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ORIGINAL ARTICLES

An experimental investigation of decompressive craniectomy in a rat model of hemispheric stroke treated with decompressive craniectomy..... 101-106
Eryılmaz F.

Does the nutritional literacy of adolescents affect their eating behavior?.....107-115
Arslan A, İnanç N, Bülbül SF, Alpcan A, Kandur Y, Tursun S.

The frequency of sleep disorders and their relationship with demographic factors in patients with tinnitus 116-119
Haznedar B.

REVIEW

Things to know about tetanus..... 120-123
Düğeroğlu H.

LETTER TO THE EDITOR

Augmented and virtual reality in medicine 124-125
Erdağ M.

An experimental investigation of decompressive craniectomy in a rat model of hemispheric stroke treated with decompressive craniectomy

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ABSTRACT

Aims: Acute ischemia can lead to severe edema in the brain, increased intracranial pressure and coma progression and death through cingular, uncus or tonsillar herniation in all the territories of the carotid artery. It is well established that cerebral and cardiovascular surgery patients benefit from decompressive craniectomy, although there is less data on how they do with regard to other forms of ischemia. In this study, we analyze the results of an experimental study on the decompressive craniectomy effects that occurs at various times after occlusion of the endovascular middle cerebral artery (MCA) in rats.

Methods: The endovascular occlusion procedure was done in 80 rats, resulting in focal ischemia. 4, 12, 24 and 36 hours after vessel occlusion decompressive craniectomies were done in 60 rats (each in groups of 15 rats). Decompressive craniectomy was not carried out on 20 specimens (control group). At day seven we used the number of infarcts and the neurological performance as endpoints.

Results: No animals infected with decompressive craniectomy died despite a mortality rate of 35 percent in untreated communities (mortality 0 percent). Both early or late treatment with a decompressive craniectomy dramatically improved neurologic function in both species. Compared to that animals that underwent endovascular occlusion of the per hour for 4 hours after their traumatic brain injury and did not have their brains decompressed, the infarction and neurological function showed statistically significant improvement after the 2 to 4 hours period ($p < 0.01$) intervention. A new study has concluded that decompressive craniectomy care reduces mortality and increases the quality of life. Right after the outset of the formation of an occlusion, the infarct period is reduced. During a stroke treatment for head injury neurosurgeons may use neurochirons to decompress the brain.

Conclusion: Cerebral vascular insufficiency decompressive craniectomy works well after the vessel is clamped eliminates the infarction. Craniectomy performed within 4 hours of surgery will restore lives, neurological results are not improved or infarction levels are minimized just as effectively as craniectomy immediately after vessel occlusion. A randomized pilot study of the clinical support is provided for the concept of providing an immediate and aggressive treatment for those who have mid-grade internal carotid artery (ICA) and MCA occlusion neurosurgeons may play an important role in the treatment of patients with stroke by decompressive craniectomy.

Keywords: Craniectomy, cerebral infarction, ischemic cerebrovascular disorder, decompression

INTRODUCTION

Ischemic cerebrovascular disorder, representing about 15 percent of all stroke casualties, represents the most common type of brain disease.¹ The MCA territory will trigger acute ischemia with a significant cerebral edema, high intracranial pressure and comatose and death in the worst-case scenario. While it has been established that isometrics, barbiturates and Tris buffers work to successfully treat ischemia-induced brain, none has been proved effective in the clinic.^{2,3} While the treatment of large cerebellar infarctions with primary craniectomy is well established, retrospective, anecdotal case reports are available of only the treatment of patients for supratentorial ischemia. The preliminary results of an

open prospective trial were recently published to see how decompressive craniectomy affects mortality and morbidity. A time-dependent basis was found to reduce mortality and increase outcomes for patients with cerebral ischemia when a decompressive craniectomy was performed.^{4,5} However this study only used 24 hours as a window period, following the occlusion of the MCA to carry out decompressive craniectomy after 1 and 24 hours have elapsed.^{6,7} Craniectomy success is largely depends on the timing of the procedure. The optimal time for craniectomy, namely the removal of the cranium, remains undiscussed. Using an endovascular occlusion model, it was possible to examine how much of a decalcifying or

deoccluding craniectomy affected death, injury and the amount of oxygen or glucose deprivation in the endocrine system at different points after an occlusion of the cerebral vessels.

METHODS

The study was initiated with the approval of the Ankara University Medical Faculty Local Ethics Committee for Animal Experiments (Date: 05.09.2022, Decision No: 34). All procedures were carried out in accordance with the ethical rules and the principles of the animal experiments.

The strain of 68-Wistar rats, whose brains measured 270 to 320 g, was used to cause focal ischemia by the occlusion of the intraluminal suture discovered by Koizumi and colleagues. The study passed the animal safety committee. The anesthetics, xylazine (1.5 mg/100 g) and ketamine (4 mg/100 g) were given I/M to rats and before the start of procedure they were freely given water and food. The pH, hematocrit, partial pressure of O₂ and CO₂ levels were all held constant with a femoral artery catheter while doing surgery. To maintain the body temperature of the process, a heat-controlled heating pad held the rectal temperature at 37 degrees Celsius.

To occlude the OSA, a medium neck incision was made, exposing the the right external carotid artery (ECA) and right common carotid artery (CCA) were exposed. This surgical procedure is illustrated in three main phases in the figure: placing the animal in a surgical position and making an incision on its skin as the first step; exposure and ligation of vessels during the second step where distal ECA and CCA were ligated while arteriotomy was performed; thirdly this illustrates proper placement through CCA arteriotomy of 4/0 nylon monofilament with silicone tip into ICA. In this operation, the filament extended to ACA such that it blocked PCA as well as origin of OSA. Additionally, these processes are visually indicated by means of diagram (Figure 1)

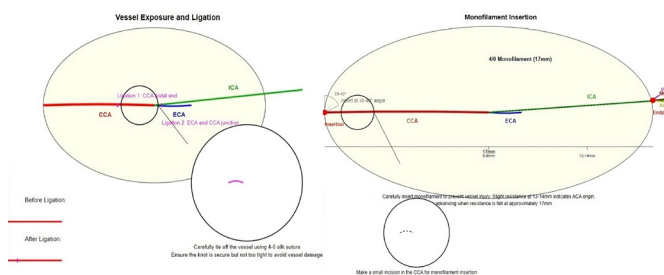


Figure 1. Vessel exposure, ligation, and monofilament insertion

Through a mid-neck incision; the right ECA and right common carotid artery CCA are exposed to occlude the MCA. To avoid bleeding, the CCA was ligated loosely distal to the arteriotomy with 4/0 silk and then the neck wound was quickly closed.

Decompressive craniectomy was carried out in four major stages: first, the animals were placed on their right side with their heads resting on cushions. The skin cut was approximately 3 cm long and situated over the right temporal muscle. Secondly, a bone flap of width 0.9cm, length 3cm and depth of 0.5cm was created. Thirdly a incision was made on the dura mater to reach the frontal and temporal lobes of the brain but it did not involve removing any brain tissues. Lastly, absorbable

sutures closed up both the temporal muscle and skin. These steps are shown in detail in Figure 2 below.

