relevant speech information. This process may involve the utilization of inhibitory control mechanisms.[25] The effects of the circadian profile on cognitive performance are particularly evident in occupations with shift or flexible working hours. It is not

Table 1. Results and significance values of the tests applied to the types in the morning and evening session

		Morning session (M ± SD)	Evening session (M ± SD)	p
Morning types	PTA-R	2.21±2.80	2.00±2.56	0.680
	PTA-L	1.89±2.20	1.89±2.13	1
	SRT-R	5.78±3.44	5.78±2.50	1
	SRT-L	5.00±3.72	5.26±3.52	0.331
	SDS-R (%)	99.36±2.00	99.78±0.91	0.414
	SDS-L (%)	99.15±1.67	99.36±149	0.331
	AVLT A1-5	11.47±2.23	10.83±1.77	0.217
	AVLT A6	12.05±2.36	10.84±2.91	0.117
	AVLT A7	11.84±2.89	10.15±2.65	**0.017***
	AVLT recognition	22.94±4.39	21.89±4.29	0.153
Intermediate types	PTA-R	2.61±2.22	2.61±1.96	1
	PTA-L	2.09±1.86	2.19±1.77	0.605
	SRT-R	4.52±3.12	4.6±2.94	0.576
	SRT-L	4.04±3.39	3.57±2.80	0.162
	SDS-R (%)	98.85±2.24	98.95±2.24	1
	SDS-L (%)	99.04±1.74	98.85±2.24	0.655
	AVLT A1-5	10.70±2.00	10.33±1.92	0.522
	AVLT A6	12.19±2.06	11.47±2.31	0.237
	AVLT A7	11.00±3.16	11.42±2.29	0.605
	AVLT recognition	22.52±4.46	21.80±3.54	0.441
Evening types	PTA-R	3.08±2.71	3.04±2.51	0.814
	PTA-L	2.60±2.90	3.00±3.24	0.405
	SRT-R	4.78±3.52	4.78±3.19	1
	SRT-L	4.34±3.47	4.34±3.78	1
	SDS-R (%)	99.13±2.07	98.95±2.16	0.317
	SDS-L (%)	99.47±1.83	99.65±1.15	0.655
	AVLT A1-5	10.72±1.49	10.97±2.64	0.598
	AVLT A6	11.56±2.08	11.39±2.33	0.761
	AVLT A7	11.82±2.22	11.39±2.49	0.389
	AVLT recognition	21.69±3.09	22.43±4.02	0.366

*p<0.05: Statistically significant.

M: Mean, SD: Standard deviation, PTA-R: Right ear pure tone average, PTA-L: Left ear pure tone average, SRT-R: Right ear speech reception threshold, SRT-L: Left ear speech reception threshold, SDS-R: Right ear speech discrimination score, SDS-L: Left ear speech discrimination score, AVLT: Auditory verbal learning test

Table 2. Significance values for the performance of morning, evening and intermediate types in the morning and evening session

	Morning session		Evening session	
	Morning vs. intermediate vs. evening types (p values)	Post-hoc (p)	Morning vs. intermediate vs. evening types (p values)	Post-hoc (p)
PTA-R	0.551	-	0.367	-
PTA-L	0.936	-	0.796	-
SRT-R	0.464	-	0.451	-
SRT-L	0.687	-	0.299	-
SDS-R	0.586	-	0.240	-
SDS-L	0.431	-	0.373	-
FPT-R (%)	0.698	-	0.220	-
FPT-L (%)	0.681	-	0.472	-
DPT-R (%)	0.299	-	0.051	-
DPT-L (%)	**0.039***	Morning > intermediate **(0.034)***	0.059	-
TSiNT (%)	0.317	-	**0.049***	Morning > intermediate **(0.038)***
AVLT A1-5	0.358	-	0.602	-
AVLT A6	0.605	-	0.691	-
AVLT A7	0.534	-	0.193	-
AVLT recognition	0.585	-	0.725	-

*p<0.05: Statistically significant.

Vs. Versus, PTA-R: Right ear pure tone average, PTA-L: Left ear pure tone average, SRT-R: Right ear speech reception threshold, SRT-L: Left ear speech reception threshold, SDS-R: Right ear speech discrimination score, SDS-L: Left ear speech discrimination score, FPT-R: Right ear frequency pattern test, FPT-L: Left ear frequency pattern test, DPT-R: Right ear duration pattern test, DPT-L: Left ear duration pattern test, TSiNT: Turkish speech in noise test, AVLT: Auditory verbal learning test

surprising that cognitive performance is affected as a result of circadian disruption or working in a period that does not match the individual's circadian rhythm.[26] Disruption of the cycle, i.e., circadian disruption, can lead to a deterioration in cognitive performance and fluctuations throughout the day. Nevertheless, when assessed according to their circadian rhythms, there is a possibility that the performance of these types may be enhanced. For this reason, the MoCA test scoring, which we determined as inclusion criteria, was conducted at the beginning of the sessions aligned with the participant's preferred type, as determined by the MEQ results.

Psychoacoustic tests such as duration pattern detection and gap detection evaluate the temporal process and are very important for audiology research. Studies in the literature have examined the effects of circadian preference on temporal processing in detail,[27,28] reporting that individuals performed better on duration pattern perception tests conducted during the time period corresponding to their circadian preference. In other words, morning types performed better in the morning than in the evening, while evening types performed better in the evening than in the morning. The results of the studies are consistent with previous studies reporting that participants typically perform best at a certain time of day.[22] In our study, it was observed that the left ear results of the DPT test performed in the morning were significant in morning types compared to intermediate types, which is consistent with the literature. Actually, we expected to see the right ear advantage here. The auditory cortex is dominant in encoding the temporal resolution of the auditory signal in the left hemisphere.[29] The right ear pathway is a more direct pathway to the left hemisphere. In other words, the pathway from the right ear to the left hemisphere is faster than the pathway from the left ear. A message traveling along the left path is at a disadvantage because it has to make more neural synapses. The increased number of synapses slows down the message to reach the center by about 25 msec.[30] However, in our results, contrary to the consensus in the literature, the DPT test in the left ear was significant in morning types. This may be explained by the advantage of the stimuli being sufficiently audible in the spectro-temporal modulation test, which is one of the evaluations for temporal processing of sound.[31-33] In this context, although no significance was observed in the PTA of the participants included in our study, it may be due to the better hearing sensitivity in the left ear compared to the right ear (Table 1, Figure 1). In the literature, no report was found to support the finding of left ear superiority in our study.

The ability to suppress unnecessary information, or the inhibitory mechanism, may play a leading role in psychoacoustic test results.[28] The inhibitory effect is thought to affect cognitive processes such as speech comprehension, selective attention and working memory.[24] Thus, a change in the inhibitory effect related to the time of day when the test is administered may influence the results of psychoacoustic measures.[27] It has been highlighted that speech perception in noise varies based on the preferred time of day. This may suggest that circadian preference may be less sensitive to distraction.

In studies evaluating the central auditory system according to circadian rhythms[34] it was found that the performance of evening listeners on the filtered speech subtest of the SCAN test improved during the day. In another study of dichotic listening,[35] those in the moderate evening category performed better in the late evening than in the morning. There was no diurnal or nocturnal effect on the listening performance of those in the intermediate category.

The TSiNT results in our study and the evening types showed a significance consistent with the literature when performed in the evening.[28] This significance may not be due to the evening types being very successful in the evening but rather due to their poor performance in the morning. However, the lower performance of evening types on morning tests is in line with,[36] who concluded that the lower performance of evening types on morning tests may be due to lack of sleep and/or effort to wake up in the morning hours. However, no significant differences were found between morning and evening types. Contrary to expectations, the lack of significance for morning types in the morning may be attributed to their high performance in the evening. Morning types with high performance in the evening may have demonstrated their high ability to concentrate on difficult tasks in the evening.[12] At the same time, the relationship between performance on tasks given during test hours outside the boundaries of chronotype preference may depend on the difficulty of the task. There are studies showing that morning people perform better in the evening and evening people perform better in the morning.[34] However, when the evening session of the TSiNT was compared across groups, it was observed that the results of the intermediate types and evening types were similar. However, the significant difference between the intermediate types and morning types favored the morning types. This may be considered an indicator of the advantage of morning people in terms of speech perception in noise, even in the evening.

The AVLT assesses verbal information processing and verbal learning (A1-A5), recall-based verbal learning (A6), and recall-based LTM (A7).[20] In order to achieve high scores on all of these assessments of the AVLT, the peripheral and central auditory systems must function properly. Given that our research question is "does the auditory system show changes according to circadian rhythm?" the cognitive test of the AVLT administered with verbal stimuli should also be reflected in the result. In our study based on this question, significance was found only in the A7 subtest in which LTM was evaluated. A study on the effects of circadian rhythms on memory reported that peak performance on LTM tasks occurs midday, although this may vary depending on the difficulty of the task.[37] This is because[34] found that unit changes were only effective when recalling difficult material, whereas easy material recall tasks were not affected by time of day[38] observed a decrease in LTM performance with increasing time after waking. In our study, it was found that the morning session was higher for the morning types than the evening session, which is consistent with the literature. However, as expected, the AVLT A7 results were not significant in the evening types who were tested in the evening. This result may be attributed to the demands of daily life, which require individuals to start their day early in the morning, leading to increased fatigue as the evening hours approach when they are still expected to remain active. However, in our study, the time the participants spent asleep on the day of the evaluations according to their chronotypes was not taken into account.

Study Limitations

This may be a limitation of the study. The likelihood of being affected by daily changes may also vary depending on whether the tasks and materials are easy or difficult. The extent of the neural networks and sub-functions involved in completing a task, the complexity of the stimulus used, and the level of attention required to perform the task may all influence the degree of susceptibility to diurnal variation.[34] This may be the reason why no significant differences were found in the results of the other subtests (A1-A5, A6), which were easier than the AVLT A7.

Conclusion

There are few studies in the literature that evaluate the human auditory system in detail in relation to circadian rhythms. This study can be considered a pilot effort to address this gap in the literature and to explore the auditory performance of circadian chronotypes at different times of the day.

In conclusion, the results of comparing individuals of the same chronotype at different times of the day revealed the existence of circadian effects on auditory perception. Our findings provide an opportunity for further studies to investigate whether central hearing and auditory processing performance, in particular, vary according to circadian rhythms, using other subjective batteries and auditory electrophysiological testing methods.

Ethics

Ethics Committee Approval: This study was conducted between February and June 2023 with the approval of the Non-Interventional Research Ethics Committee of Üsküdar University (approval number: 61351342, date: 30.12.2022).

Informed Consent: All participants signed an informed consent form.

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Footnotes

Authorship Contributions

Concept: D.Ş.C., Design: D.Ş.C., G.G., Y.S., Data Collection or Processing: D.Ş.C., B.A.A., B.A., Analysis or Interpretation: Y.S., Literature Search: D.Ş.C., G.G., Y.S., B.A.A., B.A., Writing: D.Ş.C., G.G., Y.S., B.A.A., B.A.

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Chronotype and Cognition: Comparison of Executive Functions, Sleepiness, and Fatigue According to Circadian Rhythm Preference

Kronotip ve Kognisyon: Sirkadiyen Ritim Tercihine Göre Yürütücü İşlevler, Uykululuk ve Yorgunluğun Karşılaştırılması

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Abstract

Objective: Individual differences in sleep-wakefulness and, activity timing of individuals are defined as chronotype. This study aimed to compare individuals with different chronotypes in terms of executive functions, sleepiness, fatigue, depression and anxiety.

Materials and Methods: A total of 180 people, 116 (64.4%) women and 64 (35.6%) men, aged 18-45 (23.24±7.20) years, were included in the study. Participants were administered a sociodemographic data form, the morningness-eveningness questionnaire (MEQ), Epworth Sleepiness Scale, Fatigue Severity Scale, Beck depression inventory, Beck anxiety inventory, Digit Span test, Stroop test, Verbal Fluency test, Trail Making test (TMT), and Tower of London test.

Results: Participants were divided into three groups using MEQ: morning-type (n=48), evening-type (n=42), and intermediate-type (n=90). According to the ANOVA findings conducted with the chronotype groups, there was a significant difference between the groups in terms of sleepiness, fatigue, depression, and anxiety scores, and there was a significant difference in favor of the evening-type only in the TMT-A time variable of the neuropsychological tests. According to the results of the correlation analysis, negative significant relationships were found between the scores from the MEQ, sleepiness, fatigue, depression, VFT-animals, and VFT-KAS. Therefore, it can be said that circadian typology has a limited effect on executive functions.

Conclusion: Chronotypes have been found to perform similarly in executive functions such as attention, working memory, verbal fluency, mental flexibility, resistance to interference, planning, and problem-solving.

Keywords: Chronotype, circadian rhythms, cognition, executive functions, fatigue, depression

Öz

Amaç: Bireylerin uyku-uyanıklılık ve aktivite zamanlamasındaki bireysel farklılıkları kronotip olarak tanımlanmaktadır. Bu çalışmada farklı kronotiplere sahip bireylerin yürütücü işlevler, uykululuk, yorgunluk, depresyon ve anksiyete açısından karşılaştırılması amaçlanmıştır.

Gereç ve Yöntem: Yaşları 18-45 (23,24±7,20) aralığında olan 116 (%64,4) kadın ve 64 (%35,6) erkek olmak üzere toplam 180 kişiden oluşan katılımcılara, sosyodemografik veri formu, Sabahlılık ve Akşamlılık Ölçeği (SAÖ) Epworth Uykululuk Ölçeği, Yorgunluk Şiddet Ölçeği, Beck depresyon envanteri, Beck anksiyete envanteri, Sayı Menzili testi, Stroop testi, Sözel Akıcılık testi, İz Sürme testi (İST) ve Londra Kulesi testi uygulanmıştır

Bulgular: Katılımcılar SAÖ kullanılarak sabahçıl tip (n=48), akşamcıl tip (n=42), ara tip (n=90) olarak üç gruba ayrılmıştır. Bu kronotip grupları ile yapılan ANOVA bulgularına göre uykululuk, yorgunluk, depresyon ve anksiyete puanları açısından gruplar arasında anlamlı düzeyde farklılık bulunmuşken nöropsikolojik testlerden sadece İST-A süre değişkeninde akşamcıl tip lehine anlamlı düzeyde bir farklılaşmanın olduğu tespit edilmiştir. Korelasyon analizi sonuçlarına göre SAÖ'den alınan puanlar ile uykululuk, yorgunluk, depresyon, SAT-hayvanlar ve SAT- KAS arasında negatif yönde anlamlı ilişkiler saptanmıştır.

Sonuç: Dikkat, çalışma belleği, sözel akıcılık, zihinsel esneklik, enterferansa direnç, planlama ve problem çözme gibi yürütücü işlevlerde kronotiplerin benzer performans gösterdikleri bulunmuştur. Dolayısıyla sirkadiyen tipolojinin yürütücü işlevler üzerinde sınırlı bir etkisinin olduğu söylenebilir.

Anahtar Kelimeler: Kronotip, sirkadiyen ritimler, biliş, yürütücü işlevler, yorgunluk, depresyon

Introduction

Circadian rhythms are cyclical changes in cellular, molecular, and biologic processes that repeat approximately every 24 hours.[1] Chronotype is a concept that expresses individual differences in sleep-wakefulness and activity timing in the circadian phase.[2] Chronotype is determined by both environmental and genetic factors.[3] Age and sex are also determining factors on

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chronotype.[4] There are studies suggesting that women are more morning-type and men are more evening-type, but there are others reporting that chronotope is independent of sex.[5] In addition, some studies found that the difference between the sexes decreases over time and that after the age of 40 years, both sexes tend to show morning person characteristics.[4]

Chronotypes are classified as morning, evening, and intermediate-types according to the sleep-wake cycle, rest-activity time, and preferred time for physical-mental performance.[6] Approximately 40% of the adult population falls into either the morning or evening-type, and 60% fall into the intermediate-type.[6] Individuals of the morning-type prefer to wake up early go to bed early, feel more awake earlier in the day, and reach their highest mental and physical performance in the morning.[7] By contrast, evening-types tend to sleep at night and wake up late in the morning, and show their highest mental and physical performance in the afternoon or evening.[6] Intermediate-types, positioned between the two ends of the continuum, have characteristics of both chronotypes and generally prefer the middle times of the day for physical and mental activities.[2]

The circadian clock controls 24-hour processes, from physiology to behavior, from gene expression to sleep timing.[3,8,9] Because sleep timing is largely under circadian rhythm control, chronotypes are expected to sleep and wake up on their own circadian clocks.[10] Although sleep and wake times are under the control of the circadian rhythm, individuals often use alarm clocks and/or medications to align their work hours, school schedules, and social activities.[9] The start time of school and work programs, which usually starts early in the day, is the most suitable for the sleep/wake times of morning chronotypes.[9,11] Because of this harmony between the social clock and the circadian clock, morning-types adapt more easily to environmental stimuli and perform better in academic and social areas.[6] Intermediate-types do not have difficulty adapting to external conditions such as social obligations.[10] The incompatibility between the circadian clock and the social clock, which occurs in conditions such as school and work life that require an early start to the day, is evident in evening-types. As a result of this condition, also called social jetlag, evening-types are more likely to experience chronic sleep loss, fatigue, sleepiness, and psychological and metabolic problems.[8]

Executive functions are defined as higher-level cognitive functions that include abilities such as working memory, set shifting, response inhibition, verbal fluency, abstraction, planning, and sustaining attention.[12] The relationship between chronotype and executive functions has been previously studied in the literature. Much of the literature is concerned with the synchrony effect, which refers to the situation where morning people perform better on cognitive tasks performed earlier in the day and evening people perform better on cognitive tasks performed later in the day. Chronotype has been shown to have a strong relationship with executive functioning, with each chronotype tending to perform better than the other at its optimum time (when the time of day is synchronized with one's circadian arousal).[13-16] However, it has also been reported that synchrony does not affect cognitive performance.[17] There are even literature findings that chronotypes perform better in some cognitive tasks outside of their optimum time (asynchrony/asynchronization effect) and that synchrony does not always yield better results.[18] It has been determined that morning people perform worse than evening people even when the tests are performed in the morning in the areas of working memory, processing speed, and visual-spatial areas.[19] It is suggested that the synchrony effect is more pronounced in evening chronotypes than in morning types.[20] It was even found that although there was a synchronization effect for evening people, this was not observed for morning people.[21]

Possible reasons for the conflicting results in studies examining the relationship between chronotype and executive functions include the synchrony effect, the test-repeat effect, homogeneous groups, small sample sizes, use of different cognitive tests, and the fact that circadian preferences in young and middle-aged adults are often dependent on school/work schedules.[22] In addition, it is known that executive functions are not a single function, but a whole of independent processes, and that these processes are affected differently depending on the time the test is taken.[23] As mentioned above, the relationship between chronotype and executive functions under the influence of synchrony has been studied sufficiently in the literature. However, fewer studies have been conducted without mandatory synchrony. In this context, study designs that do not require synchrony and take into account individual time planning have also been suggested in the literature to better understand the relationships between executive function components and chronotype.[24,25] Samples where individuals cannot directly choose their own sleep-wake times and working lives, such as students, and where there is an obligation to start the day early due to social demands are very important groups for this purpose.

The primary aim of this study was to compare the executive function performances of individuals with different chronotype preferences, such as attention, working memory, verbal fluency, mental flexibility, resistance to interference, planning, and problem-solving, as well as sleepiness, fatigue, depression and, anxiety levels. The secondary objective was to examine the relationships between chronotype, sleepiness, fatigue, depression, anxiety, and executive functions.

Materials and Methods

Participants

The participants of this study, in which the correlational survey method was used, consisted of a total of 180 people aged 18-45 (23.24±7.20) years, 116 (64.4%) women and 64 (35.6%) men. Twelve (6.7%) participants were primary school graduates, 7 (3.9%) were secondary school graduates, 8 (4.4%) were high school graduates, and 153 (85%) were university students and graduates. Of the participants, 7 (4%) stated that they used alcohol regularly, 24 (13.3%) stated that they had a coffee habit, 31 (17.3%) stated that they had a smoking habit, and 116 (64.4%) stated that they had no habits.

Procedure

This study was approved by the University of Health Sciences Türkiye Hamidiye Scientific Research Ethics Committee (approval number: 14/38, date: 21.07.2023). The criteria for inclusion in the study were age 18-45 years, being at least a primary school graduate, and agreeing to participate in the study. Based on the information obtained from the sociodemographic data form, those with substance abuse, sleep problems, those using drugs that could potentially affect cognitive functions, and those reporting existing neurologic or psychiatric diseases were excluded from the study. Eleven people were excluded because they did not meet these criteria.

After the purpose and method of the study were explained, written informed consent was obtained from the participants. It was also stated that participation in the study was voluntary and that participants could withdraw from the study without giving any reasons. Participants were offered a wide time frame between 08:00 and 20:00, which they determined as the time to be tested for neuropsychological evaluation. Neuropsychological tests were performed by experienced psychologists. It took approximately 1 hour to complete the scales and perform the neuropsychological tests. Participants were administered a sociodemographic data form, the morningness-eveningness questionnaire (MEQ), Epworth Sleepiness Scale (ESS), Fatigue Severity Scale (FSS), Beck depression inventory (BDI), Beck anxiety inventory (BAI), Digit Span test (DST), Stroop test (ST), Verbal Fluency test (VFT), Trail Making test (TMT), and the Tower of London (TOL) test. Neuropsychological tests appropriate to the skills mentioned in the definition of executive functions in the introduction section were selected. After the study was completed, the chronotypes of the participants were determined according to the MEQ they had previously completed. Individuals with total scores between 16-41 were classified as evening-type, those with total scores between 42-58 were classified as intermediate-type, and those with total scores between 59-86 were classified as morning-type.

Assessment Tools

Sociodemographic Data Form: This form was prepared for the study and included information about the participants' age, sex, education level, employment status, sleep habits, psychiatric and medical disease history, and medication use.

Morningness-Eveningness Questionnaire (MEQ): MEQ was developed by Horne and Ostberg[26] in 1976. It is a self-report scale that separates individuals into chronotypes as "evening-type", "intermediate-type", and "morning-type" based on their sleep-wake patterns. It is the most frequently used scale to assess chronotype in both healthy individuals and patient samples. Total scores vary between 16 and 86. Participants who score 16-41 on the scale are classified as "evening-type", those who score 42-58 are classified as "intermediate-type", and those who score 59-86 are classified as "morning-type". The validity and reliability study of the Turkish version of the scale was conducted by Agargun et al.[27]

Epworth Sleepiness Scale (ESS): The ESS is a self-report scale developed by Johns[28] in 1991 that assesses excessive daytime sleepiness. The scale consists of eight questions in total and each question is evaluated in the range of 0-3 points. The highest score that can be obtained from the scale is 24, and scores of 10 and above indicate the presence of excessive daytime sleepiness. The validity and reliability study of the Turkish version of the scale was conducted by Ağargün et al.[29]

Fatigue Severity Scale (FSS): The FSS was developed by Krupp et al.[30] The scale consists of nine items and each item is scored between 1 and 7 (1= completely disagree, 7= completely agree). The total score varies between 9 and 63. A high score on the scale indicates severe fatigue. The validity and reliability study of the Turkish version of the scale was conducted by Armutlu et al.[31]

Beck Depression Inventory (BDI): The BDI was developed to determine the presence and severity of depressive symptoms in adults.[32] The scale consists of 21 items and each item is scored between 0 and 3. The total score varies between 0 and 63. Higher total scores indicate more severe depression. The cut-off score of the scale is 17. The validity and reliability study of the Turkish version has been conducted.[33]

Beck Anxiety Inventory (BAI): The BAI was developed to determine the frequency of anxiety symptoms in adults.[34] It consists of 21 items in total and each item is scored between 0 and 3. The highest score that can be obtained from the scale is 63. A high total score indicates a high level of anxiety experienced by the person. A validity and reliability study was conducted in Turkish.[35]

Digit Span Test (DST): The DST is used to evaluate simple attention and working memory. The test consists of two parts: forward and backward digit span. In both sections, numbers are read to the participant at a rate of one number per second. In the advanced number range, the participant is asked to repeat the numbers said in the same order. In the backward number range, the participant is asked to repeat the numbers from the last to the first. The number of digits in the last repeatable sequence constitutes the person's attention span. Test normative data were collected within the scope of the BILNOT battery.[36]

Stroop Test (ST): This test assesses the ability to change perceptual set-up under interference, the ability to resist the interference of automatic processes, focused attention, and speed of information processing.[37] The participant is asked to say the colors of the colored squares in the first stage and to read the color names in the second stage. After the participant has developed a tendency to read and say colors, in the third stage, the participant is asked not to read the color names written in color but to say in which color the word is printed. The duration of the section where the words are not read but the color is said is subtracted from the duration of the section where the words are read and the color is said. Thus the interference time is calculated. Spontaneous corrections and errors are recorded. A high interference period and a high number of errors and spontaneous corrections indicate that the participant's attention is easily distracted, and that the person has difficulty suppressing inappropriate response tendencies. Test normative data were collected within the scope of the BILNOT battery. [36]

Verbal Fluency Test (VFT): The VFT is used to evaluate complex attention functions (fluency, mental retrieval, and sustaining attention). In the test, the participant is first asked to say animal names for 1 minute and recorded. This section evaluates semantic fluency. The participant is then asked to produce as many words as possible starting with the given letters (K, A, S) for 1 minute. This also measures phonetic fluency. The norms of the Turkish form of the test were collected in a psychology master's study.[38]

Trail Making Test (TMT): The TMT assesses visual-motor conceptual scanning, abstract thinking, the ability to change settings among stimulus sets, inhibition of response tendency, the ability to follow sequences, and attention.[39] It consists of two parts, forms A and B. In form A, the participant is asked to combine the circles containing numbers from 1 to 25 in the correct order and one after the other. In form B, numbers and letters are in circles and the participant is asked to connect the circles to form one number and one letter (such as 1-A, 2-B, 3-C). In the evaluation of the test, the time taken to complete both sections and the number of errors made are used. The interference period is determined by subtracting the duration of form A from the duration of form B. The validity and reliability study of the Turkish version of the test has been conducted.[40]

Tower of London (TOL): The TOL test evaluates executive function skills such as planning and problem-solving. There are several versions of the test, but this study used the Drexel University TOL test version.[41] The test consists of ten problems of increasing difficulty. The validity and reliability study of the Turkish version of the test has been conducted.[42]

Statistical Analysis

The G*Power 3.1.9.4 program was used to determine the number of participants in the study. For one-way analysis of variance (ANOVA), it was found that the smallest sample size should be 180 with an effect size of 0.25, a margin of error of 0.05 and a statistical power of 85%. Cohen[43] states that 80% effect size is sufficient. For statistical analysis, first the minimum and maximum values, and the mean and standard deviation scores of the scores obtained from the scales were calculated, then the skewness and kurtosis values were calculated to determine whether the data set showed normal distribution. Normal distribution calculations were made by taking into account George and Mallery's[44] view that the data set showed normal distribution if the skewness and kurtosis values were between +2 and -2. The differences between the three groups created in the data set were examined using One-Way ANOVA for variables showing normal distribution and the Kruskal-Wallis H test for variables not showing normal distribution. The correlations between the scale scores of the entire group were calculated using Spearman correlation analysis because the data set included scales that did not show normal distribution. The SPSS v.25 program was used for all analyses. The statistical significance level was determined as $p<0.05$.