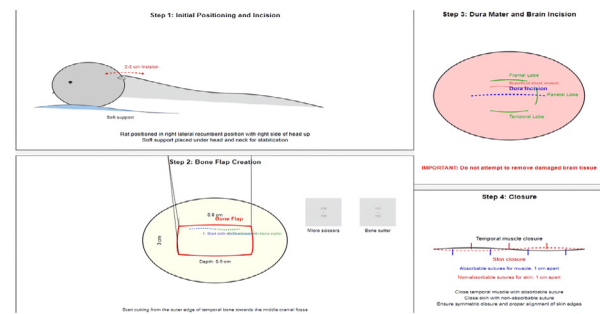


Figure 2. Surgical steps for decompressive craniectomy: positioning, incision, bone flap creation, dura mater incision, and closure

20 animals haven't received any treatment since occlusion of MCA (Group A: control group). The right cerebral hemisphere in 60 rats was decompressed surgically by performing a craniectomy. At 4 hours in Group B, at 12 hours in Group C and subsequently at 24 and 36 hours in Groups D and E after MCA decompressive craniectomy was done. The 80 animals have been randomly divided among the various control and treatment groups (and assigned letters) by a computer-generated randomization method. At the end of the procedure, the temporal muscle and skin were closed.

The ischemic study's brain tissue preparation and analysis were carried out in four steps: the first step involved removing the brain, which was then placed into a 10% formalin solution immediately for fixation lasting 24 hours. Afterward, the fixed brain was sliced using a micro-saw to create 2 mm thick sections during the second step. Subsequently, sectioned pieces of brains were incubated at 37°C for half an hour in TTC (2,3,5 triphenyl tetrazolium chloride) solution- this is third stage. Finally involved digital imaging and analysis where infarct areas are measured while total volume is calculated using these pictures. These steps are visually represented in figure 3 that gives visual representation for each step (Figure 3).

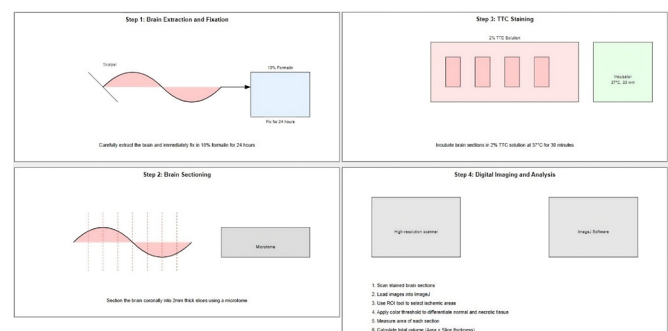


Figure 3. Brain tissue preparation and analysis: extraction, fixation, sectioning, TTC staining, and digital imaging

All of the surviving animals have been observed for 7 days to see whether they still have a neurological activity and their weight has been recorded according to a previously known protocol of Bredesen et al and has been standardized by Menzies and colleagues' (Table 1). All animals with ketamine and xylazine had been re-anesthetized and decapitated at the end of day seven. Their brain has been quickly cut and the

2 mm brain slices have, before being fixed in a 10 per cent buffered formalin solution, been incubated for 30 minutes at 37°C in 4 percent solution of TTC. When exposed to TTC, the normal tissue of the brain (with cellular membranes intact) becomes red and necrotic tissue becomes rosy and grey. The TTC has stained and then photographed five of the brain parts of each species. Once digital images have been captured, the infarction areas are measured using a monitor and software (1.41 IMAGE; Bethesda, Wayne Rasband, National Institutes of Health, MD). In each slice, an ischemic brain region is present and two millimeters of infarct volume has been stained for inflammation. At the time of the craniectomy, two of the writers who were not known about the decompressive craniectomy have made calculations and measurements. Evaluation was done twice, once on each side of the brain section and the average values were taken. Recent work by Lin et al.⁸ states that to prevent a misinterpretation of the severity of infarction, a correction factor must be calculated by contrasting the infarct hemisphere to a similar-sized non-infarcted volume.

Table 1. Neurological activity with scores	
Score	Evaluation criteria
0	No obvious deficits
1	Flexion of contralateral forelimb
2	Diminished contralateral forelimb grip while animal is dragged by the tail
3	In all directions; spontaneous movement and contralateral circling solitary if animal is pulled by tail
4	Spontaneous contralateral circling
5	Demise

Study data was compiled on a PC (off-the-shelf, Stat View was used) with off-the-shelf, cost-effective software (Brain Inc. for the results) (Macintosh Quadra, Apple Computer Inc., Cupertino, CA). The Chi-square and the Kruskal-Wallis test were used to determine the rate of ischemia and test for neurological impairment. Since the probability was below 0.05, this was deemed significant

RESULTS

In all of the intraoperative physiological parameters, there were no statistically significant variations between the five classes. The average body temperature of all animals was found to be 37.1°C±0.6°C (mean ± standard deviation). The arterial blood concentrations (PO₂ 125±36 mm Hg; PCO₂ 34±3.1 mm Hg; pH 7.40±0.03) and hematocrit values have no significant changes.

Mortality Rate

The 8 out of the 20 animals in the test group had a 40% mortality rate from MCA of 24 to 48 hours of the procedure. Without exception, during the entire observation period, all the animals that underwent decompressive craniectomy survived, whether the procedure was performed early (4 hours after) or late (24 hours after) (mortality rate 0 percent). A few weeks/the subsequent few weeks a substantial difference existed between these two classes as shown by significant differences (p<0.01).

Body Weight

Animal weights decreased in the study at the end of the week, the average weight of Group A was significantly lower than that of Group D (p<0.001). The findings are as a comparison of these weight shifts. Average neurological score of 3.8 after 7 days was obtained from the control group (Group A). The average score

for very early craniectomies (Group B) was 1.8; the score for animals that had a craniectomy was 2.4, 2.6, and 2.8 after 12 hours (Group C), 24 hours (Group D) and 36 hours (Group E). There has also been a statistically important difference between animals regulated and untreated (p<0.001), Groups B and Groups C, D and E (p<0.001). Table 2 shows the estimated infarction volumes for various treatment classes. The infarct volumes were slightly smaller than those of the animals who had early craniectomy at 4 hours. Craniectomy 12 hours or less is associated with lesser infarctions compared to no craniectomy. Infarctions occurs due to the lenticulostriate arteries seen in all animals irrespective of treatment. Patients that were treated in the control unit and in the later stage of the disease had more cortically localized, rather than larger infarctions (Groups C–E).

Table 2. The estimated infarction volumes for various treatment classes		
Group	Infarction volume (mm ³)	p value
A (20 rats)	185 ± 17.1	<0.002 vs. B Group
		<0.11 vs. C Group
		<0.7 vs. D Group
		<0.6 vs. E Group
B (15 rats)	110 ± 10.90	<0.00 vs. C Group
		<0.003 vs. D Group
		<0.006 vs. E Group
C (15 rats)	148 ± 9.90	<0.24 vs. D Group
		<0.26 vs. E Group
D (15 rats)	170 ± 12.50	<0.78 vs. E Group
E (15 rats)	171 ± 19.80	NA

When the body weights and neurologic scores of the animals in the experimental groups were analyzed, it was found that the neurologic scores of the groups that underwent decompressive craniectomy in the early period (Groups B, C, D and E) were significantly lower than the control group (Group A). While the mean neurologic score was 3.8 in the control group (Group A), this score was 1.8 in Group B, which underwent craniectomy after 4 hours. After 12 hours, the mean neurologic score was 2.4 in Group C, 2.6 in Group D after 24 hours and 2.8 in Group E after 36 hours. In addition, while the mean body weight of the control group was 270±15.2 g, these values were slightly higher in the treatment groups. These data suggest that early decompressive craniectomy contributes significantly to neurologic recovery (Table 3).

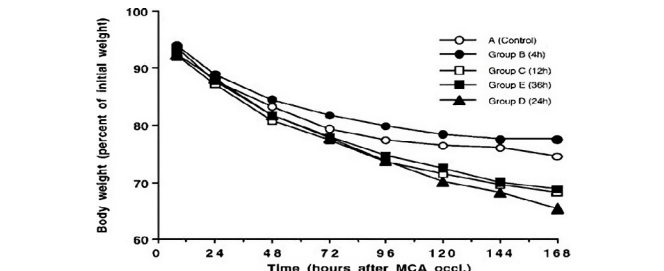


Figure 4. Changes noticed in the weight of treatment versus control group after occlusion of MCA in rats during the 168 hours

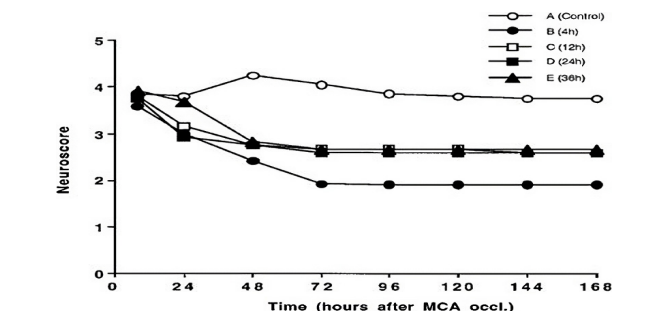


Figure 5. Changes noticed in the neurological score of treatment versus control group after occlusion of MCA in rats during the 168 hours

Table 3. Body weight and neurological scores of experimental animals

Group	Mean body weight (g)	Standard deviation (g)	Mean neurological score	Standard deviation	Statistical significance (p value)
A (Control)	270 ± 15.2	15.2	3.8	0.5	Reference Group
B (4 hours)	290 ± 14.8	14.8	1.8	0.3	<0.001 (vs. Group A)
C (12 hours)	280 ± 13.5	13.5	2.4	0.4	<0.001 (vs. Group A)
D (24 hours)	275 ± 16.0	16.0	2.6	0.4	<0.001 (vs. Group A)
E (36 hours)	272 ± 17.1	17.1	2.8	0.5	<0.001 (vs. Group A)

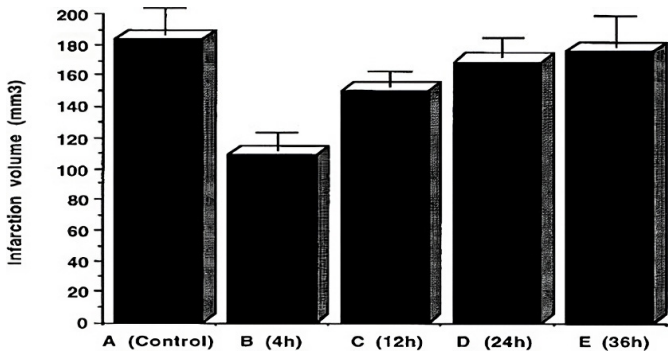


Figure 6. Changes noticed in the infarction size of treatment versus control group after occlusion of MCA in rats during the 168 hours

DISCUSSION

In 10-15 percent of supratentorial infarctions, large hemispheric infarctions affecting the whole area of the MCA may be associated with extreme brain swelling and death as a result of brain edema. This malignant hemispheric infarction is caused by embolic ICA or proximal (M1) occlusion with inadequate collateral flow and early-brain edema around the entire MCA region or a larger area (ACA and PCA regions, in severe cases). Hacke et al.⁹ indicated that the death rates ranged between 30% and 66% in unselected groups of MCA patients and their locations; patients who had developed a malignancy of the hemisphere were 80% mortal. The malignancy of an ischemic lesions must be identified within the first hours of symptoms in order to provide a prompt and likely successful treatment. The prediction of patients with malignant hemangioma comes as a surprise to researchers and healthcare practitioners alike. Where a person has had a subracial, he or she is more likely to be in a coma. However, the characteristics of computerized tomography (CT) may well be closer to perfection. In a prospective research by Kummer et al.^{10,11} that finds that “neoplastic” hypo-sign on CT-scan is 85 % certain if the rest of the parenchyma lodges in the MCA territory, find it is (European Cooperative Clinical Study) hematoma was the leading cause of death for those who had undergone the interventional treatment, occurring in 7.3% of the right group of the patients and 4.9 % of the control group within the first seven days. The prognostic of the initial nerve deficiency is directly proportional to hemiplegia and reduced awareness indicate a bad result. Altered sense is the same prognosis factor as younger, less atrophic brains that have generalized atrophy are less likely to resist swelling than brains.^{12,13} Intubation treatment, artificial ventilation and antimicrobial drugs are normally ineffective in preventing fatal hernia. Decompressive craniectomy as an alternative for such cases has been suggested and may save lives.^{14,15} The numbers can all be used to make various combinations. One of the oldest neurosurgical principles is the removal of a portion of the cranial vault to alleviate intracranial pressure.¹⁴ The palliation of high ICT