Results

Demographic Characteristics and Scale Findings

The minimum, maximum, mean, standard deviation, skewness, and kurtosis values of the continuous variables are presented in Table 1. The chronotypes of the participants were determined using the score ranges they received on the MEQ. According to the cut-off scores in the MEQ, 42 (23.33%) participants were found to be evening-type, 90 (50%) were intermediate-type, and 48 (26.67%) were morning-type. One-Way ANOVA was performed to determine whether these groups differed in terms of age, education level, and chronobiologic type. No difference was observed between the groups in terms of education level ($p=0.179$), but it was found that the groups differed in terms of age and chronobiologic type ($p<0.008$ and $p<0.001$, respectively).

In the ANOVA analysis applied to variables showing normal distribution from groups formed according to chronobiologic types, the determination of the homogeneity of the groups was calculated using Levene's test. Because the Levene's test values of the variables other than ESS were $p>0.05$, post hoc analysis was performed using Tamhane correction for ESS and Bonferroni correction for the other variables. As a result of the ANOVA analysis, statistically significant differences were found between the groups in sleepiness, fatigue, depression, and anxiety variables ($p<0.013$, $p<0.001$, $p<0.013$, and $p<0.047$, respectively). As a result of the post hoc analysis performed using Bonferroni correction to determine which groups differed for the variables with significant differences, it was found that there was a significant difference in the depression variable only between the evening and morning types in favor of the evening type, but there was no significant difference between the groups in the fatigue and anxiety variables ($p>0.018$). In the post hoc analysis performed using Tamhane correction for the sleepiness variable, there was no significant difference between the groups ($p>0.018$) (Table 2).

Neuropsychological Test Findings

As a result of the analyses performed to determine whether the study data set showed normal distribution, it was determined that the ST-interference time, ST-number of incorrect answers, ST-number of corrections, TMT-A time, TMT-B time, TMT-B-A, TMT-number of errors, and TOL-total initiation time variables did not show normal distribution; the other variables were found to be in accordance with the normal distribution. According to the Kruskal-Wallis H test performed for variables that did not show normal distribution, a significant difference was found between the groups only in the TMT-A-time ($p<0.034$); no significant difference was found between the groups in other variables. The difference between the groups for the TMT-A-time variable was examined using the Mann-Whitney U test. As a result of the

Table 1. Minimum, maximum, mean, standard deviation, skewness and kurtosis values of the study variables						
	Min.	**Max.**	**Mean**	**SD**	**Skewness**	**Kurtosis**
MEQ	22.00	69.00	49.87	9.50	-0.29	-0.319
ESS	0.00	20.00	7.68	3.95	0.69	0.047
FSS	0.00	63.00	38.59	12.96	-0.36	-0.32
BDI	0.00	33.00	12.38	6.74	0.09	-0.62
BAI	0.00	24.00	12.10	7.17	0.04	-1.15
DST-forward	4.00	8.00	6.67	1.068	-0.36	-0.89
DST-backward	3.00	7.00	4.79	0.93	0.38	-0.19
ST-interference time (sec)	8.00	83.00	33.64	12.47	1.19	2.37
ST-number of incorrect	0.00	6.00	0.52	1.033	2.55	7.34
ST-number of corrections	0.00	10.00	2.10	2.01	1.39	2.19
VFT-semantic fluency	11.00	42.00	25.17	5.57	0.49	0.26
VFT-semantic fluency, perseveration	0.00	2.00	0.42	0.69	1.35	0.41
VFT-phonetic fluency: K-A-S	16.00	86.00	46.63	12.17	0.33	0.34
VFT-phonetic fluency, perseveration	0.00	4.00	0.62	0.85	1.25	0.96
TMT-a time (sec)	12.00	76.00	29.47	11.11	1.46	2.60
TMT-b time (sec)	18.00	201.00	68.58	30.48	2.09	5.73
TMT-b-a (interference time)	3.00	184.00	39.67	27.89	2.45	8.29
TMT-number of errors	0.00	4.00	0.45	0.69	1.85	4.69
TOL-total correct score	0.00	8.00	2.69	1.90	0.38	-0.38
TOL-total move score	8.00	96.00	43.59	17.49	0.42	0.16
TOL-total initiation time	10.00	86.00	29.13	15.80	1.54	2.72
TOL-total application time	83.00	374.00	181.68	54.65	0.87	0.71
TOL-total complete time	94.00	411.00	210.28	59.10	0.79	0.68

BAI: Beck anxiety inventory, BDI: Beck depression inventory, DST: Digit span test, ESS: Epworth Sleepiness Scale, FSS: Fatigue Severity Scale, MEQ: Morningness-eeveningness questionnaire, ST: Stroop test, TMT: Trail Making test, TOL: Tower of London, VFT: Verbal Fluency test, SD: Standard deviation

Table 2. Comparison of sociodemographic data and scale scores of chronotypes						
Variables	**Evening types (n=42)**	**Intermediate types (n=90)**	**Morning types (n=48)**	**F**	**p**	**η^2**
Age (yr)	21.50±3.73	22.64±6.84	25.88±9.30	4.95	0.008	
Education (yr)	14.05±1.86	13.26±2.72	13.00±3.51	1.74	0.179	
MEQ	36.62±4.49	49.89±3.50	61.44±3.09	516.83	**0.001**	
ESS	9.09±4.80	7.54±3.74	6.69±3.18	**4.42**	**0.013**	0.048
FSS	45.05±11.98	36.38±12.72	37.08±12.63	**7.33**	**0.001**	0.076
BDI	14.76±6.12	12.22±6.48	10.60±7.24	**4.48**	**0.013**	0.048
BAI	12.93±6.95	12.88±7.08	9.92±7.22	**3.12**	**0.047**	0.034

BAI: Beck anxiety inventory, BDI: Beck depression inventory, ESS: Epworth Sleepiness Scale, FSS: Fatigue Severity Scale, MEQ: Morningness-eeveningness questionnaire

binary analyses, it was determined that there was a significant difference in favor of the evening type (Table 3 and Table 4).

Correlation Analysis

Relationships between morningness-eveningness, sleepiness, fatigue, depression, anxiety and neuropsychological variables were examined using Spearman correlation analysis because some variables in the data set did not show normal distribution. According to the results, negative significant relationships were found between MEQ and ESS (r=-0.16, p<0.01), FSS (r=-0.21, p<0.05), BDI (r=-0.25, p<0.05), and between VFT-animals (r=-0.18, p<0.01) and VFT-KAS (r=-0.16, p<0.01) among neuropsychological variables. Sleepiness was positively correlated with fatigue, depression, and anxiety neuropsychological tests, DST-backward (r=0.18, r=0.16, r=0.19, and r=0.16, respectively; p<0.01). Fatigue was positively and significantly correlated with depression, anxiety, and neuropsychological variables such as TMT-A time and TOL-total initiation time (r=0.39, p<0.05, r=0.32, p<0.05, r=0.15, p<0.01, and r=0.16, p<0.01, respectively). Depression was found to be significantly positively correlated with anxiety and only with the number of ST-number of incorrect answers among neuropsychological variables (r=0.56, p<0.05 and r=0.15, p<0.01, respectively). Anxiety was found to be positively correlated with the neuropsychological variables TMT-A time, TMT-B time, and TMT-interference (r=0.15, p<0.05, r=0.24, p<0.05, and r=0.22, p<0.05, respectively), and negatively correlated with DST-forward, VFT-animals, and VFT-KAS (r=-0.18, p<0.01 and r=-0.16, p<0.01, respectively). Additionally, significant relationships were found between neuropsychological variables (Table 5).

Table 3. ANOVA results of neuropsychological variables

	Evening types (n=42)	Intermediate types (n=90)	Morning types (n=48)	F	p	η^2
DST-forward	6.71±1.11	6.71±1.04	6.54±1.09	0.45	0.0541	0.005
DST-backward	4.93±0.95	4.80±0.96	4.67±0.86	0.89	0.414	0.010
VFT-semantic fluency	25.67±6.04	25.79±5.61	23.58±4.84	2.72	0.69	0.030
VFT-semantic fluency, perseveration	0.41±0.70	0.47±0.74	0.35±0.60	0.43	0.653	0.005
VFT-phonetic fluency: K-A-S	49.07±12.05	46.28±12.18	45.17±12.20	1.23	0.294	0.014
VFT-phonetic fluency, perseveration	0.79±0.89	0.52±0.74	0.67±0.99	1.46	0.235	0.016
TOL-total correct score	2.79±1.87	2.56±1.97	2.88±1.81	0.50	0.606	0.006
TOL-total move score	41.05±18.00	46.40±18.49	40.56±14.32	2.36	0.098	0.026
TOL-total application time	177.46±48.37	185.27±57.10	178.65±55.77	0.39	0.677	0.004
TOL-total complete time	208.62±57.08	212.74±60.18	207.13±59.83	0.16	0.851	0.002

DST: Digit Span test, TOL: Tower of London, VFT: Verbal Fluency test

Table 4. Kruskal-Wallis results for neuropsychological parameters

	Evening types (n=42)	Intermediate types (n=90)	Morning types (n=48)	Kruskal-Wallis H	p
ST-Interference time (sec)	92.63	89.26	90.97	0.126	0.939
ST-Number of incorrect	92.98	86.24	96.32	2.065	0.356
ST-Number of corrections	90.19	87.15	97.05	1.179	0.555
TMT-a time (sec)	91.11	81.92	106.06	**6.741**	**0.034**
TMT-b time (sec)	97.69	83.20	97.90	3.535	0.171
TMT-b-a (interference time)	97.70	86.12	92.41	1.503	0.472
TMT-number of errors	98.21	85.91	92.36	2.344	0.310
TOL-total initiation time	93.92	88.01	92.18	0.436	0.804

ST: Stroop test, TMT: Trail Making Test, TOL: Tower of London

Table 5. Correlations between morningness-eveningness, sleepiness, fatigue, depression, anxiety and neuropsychological variables

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	**-0.16***	**-0.21****	**-0.25****	-0.08	-0.11	-0.12	0.04	0.08	0.08	**-0.18***	-0.05	**-0.16***	-0.06	0.14	0.08	0.03	-0.04	0.03	-0.01	0.01	0.00	-0.01
2	1	**0.018***	**0.16***	**0.19***	-0.00	**0.16***	-0.11	-0.13	0.04	-0.01	0.05	0.09	0.03	0.10	0.02	-0.01	0.03	0.05	0.05	0.06	0.06	0.07
3		**1**	**0.39****	**0.32****	-0.01	0.00	0.13	0.10	0.09	-0.04	-0.10	0.059	-0.02	**0.15***	0.01	-0.04	0.09	0.04	-0.05	**0.16***	0.04	0.09
4			1	**0.56****	-0.09	-0.06	0.03	**0.15***	0.03	-0.14	-0.05	-0.095	-0.01	-0.00	0.14	0.12	0.06	0.00	-0.05	0.02	0.06	0.08
5				1	**-0.18***	-0.09	0.091	0.11	0.06	**-0.16***	-0.01	**-0.16***	-0.00	**0.15***	**0.24****	**0.22****	0.06	-0.07	0.02	0.13	0.04	0.07
6					1	**0.33****	-0.12	-0.06	-0.02	0.10	-0.02	**0.23****	-0.06	-0.08	**-0.16***	**-0.16***	0.04	0.08	-0.03	-0.07	**-0.17***	**-0.20****
7						1	-0.11	-0.05	-0.05	0.09	-0.07	**0.23****	0.05	-0.12	-0.08	-0.06	0.07	0.04	-0.07	0.05	**-0.15***	**-0.15***
8							1	**0.23****	**0.25****	**-0.19***	-0.03	-0.02	0.08	**0.23****	**0.16***	0.11	-0.02	0.03	-0.01	0.11	0.11	0.12
9								1	0.07	-0.02	0.00	**-0.20****	-0.07	**0.21****	0.08	0.00	-0.00	0.02	-0.04	-0.00	0.01	-0.01
10									1	**-0.18***	-0.02	-0.10	0.03	**0.16***	0.03	-0.03	0.03	-0.03	0.08	0.05	0.05	0.06
11										1	**0.15***	**0.30****	0.05	**-0.18***	**-0.20****	-0.11	-0.02	-0.10	0.06	**-0.20****	**-0.15***	**-0.18***
12											1	-0.02	0.04	-0.03	0.00	0.08	0.12	-0.06	-0.00	-0.06	-0.09	-0.09
13												1	**0.25****	**-0.15***	**-0.22****	**-0.15***	-0.03	0.01	-0.06	0.02	**-0.17***	**-0.17***
14													1	0.01	0.04	0.08	0.12	-0.03	-0.00	0.03	-0.09	-0.08
15														1	0.32**	-0.04	-0.07	0.07	0.03	**0.24****	**0.24****	**0.28****
16															1	**0.86****	**0.43****	-0.01	0.09	**0.25****	**0.24****	**0.29****
17																**1**	**0.50****	-0.04	0.12	0.13	**0.15***	**0.18***
18																	1	0.03	0.06	0.00	0.05	0.06
19																		1	**-0.73****	**0.37****	**-0.38****	**-0.25****
20																			1	**-0.26****	**0.63****	**0.49****
21																				1	**0.21****	**0.44****
22																					1	**0.96****
23																						1

$^{*}p<0.01$, $^{**}p<0.05$. 1. Morningness-Eveningness Questionnaire, 2. Epworth Sleepiness Scale, 3. Fatigue Severity Scale, 4. Beck Depression Inventory, 5. Beck Anxiety Inventory, 6. Digit Span Test - Forward, 7. Digit Span Test - Backward, 8. Stroop Test - Interference Time, 9. Stroop Test - Number of Incorrect Responses, 10. Stroop Test - Number of Corrections, 11. Verbal Fluency Test - Semantic Fluency, 12. Verbal Fluency Test - Semantic Fluency Perseverations, 13. Verbal Fluency Test - Phonetic Fluency - K-A-S, 14. Verbal Fluency Test - Phonetic Fluency Perseverations, 15. Trail Making Test - Part A Completion Time, 16. Trail Making Test - Part B Completion Time, 17. Trail Making Test - Difference Between Part B and Part A, 18. Trail Making Test - Number of Errors, 19. Tower of London Test - Total Correct Score, 20. Tower of London Test - Total Move Score, 21. Tower of London Test - Total Initiation Time, 22. Tower of London Test - Total Application Time, 23. Tower of London Test - Total Completion Time

Discussion

The aim of this study was to compare executive function performances such as attention, working memory, verbal fluency, mental flexibility, resistance to interference, planning, and problem-solving, and the levels of sleepiness, fatigue, depression, and anxiety of individuals according to chronotype groups classified as morning, evening, and intermediate-types. Also, to examine the relationships between chronotype, executive functions, sleepiness, fatigue, depression, and anxiety. In the study, measurements were made using neuropsychological tasks consisting of objective and standardized tests that are frequently used in clinical settings. However, while collecting data, neuropsychological tests were applied without determining the chronotypes of the individuals. Therefore, the optimal time according to the chronotype of the individuals was not taken into account, and the synchronicity effect was not taken into account, especially for executive functions. This type of application was preferred considering that individuals could not use their executive functions in accordance with their chronotype in daily life conditions (e.g., work, school).

It is seen in the literature that studies examining executive functions and chronotypes together differ from each other in terms of application. In this context, while examining the relationship between chronotype and cognitive performance, it is observed that various procedures have been developed, sometimes taking into account the synchrony and sometimes asynchrony effects, but it is evident from these studies that there is no clarity on this issue. There are studies suggesting that the strength of the relationship between the circadian clock and cognitive performance increases with age, with morning hours being the most optimal for cognitive performance in older adults and evening hours being more optimal for younger individuals,[45] there is also evidence that the time of day when testing takes place is of little importance for young college-aged individuals.[46]

The findings of the study revealed that there was a significant difference between the groups only in the TMT-A time in terms of executive functions. Part A of the TMT assesses processing speed based on visual scanning ability. This finding shows that evening-types have better processing speed than morning-types and intermediate-types. Chronotypes performed similarly in other areas of executive function, including attention, working memory, verbal fluency, mental flexibility, resistance to interference, planning, and problem-solving. In a study examining the effect of chronotype on cognition under asynchrony conditions, it was found that evening-types performed better than morning types on working memory and information processing speed tasks.[19] In their study conducted with a young sample of 77 people in 2008, Bennet et al.[14] found a synchrony effect in the area of mental flexibility from executive functions, but no effect of circadian typology or synchrony was found in the areas of simple attention, sustained attention, and verbal fluency. In a recent study, Evansová et al.[22] examined the relationship between the time of application of cognitive tests and cognitive performance of morning, intermediate-types, and evening-types in a sample of 42 people. It was found that morning people scored high in the ST-color naming section, but no effect of chronotype and synchrony was found on TMT-A and TMT-B, DST, working memory, attention, and alertness. In another study conducted with university students, morning students performed better in spatial skills when measured in the evening, and evening students performed better in spatial skills when measured in the morning. No effect of synchrony or chronotype was found on other cognitive abilities such as simple attention and picture completion.[17] In attention-related tasks, synchrony also had an effect on evening-types, and morning-types showed increased attention at suboptimal times of the day.[21] These studies, using synchrony and asynchrony designs, show that chronotype has an effect on a specific area of cognitive functions. The results of the present study, conducted at various times throughout the day under consistent conditions, align with the findings in existing literature and support these studies, while considering the limited impact of chronotype.

Another aim of the current study was to evaluate whether there was a relationship between chronotype and executive functions. In the correlation analysis, negative significant relationships were found between MEQ and VFT-animals and VFT-KAS, which are neuropsychological tests that assess verbal fluency. The VFT assesses executive control skills as well as sustaining attention because participants are required to access and retrieve words from their vocabulary stores, focus on the task while doing so, avoid perseveration, and select words with certain restrictions.[47] This finding suggests that evening chronotype is associated with better sustained attention, verbal fluency, and executive control skills. There are different findings in the literature regarding chronotype and sustained attention. For example, in a recent study where synchrony was not required, no relationship was found between chronotype and executive functions such as set shifting, sustained attention, and response inhibition.[48] In another study conducted with an adolescent sample and where synchrony was not required, no relationship was found between chronotype and different attention measures.[49] It has been found that not all components of attention are affected by chronotype and show different fluctuations at different times of the day. In this study, alertness was affected by synchrony and chronotype, and the attentional component was not affected by time of day and chronotype. Executive control was found to be lower in the middle of the day for both chronotypes.[24] It is known that evening types have difficulty adapting to external conditions that require an early start to the day. It has been claimed that evening types protect themselves from distracting elements by doing their work in the evening or at night to overcome this difficulty, and that the need to overcome these difficulties can lead to the development of some cognitive abilities of evening-types, such as problem-solving.[50] The reason why the evening-type is associated with better verbal fluency, sustained attention, and executive control may be a result of better coping with this difficulty, as suggested by Preckel et al.[50]

According to the ANOVA findings, statistically significant differences were found between the groups in terms of sleepiness, fatigue, depression, and anxiety scores among other variables examined in the current study. However, as a result of post hoc analyses, it was determined that there was a significant difference between evening and morning types only in the depression variable, in favor of the evening-type. In the present study, the evening-type's high depression scores are consistent with the findings in the literature.[51] Being an evening person is considered a risk for developing depression.[52] The evening-type has also been associated with depressive, cyclothymic, irritable, and anxious temperaments that may predispose to mental disorders.[53] On the other hand, being a morning person is considered a protective factor against depression, and it is suggested that the depressive period is milder in morning people than in evening people.[54] Although the average fatigue and sleepiness scores of the evening type were higher than the other two types, it was seen that there was no significant difference between the groups in the post hoc analysis with Bonferroni and Tamhane correction. In the correlation analysis, negative significant relationships were found between morningness-eveningness and sleepiness and fatigue. Data on sleepiness are consistent with literature findings that evening chronotypes have higher daytime sleepiness than morning people.[48,55] The higher fatigue score with evening chronotype is also consistent with the findings of a recent study.[56]

An interesting finding of our study was that sleepiness was positively correlated with fatigue, depression, anxiety variables, and DST-backward from neuropsychological tests in the correlation field. DST-backward is sensitive to working memory. Working memory capacity increases as participants' sleepiness, fatigue, depression, and anxiety levels increase. Similar to this result, a study found that university students with poor sleep quality had better attention, concentration, and spatial working memory capacity.[57,58] This may be because the younger population has developed precautions against sleep loss and has adapted to sleeplessness.[58] At the same time, an increase in cerebral activation associated with inhibition may be observed as a compensatory response after sleep deprivation.[25] It can be argued that our participants are young, have a high level of education, and, are students or working individuals, so they have developed a tolerance to sleep loss, and their executive functions are less affected in this situation.

The current study has several limitations that should be addressed in future research. First, all participants were aged 18-45 years. The majority of the participants were university students, which limits the generalizability of this study to the general population. At the same time, the higher average educational attainment may have exerted a ceiling effect on the participants' study, reducing the effect of chronotype on executive functions. This therefore limits the scope of this study and limits it to be interpretable only to young adults and educated individuals. Finally, this study was designed from a circadian typology perspective rather than a synchrony/asynchrony effect. It is known that measurements made with the simultaneity effect result in better performance in some areas of cognitive functions. In this context, some of the participants may have been tested under the influence of synchrony and some under the influence of asynchrony. Therefore, whether the neuropsychological assessment time corresponded to the participants' chronotype preference time may have affected their performance. However, the strengths of the study are that executive functions were evaluated using an objective method and the study comprised a relatively large sample.

Conclusion

The present study examined the effect of chronotype on executive functions by applying detailed executive function tests to a large sample group where individuals with different chronotype preferences, such as students and employees, could not directly choose their own sleep-wake times and were obliged to start the day early due to social demands. When executive functions were evaluated as a whole, evening chronotypes performed better than intermediate and morning types in terms of information processing speed. Morning chronotypes were associated with difficulty sustaining attention, low verbal fluency, and poor executive control skills. No significant effect or relationship was found in other areas of executive functions. It is thought that this study design, in which we also included intermediate-types, will contribute to the growing literature on the effect of chronotype on cognitive processes.

Ethics

Ethics Committee Approval: This study was approved by the University of Health Sciences Türkiye Hamidiye Scientific Research Ethics Committee (decision number: 14/38, date: 21.07.2023).

Informed Consent: Participants were informed about the purpose of the study and written informed consent was obtained from participants who volunteered to participate in the study. The study was conducted in accordance with the Principles of the Declaration of Helsinki.

Footnotes

Authorship Contributions

Concept: H.D., Design: H.D., Y.B., Data Collection or Processing: H.D., M.Ş., A.F.S., S.İ., Analysis or Interpretation: H.D., Y.B., Literature Search: H.D., M.Ş., A.F.S., S.İ., Writing: H.D., Y.B.

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Examining the Effect of Earplugs, Eye Mask, and Earplugs + Eye Mask on the Sleep Quality in Intensive Care Patients: a Randomised Controlled Trial

Yoğun Bakım Hastalarında Kulak Tıkacı, Göz Maskesi ve Kulak Tıkacı + Göz Maskesi Uygulamasının Uyku Kalitesine Etkisinin İncelenmesi: Randomize Kontrollü Çalışma

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Abstract

Objective: Quality sleep, which plays an important role in the physical, cognitive, immunological, and psychosocial functions of patients, is imperative, especially for patients hospitalised in intensive care units (ICU) to recover from their critical illnesses. The aim of this study was to investigate the effect of earplugs (EP) and eye mask (EM) on sleep quality in ICU patients.

Materials and Methods: The sample of the study consisted of 120 patients hospitalised in the general ICU of Siirt State Hospital between July 2021-May 2022. Patients were divided into four groups as EP, EM, EP + EM and control group. Each patient in the related group wore EP, EM, and EP in combination with EM between 22:00-06:00 and was allowed to sleep in this way. Data were collected using the “patient description form” and "Richards Campbell Sleep Questionnaire (RCSQ)".

Results: According to that the dependent samples t-test performed for intra-group comparison, there was a statistically significant increase between pretest and post-test RCSQ mean scores of the patients in the EP, EM, and EP + EM groups (tEP=7,899, tEM=17,268, tEP + EM=9,381, p<0.001); whereas, there was no significant difference between pretest and post-test RCSQ mean scores of the patients in the control group (tC=1,084, p>0.05). Also, the first three factors that negatively affected the sleep quality of ICU patients were noise (71.6%), light (60.8%) and nursing interventions (49.1%).