caused by tumors that cannot be traced by available neurodiagnostic techniques was one of the first signs of the treatment.¹⁵ Harvey Cushing¹⁶ used a sub temporary technique to describe cranial decompression in a landmark article published in 1905. However the beneficial effects of decompressive craniectomy in patients with massively supratentorial edemas caused by head trauma remain debatable since decompression may lead to progression of edemas.^{17,18} Kondziolka and Fazl¹⁹ found that craniectomy was a life-saving treatment in a small group of 5 stroke patients. 3 patients with large hemispheric infarctions recovered after craniectomy, according to Rengachary and colleagues but 2 of them had significant focal neurological deficits. 4 patients received decompressive craniectomy and unsustainable brain resection by Kalia and Yonas²⁰ with good clinical outcomes for all 4 patients. Earlier research was purely retrospective and anecdotal. Latest prospective studies in 53 patients with malignant hemispheric infarction have shown that decompressive hemicraniectomy decreased mortality and morbidity and suggested the immediate start of intensive surgical therapy. On the other side, there is also a debate about the best time for decompressive surgery. To date the effectiveness of decompressive craniectomy in acute stroking has only been observed for some time now. Experimental focal cerebral ischemia may require a craniectomy to explain Tamura et al.²¹ first’s model of focal ischemia. We are unable to determine whether the findings of the study apply to a control group because of the craniectomy. Conversely, on the other hand, embolic models do not involve a brain operation, but the sizes of the infarcts do differ widely, making it difficult to measure the outcomes of the surgery.^{22,23} An endovascular occlusion, which was discovered by Koizumi et al.²⁴ and refined by many others in the next decades, was almost entirely effective in human beings as well when correctly placed, the intra-lamentation should follow the ACA. As a result, a major ischemic lesion has developed from the ICAs, ACAs and PCAs, there has been significant hemispheric ischemia. In our sample, mortality rates were 0% for each animal treated with decompressive craniectomy compared with 40% for the control group. In the control community, several animals died within 24-48 hours of the occlusion. We were perplexed by the absence of deaths during the 36 hours cohort but as shown by the reduction in TIA complications after 72 hours occlusion, we conclude that it was due to the life-saving efficacy of a safe craniectomy after MCA or TAC. None of the 80 animals was randomly placed in one of the 5 treatment groups (Groups A-E). The conversion, which prevents uncalled herniation, of the cranium from a “closed” cavity is most likely to be responsible for the decrease in mortality.²⁵ A decline in infarction in animals treated early on and better neurologic results were the most striking results for our current study (Group B). There was a differential difference in Group C relative to Group D, (Figure 3). While the medication was successful, it did not save the patient’s life. All the animals

treated were much higher than untreated animals in terms of their neurological score and behavior (Group A), (Figure 2). Animals of groups C to E have lost 35% of their body weight in the course of time, probably due to the stress of an aesthetic and surgery for the second time, while animals of groups A and B have lost just 25% of their body weight (Figure 1). Since TTC staining is ineffectual so long after death, untreated group A animals that died of herniation before day seven could not calculate the infarction scale. It is much more likely that the difference in infarcts is what accounts for the significant disparity between treated and untreated animals in this population, rather than the actual infarct size. In the territory of the lentic arteries, all the findings are of ischemia. When the cerebral ischemic endovascular model is applied, this is the brain region is more impaired. Patients with a large leptomeningeal blood supply normally experience only human subcortical infarction near M1 occlusions.^{26,27} The link between human blowing and our animal model supported the hypothesis that the most common reason for decompressive craniectomy is the better performed, leptomeningeal collateral vessels. Hemicraniectomy is a straight forward procedure that can be done with minimum auxiliary help in any community hospital, which is an important benefit because of the fact that the leading cause for death is cerebrovascular disease in the USA. One dilemma facing clinicians is how long conservative treatment should be given before decompressive craniectomy is taken into consideration.²⁸ Decompressive craniectomy should not be delayed long, as it can result in irreversible brain stroke improvement, such as dural hemorrhages, although it is unclear how well craniectomy is. Shaw²⁹ and associates suggested in 1959 that vasogenic brain swelling in humans is responsible for the early mortality following a heart attack typically occurs within 2 to 5 days. In most patients, brain herniation is observed within 48 hours of the ischemia start. The edema peak is normally seen in rats during the first 24 to 48 hours, but not always in human times. As a result of this, our findings cannot provide a conclusive answer to the question as to when craniectomy is done in humans, along with other experimental studies. After the vessel was fully blocked off, we conducted four decompressive procedures 4 hours, 12 hours and then once again 24 hours later. Cranial infarction was found to be statistically important and those which received their treatment at the earlier or later stages showed greater signs of the disease than those left untreated (after 24 and 36 hours).^{30,31} So the results from experiments with rats should not be applied to humans (as discussed above). Caution should always be used when applying results of animal experiments to humans. Studies of human patients with a controlled experimental design are needed in order to test the efficacy of decompressive craniectomy in humans. Most rat studies cannot definitively determine the extent of neurological disorders because of their high level of sensitivity to various environmental factors. The true significance of rodent mortality clearly exceeds that of human mortality.³² The ultrasound results coupled with their appearance on a computerized tomography (CT) scan are more sensitive in detecting these (inferior) is chemotherapy earlier on the road to the disease process of thrombosis.³³ Future randomized trials would need to examine the prognostic factors in order to determine criteria for craniectomy in patients.

CONCLUSION

Cerebral vascular insufficiency decompressive craniectomy works well after the vessel is clamped eliminates the infarction. Craniectomy performed within 4 hours of surgery will restore lives, neurological results are not improved or infarction levels are minimized just as effectively as craniectomy immediately after vessel occlusion. A randomized pilot study of the clinical support is provided for the concept of providing an immediate and aggressive treatment for those who have mid-grade ICA and MCA occlusion neurosurgeons may play an important role in the treatment of patients with stroke by decompressive craniectomy.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was initiated with the approval of the Ankara University Medical Faculty Local Ethics Committee for Animal Experiments (Date: 05.09.2022, Decision No: 34).

Informed Consent

Because the study was designed as an animal experiments, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Does the nutritional literacy of adolescents affect their eating behavior?

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ABSTRACT

Aims: Diseases such as obesity, diabetes, hypertension, which develop as a result of the deterioration in the diet quality of adolescent individuals in our country and around the world and unhealthy eating habits acquired during this period, pose a risk for future health. Adolescents need to correctly perceive, evaluate and apply nutrition-related information for healthy food consumption. For this reason, studies have been conducted in recent years on nutrition literacy. Which is defined as the ability to acquire, understand and adopt basic nutrition information. This study was designed to determine whether the adolescents nutritional literacy (ANL) is effective in the eating behaviors of individuals.

Methods: This cross-sectionally planned study was conducted between June April-June 2022 at Kırıkkale University Faculty of Medicine Department of Child Health and Diseases. The sociodemographic characteristics. Nutritional literacy and eating behaviors of adolescents were determined by face-to-face interview method and their anthropometric measurements were examined. These measurements were evaluated with the height length of adolescents according to age, body mass index (BMI) Z scores. The participants' nutritional literacy was revealed with the 'ANL Scale' and their eating behaviors were revealed with the 'Adolescent Eating Habits Checklist' (AEHC).

Results: Of the 220 volunteer adolescents who participated in the study. 62.3% were girls and 37.7% were boys. The Functional Nutritional Literacy (FNL) score of girls was higher than that of boys ($p=0.01$). The total score of the Adolescent Nutrition Literacy (ANL) Scale. Interactive Nutrition Literacy (INL). Critical Nutrition Literacy (CNL) and Adolescent Eating Habits Checklist (AEHC) scores were lower for adolescents who did not do regular physical activity ($p<0.05$). The total score of the ANL Scale. CNL and AEHC scores of the adolescents who did not consume fast food were higher than those of the adolescents who consumed fast food ($p<0.05$). There was a negative correlation between the frequency of fast food consumption and AEHC score ($p<0.05$).

Conclusion: As a result of the study, it was found that adequate nutrition literacy of adolescents can have a positive effect on their eating habits. For this reason, it was considered necessary to provide education to adolescents in order to increase awareness of nutritional literacy.