Conclusion: The application of EM only was found to be the most effective nursing practice in enhancing the sleep quality of patients hospitalised in the ICU.

Keywords: Earplugs, eye mask, sleep quality, intensive care unit

Öz

Amaç: Hastaların fiziksel, bilişsel, immünolojik ve psikososyal işlevlerinde önemli rol oynayan kaliteli uyku, özellikle yoğun bakım ünitesi (YBÜ) hastalarının kritik hastalıklarından kurtulmaları için gereklidir. Bu çalışmanın amacı yoğun bakım hastalarına sadece kulak tıkacı (KT), sadece göz maskesi (GM) ve kulak tıkacı + göz maskesi (KT + GM) uygulamasının uyku kalitesine etkisini araştırmaktır.

Gereç ve Yöntem: Çalışmanın örneklemini Temmuz 2021-Mayıs 2022 tarihleri arasında Türkiye’de Siirt Devlet Hastanesi'nin genel YBÜ'de yatan 120 hasta oluşturdu. Hastalar KT, GM, KT + GM ve kontrol grubu olmak üzere dört gruba ayrıldı. İlgili gruptaki her bir hastaya 22:00-06:00 saatleri arasında KT, GM ve KT + GM uygulandı ve bu şekilde uyumaları sağlandı. Veriler, “hasta tanıtım formu” ve “Richards Campbell Uyku Ölçeği (RCUÖ)” ile toplandı.

Bulgular: Grup içi karşılaştırma için yapılan bağımlı örneklemler t-testi sonucuna göre KT, GM ve KT + GM gruplarındaki hastaların ön test ve son test RCUÖ puan ortalamaları arasında istatistiksel olarak anlamlı bir artış olduğu (tKT=7.899, tGM=17.268, tKT + GM=9.381, p<0,001); kontrol grubundaki hastaların öntest ve sontest RCUÖ puan ortalamaları arasında ise anlamlı bir fark olmadığı bulundu (tK=1.084, p>0,05). Ayrıca, YBÜ hastalarının uyku kalitesini olumsuz etkileyen ilk üç faktörün gürültü (%71,6), ışık (%60,8) ve hemşirelik müdahalesi olduğu saptandı (%49,1).

Sonuç: Sadece GM uygulaması, yoğun bakım hastalarının uyku kalitesini artırmada en etkili hemşirelik uygulaması olarak saptandı.

Anahtar Kelimeler: Kulak tıkacı, göz maskesi, uyku kalitesi, yoğun bakım ünitesi

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Introduction

Quality sleep, which takes a vital role in the physical, cognitive, immunological, and psychosocial functions of patients, is imperative, especially for patients hospitalised in intensive care units (ICU) to heal from their critical illnesses.[1] More than 50% of critically ill patients in the ICU suffer from sleep disturbances such as shortened total sleep time, interrupted sleep, and sleep deficiency.[2] It is known that sleep deprivation leads to sleep deficiency and poor sleep quality.[3] Sleep quality is vital for the healing process of patients who are treated and cared for in the ICU.[4] Bad sleep quality is mainly linked to immune system dysfunction, decreased resistance to infection as well as neurological consequences. Consequently, intensive care patients who lack quality sleep are likely to be hospitalised for a longer period and to die.[1] Therefore, it is critical to examine factors that can enhance the quality level of sleep for intensive care patients in order to improve their health and facilitate their recovery. Treatment and nursing practise in the ICU with significant noise sources such as equipment alarms, noisy staff chats, shriek of other patients, telephone calls and televisions cause decreased sleep quality in patients.[5,6] Another factor contributing to the insufficient sleep state of the ICU patients is the glossy light experienced at night. The body recognises that it needs to sleep at night since melatonin, a sleep hormone, is secreted only while the retina is exposed to low light. However, the illumination level of the indoor ceiling lights in the ICU is sufficient to disrupt the body's ability to produce melatonin.[1] The literature focuses particularly on the application of effect of earplugs (EP) and eye mask (EM) among non-pharmacological applications to enhance quality of sleep.[5] Many studies have determined that the application of EP alleviates the adverse effects of undesirable noise and enhances sleep quality in patients.[7-9] Also, the EM worn by patients at night effectively occlude excess light and facilitate the secretion of melatonin.[1,10] This may enhance the sleep quality of patients.[1] Randomised controlled trials using EM only showed that the sleep quality of patients enhanced.[11-13] Both randomised, controlled, and experimental studies using EP in combination with EM have also shown improved sleep quality.[14-24] From this point of view, it is observed that diminishing light, as well as noise and planning nursing practises before the patient sleeps are adjustments that increase patient comfort and enhance sleep quality.[25] Literature reviews have shown that wearing EP and EM in intensive care patients has positive outcomes on sleep quality.[1] Although the literature contains randomised controlled trials involving double and triple groups using the EP and the EM only in intensive care patients, a very limited number of related studies with four groups similar to the present study have been found. The goal of this investigation is comparing the effectiveness of applying the EP only, using the EM only as well as experiencing the EP and the EM together to the ICU patients and to incorporate these applications into routine nursing practises to enhance the quality of sleep.

Materials and Methods

Study Design

This study is a randomised controlled and single-centre trial. The study was registered on clinical trials (NCT05564351). The guidelines in the CONSORT list used for reporting randomised trials were followed.

Research Questions

Question 1: Is there any effect of using the EP, EM, and the EP + EM on sleep quality in intensive care patients?
Question 2: Is there any difference between the impact of making use of the EP, EM as well as the EP + EM on the sleep quality of the ICU patients?

Sample and Setting

The population consisted of 290 patients hospitalised in the general ICU of Siirt State Hospital in the Eastern Anatolia region of Türkiye between July 2021 and May 2022. A power analysis was done to find out the sample size of the study. A total of 108 patients (27 for each group) were calculated in four groups with a power of 80%, value of α=0.05 and an impact size of 0.50 in the G* Power 3.1.9.4 software. Each group had an additional three patients in case of data loss due to reasons such as withdrawal from the study and death. We focused on a total of 130 patients in our investigation: 30 patients were allocated to each group (Figure 1). A subtype of random sampling, which is known as the "complete (simple) random sampling", was used to reduce the possibility of selection bias resulting from sample selection phase. While randomising the patients, the website www.randomizer.org, which helps to generate random numbers in accordance with the criteria set to minimise the possibility of being influenced by each other, was used.

Inclusion Criteria

Our study consists of patients aged 18 and over, had no hearing impairment or visual impairment, could communicate verbally, were hospitalized in the general ICU for at least three days and agreed to be included in the analysis.[15,20,23]

Exclusion Criteria

Patients, who were unwilling to continue the study, had a visual analog scale score of seven or more, had a Glasgow Coma Scale score below 15, were taking sleeping pills or sedative drugs, were being treated with a diagnosis of sleep disorder, underwent mechanical ventilation therapy, had active ear or eye infections, and had diagnosed psychiatric illness were excluded.[15-26]

Data Collection

Questionnaires

Patient Descriptive Form: This form includes a total of seven questions about age, gender, marital condition, employment status, educational background, presence of chronic disease as well as factors affecting the sleep quality level in the ICU.

Richards-Campbell Sleep Questionnaire (RCSQ): This approach was constructed by Kathy C. Richards and it is a six-item scale that evaluates the depth of night-time sleep, latency of sleep state, frequency of awakenings, time to stay awake when woken up, quality of sleep as well as the ambient noise level. Scores in the range of (0.25) indicate the state of "very poor sleep" while scores in the range of (76,100) imply "very good sleep" case. A score increase calculated through the scale implies an enhancement in the sleep quality of patients. Özlü and Özer[27] adapted the RCSQ into Turkish and conducted its validity and reliability study. The Cronbach reliability coefficient of the scale is α=0.91. This finding shows that the scale is a highly reliable tool with internal consistency.[27] In our investigation, the Cronbach reliability parameter of the RCSQ was found to be α=0.94.

Instruments

Earplug: Developed by making use of the latest innovations in ergonomic design and heat-sensitive elastic materials, the minimalist-sized EP maximises sleep comfort with its soundproof feature.[23,28]

Eye Mask: The three-dimensional design fully grips the face and blocks the ambient light from catching the eyes. The black colour provides comfortable sleep by fully blocking the light. It comes in a disposable package and is sterile.[20,29]

Procedure

The researcher administered the "patient introduction form" to the patients on the first day with face-to-face interview technique and then administered the RCSQ as a pre-test to the patients in the ICU in the morning of the second day after their first night's sleep without any application.

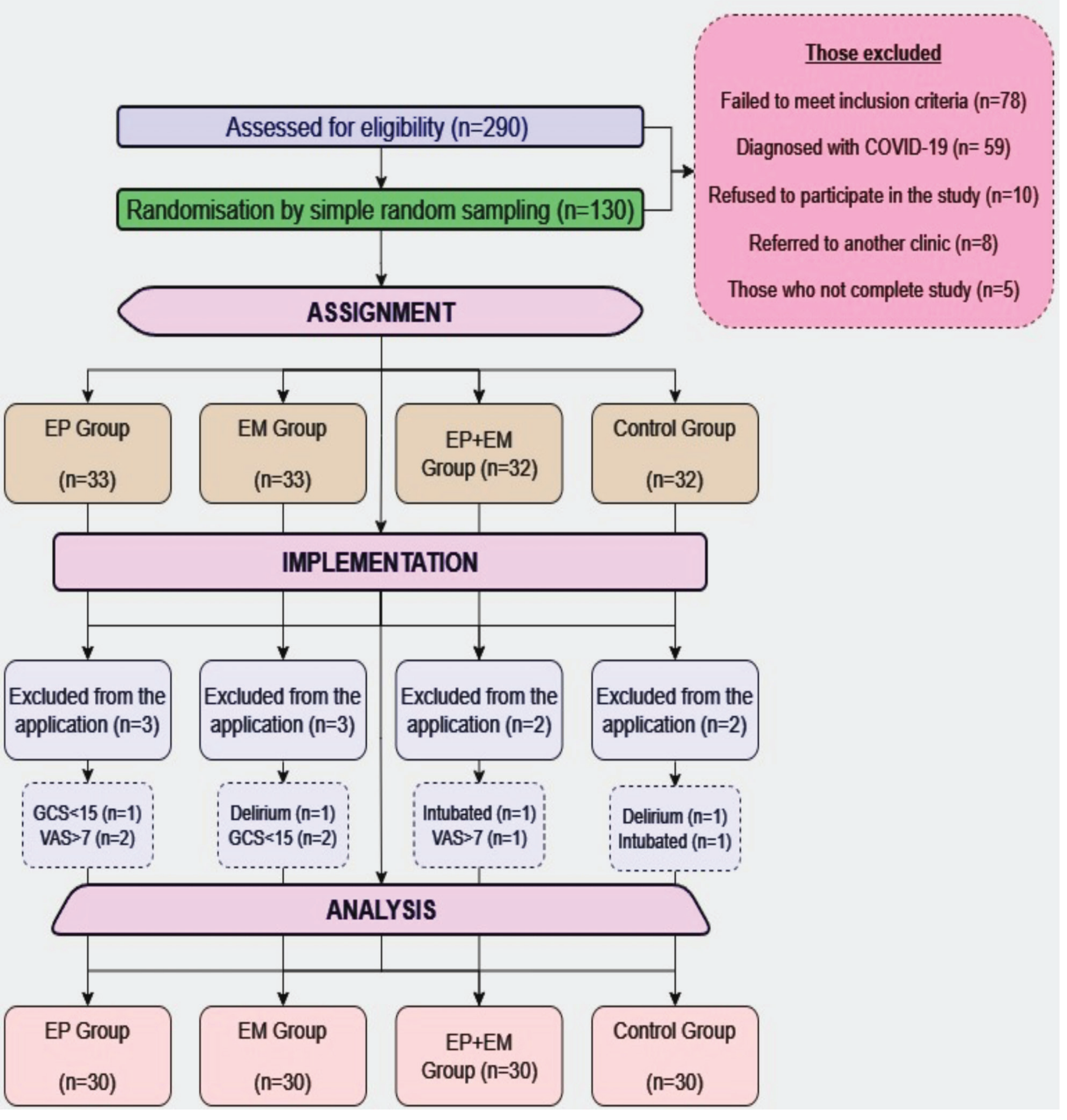

Figure 1. CONSORT flow chart of the study

EP: Earplug, EM: Eye mask, GCS: Glaskow Coma Scale, VAS: Visual Analog Scale

Treatment Group: In this study, the applications and the groups they are in have the same names and the corresponding instruments were applied by the researcher to the EP, EM and the EP + EM groups between 22:00-06:00 and the patients were allowed to sleep in this way. The researcher re-administered the RCSQ as a post-test in the morning of the third day after the second night's sleep of the patients in the ICU. Each patient in this group was followed up for three days.

Control Group: The corresponding members were allowed to sleep in the ICU without putting any EP or EM on. The researcher applied the RCSQ again as post-test on the morning of the third day of the second night's sleep of the patients in the ICU. Each patient in this group was followed up for three days.

Ethical Considerations

The ethical permission was received from the Scientific Research and Publication Ethics Committee of Gümüşhane University (approval number: 2021/1, dated: 04.02.2021) and institutional approcal was received from Siirt Provincial Health Directorate and Siirt Training and Research Hospital (approval number: E-71987595-604.02, dated: 22.06.2021) for the study. Patients who wanted to participate in the study were informed about the study and their consents were obtained. The Helsinki Declaration was followed at all stages of the study.

Statistical Analysis

We used the SPSS 27 to analyse the data in the study. The continuous datasets were shared as mean ± standard deviation and median, while the categorical ones were given as frequency and percentage. In comparison of differences between categorical variables according to groups, Pearson's chi-square was used in R x C tables where the rate of cells with 5 or more expected value or less than 5 expected value does not exceed 20%, and in R x C tables where the rate of cells with expected value below 5 exceeds 20%, Fisher-Freeman-Halton test was used. In order to decide on the analyses to be applied, the Kolmogorov-Smirnov approach was taken into account along with all scores for the assumption of normal distribution. Consequently, it was observed that the scores met the assumption of normal distribution, and therefore parametric tests were used while performing the analyses. In the analysis within groups, dependent samples t-test was used for pretest-post-test comparisons, and eta-squared (η^2) was used to calculate the effect size of the applications. In the analysis between groups, one-way analysis of variance (ANOVA) test was used for triple or more comparisons, Tukey's was used for homogeneously distributed data and Tamhane T2 test was taken into account for the data that did not indicate homogeneous distribution while carrying out multiple comparison tests. Test conclusions were appraised at the confidence interval of 95% and the significance level of $p<0.05$.

Results

While there was no statistically noteworthy difference between the patients in the EP, EM, EP + EM and control groups in terms of age, gender as well as marital status ($p>0.05$); a significant difference was found in terms of employment status and presence of chronic disease. In terms of education, the difference was found to be at the literate and middle school levels ($p<0.05$) (Table 1). The first three factors that influenced negatively the sleep quality level of the ICU patients were noise (71.6%), light (60.8%) and nursing interventions (49.1%) (Figure 2). As a result of the Dependent samples t-test performed for the within-group comparison, there was a statistically significant increase between the pre-test and the post-test RCSQ mean scores of the patients in the EP, EM, and the EP + EM groups ($p<0.001$); whereas, there was no substantial difference between the pre-test and the post-test RCSQ mean scores of the patients in the control group ($p>0.05$). When the effect size eta-squared calculation was examined, it was determined that the EP (η^2=0.683), EM (η^2=0.911) and the EP + EM (η^2=0.752) applications had a great effect on the increase in the RCSQ mean scores. After the post-test-pre-test procedure, the RCSQ score averages were compared with the significant results by one-way ANOVA test and the result was found to be significant ($F=6.277$, $p<0.01$). According to the result of Tukey test included in the multiple comparison test, it was determined that the EM application was more effective than the EP and the EP + EM applications. As a result of the one-way ANOVA test performed for the inter-group comparison, it was found that the pretest RCSQ mean scores of the patients did not differ remarkably according to the group ($F=2.321$, $p>0.05$); the post-test RCSQ mean scores differed significantly according to the group ($F=27.426$, $p<0.001$). The results of the Tamhane T2 test, which was included in the multiple comparison test to determine which group caused the difference, revealed that the control group had the lowest RCSQ mean score; whereas, the RCSQ mean values of the EM group were higher than those of the EP + EM group (Table 2).

Discussion

When the factors affecting the sleep quality of the patients participating in the current study were examined, it was understood that top three factors were noise, light, and nursing interventions, similar to the literature.[11,12,21,30] A study conducted in the coronary ICU reported that the factors affecting sleep quality were light, noise, nursing interventions, and staff conversations working in the unit.[16] In the study conducted by Kavaklı[13] to assess effect of EM application, it was determined that the most frequent intensive care environment, noise and nursing interventions were the factors that impaired the sleep quality of the patients. These results revealed that noise and light were important parameters affecting sleep quality in ICU.[13,16,31] In the studies, it was determined that bright light and noise in the ICU harmed patients psychologically and physiologically.[9,32] When uninterrupted light is perceived by the brain during the night period of the day, it is related directly to the dark-light cycle. The brain interprets the relevant light as daytime and then the biological clock of the patient's body warns the pineal gland by sending signals to block the secretion

Table 1. Descriptive characteristics of the patients (n=120)							
Variables		**EP group (n=30)**	**EM group (n=30)**	**EP + EM group (n=30)**	**Control group (n=30)**	**F**	**p**
Age ($\bar{x}$ ± SD) **Med.** (min.-max.)		57.66±12.68 58 (26-94)	58.66±12.28 63 (21-79)	51.30±16.19 51 (18-80)	52.83±10.63 48 (37-72)	2.263[a]	0.085
		n (%)*	**n (%)***	**n (%)***	**n (%)***	**$\chi 2$**	**p**
Gender	Woman Man	16 (53.3) 14 (46.7)	14 (46.7) 16 (53.3)	13 (43.3) 17 (56.7)	14 (46.7) 16 (53.3)	0.635[b]	0.888
Marital status	Married Single	29 (96.7) 1 (3.3)	27 (90.0) 3 (10.0)	23 (76.7) 7 (23.3)	26 (86.7) 4 (13.3)	5.399[c]	0.142
Working status	Yes No	5 (16.7) 25 (83.3)	8 (26.7) 22 (73.3)	14 (46.7) 16 (53.3)	13 (43.3) 17 (56.7)	8.100[b]	**0.044**
Education level	Literate Primary school Middle school High school University	15 (50.0) 5 (16.7) 1 (3.3) 7 (23.3) 2 (6.7)	16 (53.3) 4 (13.3) 0 (0.0) 6 (20.0) 4 (13.3)	8 (26.7) 7 (23.3) 5 (16.7) 7 (23.3) 3 (10.0)	2 (6.7) 9 (30.0) 7 (23.3) 7 (23.3) 5 (16.7)	28.032[c]	**0.003**
Chronic disease	Yes No	9 (30.0) 21 (70.0)	17 (56.7) 13 (43.4)	10 (33.3) 20 (66.7)	19 (63.3) 11 (36.7)	10.036[b]	**0.018**
Diagnosis of hospitalization in intensive care unit	Respiratory system diseases Cardiovascular system diseases Gastrointestinal system diseases Neurological diseases Urinary system diseases Others	11 (36.7) 2 (6.7) 3 (10.0) 5 (16.7) 2 (6.7) 7 (23.3)	11 (36.7) 5 (16.7) 4 (13.3) 2 (6.7) 4 (13.3) 4 (13.3)	8 (26.7) 1 (3.3) 1 (3.3) 3 (10.0) 3 (10.0) 14 (46.7)	5 (16.7) 14 (46.7) 0 (0.0) 4 (13.3) 0 (0.0) 7 (23.3)	35.412[c]	**0.000**

$\bar{x}$ ± SS: Arithmetic mean-standard deviation, Med.: Median, min.-max.: Minimum-maximum, *Column percentage was taken, [a]One way analysis of variance, [b]Pearson's chi-square test, [c]Fisher-Freeman-Halton test, EP: Earplugs, EM: Eye mask

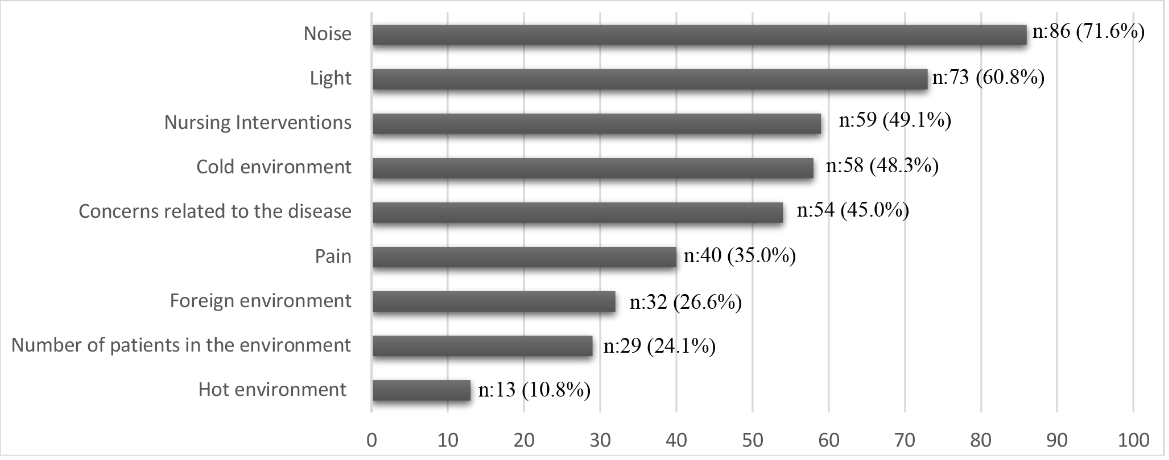

Figure 2. Factors affecting sleep quality of patients in the intensive care unit

Table 2. Comparison of RCSQ scores in ICU patients (n=120)

Measurement	EP group (n=30)	EM group (n=30)	EP + EM group (n=30)	Control group (n=30)	Between groups analysis**	Comparing applications** (Post-test-pretest)
	x̄ ± SS	x̄ ± SS	x̄ ± SS	x̄ ± SS		
Pre-test	47.37±8.42	46.50±5.24	45.27±10.20	39.67±20.45	F=2.321, p=0.079	F=6.277, **p=0.003** EM vs EP **(p=0.004)**, EM vs EP + EM **(p=0.022)**
Post-test	65.57±18.38	74.30±6.79	65.27±12.65	41.70±17.64	F=27.426, **p=0.000** EM vs C **(p=0.000[a])**, EM vs EP + EM **(p=0.007[a])**, EP vs C **(p=0.000[a])**, EP + EM vs C **(p=0.000[a])**	
Analysis within groups*	t=7.899, **p=0.000**	t=17.268, **p=0.000**	t=9.381, **p=0.000**	t=1.084, p=0.287		
η^2 Cohen's d Power rating	0.683 1.442 0.99	0.683 1.442 0.99	0.683 1.442 0.99	0.752 1.713 0.99		

*Dependent groups t-test, **One-way analysis of variance, [a]Tamhane's T2 test; x̄ ± SD, Arithmetic mean-standard deviation, C: Control group, vs.: And, RCSQ: Richards-Campbell Sleep Questionnaire, ICU: Intensive care unit, EP: Effect of earplugs, EM: Eye mask

of melatonin hormone. On the other hand, darkness is provided while the patient wears the EM and thus the brain perceives this darkness as night period and give directions to the pineal gland to enhance the production level of the hormone melatonin, which allows it to maintain sleep.[15] The ICU, where this study was conducted, has an environment that adversely affects sleep quality due to the presence of intense lighting at head level on each patient, the side by side placement of beds in a small area, and the noise caused by staff and technological devices. Although the conclusions of the current investigation are compatible with similar studies, it has been determined that there are too many stimuli that are not suitable for sleep in the ICU.[16,24,31] In patients who are affected by these stimuli and suffer from sleep problems; It is thought that wearing EM and EP by nurses as an easy and affordable method may be effective in providing patients' sleep satisfaction and enhancing their quality of life. In the present study, the effect of three interventions (the EM only, EP only and the EP + EM) on the sleep quality of the patients in the ICU was evaluated carefully. It was concluded that all three interventions enhanced the sleep quality of the patients and the EM only application enhanced the sleep quality more than the other attempts. When the studies in literature are examined, one may see that the combined use of the EM and the EP on intensive care patients can be taken into acount to enhance their sleep quality.[8,15,19,22,24,33] In a study conducted by Risch[34] to evaluate how the EM and the EP use affected sleep quality in the surgical-neurology ICU, it was determined that the combined use of the EM and the EP enhanced sleep quality by reducing environmental factors. In the meta-analysis study conducted by Fang et al.,[1] the authors stated that the EP and the EM applied to the adult patients hospitalised in the ICU have significant effects on their sleep quality, while the combined use of the EP and the EM has the largest effect size. However, in literature, some patients reported the feeling of uncomfortable, anxiety and even the claustrophobia after experiencing the combined of the EP and the EM.[35,36] In line with this information and based on our observations, we think that this was effective in the EP + EM group in our study. In their study, Khoddam et al.[37] evaluated the effect of EM and EP on sleep quality and reported that only the EM group experienced a sense of improved sleep quality compared to the EP only and the EP + EM groups. In their study, Babaii et al.[12] reported that the EM and the routine sleep care was applied to the intervention group while only the routine sleep care was applied to the control group, and then on the second and sixth days of hospital admission, sleep quality was evaluated with the Pittsburgh Sleep Quality Index. As a result of this analysis, they found that the EM can significantly improve the sleep quality of cardiac patients in the coronary ICU. The EM blocks light causes an increase in melatonin levels and improves sleep quality.[38] On the other hand, the EP limits the improvement of sleep quality as they have less effect on melatonin secretion and evoke unpleasant sensations.[1] However, after making use of the EP application, Menger et al.[39] determined in that the sleep quality was significantly different between patients staying in the postoperative care unit and control group. In another study on the cardiac surgical ICU, no significant difference was found between control and intervention groups ($p>0.05$).[8] While some of the studies in literature are similar to results of the present study, some others have yielded different results.[7,8,12,37,40] The reasons for this difference were thought to be patients' discomfort with the EP, differences in the selection of the sample group and individual factors.

Although most of sleep disorders can be treated using pharmacological methods in intensive care patients, the effectiveness of non-pharmacological methods (70-80%) has been proven by studies.[11,40-42] Methods such as the EM, EP and landscaping are used as non-pharmacological methods.[43] The use of EM and EP which recent nursing studies have focused on is one of the various strategies used to enhance sleep quality of patients and control environmental stimuli.[5,15]

Conclusion

According to the conclusions achieved via our investigation, the use of only EP, only EM and EP + EM have positive effects on the sleep quality of intensive care patients. Results of the present study revealed that only the use of EM was the most effective on the sleep quality level of intensive care patients among the groups, while the application of only EP was the least effective

Ethics

Ethics Committee Approval: The ethical permission was received from the Scientific Research and Publication Ethics Committee of Gümüşhane University (approval number: 2021/1, dated: 04.02.2021).

Informed Consent: Patients who wanted to participate in the study were informed about the study and their consents were obtained.

Footnotes

Authorship Contributions

Surgical and Medical Practices: H.T., Concept: A.K.S., H.T., S.H., Design: A.K.S., Data Collection or Processing: H.T., Analysis or Interpretation: E.Y., S.H. Literature Search: A.K.S., H.T., E.Y., S.H., Writing: A.K.S., H.T., E.Y., S.H.

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Evaluation of the Results of Polygraphy and Polysomnography Performed at Consecutive Times in the Detection of Obstructive Sleep Apnea: a Retrospective Analysis

Obstrüktif Uyku Apne Tespitinde Ardışık Zamanlarda Gerçekleştirilen Poligrafi ile Polisomnografi Sonuçlarının Retrospektif Olarak Karşılaştırılması

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Abstract

Objective: Polysomnography (PSG) performed at a sleep center is the gold standard for diagnosing sleep apnea syndrome. When PSG cannot be performed due to late appointments or in pandemic conditions, the use of home devices such as polygraphs may be preferred. We aimed to investigate the adequacy and deficiencies of polygraphy (PG) in diagnosing obstructive sleep apnea syndrome in adults who underwent PSG and PG recording at our center.

Materials and Methods: Patients who underwent cardiorespiratory PG and then PSG at the sleep center with suspicion of sleep apnea syndrome were retrospectively analyzed. Apnea Hypopnea Index (AHI) values were compared. There was a total of 34 patients in the study, 10 females and 24 males.

Results: The mean AHI was 38.3±22.1 in PG and 43.5±27.5 in PSG. No statistically significant difference was found in AHI values between the two tests (p=0.065). In both groups, one (2.9%) patient had a normal AHI value. The AHI ratings of the patients on PLG were 4 (11.8%) mild, 8 (23.5%) moderate, and 21 (61.8%) severe, and on PSG, they were 5 (14.7%) mild, 6 (17.6%) moderate, and 22 (64.7%) severe.

Conclusion: In our study, we found similar AHI values in PG used at home and PSG in the sleep center. When sleep apnea syndrome is suspected, if the PSG appointment in the sleep center is long, or the patient cannot sleep in the sleep center due to the occurrence of a pandemic or other reasons, a PG devices used at home may be preferred.

Keywords: Poligraphy (PG), polisomnography (PSG), obstructive sleep apnea syndrome (OSAS)

Öz

Amaç: Uyku apne sendromu tanısında altın standart uyku merkezinde çekilen polisomnografidir (PSG). Uyku merkezi yatış sırasının uzun olması veya pandemi gibi nedenlerle işlemin yapılamadığı zamanlarda kardiyorespiratuvar poligraf (PG) gibi ev cihazlarının kullanımı gündeme gelmektedir. Merkezimizde farklı günlerde PSG ve PG kaydı yapılan erişkin hasta grubunda, obstrüktif uyku apne sendromu tanısını koymada PG'nin yeterlilik ve eksiklerini araştırmayı hedefledik.

Gereç ve Yöntem: Uyku apne sendromu ön tanısıyla önce kardiyorespiratuVar PG sonrasında Uyku Merkezi'nde yatırılarak PSG çekilen hastalar retrospektif olarak tarandı. Apne Hipopne İndeksi (AHİ) değerleri karşılaştırıldı.

Bulgular: Çalışmada 10 kadın, 24 erkek toplam 34 hasta incelendi. PG'de ortalama AHİ 38,3±22,1 iken PSG'de 43,5±27,5 saptandı. İki test arasında elde edilen AHİ değerleri açısından istatistiksel anlamlı fark yoktu (p=0,065). Her iki grupta da 1 (%2,9) hasta normal AHİ değerine sahipti. PG'de hastaların AHİ derecelendirmesi, 4 (%11,8) hafif, 8 (%23,5) orta, 21 (%61,8) ağırken PSG'de, 5 (%14,7) hafif, 6 (%17,6) orta, 22 (%64,7) ağırdı.

Sonuç: Çalışmamızda evde çekilen kardiyorespiratuvar PG ile uyku merkezi ortamında çekilen PSG'de saptanan AHİ değerlerinin benzer olduğunu bulduk. Uyku apne sendromundan şüphelenildiğinde, uyku merkezinde PSG randevusunun uzun olması, pandemi veya başka nedenlerle hastanın uyku merkezinde yatamadığı durumlarda evde kullanılan kardiyorespiratuvar PG cihazı tercih edilebilir.

Anahtar Kelimeler: Poligrafi (PG), polisomnografi (PSG), obstrüktif uyku apne sendromu (OUAS)

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Introduction

Obstructive sleep apnea syndrome (OSAS) is a sleep-related respiratory disorder caused by anatomic narrowing of the upper airways and/or dysfunction of the upper airway muscles, resulting in inadequate ventilation. A study conducted in our country reported an estimated prevalence of OSAS in patients with symptoms of snoring to be between 0.9% and 1.9%.[1] OSAS is often associated with systemic diseases such as hypertension, cardiovascular diseases, and stroke, and makes an adverse cause-and-effect cycle with metabolic disorders.[2] One of the most significant symptoms, excessive daytime sleepiness, leads to many negative outcomes if not diagnosed and treated, including traffic or workplace accidents and impaired quality of life.[3]

The gold standard diagnostic tool for OSAS is polysomnography (PSG). PSG is an electrophysiologic method performed in sleep centers, where patients usually undergo a full-night stay to assess abnormal respiratory events, movement disorders, or paroxysmal events during sleep. It includes electroencephalography (EEG), electrooculography (EOG), electromyography (EMG), electrocardiography (ECG), nasal cannula, thermistor, thoracic and abdominal movement sensors, pulse oximetry, and simultaneous video recording.[4] Another diagnostic tool recommended by the American Academy of Sleep Medicine (AASM) is cardiorespiratory polygraphy (PG).[5,6] PG includes a nasal cannula, a sensor to record respiratory effort, ECG, and pulse oximetry. It does not include EEG, EMG, or EOG recordings, thus sleep stages cannot be scored, and arousal cannot be assessed. It cannot be used to evaluate paroxysmal nocturnal events or sleep-related movement disorders because it lacks video EEG recording. The recording takes place at the patient's home, and the connection is made by the patient or their relative. An important and positive difference from PSG is that it does not require a sleep center stay.

When there is suspicion of OSAS, the diagnostic and treatment process can take a long time due to the limited number of centers capable of performing PSG and the limited number of beds in these centers. Additionally, the affordability of PG and the fact that it does not require a sleep center stay make it a valuable tool in the diagnostic process. During the COVID-19 pandemic, the long closure of elective centers and patients' reluctance to stay in sleep centers facilitated the use of PG.

In studies comparing PG and PSG for OSAS diagnosis, it has been reported that PG had no deficiency in diagnosing OASA when compared with PSG.[7] However, it is suggested that the inability to determine sleep duration in PG may lead to a lower Apnea Hypopnea Index (AHI).[8] On the other hand, in patients with mild OSAS detected using PG, higher AHI values have been reported when PSG was performed.[9]

During the pandemic, PG use became more prominent in some patients referred with a preliminary diagnosis of OSAS to our sleep center. However, according to the regulations of the social security institution in our country, the use of airway-supporting devices for OSAS treatment requires a PSG test result as a condition for reimbursement. As a result, performing PSG in the same patient became mandatory. In this study, we aimed to retrospectively investigate the adequacy and limitations of PG in OSAS diagnosis in an adult patient group where both PSG and PG recordings were performed at our center.

Materials and Methods

Procedure and Patient Selection

Patient data were retrospectively documented for individuals who visited the Sleep Center of Dokuz Eylül University Hospital between September 2020 and May 2022 with a preliminary diagnosis of OSAS, and who underwent PG followed by PSG. In patients with moderate or severe AHI values detected using PG, the social security institution did not accept the PG test for device provision. In patients with normal and mild AHI values, where OSAS symptoms were significant and PG was considered insufficient, a full-night PSG was performed. Patients aged over 18 years who underwent both PG and PSG with PG recordings longer than 3 hours were included in the study. Patients with severe cardiovascular diseases, daytime hypoxemia, or other sleep disorders such as central hypersomnia and parasomnias were excluded from PG use.[5] The following patient data were recorded: age, sex, Body Mass Index (BMI), comorbidities, and Epworth Sleepiness Scale (ESS) results.

Philips Respironics Alice Night One and ResMed AirView (version 4.37.0-2.0.0) cardiorespiratory PG devices were used. PG recordings included a nasal cannula, pulse oximetry, thoracic and abdominal effort sensors, ECG, and body position monitoring. Philips Respironics or ResMed Embla devices were used for PSG. PSG recordings included nasal cannula, pulse oximetry, ECG, thoracic and abdominal effort, body position, 6-channel EEG (F4-M1, C4-M1, O2-M1, F3-M2, C3-M2, O1-M2), 2-channel EOG, submental EMG, and 2-channel tibialis anterior EMG.

For PG, the following criteria were used for diagnosis: a >90% reduction in nasal airflow for apnea, a ≥30% reduction in nasal airflow with a 3% drop in oxygen saturation for hypopnea.[4] In PSG, the criteria for diagnosis were a >90% reduction in nasal airflow for apnea, a ≥30% reduction in nasal airflow with a 3% oxygen saturation decrease or the presence of an arousal for hypopnea.[4]

The method of connecting the PG was demonstrated to the patients, and the device was placed by the patients or their relatives. The recordings were delivered to the physicians the following day. The data were transferred to the computer. PSG recordings were obtained for a full night. PG and PSG evaluations were manually assessed by two physicians with at least 1 year of sleep medicine training (İ.Ş.Ö., C.A.) and at least one experienced sleep medicine physician (İ.Ö.).

AHI data from both PG and PSG results were evaluated. AHI values were classified as follows: <5 normal, 5-14.99 mild, 15-29.99 moderate, and ≥30 severe OSAS.[5] In patients with a general AHI ≥5, if non-supine AHI <5 and supine AHI ≥5, the diagnosis was considered as position-dependent OSAS.[10]

This study has been approved by the Non-interventional Research Ethics Committee of Dokuz Eylül University (approval number: 2023/20-11, date: 14.06.2023).

Statistical Analysis

In statistical analysis, the SPSS version 22 software was used. Normality distributions were evaluated using the Shapiro-Wilk test. Because the PG AHI and PSG AHI values followed a normal distribution, descriptive statistics were presented as mean and standard deviation (±SD). The frequencies of categorical variables were also reported. The role of the results obtained from PSG and PG in the diagnosis of OSAS was evaluated using the McNemar test for two dependent categorical groups. A p-value of <0.05 was considered statistically significant. The differences in AHI values obtained from PSG and PG for two dependent count data groups were analyzed using the paired t-test. AHI values obtained from PSG and PG were visually represented and interpreted using the Bland-Altman plot.

Results

The PG and PSG results of 34 patients were examined. Ten (29.4%) were female, and 24 (70.6%) were male. The mean age was 48.41±13.1 years, and the mean BMI was 30.6±4.6 kg/m^2. The mean Epworth Score was found as 10.3±6.1. Eleven (32.4%) patients had no comorbid diseases, hypertension was present in 11 (32.4%), three (8.8%) had diabetes mellitus, three (8.8%) had myasthenia gravis, two (5.9%) had hyperlipidemia, one (2.9%) had chronic inflammatory demyelinating polyneuropathy, one (2.9%) had hyperthyroidism, and one (2.9%) had epilepsy.

In both groups, one (2.9%) patient had a normal AHI value. In PG, the AHI classification of the patients was as follows: mild (n=4, 11.8%), moderate (n=8, 23.5%), and severe (n=21, 61.8%). In PSG, five (14.7%) were mild, six (17.6%) were moderate, and 22 (64.7%) were severe. The mean AHI in PG was 38.3±22.1, and in PSG, it was 43.5±27.5. There was no statistically significant difference between the AHI values obtained from the two tests (p=0.065). PG and PSG AHI results were evaluated using Bland-Altman plots, comparing the difference between AHI values and their averages. Upon examining the plot, most values were observed to fall within the confidence interval (1.96*mean ± SD) (Figure 1).

When comparing patients with mild OSAS with those with moderate and severe OSAS, no statistically significant difference was observed (p=0.052). Positional sleep apnea was detected in five patients using PG and in two patients using PSG, but this difference was not statistically significant (p=0.276).

During the recording period, the percentage of time with oxygen saturation below 90% was 19.41±16.8% in PG and 16.05±19.9% in PSG. There was no statistically significant difference between the groups (p=0.24). The results are summarized in Table 1.

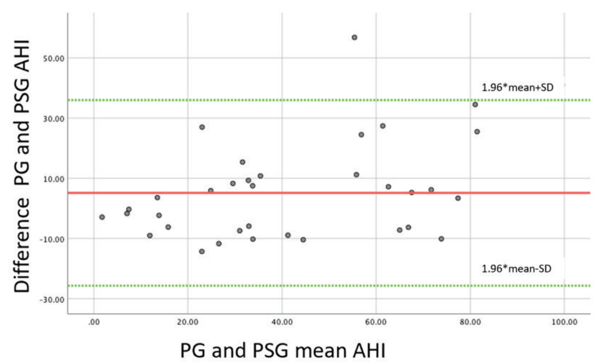

Figure 1. Bland-Altman graph comparing PSG-PLG AHI difference and AHI means

PSG: Polisomnography, PLG: Poligraphy, AHI: Apnea Hypopnea Index, SD: Standard deviation

Table 1. Comparison of polygraphy and polysomnography results			
	Polygraph	**Polysomnograhy**	**p**
Total recording duration (min.)	413.93±98.2	444.62±40.6	0.096
Sleep time (min.)	413.93±98.2 (supposed)	428.14±39.6	
OSAS	33 (97.1%)	33 (97.1%)	
Positional OSAS n (%)	5 (14.7%)	2 (5.9%)	0.276
AHI/hour	38.37±22.1	43.52±27.5	0.065
AHI 0-4.99/hour n (%)	1 (2.9%)	1 (2.9%)	
AHI 5-14.99/hour n (%)	4 (11.8%)	5 (14.7%)	
AHI 15-29.99/hour n (%)	8 (23.5%)	6 (17.6%)	
AHI ≥30/hour n (%)	21 (61.8%)	22 (64.7%)	
Mean SpO_2 (%)	92.47±2.2	92.20±3.8	0.696
SpO_2<90 sleep percentage	19.41±16.8	16.05±19.9	0.24
Average pulse	70.52±15	68.35±10.8	0.49
p<0.05, min.: Minimum, AHI: Apne Hypopnea Index, OSAS: Obstructive sleep apnea syndrome, SpO_2: Oxygen saturation			

Discussion

Although patients frequently present with symptoms such as snoring, breathing pauses during sleep, and excessive daytime sleepiness, the limited number of sleep laboratories and bed availability make it necessary to use PG to reduce the patient load waiting for PSG. During the pandemic, the use of PG became even more widespread because many centers were closed, and patients preferred not to stay in sleep laboratories for diagnosis. Sleep laboratory admission is always more costly and may require patients to sleep in an unfamiliar and less comfortable environment, potentially affecting sleep quality and efficiency. In contrast, PG allows patients to sleep in their home environment.

The use of PG in OSAS diagnosis is recommended by the AASM.[5,6] However, if non-obstructive sleep-related breathing disorders are suspected-such as central apnea, hypoventilation, sleep-related hypoxemia due to severe cardiopulmonary disease, neuromuscular disease causing respiratory muscle weakness, a history of stroke, chronic opioid use, central hypersomnolence, parasomnias, or sleep-related movement disorders-PSG is recommended instead of PG.[5] In our study, there were no patients with severe cardiopulmonary disease, wake-time hypoventilation, sleep-related hypoxemia, or central hypersomnolence/parasomnia history. In the three patients with myasthenia gravis, no hypoxemia or hypoventilation was detected.

Several studies comparing PG and PSG in the diagnosis and treatment of OSAS have demonstrated that PG is a viable option for diagnostic and therapeutic use.[7,8,11,12] Our study showed no significant difference in AHI values between home-based cardiorespiratory PG and PSG conducted in a sleep laboratory ($p=0.065$). A previous study where both PSG and PG were conducted on the same night reported that PG tended to classify mild sleep apnea as more severe and severe sleep apnea as less severe, although the average AHI values remained similar.[13] However, in our study, the number of patients with moderate and severe AHI values was similar between the two groups. No difference was observed between PG and PSG in identifying the presence of OSAS, its severity, or positional dependence.

Study Limitations

Despite its advantages, PG has certain limitations. When patients use PG at home, issues such as improper electrode placement or nasal cannula displacement during the night are not uncommon. An optimal PG recording duration of at least 3 hours is recommended. Generally, AHI values obtained from PG tend to be lower than those from PSG because PG cannot determine exact sleep onset times, leading to an overestimation of total sleep duration. Additionally, PG cannot detect arousal-related hypopneas, which can be identified in PSG. Nerfeldt et al.[9] examined patients with a high clinical suspicion of sleep apnea but normal PG results and found that 64% of these patients had moderate or severe AHI values when assessed using PSG. The inability of PG to detect arousal-related hypopneas was suggested as the reason for this discrepancy. In our study, only one patient had a normal PG result but was diagnosed as having OSAS using PSG.

One major limitation of our study is that PG and PSG were not performed on the same night. Changes in sleep position and deep sleep duration on different nights could affect the results. Additionally, when PSG is conducted after a prior PG recording, the first-night effect may be reduced, even if the initial test was performed using PG. These factors could contribute to variations in AHI values. However, despite these limitations, no significant difference was found between the PG and PSG groups in diagnosing positional OSAS.

Conclusion

In conclusion, when OSAS is suspected, and sleep laboratory admission is delayed due to long waiting times, pandemic conditions, or other reasons preventing in-laboratory sleep studies, home-based cardiorespiratory PG can be used for OSAS diagnosis, considering its limitations.

Ethics

Ethics Committee Approval: This study has been approved by the Non-Interventional Research Ethics Committee of Dokuz Eylül University (approval number: 2023/20-11, date: 14.06.2023).

Informed Consent: Since this was a retrospective study, patient consent was not required.

Footnotes

Authorship Contributions

Concept: İ.Ö., Design: İ.Ö., Data Collection or Processing: İ.Ş.Ö., C.A., Analysis or Interpretation: İ.Ş.Ö., D.M.D., İ.Ö., B.B., Literature Search: İ.Ş.Ö., D.M.D., Writing: İ.Ş.Ö., D.M.D., İ.Ö.

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The Associations between Sleep Problems, Parental Attitudes, and Behavioral Problems in Preschool Children

Okul Öncesi Çocuklarda Uyku Sorunları, Ebeveyn Tutumları ve Davranışsal Sorunlar Arasındaki İlişkiler

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Abstract

Objective: This study aims to examine the relationships between preschool children's sleep characteristics, social competence, behavioral problems, and parental attitudes and focus specifically on how preschool children's sleep mediates the relationship between parental attitudes and children's social competence and behavioral problems.

Materials and Methods: This study's sample consisted of 142 parents of preschoolers. Data were collected using the "Demographic Information Form", "Children's Sleep Habits Questionnaire", "Social Competence" and Behavior Evaluation Scale-30, and Parenting Attitude Scale.

Results: Significant moderate correlations were found between sleep habits, parental attitudes, and children's behavioral-emotional problems. The mediatory role of sleep duration and sleep anxiety of the children between democratic parental attitude and social competence was also significant. The mediators (sleep duration and sleep anxiety) accounted for part of the pathway through which democratic parenting affects social competence.

Conclusion: This study emphasizes the pivotal role of parental attitudes in influencing children's sleep-related difficulties and daytime behavioral problems. Effective management of sleep anxiety and sleep duration in children has the potential to enhance their behavioral and emotional outcomes.

Keywords: Parental attitudes, behavioral problems, sleep problems, preschool

Öz

Amaç: Bu çalışma, okul öncesi çocukların uyku özellikleri, sosyal yeterlilik, davranışsal sorunlar ve ebeveyn tutumları arasındaki ilişkileri incelemeyi amaçlamakta olup, özellikle okul öncesi çocukların uykusunun, ebeveyn tutumları ile çocukların sosyal yeterlilik ve davranışsal sorunları arasındaki ilişkiyi nasıl açıkladığını ele almayı hedeflemektedir.

Gereç ve Yöntem: Bu çalışma kesitsel bir çalışmadır. Çalışmanın örneklemi, okul öncesi eğitime devam eden çocukların 142 ebeveyninden oluşmaktadır. Çalışmada "Demografik Bilgi Formu", "Çocukların Uyku Alışkanlıkları Anketi", "Sosyal Yetkinlik ve Davranış Değerlendirme Ölçeği-30" ve "Ebeveyn Tutum Ölçeği" kullanılmıştır.

Bulgular: Uyku alışkanlıkları, ebeveyn tutumları ve çocukların davranışsal-duygusal sorunları arasında orta düzeyde anlamlı korelasyonlar bulunmuştur. Çocukların uyku süresi ve uyku kaygısının demokratik ebeveyn tutumu ve sosyal yetkinlik arasındaki aracı rolü anlamlıdır. Aracılar (uyku süresi ve uyku kaygısı) demokratik ebeveynliğin sosyal yetkinlik üzerindeki etkisinin bir kısmını açıklamaktadır.

Sonuç: Bu çalışma, ebeveyn tutumlarının çocukların uykuyla ilgili zorluklarını ve gündüz davranış sorunları üzerindeki önemli rolünü vurgulamaktadır. Çocuklarda uyku kaygısı ve uyku süresinin etkin yönetimi, çocukların davranışsal ve duygusal sorunlarını iyileştirme potansiyeline sahiptir.

Anahtar Kelimeler: Ebeveyn tutumları, davranış sorunları, uyku sorunları, okul öncesi

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Introduction

Healthy sleep, which requires proper timing, sufficient duration, and regularity without disturbances, is vital. Sleep problems are frequent in early childhood, affecting approximately 15-43% of children.[1-6] Common sleep difficulties caregivers report include bedtime resistance, trouble staying in bed, and overnight awakenings.[7] A noteworthy study noted that the most problematic behavior reported in infancy was overnight waking, which decreased into middle childhood.[8] A study in Trondheim, Norway, found that 19.2% of children born in 2003 or 2004 experienced sleep problems, with primary insomnia being the most prevalent at 16.6%.[9] Sleep problems often co-occur with psychological conditions like depression and anxiety. Research highlights the significant role of sleep in the brain development and cognitive and emotional growth of preschool-aged children.[10,11] Sleep's impact on early life cognitive functions, such as attention, working memory, and emotional regulation, is well documented.[12-15] Better sleep is linked to superior executive functions in young children.[16] Addressing sleep issues early can thus enhance overall cognitive development.

Earlier research shows a significant link between sleep disturbances and children's daytime behavioral issues. Owens-Stively et al.[17] observed that temperament and sleep disturbances are closely related, primarily influenced by the child's age and behavioral issues. Similarly, Komada et al.[18] found a relationship between short sleep durations and increased aggression in 2-3-year-old children, and between impulsive behaviours and irregular bedtimes and attention problems in 4-5-year-old children. Furthermore, a study by Horiuchi et al.[19] showed higher sleep anxiety and daytime sleepiness in Japanese preschoolers with poor mental health than their peers. Regular sleep routines are essential to reduce behavioral problems.

Parenting styles significantly affect children's psychological outcomes. Baumrind[20] and Maccoby and Martin[21] outlined parenting styles that range from authoritative to neglectful, influencing children's behavior and sleep quality. Adverse parenting styles have been linked to poor sleep and increased psychological problems in adolescents.[22] For younger children, parental discipline and mental health conditions, like depression, anxiety, and aggression, predict sleep difficulties.[23,24] Despite the known impacts of biological, psychological, and social factors, few studies specifically examine the link between preschoolers' sleep patterns and parenting styles.[18,25,26] This gap highlights the need for more focused research in this area.

Several studies have examined the socio-cultural dimensions of children's sleep habits and problems using large, diverse samples. For example, Chinese and Italian children are reported to go to bed later and sleep less than their American counterparts.[27,28] A comprehensive cross-cultural internet study involving 29,287 infants and toddlers from 17 countries analyzed factors affecting parental perception of sleep problems.[29] This study found that Asian parents were more likely to report sleep problems in their children compared to parents from Caucasian countries, with frequent awakenings and long sleep onset latencies being major indicators of severe sleep problems. Specifically, infants and toddlers in Asian countries faced more challenges with sleep initiation and maintenance than those in Caucasian countries.