Keywords: Adolescent, nutrition literacy, eating habits checklist

INTRODUCTION

According to the World Health Organization (WHO) adolescence is defined as the period from ages 10 to 19.¹ During this time, adolescents experience increased growth and development, along with heightened nutritional needs. The dietary habits established in adolescence are significant because they impact later life and are linked to nutritional disorders and nutrition-related diseases.^{2,3} Diseases such as obesity, diabetes, hypertension, which develop as a result of the deterioration in the diet quality of adolescent individuals

in our country and around the world and unhealthy eating habits acquired during this period, pose a risk for future health. Adolescents need to correctly perceive, evaluate and apply nutrition-related information for healthy food consumption.⁴ As information on diet and nutrition becomes more accessible, people must make informed food choices to safeguard their health amid rising chronic disease rates.^{5,6} Nutrition literacy has become increasingly important as it relates to healthy eating and the nutritional environment.⁷

For this reason, studies have been conducted in recent years on nutrition literacy, which is defined as the ability to acquire, understand and adopt basic nutrition information. However, research on nutrition literacy is limited due to the inadequate reliability assessments of the tests used, the validity of new tools being tested only on select groups, and the current health literacy criteria not adequately encompassing nutrition literacy.^{8,9} Therefore, this study aims to identify factors affecting nutritional literacy and eating behaviors among adolescents.

METHODS

This cross-sectionally planned study was conducted at Pediatric Clinic of Kırıkkale University Faculty of Medicine Hospital between April and June 2022. The inclusion criteria for the study were adolescents aged between 10 and 18 years without any chronic diseases except obesity and not on continuous medication. The sociodemographic characteristics, Nutritional literacy and eating behaviors of adolescents were determined by face-to-face interview method and their anthropometric measurements were examined. The participants' weight, Height, and body mass index were measured. These measurements were evaluated with the height length of adolescents according to age, body mass index (BMI) Z scores.

The sociodemographic information and lifestyle behaviors of the participants were gathered using a survey form consisting of 24 questions developed by the researcher based on existing literature.⁴ The survey collected data on the adolescents' age, body weight, height, eating habits, physical activity levels, and behaviors such as sleep and screen time. It also included questions about the educational status of their families, family income level, and the occupations of the parents. The participants' nutritional literacy was revealed with the 'Adolescent Nutrition Literacy Scale (ANLS) and their eating behaviors were revealed with the 'Adolescent Nutrition Habits Checklist' (ANHC). The study was approved by the Kırıkkale University Faculty of Medicine Scientific Researches and Publication Ethics committee (Date: 23.03.2022, Decision No: 87606). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

The participants were grouped based on specific criteria:

- Sleep duration
- Screen time: 0-6 hours, 7-12 hours, and >12 hours
- Fast food consumption frequency: never, <3 times/day, and ≥3 times/day (4)
- Family income status (self-reported): no regular income, income does not cover expenses, income covers expenses

Height-for-age and BMI Z-scores of adolescents were calculated with the Child Metrics application and classified according to WHO's reference values for ages 5-19.¹⁰

Adolescent Nutrition Literacy Scale

Bari developed an ANLS survey with 29 questions based on Pettersen et al.'s¹¹ work in a cross-sectional study involving 506 adolescents in the Kampala region of Uganda. The scale is divided into the following three subgroups: Functional Nutrition Literacy (FNL) that measures the ability to apply basic nutrition-related literacy skills; Critical Nutrition

Literacy (CNL) that assesses the ability to evaluate situations that hinder good nutrition through critical thinking; Interactive Nutrition Literacy (INL) that evaluates the skills to interact and communicate effectively about nutrition topics. The scale aims to provide a comprehensive assessment of adolescents' nutritional literacy by evaluating their basic skills, critical thinking abilities and interactive capabilities related to nutrition. The adaptation of the scale to Turkish was conducted in 2017, using data collected from 474 adolescents.¹² The validated scale is a five-point Likert-type scale consisting of 22 items divided into three sub-dimensions. The total possible score ranges from a minimum of 22 to a maximum of 110. Higher scores on the scale indicate a higher level of nutritional literacy, reflecting the ability to apply knowledge and skills in real-world nutrition-related situations.^{4,12}

Adolescent Nutrition Habits Checklist

The Adolescent Nutrition Habits Checklist is used to assess the validity of the ANLS by evaluating eating habits among adolescents. It was originally developed by Johnson et al.¹³ in 2002 and consists of 23 items that measure healthy eating behaviors. Each correct answer related to healthy eating is awarded one point. The maximum score attainable on the scale is 23 points. An increase in scores signifies an improvement in the healthy eating behaviors of adolescents. The Turkish adaptation of the ANHC was conducted by Arikan et al.⁴ in 2012. The adapted scale consists of 19 items divided into the following categories: sugar consumption (4 items), fat intake (6 items), fruit-vegetable consumption (6 items), carbohydrate-fast food consumption (2 items), general diet status (1 item). Each correct response regarding healthy nutrition is worth one point. The maximum score on the checklist is 19 points. Higher scores indicate better adherence to healthy eating behaviors among adolescents. This checklist is a valuable tool for evaluating adolescents' nutritional habits and identifying areas for improvement in promoting healthier eating patterns.

Statistical Analysis

The analysis of the data obtained from the study was conducted using the SPSS (Statistical Package for Social Science) version 26.0 software. The mean ($\bar{X}$) and standard deviation values were calculated for quantitative data. Frequency tables and percentage values were provided for categorical variables. The Kolmogorov-Smirnov test was used to assess the suitability of the data for a normal distribution. An independent two-sample t-test was used to evaluate whether there was a difference between the means of two independent groups. One-way analysis of variance (ANOVA) was used to determine if there were differences between the means of three or more independent groups. For variables showing significant differences, Tukey's test (a Post Hoc test) was used to identify which specific group(s) caused the difference. Linear regression was employed to evaluate the relationship between adolescents' height-for-age and BMI Z-scores, and the scores of ANHC, ANLS, and their sub-dimensions. A p-value of less than 0.05 was considered statistically significant. This statistical approach provided a thorough analysis of the study data, enabling a better understanding of the differences and relationships observed.