Additionally, differences in sleep patterns and related behavioral issues exist in Asia among preschoolers. In a study comparing Chinese and Japanese preschool children, sleep-related breathing disorders and daytime sleepiness were associated with emotional and behavioural problems in the Chinese group. In contrast, sleep anxiety and night waking were found to be important factors for such problems in the Japanese group.[30] These findings highlight the impact of both broad cultural and narrower subcultural factors on children's sleep and associated behavioral outcomes. In a recent multicenter cross-sectional study in Türkiye, 2,434 mothers completed an online survey revealing that children generally sleep 11.5 hours, go to bed at 10:00 p.m., and wake twice nightly. Notably, 35.8% reported sleep issues in their children, with increased complaints among more educated mothers.[23] Additionally, 11.5% of children bedshared, and 52.9% room shared. Parenting discipline significantly influences healthy sleep behaviors. Consistent bedtime routines and promoting independent sleep are beneficial, while irregular schedules and excessive parental involvement can lead to sleep problems. These often point to broader behavioural difficulties in setting limits.[31,32] Persistent sleep difficulties also point to deeper problems in the parent-child dynamic related to the following.[33] Empirical evidence shows that sleep problems in young children are common, and addressing this is critical for avoiding short and long-term adverse outcomes.[11] Research has shown that both the quantity and quality of sleep are essential for positive behavioral outcomes and that the link between sleep, behavior, and cognition emerges in the preschool years.[34] Key influences on the development of sleep problems include the parent-child relationship and parenting style. However, few studies have investigated how parenting impacts sleep, children's daytime behavior and emotional difficulties. Most existing research focuses on the effects of family psychopathologies and parental anxiety on children's sleep anxiety and the impact of conditions like attention-deficit/hyperactivity disorder on sleep and parental responses.[25,26,35] Notably, there is a gap in the literature regarding how sleep mediate the relationship between children's behavior and parental styles.

Purpose of the Present Study

This study examines the relationships between preschool children's sleep characteristics, social competence and behavioral problems, and parental attitudes. In particular, this study investigates how preschool children's sleep (including sleep duration and sleep anxiety) mediates the relationship between parental attitudes and children's behavioral problems. The hypothesis was that preschool children's sleep characteristics mediate the relationship between democratic parental attitudes and social competence.

Materials and Methods

Participants

This study's sample consisted of 142 parents (119 mothers, 23 fathers) of healthy preschoolers [64 girls, 78 boys; age ranged=3-7 years, mean age=4.97 years, standard deviation (SD)=0.90]. The participants were selected using a convenient sampling technique from three different kinder gardens in Ankara in Türkiye. Parents completed the questionnaires and voluntarily participated in this quantitative survey by signing informed consent forms. Study data were collected through various methods, including online, paper, and in-person interviews, to ensure a comprehensive and representative sample. This multi-method approach facilitated greater accessibility and engagement from participants, enhancing the reliability and validity of the study findings. This study was approved by the Çankaya University Ethical Committee (approval number: 76373453-605.01/00000035142, date: 16.04.2019). The data were collected between January 2020 and March 2020.

Measures

The Demographic Information Form

Provided information about children's date of birth, age at which they started kindergarten, gender, sleep habits and medical history. Parents' economic status, occupation, and level of education were collected in a structured form.

Children's Sleep Habits Questionnaire (CSHQ)

CSHQ was developed to measure young children's sleep behaviors.[36] The CSHQ is a parent questionnaire comprising 45 items with eight subscales: bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night walking, parasomnias, sleep-disordered breathing, and daytime sleepiness. Higher total scores predict that an individual has a discomposed sleep pattern. The Cronbach alpha's coefficients of the subscales ranged from 0.36 to 0.70. The scale was adapted into Turkish with a Cronbach's alpha coefficient of 0.78.[37]

Social Competence and Behavior Evaluation Scale-30 (SCBE-30)

SCBE-30 was developed by LaFreniere and Dumas[38] to measure young children's behavioral and emotional adaptations. It has 30 items and three subscales, which are social competence, anger-aggression, and anxiety-withdrawal. Cronbach's alpha coefficient for subscales ranged from 0.85 to 0.92. The Social Competence subscale measures the child's ability to interact effectively with peers and adults, including skills in forming friendships, cooperating, and engaging in positive social behaviors. Anger-aggression subscale assesses the child's tendency towards anger and aggressive behaviors, including outbursts, physical aggression, and confrontational actions. The anxiety-withdrawal subscale evaluates signs of anxiety and social withdrawal, such as excessive worry, shyness, and reluctance to engage in social situations. It has been shown that the Turkish version of SCBE-30 has good internal consistency for each subscale: social competence 0.88, anger-aggression 0.87, and anxiety-withdrawal 0.84.[39]

Parenting Attitude Scale (PAS)

PAS measures parents'attitudes when raising children.[40] The scale consists of four subscales as democratic 0.83, authoritarian 0.76, overprotective 0.75 and permissive 0.74 internal consistencies. Democratic reflects parenting characterized by open communication, mutual respect, and shared decision-making between parents and children, promoting a balanced and cooperative relationship. Authoritarian parenting is marked by high demands and low responsiveness, emphasizing strict rules, high control, and little room for the child's input or independence. Overprotective assesses parenting that involves excessive concern and control over the child's activities and experiences, often restricting the child's autonomy and exploration due to fear of potential harm. Permissive indicates a parenting approach with low demands and high responsiveness, where parents are lenient and indulgent, allowing considerable freedom and few rules or expectations.

Statistical Analysis

Statistical analyses were performed by SPSS 25.0 [IBM SPSS statistics 25 software (Armonk, NY: IBM Corp.)] and AMOS 23.0 [IBM SPSS AMOS 23.0 software (Armonk, NY: IBM Corp.)]. Continuous variables were expressed as mean ± SD and median (minimum-maximum values), and categorical variables were expressed as frequencies and percentages. Data were tested for normality using the Kolmogorov-Smirnov test. The spearman correlation coefficient was used for relations between continuous variables, and mediation analysis was carried out using structural equation modeling. For the significance and effects of the variables in the model, we used standardized regression weights (standardized beta values), standard error values, and critical ratios. P-values ≤0.05 was considered statistically significant.

Results

Sample Characteristics

Sample characteristics are presented in Table 1. Our data relied on the reports of the parents of preschoolers. The sample consisted of 142 healthy parents. The education level and age of the parents are presented in Table 1. At the time of the study enrollment, the mean age of the children was between three and seven years (M=4.97, SD=0.91).

Pearson Correlation Coefficients

As shown in Table 2 below, significant moderate correlations were found between parental attitudes and children's behavioral-emotional and sleep problems. Similarly, a group of sleep problems was associated significantly with the children's behavioral-emotional problems.

According to the correlation matrix, there were significant correlation coefficients between overprotective parental attitude and anger aggression ($r=-0.25$, $p<0.05$), social competence ($r=0.34$, $p<0.05$), and night waking

Table 1. Sample characteristics		
	n	%
Children's gender		
Boy	78	54.9
Girl	64	45.1
Children having daytime sleep		
Yes	43	30.7
No	97	69.3
Children's sleep condition		
Fall asleep on their own	80	56.3
Sleeping alone (no room sharing)	44	31.0
Room sharing with a sibling	44	31.0
Sleep at parents' room	18	12.7
Parent's gender		
Mother	119	83.8
Father	23	16.2
Mother's educational level		
Primary school	1	0.7
Middle school	6	4.2
High school	29	20.4
Associate degree	26	18.3
Undergraduate degree	66	46.5
Postgraduate degree	14	9.9
Father's educational level		
Primary school	5	3.5
Middle school	5	3.5
High school	25	17.7
Associate degree	12	8.5
Undergraduate degree	68	48.2
Postgraduate degree	26	18.4
Mother's occupation		
Housewife	81	58.3
Officer	29	20.9
Employee	8	5.8
Self-employment	4	2.9
Retired	1	0.7
Other	16	11.5
Father's occupation		
Unemployed	3	2.1
Officer	50	35.7
Employee	25	17.9
Self-employed	33	23.6
Retired	3	2.1
Other	26	18.6
Economic status		
Low	9	6.4
Moderate	116	82.3
High	16	11.3

($r=-0.34$, $p<0.05$); between authoritarian parental attitude and anger aggression ($r=0.31$, $p<0.05$), anxiety-withdraw ($r=0.38$, $p<0.05$), and social competence ($r=-0.36$, $p<0.05$); between democratic parental attitude and anger aggression ($r=-0.31$, $p<0.05$), anxiety-withdraw ($r=-0.27$, $p<0.05$), social competence ($r=0.43$, $p<0.05$). In addition, daytime sleepiness of the child was positively correlated with anxiety-withdraw ($r=0.31$, $p<0.05$), and was negatively correlated with social competence ($r=-0.28$, $p<0.05$); sleep disordered breathing was positively correlated with anxiety-withdraw ($r=0.28$, $p<0.05$); parasomnias were negatively correlated with social competence ($r=-0.26$, $p<0.05$). Night waking was negatively correlated with both overprotective and permissive parental attitudes respectively ($r=-0.27$ and $r=-0.34$, $p<0.05$). Sleep anxiety was positively correlated with anger aggression ($r=0.30$, $p<0.05$), anxiety-withdraw ($r=0.34$, $p<0.05$), and was negatively correlated with social competence ($r=-0.33$, $p<0.05$). Sleep duration was positively correlated with anxiety-withdraw ($r=0.30$, $p<0.05$), and was negatively correlated with social competence ($r=-0.23$, $p<0.05$).

Mediation Analysis

The mediation models showed that sleep characteristics partially mediated the effects of parental attitudes on children's problematic behavior. Table 3 demonstrates the mediated effect of behavioral sleep problems on children's behavioral difficulties by parenting attitudes. The results indicated that democratic parental scores significantly affected sleep duration, sleep anxiety, and social competence. Sleep anxiety and sleep duration had statistically significant effects on social competence, with sleep anxiety showing a negative impact (Std. $\beta=-0.308$; $p=0.0001$) and sleep duration demonstrating a negative but less significant effect (Std. $\beta=-0.192$; $p<0.05$). As shown in Table 3, democratic parenting scores had a significant negative effect on both sleep anxiety (Std. $\beta=-0.241$; $p<0.05$) and sleep duration (Std. $\beta=-0.394$; $p=0.0001$). Democratic parenting also showed a significant direct positive effect on social competence (Std. $\beta=0.489$). When sleep anxiety and sleep duration were included as mediators, the direct impact decreased to Std. $\beta=0.391$, indicating partial mediation. This suggests that sleep anxiety and duration partially explain the relationship between democratic parenting and social competence. Notably, while democratic parenting was associated with reduced sleep duration, the indirect effect of reduced sleep duration on social competence was small and negative (Std. $\beta=-0.192$; $p=0.049$). These findings underscored the importance of sleep-related factors as partial mediators while maintaining the strong direct effect of democratic parenting on social competence (Figure 1).

Several "goodness-of-fit" statistics were applied to test the proposed models. The model's overall fit was assessed using model-fit metrics, including CMIN/df, CFI, GFI, RMR, SRMR, and RMSEA. For Model 2, all values fell within the acceptable

Table 2. Descriptive statistics and correlations for study variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Anger-aggression	-													
2. Anxiety-withdrawal	0.40**	-												
3. Social competence	**-0.46****	-0.43**	-											
4. Permissive	0.05	0.16	-0.09	-										
5. Overprotective	**-0.25***	0.00	**0.34****	0.15	-									
6. Authoritarian	**0.31****	**0.38****	**-0.36****	**0.25***	-0.12	-								
7. Democratic	**-0.31****	**-0.27***	**0.43****	-0.19	**0.26***	**-0.52****	-							
8. Daytime sleepness	0.22	**0.31****	**-0.28***	0.11	0.04	**0.23***	-0.23	-						
9. Sleep disordered breathing	0.16	**0.28***	-0.15	-0.03	-0.09	0.08	-0.01	**0.27***	-					
10. Parasomnias	0.16	0.22	**-0.26***	-0.12	-0.12	0.10	-0.16	**0.31****	**0.54****	-				
11. Night wakings	0.17	0.06	**-0.23***	**-0.27***	**-0.34****	0.08	-0.05	**0.31****	**0.27****	**0.35****	-			
12. Sleep anxiety	**0.30****	**0.34****	**-0.33****	-0.16	-0.19	0.06	-0.10	**0.39****	**0.20***	**0.23****	**0.40****	-		
13. Sleep duration	0.11	**0.30****	**-0.23***	0.18	0.10	0.19	-0.16	**0.30***	0.09	**0.18***	0.11	0.19*	-	
14. Sleep onset delay	-0.13	-0.18	0.10	-0.02	0.05	-0.18	0.21	**-0.35****	-0.14	-0.09	-0.16	**-0.17***	**-0.32****	-

*p<0.05, **p<0.01

range, indicating a satisfactory fit: CMIN/df=1.41, GFI=0.999, CFI=1.000, RMR=0.107, SRMR=0.0139, and RMSEA=0.0001.

Discussion

Our study revealed a negative correlation between social competence skills and anger-aggression and anxiety-withdrawal levels in early childhood. This result is consistent with previous studies.[41,42] Increased social competence, which governs the use of social skills required in social environments in early childhood, is crucial in reducing internalizing (e.g., anxiety and depression) and externalizing (e.g., hyperactivity and aggression) behaviors.

This study found that democratic parenting is positively correlated with children's social competence and negatively correlated with their anger, aggression, and anxiety withdrawal. In contrast, authoritarian parenting shows the opposite effects. Extensive research, including a meta-analysis of 1,400 studies, indicates that authoritarian parenting, characterized by rigid discipline, is linked to increased externalizing behaviors like aggressiveness and hyperactivity.[34,43,44] Conversely, as democratic parenting increases, children's social competence improves, and internalizing and externalizing behaviors decrease.[45,46] Additionally, overprotective parenting styles negatively correlated with children's anger, aggression, and night awakenings while positively influencing social competence. This finding is inconsistent with Zaidman-Zait and Hall's[47] study findings, which found that overprotectiveness was linked to waking after sleep onset in young children, suggesting that cultural differences may account for these divergent findings.[48] The present study found that sleep anxiety is positively correlated with anger-aggression and anxiety-withdrawal behaviors in children and negatively associated with social competence. Daytime sleepiness and sleep-disordered breathing are also positively linked to anxiety-withdrawal symptoms, while parasomnias negatively impact social competence. Consistent with these findings, a recent study indicated that sleep-disordered breathing and daytime sleepiness in Chinese children were associated with emotion regulation difficulties and behavioral disinhibition.[30] The scientific consensus underscores sleep as vital for child development and crucial for physical and mental health. However, the high prevalence of sleep inadequacy and disorders worldwide poses a significant public health concern.[2] Comparative studies reveal that short sleep durations in 2-to 3-years old are linked to increased aggression, and irregular bedtimes at ages 4 and 5 correlate with heightened aggression and inattention.[18] Cross-sectional research suggests that poor sleep quality and disturbances can elevate behavioral problems in adolescents, and a systematic review highlights that early childhood sleep disorders are significant predictors of developing anxiety, depression, and ADHD later in adolescence.[48,49]

Moreover, our study found that sleep duration and sleep anxiety mediated the effects of democratic parenting on social competence, indicating that parenting styles significantly influence children's anxiety and social skills through mechanisms related to sleep. Authoritarian parents enforce strict obedience, often suppressing children's attempts to assert independence, which can impact their emotional and social development.[20,21] Previous studies show mixed findings on the relationship between parenting styles and children's sleep patterns. Owens-Stively et al.[17] found

Table 3. The investigation of the potential mediating role of sleep duration and sleep anxiety of the children between democratic parental attitude and social competence						
Model 1			**Std. Beta**	**S.E.**	**C.R.**	**P**
Sleep duration	<---	Democratic parental	-0.394	0.017	-3.949	0.0001*
Sleep anxiety	<---	Democratic parental	-0.241	0.029	-2.294	0.022*
Social competence	<---	Democratic parental	0.391	0.11	3.893	0.0001*
Social competence	<---	Sleep duration	-0.192	0.633	-1.965	0.049*
Social competence	<---	Sleep anxiety	-0.308	0.367	-3.333	0.0001*
p<0.05 Statistically significant, Std.Beta: Standardized beta coefficient, S.E: Standard error; C.R: Critical ratio						

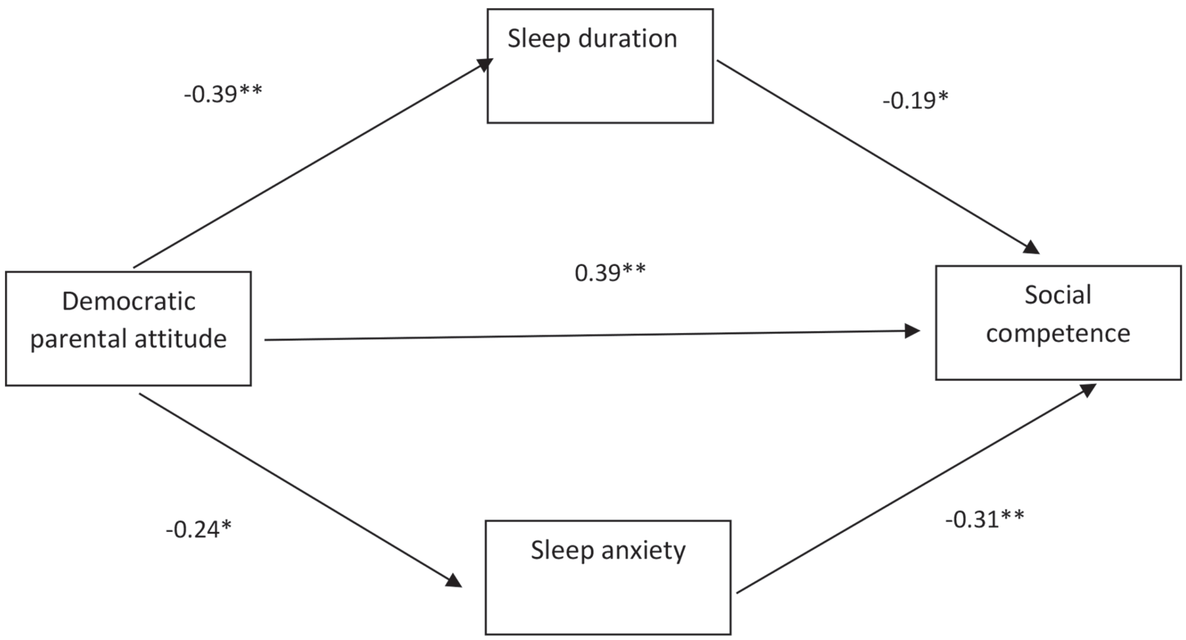

Figure 1. Mediatory role of sleep duration and sleep anxiety of the children between democratic parental attitude and social competence.
*p<0.05, **p<0.001 statistically significant

no correlation between ineffective parental discipline and behavioral sleep problems, and Tyler et al.[26] reported that neither authoritarian nor authoritative parenting styles significantly affected sleep problems. These varying results might be attributed to cultural differences and definitions of authoritarian or ineffective parenting.[50] However, our research indicates that sleep duration and anxiety mediate the relationship between democratic parenting and children's social competence positively. Democratic parenting, which involves warmth, care, and a consultative approach to family decisions, enhances children's sleep duration and reduces sleep anxiety, thereby boosting their social competence. According to Baumrind,[20] democratic parents encourage mature behavior, requiring rule adherence when necessary while maintaining a supportive and empathetic relationship with their children. Another finding, which seems paradoxical, shows an inverse relationship between democratic parenting and sleep duration. In our sample, as sleep duration increased, anxiety-withdraw symptoms also increased. Increased sleep duration in some children may arise from parental overprotective attitudes. Oversleeping can sometimes be associated with overprotection and limited social interaction, harming children's social competence. Excessive sleep can inhibit the development of social skills by affecting the child's physical activity levels and emotional state. On the other hand, democratic parenting appears to affect children's sleep quality positively. This positive effect reflects increased social and behavioral skills needed for successful social adaptation. In a study, researchers examined associations between adolescents' sleep duration, difficulties initiating and maintaining sleep, and three parenting types: parental involvement, parent-child conflict, and parental control. According to the regression analyses, parental control and parent-child conflict predicted adolescent sleep functioning.[51] In another study, variables such as low parental endurance, maladaptive beliefs regarding sleep, and parental interaction during bedtime significantly predicted child sleep problems.[52] In more democratic families, this conflict may be less, closeness may be high, and rules may be explained clearly, increasing sleep quality in this population.

Kohyama argues that sleep acts as "a window on the developing brain"[53], influencing children's emotional, cognitive, and behavioral development.[54-56] Frequent night awakenings and short sleep durations are associated with behavioral problems and learning difficulties. Longitudinal studies show that poor sleep in early years can delay cognitive and language development.[57,58] Kocevska et al.[59] further link atypical sleep durations at age 2 to cognitive delays over 4 years, and sleep problems from ages 2 to 6 correlate with reduced brain development. Recent studies also connect poor sleep with emotional problems and adverse mental health outcomes in preschoolers.[60,19] Addressing these early sleep abnormalities is crucial for preventing long-term developmental impacts, emphasizing the need for early detection and intervention in clinical settings.

Conclusion

Research regarding the influence of parenting styles on children's sleep and subsequent behavior is limited. Authoritarian parenting is linked to higher insomnia symptoms, while flexible and warm discipline is associated with fewer symptoms. Understanding these dynamics can help tailor clinical interventions and assist parents in managing sleep difficulties during critical preschool years. This study's cross-sectional nature limits long-term conclusions. While associations between democratic parenting, sleep duration, sleep anxiety, and social competence can be observed, It is not possible to ascertain the directionality of the relationship. For example, it could be that children with higher social competence have better sleep hygiene, or sleep anxiety may cause changes in parenting style rather than democratic parenting, leading to reduced sleep anxiety or improved social competence. Further research should assess the effects of parental attitudes longitudinally in a larger sample using more objective sleep measures, such as actigraphy, considering the potential biases of parent-reported data collected using online and paper questionnaires.

Ethics

Ethics Committee Approval: This study was approved by the Çankaya University Ethical Committee (approval number: 76373453-605.01/00000035142, date: 16.04.2019).

Informed Consent: The parents voluntarily participated in this quantitative survey by signing informed consent forms.

Footnotes

Authorship Contributions

Concept: N.Y.T., Design: N.Y.T., S.S., H.N.K., Data Collection or Processing: S.S., H.N.K., Analysis or Interpretation: N.Y.T., K.M.K., Literature Search: N.Y.T., S.S., H.N.K., K.M.K., Writing: N.Y.T., S.S., H.N.K., K.M.K.

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Monocyte/HDL Cholesterol Ratio and Matrix Metalloproteinase-2 in Obstructive Sleep Apnea Syndrome Without Heart Disease

Kardiyak Hastalık Öyküsü Olmayan Obstrüktif Uyku Apne Sendromu Hastalarında Serum Monosit/HDL Kolesterol Oranı ve Matriks Metalloproteinaz-2

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Abstract

Objective: Long waiting periods for polysomnography (PSG) may delay the diagnosis of obstructive sleep apnea syndrome. We aimed to assess the value of the serum monocyte/high-density lipoprotein (HDL) cholesterol ratio and matrix metalloproteinase-2 (MMP-2) levels in the early diagnosis and determination of disease severity.

Materials and Methods: This cross-sectional analytical study enrolled 162 adult participants-31 with mild, 38 with moderate, and 47 with severe disease and 46 non-affected controls. The clinical and demographic data and the ratio and MMP-2 levels were recorded and compared.

Results: A ratio >8.78 discriminated between cases with and without the condition, with a 73.3% sensitivity and 60.9% specificity (p=0.004). A serum MMP-2 level ≤4.01 ng/mL was also effective, with a 75% sensitivity and 50% specificity (p=0.012). There was a significant positive correlation between the serum monocyte/HDL cholesterol ratio and disease severity, with a 38% sensitivity and 92% specificity (p=0.025), but an insignificant negative correlation with (MMP-2) level. The ratio, but not MMP-2 level, was significantly higher in affected subgroups than in the controls. Reanalysis of risk factors using a multivariate model revealed that higher HDL and metalloproteinase-2 levels were associated with a decreased likelihood of developing the condition.

Conclusion: Assessment of the serum monocyte/HDL cholesterol ratio and MMP-2 levels may be useful as rapid and low-cost methods for identifying the condition, and the former may help predict disease severity. Evaluation of these parameters may help plan PSG when obstructive sleep apnea is suspected.

Keywords: Cholesterol, matrix metalloproteinase-2, monocytes, obstructive sleep apnea syndrome

Öz

Amaç: Obstrüktif uyku apne sendromu tanısı (OUAS), polisomnografi için uzun bekleme süreleri nedeniyle gecikebilmektedir. Bu çalışmada serum monosit/yüksek dansiteli lipoprotein kolesterol oranı (MHR) ve matriks metalloproteinaz-2 (MMP-2) düzeylerinin erken tanı koyma ve hastalık şiddetini belirlemedeki değerini değerlendirmeyi amaçladık.

Gereç ve Yöntem: Çalışma kesitsel analitik bir çalışma olarak tasarlanmıştır. Çalışmaya 31 hafif, 38 orta ve 47 ağır OUAS hastası ve 46 OUAS olmayan kontrol olmak üzere 162 yetişkin katılımcı dahil edildi. Klinik ve demografik veriler ile MHR ve MMP-2 düzeyleri kaydedildi ve karşılaştırıldı.

Bulgular: MHR >8,78, OUAS ve OUAS olmayan olguları %73,3 duyarlılık ve %60,9 özgüllük ile ayırt etmektedir (p=0,004). Serum MMP-2 düzeyinin ≤4,01 olması OUAS ve OUAS olmayan olguları %75 duyarlılık ve %50 özgüllük ile ayırt etmektedir (p=0,012). Serum MHR ile %38 duyarlılık ve %92 özgüllük (p=0,025) arasında anlamlı bir pozitif korelasyon, serum MMP-2 ile OSAS şiddeti arasında ise anlamsız bir negatif korelasyon (p=0,291) tespit edilmiştir. Medyan MMP-2 seviyeleri OSAS alt grupları ve kontroller arasında benzer olsa da, MHR OSAS alt gruplarında anlamlı derecede yüksektir. Risk faktörlerinin çok değişkenli bir model kullanılarak yeniden analizi, daha yüksek HDL ve MMP-2 düzeylerinin OSAS gelişme olasılığının azalmasıyla ilişkili olduğunu ortaya koymuştur.

Sonuç: MHR ve MMP-2 değerlerinin OSAS hastalarının belirlenmesinde hızlı ve düşük maliyetli yöntemler olarak yararlı olabileceği sonucuna vardık. Ayrıca, MHR hastalığın şiddetini öngörmede yardımcı olabilir. Bu testlerin değerlendirilmesi, OUAS olduğundan şüphelenilen bir hastada PSG testinin planlanmasına yardımcı olabilir.

Anahtar Kelimeler: Kolesterol, matriks metaloproteinaz-2, monositler, obstrüktif uyku apne sendromu

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Introduction

The obstructive sleep apnea syndrome (OSAS) is a serious sleep-related disorder characterized by recurrent breathing pauses during sleep. These pauses lead to deterioration in sleep quality and architecture, oxidative stress, hyperinflammation, increased sympathetic activity, and elevated risk of cardio-cerebrovascular disease.[1,2]

OSAS affects many systems and has negative consequences on the life of the individual.[3] Hypertension, heart failure, pulmonary hypertension, cardiac arrhythmias, coronary artery disease, cerebrovascular disease, and sudden cardiac death may occur.[4] Studies are ongoing to determine the primary cause of OSAS in patients in whom metabolic syndromes and obesity are at the forefront.[5] Decreased cognitive function, attention deficits, and depression are observed in patients with OSAS owing to sleep desaturations.[6] Losses in work-school productivity and an increase in occupational and traffic accidents occur in patients with OSAS.[7] Although OSAS is a prevalent sleep disorder with serious consequences, the diagnosis may be delayed because of the long waiting periods for polysomnography (PSG). There is a need for alternative diagnostic tools for OSAS that allow for faster screening, early diagnosis, and determination of disease severity.

Previous studies have suggested a potential association between oxidative stress and inflammation with high monocyte counts and low serum high-density lipoprotein (HDL) cholesterol levels, emphasizing the monocyte/HDL cholesterol ratio (MHR) as a novel prognostic marker for various cardiovascular diseases.[8-10] Both cardiovascular diseases and oxidative stress are linked to matrix metalloproteinases (MMPs), particularly MMP-2. MMP-2, which is involved in long-term processes (days to weeks), becomes more active within minutes, such as in acute ischemia-reperfusion damage in the heart.[11]

Although the pathogenesis of inflammatory activity in OSAS differs from that in cardiovascular diseases, we suggest that MHR and serum MMP-2 levels may reflect the presence and severity of inflammation regarding upper airway obstruction and oxygen desaturation. In this study, we investigated whether these parameters are associated with the presence and severity of OSAS and, unlike in previous studies, whether they can be helpful in the early diagnosis and determination of disease severity in patients without a history of previously known or detected cardiac disease (all cardiogenic diseases such as valvular diseases, rhythm disorders, inflammatory diseases, or insufficiencies).

Materials and Methods

The study enrolled 162 participants, including 31 patients with mild, 38 with moderate, and 47 with severe OSAS, and 46 non-OSAS controls. The study was approved by the University of Health Sciences Türkiye, Ümraniye Training and Research Hospital Clinical Research Ethics Committee (approval number: 209, date: 23.06.2022). The study included adult patients referred to the University of Health Sciences Türkiye, Sultan 2. Abdülhamid Han Training and Research Hospital Sleep Laboratory between November 29, 2022 and May 4, 2023, who were diagnosed with OSAS based on PSG with an apnea-hypopnea index (AHI)[12] greater than 5. The control group consisted of volunteers without OSAS aged 18 to 65 years, without any cardiac disease and who denied complaints of witnessed apnea, snoring, or excessive daytime sleepiness; the diagnosis of OSAS was excluded based on findings from the Epworth Sleepiness Scale, STOP-BANG, and Berlin questionnaires. Studies have been conducted using the Turkish version of these questionnaires and their reliability has been determined.[13-17] All participants provided voluntary written informed consent. The exclusion criteria included: chronic alcohol use, thyroid dysfunction, malignancy, active infection, history of cardiogenic diseases such as valvular heart disease, history of myocardial ischemia, history of endocarditis-pericarditis, congenital heart disease, heart failure, coronary artery disease, and heart rhythm disorders (atrial fibrillation, history of pacemaker use, and others). Patients on statins and patients with a history of stroke were excluded. PSG could not be performed in the control group owing to the process of PSG examination and load of the currently planned patients. Patients with excessive daytime sleepiness, snoring, or those diagnosed with apnea symptoms were also excluded. Patients with a body mass index (BMI) above 30 were excluded from the study. The ESS, STOP-BANG, and Berlin questionnaires were used, and individuals with a high risk of OSAS were excluded from the study.

Venous blood samples were collected from all groups after 12 h of fasting and analyzed. The samples were analyzed for MMP-2 levels using enzyme-linked immunosorbent assay. The patients with OSAS were classified based on AHI; values between 5 and 15 indicated mild, 16 to 30 indicated moderate, and greater than 30 indicated severe condition.

Statistical Analysis

The data were analyzed using the IBM Statistical Package for the Social Sciences version 23.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as the mean and standard deviation or frequency and percentage, for continuous and categorical data, respectively. For group comparisons, the Mann-Whitney U test was used for two groups and the Kruskal-Wallis H test was used for more than two groups. The Pearson chi-square or Fisher's exact test was used to compare categorical variables. Receiver operating characteristic (ROC) analysis was conducted for parameters that had a discriminative effect on disease diagnosis and severity, and ROC curves were plotted. Logistic regression analysis was used to determine the risk factors affecting the diagnosis of the disease and severe disease. The results were considered statistically significant when the p-value was less than 0.05.

Results

A total of 162 individuals [105 (64.8%) men and 57 (35.2%) women], were included in the study. The median age was 45 (25-62) years. One hundred sixteen of the 162 (71.6%) participants were diagnosed with OSAS. In our cohort, 73.3% (n=85) in the OSAS group and 43.5% (n=20) in the control group were men (p<0.001). The median age was 47 (25-62) years in the OSAS group and 35 (26-59) years in the control group (p<0.001). Among the patients with OSAS, 29% (n=47) were classified with severe, 23.5% (n=38) with moderate, and 19.1% (n=31) with mild disease.

The distribution of demographic characteristics in the control and patient groups is presented in Table 1. Examination of the data revealed statistically significant differences between the two groups in terms of age, sex, weight, BMI, and presence of comorbidities (p<0.05). The proportion of men was higher in the patient group, while the proportion of women was higher in the control group. In addition, the age, weight, and BMI of the patient group were higher than those of the control group. Comorbidities were more common in the patient group. Statistically significant differences were determined between the participants who were included in the control group and who were identified using the ESS, STOP-BANG, and Berlin questionnaires and the patients with OSAS who were identified using PSG.

The median MMP-2 level was significantly lower in the OSAS group [3.4 ng/mL (min.-max., 0.3-14.2) vs. 4 ng/mL (2.3-15.3), p=0.013]. The median MHR was higher in the OSAS group than in the controls [11.7 (4.4-32.1) vs. 8.3 (4.1-29.6), p=0.003] (Table 2).

The median MMP-2 levels were similar between the OSAS subgroups and controls [mild OSAS: 3.4 ng/mL (0.5-9.3), moderate OSAS: 3.5 ng/mL (0.3-14.2), and severe OSAS: 3.3 ng/mL (2.2-13.2); p=0.063]. The MHR was significantly higher in the OSAS subgroups than in the controls [mild OSAS: 10.5 (4.4-16.9), moderate OSAS: 12 (5.1-18), and severe OSAS: 12.4 (6.3-32.1), p=0.002] (Table 3).

Table 1. Distribution of demographic characteristics of the OSAS and control groups

	Control group (n=46)	OSAS group (n=116)	p
	n (%) or median (min.-max.)	n (%) or median (min.-max.)	
Age (years)	35 (26-59)	47 (25-62)	<0.001
Sex			<0.001
Men	20 (43.5)	85 (73.3)	
Women	26 (56.5)	31 (26.7)	
Height (cm)	167 (150-187)	170 (140-189)	0.513
Weight (kg)	70 (50-98)	90 (57-155)	<0.001
BMI	24.7 (18.3-33.6)	31.2 (20.7-58.4)	<0.001
Smoker	7 (15.2)	36 (31)	0.063
Family history	0 (0)	2 (1.7)	1.000
Comorbidity	3 (6.5)	32 (27.6)	0.006
Diabetes mellitus	2 (4.3)	18 (15.5)	0.092
Hypertension	1 (2.2)	23 (19.8)	0.009
Epworth Sleepiness Scale			<0.001
Low risk	40 (87)	44 (37.9)	
High risk	6 (13)	72 (62.1)	
STOP-BANG questionnaire			<0.001
Low risk	38 (82.6)	16 (13.8)	
High risk	8 (17.4)	100 (86.2)	
Berlin questionnaire			<0.001
Low risk	33 (71.7)	18 (15.5)	
High risk	13 (28.3)	98 (84.5)	

BMI: Body mass index, OSAS: Obstructive sleep apnea syndrome, min.-max.: minimum-maximum

Table 2. Comparison of laboratory data between the OSAS and control groups

	Entire group (n=162) median (min.-max.)	OSAS group (n=116) median (min.-max.)	Control group (n=46) median (min.-max.)	p
Monocyte count (/µL)	440 (210-1,030)	440 (210-1,030)	420 (260-850)	0.359
HDL level (mg/dL)	41.5 (20-83)	40 (20-68)	47 (23-83)	<0.001
MHR	10.7 (4.1-32.1)	11.7 (4.4-2.1)	8.3 (4.1-29.6)	0.003
MMP-2 level (ng/mL)	3.4 (0.3-15.3)	3.4 (0.3-14.2)	4 (2.3-15.3)	0.013

OSAS: Obstructive sleep apnea syndrome, MMP-2: Matrix metalloproteinase-2, HDL: High-density lipoprotein cholesterol, MHR: Monocyte/HDL cholesterol ratio, min.-max.: minimum-maximum

Table 3. Comparison of the laboratory data between the OSAS subgroups and controls					
	Mild OSAS (n=31)	Moderate OSAS (n=38)	Severe OSAS (n=47)	Control (n=46)	p
Monocyte count (/µL)	440 (230-680)	440 (210-830)	450 (280-1,030)	420 (260-850)	0.422
HDL level (mg/dL)	42 (26-65)	40.5 (20-68)	38 (24-54)	47 (23-83)	<0.001
MHR	10.5 (4.4-16.9)	12 (5.1-18)	12.4 (6.3-32.1)	8.3 (4.1-29.6)	0.002
MMP-2 level (ng/mL)	3.4 (0.5-9.3)	3.5 (0.3-14.2)	3.3 (2.2-13.2)	4 (2.3-15.3)	0.063

OSAS: Obstructive sleep apnea syndrome, MMP-2: Matrix metalloproteinase-2, HDL: High-density lipoprotein cholesterol, MHR: Monocyte/HDL cholesterol ratio

The ROC curve results for the differentiation effect of MHR and MMP-2 levels in the patients with OSAS and control group are presented in Table 4 and Figure 1.

Regarding MHR, the area under curve (AUC) the ROC value was 65.1%, with a cut-off value >8.78 (p<0.05). Regarding the MMP-2 level, the AUC and cut-off values were 62.5% and ≤4.01 ng/mL, respectively. MHR and MMP-2 were found to have 60-70% accuracy in disease diagnosis.

ROC analysis was further conducted to examine the differential effect of being in the severe OSAS group compared to the moderate or mild group in terms of MHR and MMP-2 measurements. We determined that the cut-off value for MHR was >14.05 (p=0.025). The MMP-2 measurement did not discriminate the severe OSAS group from the moderate or mild group (p=0.025 and 0.291, respectively). We determined that MHR had a weak ability (60-70%) to distinguish severe OSAS from mild or moderate cases. The ROC curve for MHR is shown in Figure 2.

The results of the logistic regression analysis examining the risk factors affecting the development of sleep apnea in the study participants are presented in Table 5. Potential risk factors affecting the development of sleep apnea were first evaluated in the univariate model, and the statistically significant variables were re-evaluated in the multivariate model. In the univariate analysis, all variables included in the model were statistically significant (p<0.05). We determined that each increase in HDL and MMP-2 values had a decreasing effect on disease development, while each increase in the value of the other parameters had the opposite effect. The disease was 3.57 times more likely to develop in men and 5.46 times more likely in individuals with, rather than without, comorbidities.

When the variables found to be significant in the univariate model were re-evaluated in the multivariate model using the retrospective method, sex and MHR were found to be the most appropriate parameters. When the variables were analyzed, it was determined that the disease developed 11.4 times more frequently in men than in women, and each increase in BMI and MHR had an increasing effect on disease development.

Discussion

In OSAS, ischemia-reperfusion injury, increased sympathetic activation, oxidative stress, systemic inflammation, and endothelial dysfunction due to periodic episodes of hypoxia

Table 4. ROC analysis results for MHR and MMP-2							
	AUC (95% CI)	p	Cut-off value	Sensitivity (%)	Specificity (%)	PPV	NPV
MHR	0.651 (0.548-0.753)	0.004	>8.78	73.3	60.9	82.5	47.5
MMP-2 (ng/mL)	0.625 (0.528-0.723)	0.012	≤4.01 ng/mL	75.0	50.0	79.1	44.2

ROC: Receiver operating characteristic curve, AUC: Area under the curve, CI: Confidence interval, NPV: Negative predictive value, PPV: Positive predictive value, MHR: Monocyte/high-density lipoprotein cholesterol ratio, MMP-2: Matrix metalloproteinase-2

Table 5. Investigation of risk factors affecting disease development				
	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p	OR (95% CI)	p
Age	1.11 (1.06-1.16)	<0.001		
Sex				
Men	3.57 (1.75-7.28)	<0.001	11.40 (2.55-50.97)	0.001
BMI	1.50 (1.31-1.72)	<0.001	1.39 (1.17-1.66)	<0.001
Comorbidity	5.46 (1.58-18.85)	0.007		
HDL level (mg/dL)	0.92 (0.89-0.96)	<0.001		
MHR	1.10 (1.01-1.20)	0.026	1.09 (1.05-1.07)	0.007
MMP-2 level (ng/mL)	0.85 (0.76-0.95)	0.005		

BMI: Body mass index, CI: Confidence interval, HDL: High-density lipoprotein, MHR: Monocyte/HDL cholesterol ratio, MMP-2: Matrix metalloproteinase-2, OR: Odds ratio increase the risk of atherosclerosis. Both MMP-2 and MHR have the potential to be important biomarkers for the assessment of inflammation and cardiovascular risk associated with OSAS. According to the results of our study, the MHR and MMP-2 values had a low ability to differentiate between the patient and control groups. Median MMP-2 levels were similar between the OSAS subgroups and controls; in contrast, MHR was significantly higher in the OSAS subgroups (mild, moderate, and severe) than in the controls. The statistically significant variables among the risk factors affecting the development of sleep apnea were re-evaluated in the multivariate model. It was found that as HDL and MMP-2 values increased, the risk of disease development decreased.

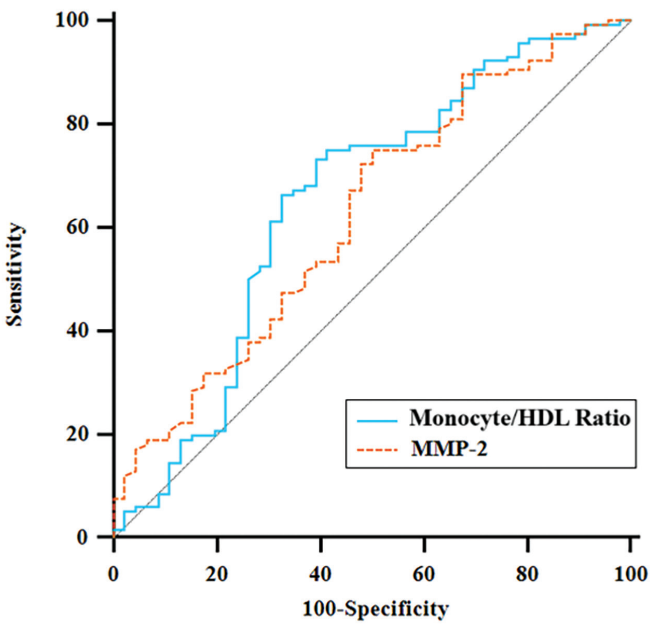

Figure 1. ROC curves for MHR and MMP-2

ROC: Receiver operating characteristic, HDL: High-density lipoprotein, MHR: Monocyte/HDL cholesterol ratio, MMP-2: Matrix metalloproteinase-2

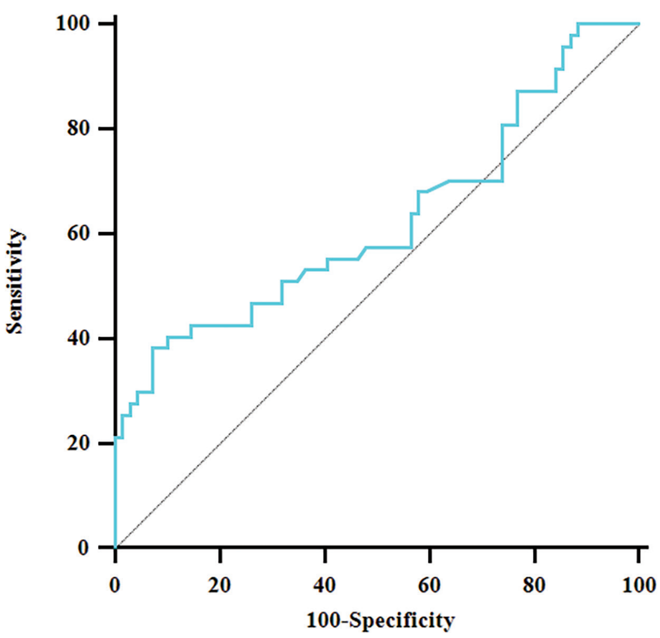

Figure 2. ROC curve for MHR in severe OSAS

ROC: Receiver operating characteristic, MHR: Monocyte/high-density lipoprotein cholesterol ratio, OSAS: Obstructive sleep apnea syndrome

Monocytes are vital immune cells involved in oxidative stress and inflammatory processes. Hypoxia has been shown to increase peripheral blood monocyte counts.[18,19] Sun et al.[20] reported that the monocyte count was similar between patients with OSAS and controls but was significantly higher in the severe OSAS subgroup than in the controls. In our study, the median monocyte count was slightly higher in the OSAS group and subgroups than in the controls but the difference was not statistically significant. This lack of significance was attributed to the small size of the study population, suggesting that different results could be obtained with a larger sample size.

Basoglu et al.[21] reported that the HDL cholesterol levels are lower in patients with OSAS than in those without, and lower in the severe OSAS group than in the other groups. They concluded that non-HDL cholesterol, reflecting atherogenic dyslipidemia, is significantly correlated with the severity of OSAS as well as with parameters reflecting hypoxia. Although our analysis included fewer cases, the results are compatible with those of the earlier study. In addition, since variables such as diet and physical activity affect HDL levels,[22,23] long-term follow-up of participants should be planned.

MHR has been proposed as a predictor that reflects the balance between inflammatory and oxidative stress in monocytes and HDL cholesterol. MHR has been investigated extensively in cardiovascular events and many studies have demonstrated that it is a strong index of cardiovascular mortality in patients with specific diseases, especially coronary artery disease.[24-29]

Sun et al.[20] reported that MHR is higher in OSAS groups than in controls and increases in relation to disease severity. A multicenter study of 1050 cases conducted by Inonu Koseoglu et al.[30] reported that MHR is significantly positively correlated with AHI and the Oxygen Desaturation Index (ODI) and negatively correlated with minimum peripheral oxygen saturation during sleep. Furthermore, MHR is associated with cardiovascular events, and values >14.73 predict the development of a cardiovascular event with 77.9% sensitivity and 59.3% specificity. In a recent study of 172 patients in our country, MHR was positively correlated with the presence of OSAS.[31] In our study, we evaluated patients with OSAS who had not yet developed cardiac comorbidities, and found that MHR was significantly higher in the OSAS subgroups than in the controls and that it increased with disease severity. An MHR >8.78 discriminated between OSAS and non-OSAS cases with 73.3% sensitivity and 60.9% specificity. The threshold value for discriminating severe from mild and moderate OSAS was >14.05, with a 38.3% sensitivity and 92.8% specificity.

This result suggests that the cut-off value pointing to OSAS in individuals without a known cardiac history is lower than that reported in previous studies and increases with disease severity. MMPs are enzymes that play important roles in various physiological and pathological processes, such as organogenesis, wound healing, tumor invasion, and metastasis, which require extracellular matrix remodeling. Gelatinase A (MMP-2) and B (MMP-9) belong to the group of gelatinases of this family.[32] MMP-2 and MMP-9 are involved in extracellular matrix degradation and intimal remodeling after angioplasty and play an important role in the pathogenesis of re-stenosis. Inflammation and oxidative stress contribute to plaque formation and destabilization by increasing MMP activity. MMP-2 is closely associated with cardiovascular events through its rapid activation in both long-term processes and acute ischemia-reperfusion injury. The expression of MMP-2 in cells is unique among the MMPs. Unlike other MMPs, MMP-2 does not appear to be particularly sensitive to stress stimuli.[33] MMP-2 is known to increase in cardiovascular events but the information on MMP-2 in OSAS is limited. Although one study found no association between MMP-2 and OSAS severity, Volná et al.[34] found that MMP-2 levels were similar between the OSAS group and controls.

In 2016, Bonanno et al.[35] investigated the levels of relaxin-2 (a hormone increased during pregnancy) in 50 men men patients with OSAS without a history of cardiovascular disease, and revealed that although the relaxin level was similar in the two groups, the MMP-2 level-which is controlled by relaxin-2 release-decreased significantly as OSAS severity increased. The effectiveness of this molecule in OSAS will be better understood in future research.

Two studies found elevated MMP-2 levels in OSA. In 2016, Hopps et al.[36] conducted a study of 48 patients with OSAS and 31 controls to investigate the relationship between gelatinase levels and OSAS and found a statistically significant increase in MMP-2 values in OSAS. In addition, when grouped according to disease severity, a statistically significant positive correlation was observed between MMP-2 levels and OSAS subgroups. Compared to that study, our study included a larger patient group.

Franczak et al.[11] compared the MMP-2 level in 124 patients with OSAS (58% men) and 26 controls (46% men) and reported a positive correlation between MMP-2 level and OSAS severity. However, the authors did not exclude the patients with a history of cardiovascular disease. Unlike that study, we investigated whether MMP-2 was associated with the presence and severity of OSAS in a group of patients without any history or diagnosis of cardiac disease (all cardiogenic diseases, including valvular diseases, rhythm disorders, inflammatory diseases, and insufficiencies) and whether it can help in the early diagnosis and assessment of disease severity. In contrast to the previous results, we revealed a negative correlation, which may be due to the younger age and men predominance in our OSAS group (73.3%) and the exclusion of patients with cardiac diseases. We suggest that, in OSAS, as the intensity of inflammation increases, MMP-2 levels are suppressed. Increased oxidative stress may also contribute to the modification of MMP-2 levels. The imbalance between MMP-2 and tissue inhibitors in this group can be observed in tissue reshaping and repair.

In our population of patients with OSAS aged 65 years or younger without a history of known cardiovascular system pathology, such as valvular heart disease, cardiomyopathies, or coronary artery disease, the MMP-2 levels were found to be low compared to those in our healthy control group who were thought not to have OSAS based on anamnesis, clinical findings, and questionnaires. In this sense, our study suggests that MMP-2 and monocyte/HDL control levels may be acceptable as early discriminatory criteria in patients younger than 65 years without cardiovascular system pathology in areas where access to PSG is difficult.

Study Limitations

Our study had a few limitations. A major limitation was the inability to perform PSG in the control group. PSG was not planned for the non-OSAS group to avoid prolonged PSG admission times in the community. Second, as the study was planned in a single center, the sample size was small. Further multicenter studies with more patients may help assess the cut-off levels for discriminating between OSAS and non-OSAS populations.

Conclusion

We conclude that the HDL, MHR, and MMP-2 values may be useful as rapid and low-cost methods for identifying individuals with and without OSAS. HDL and MHR may also be important in determining disease severity. Evaluation of these parameters may help plan PSG in individuals suspected of having OSAS.

Ethics

Ethics Committee Approval: University of Health Sciences Türkiye, Ümraniye Training and Research Hospital Clinical Research Ethics Committee (approval number: 209, date: 23.06.2022).

Informed Consent: All participants provided voluntary written informed consent.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: G.K., B.Ş., Ş.B., T.Ç., Concept: G.K., B.Ş., Ş.B., T.Ç., Design: G.K., B.Ş., Ş.B., T.Ç., Data Collection or Processing: G.K., B.Ş., Ş.B., T.Ç., Analysis or Interpretation: G.K., B.Ş., Ş.B., T.Ç., Literature Search: G.K., B.Ş., Ş.B., T.Ç., Writing: G.K., B.Ş., Ş.B., T.Ç.

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Determining the Priority of Polysomnography in Obstructive Sleep Apnea Syndrome

Obstrüktif Uyku Apne Sendromunda Polisomnografi Önceliğinin Belirlenmesi

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Abstract

Objective: The growing awareness of obstructive sleep apnea syndrome (OSAS) has resulted in a backlog in sleep laboratories. This study aimed to assess the severity of OSAS using anthropometric and cardiac parameters before polysomnography (PSG), helping to prioritize patients for PSG.