RESULTS

Of the 220 volunteer adolescents who participated in the study, 62.3% were girls and 37.7% were boys. A majority of the

participants (57.2%) are high school students. While 12.2% come from families with insufficient income to meet their expenses. Additionally, 21.8% of the adolescents' mothers are employed. Examining the educational background of the adolescents' families reveals that 35.5% of the mothers and 40.9% of the fathers have graduated from high school and 6.8% of the parents are divorced. It was also found that a large portion of adolescents (71.8%) do not engage in regular physical activity, 90.4% sleep between 7 and 12 hours daily and 79.6% spend at least 1 hour per day in front of a screen. Demographic characteristics are shown in Table 1

Table 1. Demographic characteristics

	Female		Male		Total	
	n	%	n	%	n	%
Children's education status						
No education	5	3.6	9	10.8	14	6.4
Primary school	48	35	32	38.6	80	36.4
High school	84	61.3	42	50.6	126	57.3
Mother's education status						
Illiterate/non-literate	3	2.2	4	4.8	7	3.2
Primary school	65	47.4	40	48.2	105	47.7
High school	50	36.5	28	33.7	78	35.5
University	19	13.9	11	13.3	30	13.6
Father's education status						
Illiterate/non-literate	1	0.7	0	0	1	0.5
Primary school	42	30.7	26	31.3	68	30.9
High school	57	41.6	33	39.8	90	40.9
University	37	27	24	28.9	61	27.7
Well-organized income	18	13.1	6	7.6	24	11.1
Organized income that covers expenses	104	75.9	63	79.7	167	77.3
Organized income that does not cover expenses	15	10.9	10	12.7	25	11.6

BMI: Body mass index, IQR: Interquartile range, $\bar{X} \pm SD$: Standart $\pm$ deviation

The FNL score of girls was higher than that of boys ($p=0.01$). The total score of the ANLS, INL, CNL and ANHC scores were lower for adolescents who did not do regular physical activity ($p<0.05$). The total score of the ANLS, CNL and ANHC scores of the adolescents who did not consume fast food were higher than those of the adolescents who consumed fast food ($p<0.05$). There was a negative correlation between the frequency of fast food consumption and ANHC score ($p<0.05$). The age and certain anthropometric measurements of the adolescents are detailed in Table 2. There was no significant difference in mean of age and BMI between genders ($p=0.440$, $p=0.242$ respectively). The median weight was significantly higher in males than females ($p=0.015$) but there was no difference in mean of height between them ($p=0.479$).

Table 2. Age and some anthropometric measurements of adolescents

Variables	Female n=137	Male n=83	p
Age (year) $\bar{X} \pm SD$	14.35 $\pm$ 2.04	14.10 $\pm$ 2.36	0.440
BMI (kg/m) $\bar{X} \pm SD$	22.61 $\pm$ 5.08	21.71 $\pm$ 5.38	0.242
	Median (IQR)	Median (IQR)	
Height (cm)	160 (155-166)	165 (154.5-175.0)	0.479
Weight (kg)	54(46.1-69.0)	57 (48.0-71.0)	0.015

According to the distribution of various characteristics related to the eating habits of the adolescents. 80.5% of the adolescents skip meals. Among the skipped meals, breakfast is skipped by 26% lunch by 36.2%, dinner by 4.5%, and snacks by 33.3%. Additionally, 72.7% of the

Table 3 illustrates the distribution of height and BMI scores among adolescents categorized by age. The data shows that 3.2% of the participants are classified as very short. 6.8% as short. 62.3% as having normal height, 20.9% as tall, and 6.8% as very tall. Regarding BMI 2.2% of the participants are considered very thin, 12.3% are underweight, 47.3% are of normal weight, 17.3% are slightly overweight, and 20.5% are classified as obese.

Table 3. Adolescents' BMI scores distribution by age

BMI	Female		Male		Total	
	n	%	n	%	n	%
<3p	5	3.6	5	6	10	4.5
5-15.p	11	8	4	4.8	15	6.8
15-85p	73	53.3	39	47	112	50.9
85-97p	16	11.7	16	19.3	32	14.5
>97p	32	23.4	19	22.9	51	23.2

Table 4 presents a comparison of scores from the ANLS and the ANHC based on the sociodemographic characteristics of the adolescents. The data reveals that while there are no significant differences in the ANLS total score, INL, CNL and ANHC scores based on gender ($p>0.05$). There is a significant difference in ANLS scores by gender with girls having higher FNL scores compared to boys ($p=0.01$). There are no significant differences in the ANLS total score, FNL, INL, and CNL scores based on the adolescents' educational level ($p>0.05$), but differences in ANLS scores by educational level are significant ($p<0.05$). Specifically, adolescents in primary school have higher ANHC scores than those in high school ($p=0.04$). Family income level does not significantly affect the ANLS total score, FNL, INL, and CNL scores ($p>0.05$). However, there are significant differences in ANHC scores related to the father's employment status with adolescents whose fathers are employed having higher ANHC scores than those whose fathers are not ($p=0.02$). Additionally, the INL score is higher for adolescents whose mothers are employed compared to those whose mothers are not ($p<0.05$). There are no significant differences in the ANLS total score, FNL, INL, CNL, and ANHC scores based on the educational level or marital status of the families ($p>0.05$). Adolescents who do not engage in regular physical activity have lower ANLS total, INL, CNL, and ANHC scores compared to those who are physically active ($p<0.05$). Furthermore, adolescents who spend at least 1 hour in front of a screen have significantly lower ANHC scores than those who do not spend any time in front of the screen ($p=0.01$).

Table 5 presents a comparison of scores from the ANLS and the ANHC based on various eating habits of the adolescents. The data shows that FNL and INL scores do not differ significantly based on fast-food consumption status ($p>0.05$). However, there are significant differences in the ANLS total score, CNL and ANHC scores, with adolescents who do not consume fast food scoring higher in these areas compared to those who do consume fast food ($p<0.05$). Regarding meal skipping there are no significant differences in the ANLS total score, FNL, INL and CNL scores ($p>0.05$). However significant differences in ANHC scores are observed based on the frequency of fast-food consumption ($p=0.03$). Specifically, adolescents who consume fast food three or more times per day have lower ANHC scores compared to those who do not consume fast food ($p=0.03$). There are no significant differences in the ANLS total score, FNL, INL, CNL, and ANHC scores based on meal skipping

Table 4. Comparison of adolescent nutrition literacy scale and adolescent nutrition habits checklist scores according to sociodemographic characteristics of adolescents