Materials and Methods: In this cross-sectional study, 91 patients with OSAS symptoms were included from an accredited sleep laboratory in a research hospital. Demographic and clinical data, including body mass index (BMI) and neck circumference (NC), were collected. The Epworth Sleepiness Scale (ESS) was used to assess sleepiness, while transthoracic echocardiography measured cardiac parameters, including maximal pulmonary artery pressure (PAP maximum), interventricular septum thickness (IVST), aortic root diameter (ARD), right atrium diameter (RAD), and B-type natriuretic peptide (BNP) levels. Based on PSG results, patients were categorized into non-OSAS/mild OSAS [Apnea-hypopnea Index (AHI) <15] or moderate/severe OSAS (AHI ≥15) groups. Data were analyzed using SPSS software.

Results: Of the 91 patients, 49 were in the moderate/severe OSAS group and 42 in the non-OSAS/mild OSAS group. Statistically significant differences were observed between the groups regarding ESS, BMI, NC, BNP, IVST, ARD, RAD, and PAP max ($p<0.05$). Cut-off values were determined for each parameter. Multivariate logistic regression analysis showed that BMI, PAP max, and BNP were significant predictors of OSAS severity ($p<0.05$).

Conclusion: BMI, BNP, and PAP max were identified as the key parameters in predicting OSAS severity. These factors can be used to prioritize patients for PSG, improving the efficiency of diagnosis and treatment.

Keywords: Obstructive sleep apnea syndrome, Epworth Sleepiness Scale, anthropometric measurements, B-type natriuretic peptide, echocardiography

Öz

Amaç: Obstrüktif uyku apne sendromu (OUAS) konusunda artan farkındalık, uyku laboratuvarlarında yığılmaya neden olmuştur. Bu çalışmanın amacı, polisomnografi (PSG) öncesinde antropometrik ve kardiyak parametreleri kullanarak OUAS'nin ciddiyetini değerlendirmek ve PSG için hastalara öncelik verilmesine yardımcı olmaktır.

Gereç ve Yöntem: Bu kesitsel çalışmaya, bir araştırma hastanesindeki akredite bir uyku laboratuvarından OUAS semptomları olan 91 hasta dahil edildi. Vücut kitle indeksi (VKİ) ve boyun çevresi (NC) dahil olmak üzere demografik ve klinik veriler toplandı. Uykululuk halini değerlendirmek için Epworth Uykululuk Ölçeği (ESS) kullanılırken, transtorasik ekokardiyografi ile pulmoner arter basıncı (PAP maksimum), interventriküler septum kalınlığı (IVST), aort kökü çapı (ARD), sağ atriyum çapı (RAD) ve b-tipi natriüretik peptid (BNP) düzeyleri gibi kardiyak parametreler ölçüldü. PSG sonuçlarına göre hastalar OUAS olmayan/hafif OUAS [Apne-hipopne İndeksi (AHİ) <15] veya orta/ağır OUAS (AHİ) ≥15 gruplarına ayrıldı. Veriler SPSS yazılımı kullanılarak analiz edildi.

Bulgular: Doksan bir hastanın 49'u orta/ağır OUAS grubunda ve 42'si OUAS olmayan/hafif OUAS grubundaydı. Gruplar arasında ESS, VKİ, NC, BNP, IVST, ARD, RAD ve PAP maks açısından istatistiksel olarak anlamlı farklılıklar gözlendi ($p<0,05$). Her parametre için kesme değerleri belirlenmiştir. Çok değişkenli lojistik regresyon analizi VKİ, PAP maks ve BNP'nin OUAS şiddetinin anlamlı belirleyicileri olduğunu gösterdi ($p<0,05$).

Sonuç: VKİ, BNP ve PAP maks, OUAS şiddetini öngörmede anahtar parametreler olarak tanımlanmıştır. Bu faktörler PSG için hastalara öncelik vermek için kullanılabilir ve tanı ve tedavinin etkinliğini artırabilir.

Anahtar Kelimeler: Obstrüktif uyku apne sendromu, Epworth Uykululuk Ölçeği, antropometrik ölçümler, b-tipi natriüretik peptid, ekokardiyografi

Introduction

Obstructive sleep apnea syndrome (OSAS) is a sleep disordered breathing condition characterized by recurring episodes of apnea (complete cessation of breathing) and hypopnea episodes (insufficient breathing) due to collapses in the upper airway during sleep. These episodes of apnea and hypopnea occur repeatedly throughout sleep, disrupting sleep quality and leading to oxygen desaturation.[1,2]

OSAS is not only a problem that affects the quality of sleep of an individual but also a serious public health issue that directly

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impacts public health, work, and traffic safety. Especially in professional drivers, OSAS poses a significant threat to traffic safety. Lack of restful sleep causes excessive daytime sleepiness, negatively affecting driving performance and increasing the risk of accidents. Studies have shown that professional drivers are at a higher risk of OSAS than the general population. For example, while 26% to 50% of professional drivers are at risk of OSAS, this figure is only about 3% to 7% in the general adult population, highlighting the critical need for early detection and effective management of the disease in professional drivers.[2-4]

In OSAS cases, overcoming episodes of apnea and hypopnea episodes during sleep leads to increased breathing effort, resulting in increased negative intrathoracic pressure. Consequently, this increase in negative intrathoracic pressure affects the cardiovascular system, leading to severe cardiac complications such as right heart failure.[5,6] Furthermore, increased breathing effort disrupts sleep architecture, preventing the individual from achieving deep and restful sleep, which results in symptoms such as excessive daytime sleepiness, concentration problems, and fatigue.[7,8]

Over time, these negative pathophysiological processes affect mental and physical health in multiple ways, leading to a complex set of complications, including hypertension, cardiovascular diseases, type 2 diabetes, obesity, stroke, and even sexual dysfunction.[9,10] Long term, structural cardiac changes detectable by echocardiography (ECHO) and an increase in B-type natriuretic peptide (BNP) levels, a biochemical marker of cardiac load, are observed.[11,12]

The diagnosis of OSAS begins with the evaluation of excessive sleepiness during the day.[13] Furthermore, factors such as advanced age, male, obesity, large neck circumference (NC), retrognathia, and tonsillar hypertrophy are important risk factors for OSAS.[14,15] The presence of hypertension and other metabolic-cardiovascular comorbidities in a patient with OSAS symptoms may suggest the likelihood of a severe and complicated case of OSAS.[16] After completing all clinical, anthropometric, and laboratory evaluations, polysomnography (PSG) is the ultimate test requested to diagnose and determine the severity of OSAS. However, due to insufficient sleep laboratories and increasing demand, waiting times for PSG appointments range from 3 to 12 months in many countries. These long waiting periods may prevent moderate and severe cases of OSAS from receiving effective treatment on time, leading to the progression of the disease, worsening health conditions, and negatively impacting public health by posing risks to work and traffic safety. This situation has created the need to classify moderate and severe OSAS cases for priority PSG performing.[17-19]

Our study aims to evaluate the predictive ability of the Epworth Sleepiness Scale (ESS), anthropometric measurements, serum BNP levels, and ECHO parameters to identify moderate and severe cases of OSAS before PSG.

Materials and Methods

This study included 91 patients who underwent PSG testing at the accredited sleep laboratory of a training and research hospital. The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of İstanbul Göztepe Training and Research Hospital (current: Göztepe Prof. Dr. Süleyman Yalçın City Hospital) (approval number: 54/A, date: 10.02.2009) and informed consent was obtained from all participants.

Patient Selection

The study included patients aged between 18 and 65 years old who had no known chronic respiratory, cardiovascular, or metabolic comorbidities and who gave informed consent for the research. Patients with a known history of respiratory, cardiovascular, or metabolic diseases, pregnant women, those outside the 18-65 age range, or those who did not provide informed consent were excluded from the study.

Physical Examination, Anthropometric Measurements, and Blood Sampling

The age, sex, and smoking history (pack-year) of all patients were recorded, and the Turkish-adapted ESS was administered. Body mass index (BMI) and NC were observed. Blood samples from all cases were collected in EDTA tubes before getting out of bed on the morning of the PSG study duo to minimize individual variations, and serum BNP levels were analyzed using the minividas device (Biomerieux, France) via an enzyme-linked fluorescence assay method. To further reduce variability, the arterial blood pressure of each patient was manually measured on the morning of the PSG study using an Erka-brand sphygmomanometer applied to the right arm before getting out of bed.

Echocardiography

ECHO was performed on all patients in the left lateral decubitus position at a 45° angle at rest. To minimize individual variability, a single cardiologist performed M-mode, two-dimensional, and colour flow doppler recordings using Siemens Acuson Sequoia C256 and GE Vivid 3 ECHO devices. The following ECHO parameters were measured and recorded: left ventricular end-systolic and end-diastolic volumes (LV-ESV and LV-EDV), left ventricular ejection fraction (LV-EF), left atrium diameter (LAD), left ventricular end-systolic and end-diastolic diameters (LV-ESD and LV-EDD), right atrium diameter (RAD), interventricular septum thickness (IVST), aortic root diameter (ARD), and maximal pulmonary artery pressure (PAP max).

Polysomnography

PSG was recorded using the Grass-Telefactor Comet device by a certified sleep technician and evaluated by a pulmonologist experienced in diagnosing and treating sleep-related breathing disorders, according to current guidelines of the American Academy of Sleep Medicine. The patients in our study were divided into two groups according to their Apnea-hypopnea Index (AHI). The patients with an AHI ≥15 were classified as moderate/severe OSAS cases, while those with an AHI <15 were classified as non-OSAS or mild OSAS cases.

Statistical Analysis

Data from both groups were analyzed using IBM Statistical Package for the Social Sciences for Windows 29.0 (IBM

Corp., Armonk, NY). The following parameters were compared between the two groups: age, sex, smoking status, systolic blood pressure (SBP), diastolic blood pressure (DBP), ESS, BMI, NC, BNP, IVST, ARD, RAD, LV-ESD, LV-EDV, LV-ESV, LV-EDD, LV-EF%, LAD, and PAP max. Descriptive statistics were presented as frequencies and percentages for categorical variables and as means and standard deviations for continuous variables. An independent samples t-test was used to compare the two groups, and the Pearson chi-square test was used for categorical variables. The Youden Index formula was used to determine the optimal cut-off points in the receiver-operating characteristic (ROC) curve analysis:

Youden Index = Sensitivity + specificity-1

Thus, the cut-off points showing the best performance in sensitivity and specificity were identified. The statistical significance of the results was accepted at a p-value <0.05.

Results

Of the 91 cases included in the study, 72.5% (n=66) were male, and 27.5% (n=25) were female. The mean age was 46.03 years (standard deviation=9.27), with an age range of 28 to 67 years. While 45.1% (n=41) of the cases were in the group of "non-OSAS or mild OSAS", 54.9% (n=50) were in the moderate and severe OSAS groups.

In the analysis of the mean values of the two OSAS groups, significant differences were found between the ESS, BMI, NC, BNP, and SBP parameters (p<0.05). Furthermore, significant differences in echocardiographic parameters, were observed, including measurements of IVST, ARD, PAP max, and left LV-ESD between the two groups (p<0.05). However, there were no significant differences in age, smoking status, DBP, LV-EDV, LV-ESV, LAD, and LV-EF% values between the two groups (p>0.05) (Table 1).

The results of the Spearman correlation analysis revealed significant correlations between OSAS severity and various parameters. Among the non-PSG parameters, serum BNP, BMI, and PAP max values strongly correlated with OSAS severity (r=0.650-0.676, p<0.001). Another anthropometric measurement, NC, and the ECHO parameters, ARD and IVST, showed moderate positive correlations (r=0.469-0.541, p<0.001). RAD and ESS showed moderate correlations with OSAS severity (r=0.428 and 0.444, p<0.001), whereas SBP and LV-ESD showed lower but statistically significant correlations (p<0.05). DBP and other echocardiographic parameters did not correlate significantly (Table 2).

Logistic regression analysis evaluated the cumulative effect of the parameters that showed correlations in predicting OSAS severity. BMI (p=0.033), BNP (p=0.049), and PAP max (p=0.031) were found to have statistically significant performance in

Table 1. Statistical analysis of the differences between the mean of continuous variables between the non-OSAS and mild OSAS group and the moderate OSAS and severe OSAS groups

Parameter	Mann-Whitney U	Wilcoxon W	Z value	2-Way P
BMI (kg/m²)	240.000	1101.000	-6.262	0.001
PAP max (mmHg)	252.500	1113.500	-6.162	0.001
BNP (pg/mL)	221.000	1082.000	-6.413	0.001
NC (cm)	385.500	1246.500	-5.134	0.001
IVST (cm)	498.500	1359.500	-4.447	0.001
ARD (cm)	466.000	1327.000	-4.470	0.001
RAD (cm)	518.500	1379.500	-4.060	0.001
ESS	498.000	1359.000	-4.216	0.001
SBP (mmHg)	676.500	1537.500	-2.822	0.005
LV-ESD (cm)	760.000	1621.000	-2.141	0.032
LV-EDV (mL)	828.000	2103.000	-1.572	0.116
Age (year)	851.000	1712.000	-1.389	0.165
Smoking (pack year)	871.500	2146.500	-1.246	0.213
DBP (mmHg)	891.500	1752.500	-1.102	0.270
LV-ESV (mL)	879.000	2154.000	-1.165	0.244
LV-EDD (cm)	865.500	1726.500	-1.278	0.201
EF (%)	975.500	1836.500	-0.395	0.693
LAD (cm)	1007.500	1868.500	-0.141	0.888

p<0.05 was considered statistically significant.

BMI: Body mass index, PAP max: Maximal pulmonary arterial pressure, BNP: B-type natriuretic peptide, NC: Neck circumference, IVST: Interventricular septum thickness, ARD: Aortic root diameter, RAD: Right atrium diameter, ESS: Epworth sleepiness scores, SBP: Systolic blood pressure, LV-ESD: Left ventricle end systolic diameter, LV-EDV: Left ventricle end diastolic volume, DBP: Diastolic blood pressure, LV-ESV: Left ventricle end systolic volume, LV-EDD: Left ventricle end diastolic diameter, EF: Ejection fraction, LAD: Left atrium diameter, OSAS: Obstructive sleep apnea syndrome determining OSAS severity. Each unit increase in BMI was found to increase the likelihood of OSAS severity by 9.56 times (odds ratio=9.563). On the contrary, increases in BNP and PAP max values increased OSAS severity 1.16 and 4.48 times, respectively. Other parameters, including ESS, NC, SBP, LV-ESD, ARD, IVST, and RAD, did not show significant performance in this model (p>0.05) (Table 3).

ROC curve analysis determined the highest sensitivity and specificity parameters to predict the severity of OSAS using the Youden Index. The optimal cut-off value for BNP was calculated to be 27.07 pg/mL, with 94% sensitivity and 75.6% specificity. A 31.2 kg/m^2 cut-off value for BMI provided 82% sensitivity and 78% specificity. For PAP max, a cut-off value of 21.27 mmHg provided 94% sensitivity and 58.5% specificity.

Table 2. Spearman correlation coefficient and correlation directions of data between non-OSAS and mild

Parameter	Spearman correlation coefficient (rho)	2-way p-value
BNP (pg/mL)	0.676	0.001
BMI (kg/m^2)	0.660	0.001
PAP max (mmHg)	0.650	0.001
NC (cm)	0.541	0.001
ARD (cm)	0.471	0.001
IVST (cm)	0.469	0.001
ESS	0.444	0.001
RAD (cm)	0.428	0.001
SBP (mmHg)	0.297	0.004
LV-ESD (cm)	0.226	0.032

p<0.05 was considered statistically significant.

BNP: B-type natriuretic peptide, BMI: Body Mass Index, PAP max: Maximal pulmonary arterial pressure, NC: Neck circumference, IVST: Interventricular septum thickness, ARD: Aortic root diameter, RAD: Right atrium diameter, ESS: Epworth sleepiness scores, SBP: Systolic blood pressure, LV-ESD: Left ventricle end systolic diameter, OSAS: Obstructive sleep apnea syndrome

Among other variables, NC, ARD, IVST, and ESS performed less in the ROC analysis (Table 4). LV-ESD and SBP showed limited sensitivity and specificity values.

Discussion

In our study, serum measurements of BNP, BMI, and PAP max were paramount in determining moderate and severe cases of OSAS and prioritizing PSG.

Excessive daytime sleepiness, the primary symptom of OSAS, is typically evaluated using the ESS in clinical practice. An ESS score of 11 or higher indicates-OSAS risk, and PSG is recommended.[3,8] Our study found a cut-off value of 11 for ESS, which was 70% sensitivity and 65.9% specificity in predicting moderate and severe OSAS. In a study by Walker et al.[14] ESS was highlighted as an effective tool for detecting daytime sleepiness symptoms of OSAS. However, it was noted that ESS is a subjective assessment tool and should be supported by more objective diagnostic methods. In our study, ESS did not perform significantly in the multivariate regression model, which supports the notion that, as a subjective measure, ESS provides a limited contribution to determining OSAS severity, which aligns with the literature.

In our study, BMI and NC were found to have significant correlations with OSAS severity as anthropometric measurements. When the cut-off value for BMI was established at 31.2 kg/m^2, 82% sensitivity and 78% specificity were achieved. BMI demonstrated significant performance in predicting moderate and severe OSAS cases in the multivariate regression model. Although NC had a cut-off value of 38.5 cm, with 76% sensitivity and 70.7% specificity, it did not show significant performance in predicting moderate and severe OSAS cases in the multivariate regression model. In the literature, Dong et al.[15] found a strong relationship between obesity, overweight status, and OSAS. In a systematic review and meta-analysis, 12 case-control studies were examined, and data from 3.214 participants were analyzed. The findings revealed that an increase in BMI significantly increases the risk of OSAS in both

Table 3. Evaluation of factors affecting OSAS severity by logistic regression analysis

Variable	B	S.E.	Wald	p	Exp (B)
PAP max (mmHg)	1.5	0.695	4.665	0.031	4.484
BMI (kg/m^2)	2.258	1.06	4.541	0.033	9.563
BNP (pg/mL)	0.15	0.076	3.859	0.049	1.162
NC (cm)	-1.546	0.886	3.044	0.081	0.213
SBP (mmHg)	0.12	0.082	2.134	0.144	1.127
LV-ESD (cm)	4.783	4.456	1.152	0.283	119.484
ARD (cm)	-1.28	2.105	0.37	0.543	0.278
IVST (cm)	10.255	17.3	0.351	0.553	28428.13
RAD (cm)	-1.926	5.309	0.132	0.717	0.146
ESS	-0.003	5.309	0.132	0.989	0.997

p<0.05 was considered statistically significant.

PAP max: Maximal pulmonary arterial pressure, BMI: Body Mass Index, BNP: B-type natriuretic peptide, NC: Neck circumference, SBP: Systolic blood pressure, LV-ESD: Left ventricul end systolic diameter, ARD: Aortic root diameter, IVST: Interventricular septum thickness, RAD: Right atrium diameter, ESS: Epworth sleepiness scores, OSAS: Obstructive sleep apnea syndrome, S.E.: Standard error

Table 4. OSAS weight and AUC values of associated variables					
Test result variables	**Cut-off**	**Sensitivity (%)**	**Specifity (%)**	**AUC**	**p value**
BNP (pg/mL)	27.07	94	75.6	0.892	0.001
BMI (kg/m^2)	31.2	82	78	0.883	0.001
PAP max (mmHg)	21.27	94	58.5	0.877	0.001
NC (cm)	38.5	76	70.7	0.812	0.001
ARD (cm)	2.85	92	46.3	0.773	0.001
ESS	11	70	65.9	0.757	0.001
IVST (cm)	1.05	54	82.9	0.757	0.001
RAD (cm)	3.75	92	48.8	0.747	0.001
SBP (mmHg)	122.5	62	63.4	0.670	0.005
LV-ESD (cm)	2.7	98	34.1	0.629	0.035

p<0.05 was considered statistically significant.

BNP: B-type natriuretic peptide, BMI: Body Mass Index, PAP: Pulmonary arterial pressure, NC: Neck circumference, ARD: Aortic root diameter, ESS: Epworth sleepiness scores, IVST: Interventricular septum thickness, RAD: Right atrium diameter, SBP: Systolic blood pressure, LV-ESD: Left ventricle end systolic diameter, OSAS: Obstructive sleep apnea syndrome, AUC: Area under the curve

adults and children. However, severe OSAS cases can also be observed in individuals who are not obese or who do not have thick NC due to genetic factors and clinical conditions affecting upper airway muscle tone. This multifactorial nature of OSAS risk may explain why NC did not perform significantly in our study's multivariate regression model.

BNP was identified as one of the most decisive parameters for predicting OSAS severity, providing 94% sensitivity and 75.6% specificity with a cut-off value of 27.07 pg/mL in the ROC analysis. A meta-analysis by Wu et al.[16] reported that continuous positive airway pressure therapy reduced NT-pro-BNP levels, lowering cardiovascular risks. A review article by Lee and Sundar[19] also highlighted the role of biomarkers such as BMI, NC, and BNP in diagnosing OSAS. BNP is considered an essential marker in evaluating the cardiovascular effects of OSAS and should be considered in managing treatment and follow-up.[17] Our study supports the literature by showing that BNP and other parameters contribute to PSG triage for moderate and severe OSAS cases.

The relationship between ECHO parameters and OSAS severity is particularly notable in severe cases where chronic structural cardiac changes have developed. In the pathophysiology of OSAS, repeated episodes of apnea and hypopnea cause changes in intrathoracic negative pressure, leading to increased cardiac preload and resulting in respiratory failure and pulmonary hypertension.[5,6,11,12] In their study, Malhotra et al.[20] emphasized that while the AHI is commonly used to assess the severity of OSAS, alternative metrics, such as cardiopulmonary load indicators, are also beneficial for this assessment.

In this context, PAP max values measured by standard chest ECHO emerged as a significant parameter for predicting the severity of OSAS, providing 94% sensitivity and 58.5% specificity with a cut-off value of 21.7 mmHg in our study. In a study published by Chetan et al.[21] it was suggested that right ventricular dysfunction in OSAS cases could be associated with parameters such as aortic ARD and RAD and that 3D speckle tracking ECHO (3D-STE) could be a sensitive method to evaluate right ventricular functions to determine OSAS severity. In our study, the measurements of ARD, RAD, and IVST showed significant correlations with OSAS severity; however, they were insufficient to predict the severity of OSAS in the multivariate logistic regression model, probably due to the exclusion of cases with known cardiovascular disease and the use of standard chest ECHO for cardiac measurements.

When examining the pathophysiology of OSAS, hypertension has been reported to lead to impaired left heart function, triggering left ventricular dilation, left atrial enlargement, and diastolic dysfunction.[6,12,21] A study by Xu et al.[22] reported that moderate and severe OSAS significantly increased blood pressure variability in hypertensive patients. The same study showed a negative relationship between high blood pressure and AHI, oxygen desaturation, and the dureation of mean apnea. In our study, systolic and DBP values and left heart ECHO findings in individuals without known cardiovascular comorbidities showed a limited relationship with OSAS severity.

Study Limitations

The results of this study should be considered in light of several limitations:

1. ECHO measurements in this study were performed using standard transthoracic methods, but more advanced imaging techniques (eg, 3D ECHO) could provide more precise results.
2. Since individuals with a known history of cardiovascular disease were excluded from the study, the evaluation of blood pressure values, particularly the ECHO parameters, may be limited.
3. The small sample size limits the generalizability of the findings to a larger population.

Future studies conducted in different centers with more extensive case series, including patients with comorbidities, may enhance the validity of the results.

Conclusion

In our study, serum measurements of BNP, BMI, and PAP max significantly identified moderate and severe OSAS cases. BNP, in particular, emerged as a robust biomarker, not only for predicting OSAS severity but also for assessing cardiovascular risk. Although, BMI provided high sensitivity and specificity in predicting moderate and severe OSAS, NC showed limited performance. Due to its subjective nature, ESS was not found to be significant in the multivariate regression analysis and should be supported by more objective methods. Among the ECHO parameters, PAP max was the strongest predictor of OSAS severity.

In conclusion, the maximum values of BNP, BMI, and PAP can be used to determine the severity of OSAS before PSG and to classify the cases of priority PSG in sleep laboratories. However, further large-scale studies evaluating different patient groups are needed to confirm these findings.

Ethics

Ethics Committee Approval: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of İstanbul Göztepe Training and Research Hospital (current: Göztepe Prof. Dr. Süleyman Yalçın City Hospital) (approval number: 54/A, date: 10.02.2009).

Informed Consent: Informed consent was obtained from all participants.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: M.S.B., Concept: B.Ç., Design: M.S.B., B.Ç., Data Collection or Processing: M.S.B., Analysis or Interpretation: B.Ç., Literature Search: M.S.B., Writing: M.S.B.

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Sleep Patterns and Disturbances in Children Aged 6-16 Years During the COVID-19 Pandemic in Türkiye

COVID-19 Pandemisi Sürecinde Türkiye'de 6-16 Yaş Arası Çocuklarda Uyku Düzeni ve Bozuklukları

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Abstract

Objective: This study aimed to evaluate the factors causing sleep patterns and disturbances in children during the coronavirus disease-2019 (COVID-19) pandemic.

Materials and Methods: This descriptive and cross-sectional study collected data from 408 mothers with children aged between 6 and 16 years. "The Sleep Disturbance Scale for Children (SDSC)" was used to collect data.

Results: The study found the mean SDSC score was 46.25±16.34, with 11.8% of children showing symptoms of sleep disturbances. With increased sleep latency, significant bedtime and rise time delays were observed on weekdays and weekends. Children aged 6-12 slept less, whereas those aged 13-16 slept more (p<0.001). During the pandemic, irregular sleep, oversleeping, inability to sleep, and nightmares increased significantly (p<0.001). Late dinners, increased daytime sleep, and nighttime awakening were also significant (p<0.001). There was also a significant increase in the use of electronic devices before bedtime and during television viewing.