Demographic variables	ANLS total score X±SS	p	FNL score X±SS	p	INL score X±SS	p	CNL score X±SS	p	ANHC score X±SS	p
Gender										
Female	69.83±9.81		24.17±5.52		17.92±4.91		27.67±4.56		8.70±3.94	
Male	67.75±10.20	0.13	22.25±5.96	0.01	16.98±5.13	0.17	27.93±3.83	0.65	8.55±4.47	0.80
Educational status										
Continuing primary education	68.57±9.67	0.58	23.54±5.54	0.84	17.40±4.62	0.69	27.59±4.39	0.61	9.32±4.13	0.04
Continuing high school	69.37±10.21		23.38±5.90		17.68±5.26		27.89±4.24		8.18±4.09	
Income status										
No income	69.02±8.24		24.20±5.17		17.08±4.41		27.87±3.39		8.25±4.22	
Income meets expenses	69.07±10.45		23.59±5.73		17.67±5.19		27.67±4.51		8.79±4.12	
Income does not cover expenses	67.68±8.65	0.77	22.28±6.68	0.47	17.4±4.71	0.85	28.20±3.87	0.84	8.24±4.21	0.72
Father's employment status										
Employee	69.02±9.76		23.37±5.72		17.56±5.01		27.84±4.28		8.84±4.0	
Non-Employee	69.33±12.17	0.89	24.19±6.11	0.53	17.61±5.04	0.96	27.04±4.52	0.41	6.76±4.7	0.02
Mother's employment status										
Employee	70.35±10.68		23.62±5.43		19.08±5.17		27.35±3.83		8.14±3.8	
Non-Employee	68.69±9.78	0.30	23.40±5.85	0.81	17.15±4.89	0.01	27.88±4.42	0.44	8.78±4.2	0.34
Mother's educational status										
Illiterate	72.42±2.22		23.28±6.82		20.57±2.87		28.57±4.15			
Primary school	67.78±9.63		23.44±5.70		16.66±4.77		27.54±4.14			
Middle school	69.72±10.58		22.93±5.30		17.29±4.98		28.70±3.96			
High school	69.26±9.82		23.37±5.64		17.89±4.78		27.88±4.48			
Bachelor's degree	69.69±11.45	0.80	24.57±7.07	0.92	18.50±6.32	0.31	26.46±4.48	0.34	0.68	
Postgraduate	69.75±12.63		23.75±4.27		17.00±5.59		26.00±5.09			
Father's educational status										
Illiterate	67.73±9.97		22.56±6.44		16.93±5.33		28.21±3.46			
Primary school	69.18±10.64		23.28±5.9		17.15±5.40		27.23±4.98			
Middle school	68.83±10.12		23.37±5.56		17.45±4.82		27.96±4.37			
High school	69.73±9.06	0.94	23.84±5.73	0.81	18.26±4.81	0.92	27.54±4.33	0.92	0.73	
Bachelor's degree	71.25±13.38		25.12±5.43		19.12±5.81		27.00±5.04			
Maritalstatus of families										
Married	68.96±10.08	0.60	23.46±5.74	0.86	17.52±5.05	0.61	27.68±4.37	0.28	0.83	
Divorced	70.33±8.73		23.20±6.06		18.20±4.42		28.93±2.89			
Regular physical activity status										
Yes	72.40±10.5		24.33±6.16		19.14±5.31		28.79±3.93		10.50±4.19	
None	67.74±9.44	0.02	23.10±5.56	0.14	16.95±4.76	0.00	27.37±4.38	0.00	7.91±3.89	0.00
Sleep time										
0-6 saat	66.28±8.86		23.42±4.19		16.71±5.28		26.14±4.8		8.00±5.65	
7-12saat	69.04±10.07		23.33±5.85		17.66±5.10		27.79±4.30		8.67±4.15	
>12 saat	70.64±9.63	0.64	25.07±5.01	0.55	16.64±3.29	0.68	28.21±4.09	0.56	8.5±3.36	0.90
Time spent on screen										
Ever	68.60±7.83		24.50±4.35		16±6.11		28.10±4.93		10.30±4.27 ^a	
<1 saat	69.97±8.88	0.83	23.25±6.07	0.83	18±5.09	0.54	29.0±3.88	0.16	10.17±4.17	0.01
≥1 saat	68.89±10.33		23.42±5.78		17.57±4.93		27.50±4.32		8.24±4.00 ^b	

* Independent 2-sample t test (t) and one-way analysis of variance ANOVA (F), post-hoc Tukey test were applied. ** ANLS: Adolescent Nutrition Literacy Scale, ANHC: Adolescent Nutrition Habits Checklist, FNL: Functional Nutrition Literacy, INL: Interactive Nutrition Literacy, CNL: Critical Nutrition Literacy

Table 5. Comparison of adolescent nutrition literacy scale and adolescent nutrition habits checklist scores according to the features of adolescents' nutritional habits

Nutrition habits	ANLS total score X±SS	p	FNL score X±SS	p	INL score X±SS	p	CNL score X±SS	p	ANHC score X±SS	p
Fastfood Consumption Status										
Yes	68.37±9.57		23.28±5.62		17.41±4.91		27.36±4.17		8.09±3.9	
None	71.17±11.1	0.04	24.09±6.26	0.41	18.20±5.38	0.35	29.38±4.45	0.00	10.84±4.38	0.00
Fastfood consumption frequency										
None	70.50±10.28		23.67±6.36		18.07±5.13		28.37±4.97	1	9.89±4.65 ^a	
<3 time/day	68.86±9.80	0.14	23.70±5.13	0.11	17.56±4.92	0.24	27.65±3.90	0.24	8.29±4.25	0.03
≥3 time/day	65.33±9.76		20.72±7.46		15.83±5.06		26.55±4.55		6.88±3.26 ^b	
Skipping meals										
Skip	69.22±10.07	0.64	23.62±5.62	0.41	17.76±5.04	0.29	27.67±4.44		8.52±4.18	0.42
Non-skip	68.48±9.77		22.86±6.20		16.92±4.88		28.10±3.78	0.54	9.06±3.99	

Independent 2-sample t test (t) and one-way analysis of variance ANOVA (F), post-hoc Tukey test were applied. ** ANLS: Adolescent Nutrition Literacy Scale. ANHC: Adolescent Nutrition Habits Checklist. FNL: Functional Nutrition Literacy. INL: Interactive Nutrition Literacy. CNL: Critical Nutrition Literacy

Table 6. Comparison of adolescent nutrition literacy scale and adolescent nutrition habits checklist scores according to height-for-age Z-score of adolescents

Height Z scores by age	ANLS total score X±SS	p	FNL score X±SS	p	INL score X±SS	p	CNL score X±SS	p	ANHC score X±SS	p
Very short (<-2SD)	59.7±12.4		18.00±6.29 ^a		14.85±5.30		26.85±3.62		7.00±4.86	
Short (≥ -2-<-1SD)	71.46±7.90	0.11	25.80±6.47 ^b	0.001	17.33±4.43	0.48	28.33±5.20	0.74	8.86±3.92	0.21
Normal (≥-1<1SD)	69.10±10.60		23.71±5.83		17.62±5.39		27.53±4.36		8.92±4.16	
Tall (≥1-<2SD)	68.93±8.73		22.80±5.01		17.43±3.89		28.39±4.00		7.54±3.78	
Very tall (≥2 SD)	70.86±6.37		23.20±4.98		19.06±4.83		27.93±4.13		10.00±4.45	

* One-way analysis of variance ANOVA (F) and post hoc Tukey test were performed, ** ANLS: Adolescent Nutrition Literacy Scale, ANHC: Adolescent Nutrition Habits Checklist, FNL: Functional Nutrition Literacy, INL: Interactive Nutrition Literacy, CNL: Critical Nutrition Literacy

Table 7. Comparison of adolescents' BMI Z score and adolescent nutrition literacy scale and adolescent nutrition habits checklist scores by age

BMI Z score by age	ANLS total score X±SS	p	FNL score X±SS	p	INL score X±SS	p	CNL score X±SS	p	ANHC score X±SS	p
Extreme underweight	64.80±12.70	0.62	21.80±6.45	0.67	16±4.30	0.69	27±4.60	0.86	8.40±4.80	0.31
Underweight	70.20±9.90	0.64	21.70±6.10	0.61	18±5.56	0.59	27.40±4.60	0.48	8.10±4.60	0.86
Normal	69.70±10.70		23.00±6.30		18.01±4.76		28.20±4.47		8.90±4.00	
Overweight	68.40±8.97		24.00±4.53		16.81±5.50		27.60±3.80		8.10±3.80	
Obese	67.80±8.80		23.24±4.75		17.08±4.89		26.90±4.00		8.70±4.20	