Conclusion: It was observed that approximately one in ten children experienced sleep disturbance symptoms during the pandemic. In addition, it was concluded that the sleeping/waking times of the children were negatively affected and that they had more frequent sleep disturbances. Based on these findings, it is crucial for pediatric nurses to identify and address sleep disturbances in children, particularly during situations such as the COVID-19 pandemic, which affects children's daily routines. Based on these findings, it is crucial for pediatric nurses to identify and address sleep disturbances in children, particularly during situations such as the COVID-19 pandemic, which affects children's daily routines.

Keywords: Pandemic, sleep, children, sleep habits

Öz

Amaç: Bu çalışmada, yeni koronavirüs hastalığı-2019 (COVID-19) pandemisi sürecinde çocuklarda uyku düzenini ve bozukluklarını etkileyen faktörlerin değerlendirilmesi amaçlanmıştır.

Gereç ve Yöntem: Tanımlayıcı ve kesitsel tipte olan bu çalışma, 6-16 yaş aralığında çocuğu olan 408 anne ile gerçekleştirilmiştir. Veriler "Çocuklar İçin Uyku Bozukluğu Ölçeği (ÇUBÖ)" kullanılarak toplanmıştır.

Bulgular: Çalışmada ÇUBÖ ortalama puanı 46,25±16,34 olarak bulunmuş ve çocukların %11,8'inin uyku bozukluğu belirtileri gösterdiği saptanmıştır. Hafta içi ve hafta sonu yatma ve kalkma saatlerinde önemli gecikmeler ile artmış uykuya dalma süresi gözlenmiştir. Altı-on iki yaş grubundaki çocukların daha az, 13-16 yaş grubundakilerin ise daha fazla uyuduğu tespit edilmiştir (p<0,001). Pandemi sürecinde düzensiz uyku, aşırı uyuma, uyuyamama ve kabus görme sıklığında artış olduğu belirlenmiştir (p<0,001). Ayrıca geç saatlerde yemek yeme, gündüz uykuları ve gece uyanmaları da anlamlı düzeyde artmıştır (p<0,001). Uyku öncesi elektronik cihaz kullanımı ve televizyon izleme davranışlarında da önemli bir artış olduğu gözlenmiştir.

Sonuç: Pandemi sürecinde çocukların yaklaşık her on çocuktan birinin uyku bozukluğu belirtileri gösterdiği saptanmıştır. Ayrıca çocukların uyuma ve uyanma saatlerinin olumsuz etkilendiği ve daha sık uyku bozukluğu yaşadıkları sonucuna ulaşılmıştır. Bulgulara dayanarak, çocukların günlük rutinlerini etkileyen COVID-19 pandemisi gibi durumlarda pediatri hemşirelerinin çocuklardaki uyku bozukluklarını belirlemesi ve bu sorunlara yönelik müdahalelerde bulunması büyük önem taşımaktadır.

Anahtar Kelimeler: Pandemik, uyku, çocuk, uyku alışkanlıkları

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Introduction

The coronavirus disease-2019 (COVID-19), which the World Health Organization declared a pandemic on March 11, 2020, has caused a global crisis affecting the daily lives of millions of people.[1] Measures taken in many countries to prevent the transmission of COVID-19, such as social distancing, closure of schools, and home confinement, have significantly affected and changed children's daily routines.[2] These measures, taken to reduce the rate of contagion and spread of the COVID-19 virus, have caused deficiencies in many areas, such as nutrition, physical activity, and psychosocial well-being of children.[3] In addition, changes in daily routines and pandemic conditions adversely affect sleep quality, which is an important factor for protecting and developing children's health.[4]

Sleep is an important component of a child's health.[5] Sufficient sleep duration in children is associated with better attention, behavior, cognitive functions, quality of life, emotional regulation, and physical health, whereas insufficient sleep leads to accidents and injuries, hypertension,[6] poor brain development and cognitive performance,[7] depression and obesity in children[5-8]. Additionally, insufficient sleep increases the risk of self-harm, suicidal thoughts, and suicide attempts among adolescents.[9]

The American Academy of Pediatrics (AAPs) reported that insufficient physical activity during the day, snacks, and caffeinated/carbonated beverages consumed before bedtime adversely affected sleep quality.[10] With the lockdown measures taken to prevent the COVID-19 outbreak, the physical activity rates of children decreased, and their snack food consumption increased.[3,11] For quality sleep in children, the AAPs suggests turning off electronic devices at least one hour before bedtime and keeping them out of room.[10] However, the increase in children's screen use during the pandemic[12] caused nighttime bright light exposure and suppression of melatonin production, thus reducing sleep quality.[13] These changes in children's daily routines during the pandemic have led to a decrease in sleep quality and sleep disturbances in children.[4]

Initiatives implemented by pediatric nurses for the development and protection of sleep, which directly affects children's health, have positive results.[14] Therefore, pediatric nurses play an important role in determining the factors that lead to sleep disturbances and preventing them during the COVID-19 pandemic. In this context, this study aimed to evaluate the sleep patterns and factors that lead to sleep disturbances in children aged 6-16 during the COVID-19 pandemic.

Materials and Methods

Study Design and Setting

This study was cross-sectional and descriptive in nature. Between June 1 and September 1, 2021, the study was conducted in the center of Zonguldak, Türkiye's Western Black Sea area.

Sample and Recruitment Procedure

Mothers who lived in Zonguldak made up the universe of study. The Turkish Statistical Institute 2020 address based population registration statistics show that there are 81,882 children in Zonguldak city center between the ages of 6 and 16.[15] Using the sample formula, a minimum sample size of 380 was required to obtain a 95% confidence interval and 5% margin of error. The inclusion criteria were being literate, residing in Zonguldak, and having a child aged between 6 and 16 years. The exclusion criteria were mothers who did not provide written or electronic consent. Significantly, children diagnosed with neurological or psychiatric disorders that could affect their sleep patterns were excluded. A total of 434 mothers consented to participate in this study. However, because 26 mothers failed to complete the written/electronic permission form on the first page of the information form, they were not allowed to participate in the study. In total, 408 mothers were included in the final sample.

Demographic and Scale Data

In this study, the "participant information form" and the "Sleep Disturbance Scale for Children" (SDSC) developed by the researchers were used to collect data.

The participant information form included 49 questions about the introductory characteristics of mothers and children, the bedtime and rise time of the children before and during the pandemic, sleep disturbances, and activities before bedtime.

Sleep Disturbance Scale for Children was developed by Bruni et al.[16] The validity and reliability of the Turkish version of the scale were assessed by Agadayi et al.[17] The SDSC is a five-point Likert-type Scale that investigates sleep disturbances in school-age children aged 6-16 in the last six months. The scale was completed by the children's mothers. The child's sleep disturbances were assessed using 26 items and six subscales on the scale. High scores on this scale indicate sleep disturbances. In addition, according to the T-score table in the original scale, a T-score >70 indicates sleep disturbance symptoms.[17]

Data collection forms were delivered to the mothers via social media (Facebook, Instagram, and WhatsApp). Mothers answered the survey questions for only one child aged 6-16. The online survey took an average of 15 minutes to complete.

Ethical Considerations

This study was conducted following the ethical guidelines of the Declaration of Helsinki. The Turkish Republic Ministry of Health, General Directorate of Health Services and Zonguldak Bülent Ecevit University Human Research Ethics Committee granted the required authorization prior to the study (approval number: 44860, date: 31.05.2021). A written informed consent form explaining the study's goal, data confidentiality, voluntary nature of participation, and participants' right to withdraw from the questionnaire at any time was given to them on the first page of the online survey.

Statistical Analysis

The Statistical Package for the Social Sciences Program (SPSS-24) was used to analyze the data. Descriptive statistical methods (number, percentage, mean, and standard deviation) were used for data evaluation. The chi-square test was used to examine group differences in the categorical variables. The mean SDSC score was examined using analysis of variance and t-tests in several groups based on sociodemographic traits. Statistical significance was set at $p<0.05$, and data were assessed at a 95% confidence interval.

Results

Data were collected from 408 children and their mothers. Of the children, 69.9% (n=285) were between the ages of 6 and 12 years and 55.9% (n=228) were male. During the pandemic, 49.0% (n=200) of the mothers said that the quality of their children's sleep had declined (Table 1). The study indicated that the SDSC overall mean score was 46.25±16.34. The SDSC T-score table indicates that among the children in the study, 11.8% (n=48) exhibited signs of sleep disturbances (T-score >70).

The mean SDSC scores of the children in the study were not statistically different based on the mother's level of education, gender, age, or family economic level ($p>0.05$). The SDCS mean scores for secondary school-aged children were found to be significantly higher than those of high school-aged children ($p=0.001$) and for children whose mothers were between the ages of 20 and 40 compared to those whose mothers were between the ages of 41 and 60 ($p=0.04$). In addition, it was observed that the SDSC mean scores of children with three or more siblings were significantly higher than those of children with only one or two siblings ($p=0.002$). According to the mothers' statements, those whose children's sleep quality decreased during the pandemic had statistically significantly higher SDSC mean scores than those whose sleep quality did not change (Table 1).

Children in both age groups (6-12 years and 13-16 years) went to sleep ($p<0.001$) and woke up later during the pandemic than before ($p<0.001$), according to an analysis of their weekday and weekend sleeping patterns (Table 2). In comparison to the pre-pandemic period, children aged 13-16 slept longer ($p<0.001$), and children aged 6-12 slept for shorter periods ($p<0.001$) during the pandemic, according to an evaluation of the children's overall sleep duration. The pandemic caused increased sleep latency in both age groups (6-12 years, 13-16 years) ($p<0.001$) (Table 3).

It was determined in the study that during the pandemic period, children had disturbances with irregular sleep, oversleeping, inability to sleep, and experience nightmares more frequently than in the pre-pandemic period ($p<0.001$). In addition, while there was a statistically significant decrease in the number of children who had dinner at 6 p.m. during the pandemic, there was an increase in the number of children who had dinner at 8 p.m. and later ($p<0.001$). There was a statistically significant increase in the rate of children who slept during the day and woke up at night during the pandemic process ($\text{sleeping}_{\text{during the day}}<0.001$; $p_{\text{waking up at night}}<0.001$) (Table 4).

In this study, when the activities of children before bedtime were examined, it was found that 52.7% (n=215) of the children were using electronic devices before the pandemic, while this rate increased to 71.1% (n=290) during the pandemic, and the rate of watching television increased from 55.1% (n=225) to 58.8% (n=240). The rate of children reading before sleep decreased from 54.9% (n=224) to 36.0% (n=147), the rate of doing homework from 50.2% (n=205) to 38.7% (n=158), and the rate of brushing teeth from 65.4% (n=267) to 59.1% (n=241) (Table 5).

Discussion

One of the important effects of the pandemic on child health is sleep disturbances.[4,18] According to the SDSC scores in this study, 11.8% of the children experienced sleep disturbance symptoms. When the literature was examined, the general mean SDSC score in a study conducted in Türkiye was somewhat lower[19] but closer to the results observed in Egypt.[20] In a study conducted in Italy, the SDSC score during the pandemic was slightly higher than the pre-pandemic level; however, it remained lower than the mean score observed in this study.[21] In addition, the frequency of sleep disturbance during the pandemic was reported to be 54%[22] in a meta-analysis, 65.6% in Egyptian children[20], and 2.6% in Türkiye. It is thought that the variance in the SDSC mean scores and sleep disturbance frequency rates in children between countries is due to differences in the countries' implementation of pandemic measures.

In our study, similar to the literature, it was found that there was a delay in bedtime and rise time in children aged 6-16 years and an increase in the length of time they fell asleep during the pandemic. In a study examining the sleep habits of children aged 3-16 during the pandemic, it was reported that secondary school children slept and woke up later and slept longer than the pre-pandemic period.[4] Similarly, two studies examining children's sleep patterns during the quarantine period in Italy revealed a delay in bedtime and rise time[18,21] and an increase in sleep duration and the length of time to fall asleep.[18] The results of this study are compatible with those of other studies conducted in different countries. Our study determined that the dinner was eaten later, the use of technological devices such as phones and tablets, and the rate of watching television increased during the pandemic compared to the pre-pandemic period. During the pandemic, the AAPs recommends that children should be physically active during the day for healthy sleep, stop consuming snacks and fizzy/caffeinated drinks at least one hour before sleep, stop using electronic devices, and keep electronic devices out of the room.[10] In light of the literature, it is thought that the measures taken to prevent the spread of the COVID-19 virus in Türkiye, such as the closure of schools, transition to online lessons, and home confinement, which restrict the physical mobility of children and cause an increase in screen exposure, affect their sleep routines. Changes in mealtime and screen time may cause children in all age groups to go to sleep later, increase the length of time to fall asleep, and therefore wake up later.

According to the AAPs, children aged 6-12 should sleep 9-12 hours daily, and children aged 13-18 should sleep 8-10 hours daily to promote optimal health.[9] Our research, however, found that although 39.3% of children aged 6 to 12 years had sleep durations that met the AAP guidelines prior to the pandemic, this percentage dropped to 35.8% during the outbreak. Prior to the pandemic, 48% of the 13-16-year-old children in our

Table 1. Characteristics of the participants (n=408)				
Variables			**SDSC**	
	n	**%**	**Mean ± SD**	**p**
Gender				
Male	180	44.1	46.14±15.63	p*=0.905
Female	228	55.9	46.33±16.91	
Ageǂ				
6-12 years	285	69.9	45.89±16.07	p*=0.499
13-16 years	123	30.1	47.08±16.98	
Education level				
Primary school (a)	144	35.3	45.25±15.97	**p**=0.001** b>c
Secondary school (b)	214	52.5	48.19±17.45	
High school (c)	50	12.3	40.82±9.98	
Siblings				
Only child (a)	91	22.3	44.86±16.92	**p**=0.002** c>a c>b
Two children (b)	222	54.4	44.30±13.96	
More than three children (c)	95	23.3	52.13±19.43	
Family income				
The income is less than expenses.	75	18.4	47.97±18.63	p**=0.117
The income is equal to expenses.	238	58.3	46.73±16.78	
The income is more than expenses.	95	23.3	43.68±12.76	
Mother's age				
20-40 years	214	52.5	47.81±18.10	**p*=0.04**
41-60 years	194	47.5	44.52±13.99	
Mother's education				
No graduation/primary school	54	13.2	48.13±20.83	p**=0.142
Secondary school	46	11.3	50.20±17.39	
High school	113	27.7	43.75±15.72	
University	195	47.8	46.24±14.84	
Mother's perception of child's sleep quality during the COVID-19 pandemic				
It has not changed (a)	183	44.9	42.01±15.72	**p**<0.001** b>a
It has decreased (b)	200	49.0	49.66±15.86	
It has increased (c)	25	6.1	50.00±17.81	

ǂData were organized per age groups (6-12 years: school-age child, 13-16 years: adolescent), *: Student's t-test, **: One-way ANOVA and post-hoc.
SD: Standard deviation, SDSC: Sleep Disturbance Scale for Children

study had sleep durations that complied with AAP guidelines; during the pandemic, this percentage increased to 52.8%. Children aged 6-12 slept for shorter periods than before the pandemic, but children aged 13-16 slept for longer periods. When the literature was examined, the sleep duration of 27.1% of children aged 5-11 and 54.0% of children aged 12-17 increased during the pandemic period in America compared to the pre-pandemic period.[23] A study conducted by Kaditis et al.[24] in various countries across Asia, Europe, the Middle East, North America, and South America reported an increase in children's sleep duration during home confinement.

An important finding of our study was that children experienced sleep disturbances more frequently during the pandemic than during the pre-pandemic period, and there was an increase in sleeping during the day and night awakenings in children during the pandemic. When the literature was examined, similar results were found.[22,25,26] In a study conducted in Italy, Spain, and Portugal, 12.2% of parents with children aged 3-18 reported that their children frequently woke up, 12.8% stated that their children slept less, 17.1% indicated that their children were afraid of sleeping alone, 11.4% noted that their children had nightmares, and 16.8% reported that their children experienced sleep difficulties.[27] In the study conducted by Bruni et al.[18], it was observed that while the children aged 6-12 had difficulty falling asleep, had anxiety at bedtime, woke up at night, ground their teeth, and had nightmares more frequently, children aged 13-18 had difficulty falling asleep. It is thought that children are at home all day because of the closure of schools, which is an important part of social and physical activity, and the increase in screen exposure is effective for children's sleep disturbances.

Table 2. Changes in bedtime and rise time during the COVID-19 pandemic and pre-pandemic period

	Bedtime	**20:00-22:00**	**22:00-24:00**		**24:00-02:00**	**02:00-04:00**	**p***
Weekdays	**6-12 years**						
	Pre-pandemic period	147 (51.6)	132 (46.3)		6 (2.1)	0 (0)	**<0.001**
	During pandemic	34 (11.9)	196 (68.8)		52 (18.2)	3 (1.1)	
	13-16 years						
	Pre-pandemic period	29 (23.6)	82 (66.7)		12 (9.8)	0 (0)	**<0.001**
	During pandemic	10 (8.1)	54 (43.9)		49 (39.8)	10 (8.1)	
Weekend	**6-12 years**						
	Pre-pandemic period	48 (16.8)	200 (70.2)		36 (12.6)	1 (0.4)	**<0.001**
	During pandemic	14 (4.9)	165 (57.9)		95 (33.3)	11 (3.9)	
	13-16 years						
	Pre-pandemic period	6 (4.9)	63 (51.2)		46 (37.4)	8 (6.5)	**<0.001**
	During pandemic	1 (0.8)	43 (35.0)		58 (47.2)	21 (17.1)	
	Rise time	**05:00-07:00**	**07:00-09:00**	**09:00-11:00**	**11:00-13:00**	**13:00-15:00**	
Weekdays	**6-12 years**						
	Pre-pandemic period	10 (3.5)	239 (83.9)	34 (11.9)	2 (0.7)	0 (0)	**<0.001**
	During pandemic	2 (0.7)	146 (51.2)	123 (43.2)	13 (4.6)	1 (0.4)	
	13-16 years						
	Pre-pandemic period	12 (9.8)	99 (80.5)	8 (6.5)	2 (1.6)	2 (1.6)	0.280
	During pandemic	4 (3.3)	70 (56.9)	37 (30.1)	9 (7.3)	3 (2.4)	
Weekend	**6-12 years**						
	Pre-pandemic period	0 (0)	87 (30.5)	175 (61.4)	23 (8.1)	0 (0)	**<0.001**
	During pandemic	0 (0)	68 (23.9)	167 (58.6)	47 (16.5)	3 (1.1)	
	13-16 years						
	Pre-pandemic period	1 (0.8)	23 (18.7)	75 (61.0)	24 (19.5)	0 (0)	**<0.001**
	During pandemic	1 (0.8)	14 (11.4)	60 (48.8)	42 (34.1)	6 (4.9)	

*: Chi-square test
COVID-19: Coronavirus disease-2019

Table 3. Changes in sleep duration and sleep latency during the COVID-19 pandemic and pre-pandemic period

Sleep duration	**9-11 hours**	**8-9 hours**	**7-8 hours**	**5-7 hours**		**p***
6-12 years						
Pre-pandemic period	112 (39.3)	130 (45.6)	41 (14.4)	2 (0.7)		**<0.001**
During pandemic	102 (35.8)	123 (43.2)	54 (18.9)	6 (2.1)		
13-16 years						
Pre-pandemic period	25 (20.3)	59 (48.0)	33 (26.8)	6 (4.9)		**<0.001**
During pandemic	24 (19.5)	65 (52.8)	29 (23.6)	5 (4.1)		
Sleep latency	**Less than 15 minutes**	**Between 15-30 minutes**	**Between 30-45 minutes**	**Between 45-60 minutes**	**More than 60 minutes**	
6-12 years						
Pre-pandemic period	102 (35.8)	148 (51.9)	21 (7.4)	7 (2.5)	7 (2.5)	**<0.001**
During pandemic	58 (20.4)	160 (56.1)	51 (17.9)	8 (2.8)	8 (2.8)	
13-16 years						
Pre-pandemic period	49 (39.8)	58 (47.2)	10 (8.1)	5 (4.1)	1 (0.8)	**<0.001**
During pandemic	28 (22.8)	59 (48.0)	31 (25.2)	2 (1.6)	3 (2.4)	

*: Chi-square test
COVID-19: Coronavirus disease-2019

Similar to the results of our study, it was reported in studies conducted in Türkiye that there was an increase in children's use of the Internet[28] and the duration of screen and digital games during the pandemic.[29] Studies conducted in other countries have also reported that children's screen duration increased to very high levels during the pandemic.[23,30] In a study by El Refay et al.[20], a positive correlation was reported between SDSC scores, screen duration, and anxiety symptoms. In light of the literature, in addition to the increase in screen exposure, it is thought that the majority of children (79.4%) experienced behavioral/psychological problems such as anxiety, depression, and restlessness during the pandemic period[2], which caused an increase in the frequency of sleep disturbances.

Table 4. Sleep characteristics of children during the COVID-19 pandemic and pre-pandemic period

	Pre-pandemic	During pandemic	p*
	n (%)	n (%)	
Sleep disturbances			
No sleep problems	344 (84.3)	225 (55.1)	<**0.001**
İrregular sleep	42 (10.3)	113 (27.7)	
Oversleep	6 (1.5)	26 (6.4)	
Inability to sleep	14 (3.4)	40 (9.8)	
Nightmares	2 (0.5)	4 (1.0)	
Dinner time			
6 p.m.	139 (34.1)	116 (28.4)	<**0.001**
7 p.m.	204 (50.0)	207 (50.7)	
8 p.m. and later	65 (15.9)	85 (20.9)	
Sleeping during the day			
Yes	24 (5.9)	43 (10.5)	<**0.001**
No	384 (94.1)	365 (89.5)	
Waking up at night			
Yes	59 (14.5)	91 (22.3)	<**0.001**
No	349 (85.5)	317 (77.7)	

*: Chi-square test
COVID-19: Coronavirus disease-2019

Table 5. Activities prior to bedtime during the COVID-19 pandemic and pre-pandemic period

	Pre-pandemic	During pandemic
	n (%)	n (%)
Activities prior to bedtime*		
Using an electronic device (computers, phones, tablets)	215 (52.7)	290 (71.1)
Reading a book	224 (54.9)	147 (36.0)
Watching TV	225 (55.1)	240 (58.8)
Doing homework	205 (50.2)	158 (38.7)
Drinking milk	104 (25.5)	87 (21.3)
Brushing teeth	267 (65.4)	241 (59.1)
Others	8 (2.0)	0 (0)

*More than one option was ticked
COVID-19: Coronavirus disease-2019

Mothers play a significant role in childcare in Türkiye. The SDSC scale used in our study was also completed by mothers of children aged 6-16. According to the mothers' evaluations, the mean SDSC scores of children reported to have decreased sleep quality during the pandemic were higher. This situation can be considered an indication that mothers indeed interpret their children's sleep characteristics. The fact that the mother was younger and the child had three or more siblings was associated with an increase in SDSC scores in the study. During the pandemic, children's sleep disturbance symptoms were affected by factors such as screen exposure, decrease in physical activity, closure of schools, increase in snack consumption and family characteristics. It is thought that the number of siblings from different age groups of three or more may cause difficulties in establishing a daily routine and sleep routine, and it may also affect each other's sleep characteristics since siblings mostly share the same room. Previous studies have reported that the mother's work schedule during the pandemic affects the sleep characteristics of children.[21,25] However, no study has reported the effects of maternal age on children's sleep characteristics.

Study Limitations

The study was limited to mothers living in Türkiye. The results of this study cannot be generalized to all children living in the world or Türkiye. Additionally, delivering the questions via social media instead of face-to-face meetings and obtaining responses from mothers rather than directly from children are other limitations of this study. The strengths of this study are the use of a frequently preferred questionnaire in evaluating sleep disturbance and the consideration of two different age groups to evaluate age-related changes.

Conclusion

This study determined that the children's SDSC mean scores were at an average level (46.25±16.34). However, approximately one in nine (11.8%) of the children included in the study showed symptoms of sleep disturbances. It was revealed that the pandemic caused changes in children's sleep patterns. Children were observed to go to sleep and wake up later and had difficulty falling asleep. It was concluded that children experienced sleep disturbance more frequently, and their use of electronic devices and watching television, which were factors affecting sleep disturbance, were much higher during the pandemic than during the pre-pandemic period.

Sufficient sleep quality is one of the key factors in ensuring and sustaining a child's health. Improving children's sleep quality has become increasingly important, particularly when the child's health is directly impacted by the steps taken to stop the spread of COVID-19. Therefore, pediatric nurses should actively identify sleep issues and enhance children's sleep quality. Nurses are advised to counsel parents on creating a sleep schedule and steps to take for healthy sleep, given the shifts in children's sleep habits during the pandemic.

In future studies on this subject, it is recommended that the sample be formed from children and mothers living in different countries and regions and that sleep duration be evaluated using objective methods. In addition, studies should be conducted to evaluate the effects of the pandemic on the frequency of sleep disturbances in children with chronic diseases or developmental disorders.

Ethics

Ethics Committee Approval: The Turkish Republic Ministry of Health, General Directorate of Health Services and Zonguldak Bülent Ecevit University Human Research Ethics Committee granted the required authorization prior to the study (approval number: 44860, date: 31.05.2021).

Informed Consent: A written informed consent form explaining the study's goal, data confidentiality, voluntary nature of participation, and participants' right to withdraw from the questionnaire at any time was given to them on the first page of the online survey.

Footnotes

Authorship Contributions

Concept: A.A., Ö.Ö.Ş., Design: Ö.Ö.Ş., Y.T., Data Collection or Processing: A.A., Ö.Ö.Ş., Y.T., Analysis or Interpretation: A.A., Ö.Ö.Ş., Y.T., Literature Search: Ö.Ö.Ş., Y.T., Writing: A.A., Ö.Ö.Ş., Y.T.

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