One-way analysis of variance ANOVA (F) was applied, ANLS: Adolescent Nutrition Literacy Scale, ANHC: Adolescent Nutrition Habits Checklist, FNL: Functional Nutrition Literacy, INL: Interactive Nutrition Literacy, CNL: Critical Nutrition Literacy

Table 6 compares adolescents' height-for-age Z scores with their scores on the ANLS and the ANHC. The data shows that there are no significant differences in the ANLS total score. INL and CNL scores based on height-for-age Z scores ($p>0.05$). However adolescents with very short height have significantly lower FNL scores compared to those who are short ($p=0.002$). Additionally ANHC scores do not differ significantly based on height-for-age Z scores ($p>0.05$). Table 7 presents a comparison of adolescents' BMI Z-scores by age with their scores on the ANLS and the ANHC. The data indicates that

there are no significant differences in the ANLS total score. FNL, INL and ANHC scores among adolescents classified as very thin, underweight, normal weight, slightly overweight or obese based on their BMI Z-scores for age ($p>0.05$).

DISCUSSION

This cross-sectional study aimed to explore the 'Relationship Between Nutritional Literacy, Eating Behavior, and Influencing Factors in Adolescents. Maintaining healthy eating habits is

crucial for overall health. It is recommended for adolescents to develop a routine of consuming 4-6 meals per day, including 2-3 snacks alongside the three main meals, while considering their physical activity levels and individual needs.¹⁴ In this study 80.5% of adolescents skip meals, with lunch (36.2%) and snacks (33.3%) being the most frequently missed. A study involving 625 adolescents found that 69.3% skipped at least one meal.¹⁵ Similarly, Yavuz and Özer's¹⁶ study with 933 adolescents identified lunch as the most commonly skipped meal, followed by breakfast. These findings highlight the need for educational interventions for adolescents and their families on proper nutrition and the importance of regular meals.

Micronutrient deficiencies commonly occur during adolescence due to rapid growth and development. To counteract these deficiencies, it is crucial to include fruits and vegetables in snacks.¹⁷ In this study, 72.7% of adolescents reported consuming snacks with fruits and vegetables (33.2%) and milk and dairy products (21.8%) being the most frequently consumed items. Another study in Izmir found that adolescents' snacks included 57.4% fruits and vegetables, 42.6% milk and dairy products, and 70.9% fast food.⁴ In this study about one-third of adolescents included fruit in their snacks, and 21.8% included milk and dairy products. These results are consistent with previous findings. However, a limitation noted in this and other studies is the lack of data on the quantity of food consumed.

Fast food often referred to as 'garbage food' in Western terminology, has become an unavoidable aspect of contemporary life and nutrition.¹⁸ Research involving adolescents has revealed a high frequency of fast food consumption. These foods which are high in energy and fat contribute to the development of obesity and related health issues.¹⁹ Consistent with previous studies.^{4,20} In this study found that 80% of adolescents consume fast food. The fact that 15.5% of them also consume junk food (such as hamburgers, lahmacun, french fries, and packaged products) during snacks indicates a nutritional problem among adolescents in our country.

Regular physical activity is essential for enhancing health, physical fitness, and overall competence in children and adolescents. Physically active adolescents generally have better cardiorespiratory health, lower body fat, stronger muscles and bones, and improved mental health compared to their inactive peers.²¹ The WHO advises that adolescents engage in at least 60 minutes of moderate to vigorous physical activity each day.²² Despite this, inadequate physical activity is a global issue with 81% of adolescents not meeting the recommended activity levels.²³ In a study with 1033 adolescents 63% of children took part in organised sport training.²⁴ In this study finding that 71.8% of adolescents did not engage in regular physical activity aligns with these previous results. During adolescence marked psychological and biological changes significantly impact the sleep-wake cycle. Adolescents require 8-10 hours of sleep per day which is more than the sleep needed by children and adults.^{25,26} A study in Austria reported that adolescents slept between 8.5 and 9.1 hours.²⁷ Similarly, in this study found that 90.5% of adolescents slept between 7 and 12 hours per day. The high rate of obesity in this study may be due to the fact that obesity is among the reasons for admission to the pediatric nutrition and diet clinic.

Stunting is defined as low height for age and chronic malnutrition. It is an indicator of malnutrition and health conditions.²⁸ In the Türkiye Nutrition Health Survey, it was found that the prevalence of stunting in children and adolescents aged 6-18 was 6.4% and this rate decreased with age.²⁹ In a study conducted in 2020 in Ankara with 1484 participants to evaluate the growth of children and adolescents people between the ages of 10-17, 2.2% were stunted (<-2SD), 95.1% were normal (>-1SD, <1SD), 2.5% were tall (>2SD), 0.2% of them are too long.³⁰ In this study, the rate of stunting among adolescents is lower than the countrywide rate, but is similar to the study by Özer et al.³⁰

The total scores for the ANLS, INL, and ANHC were similar across genders ($p>0.05$). However the FNL score was higher for girls ($p=0.01$). This finding is supported by a study conducted at Gazi University which explored the relationship between nutritional knowledge, habits, Behaviors, and body mass indexes in 1304 adolescents.³¹ It was observed that the nutrition knowledge levels of female students were significantly higher than those of male students. Additionally a study in Iran measuring nutritional literacy with the ANLS found that girls had a higher FNL nutritional literacy level, with this difference being statistically significant.³² These results suggest that girls may be more sensitive to nutrition literacy, possibly influenced by their body perception as they tend to view themselves as more overweight compared to boys who are actually overweight.

The educational level of parents is a key socioeconomic factor influencing adolescent nutrition. Galvan-Portillo et al.³³ found a significant correlation between nutrition knowledge and adolescents' nutritional literacy. Contrary to this, in this study showed that the ANLS total score, FNL, INL, CNL and ANHC scores which reflect nutrition behavior were similar across different levels of parental education ($p>0.05$). However the study revealed that the INL score was higher among adolescents with working mothers, and the ANHC score indicating positive nutritional habits was higher among adolescents with working fathers ($p=0.02$, Table 4, 5). While the increased participation of women in the workforce might negatively impact children's food preferences and eating habits the presence of working parents may contribute to better nutritional habits by potentially enhancing the family's overall welfare.

To explore the connection between physical activity and nutritional behavior in adolescents, a study with 436 participants evaluated physical activity levels using the "Physical Activity Questionnaire for Children" and assessed nutritional behavior with the "Nutrition Behavior Scale".³⁴ The study found a significant positive relationship between physical activity and nutritional behavior among adolescents. Another study involving 740 participants examined the relationship between nutritional literacy and various factors including physical activity, and found a link between physical activity level and nutrition literacy.³⁵

Yilmazel and Bozdoğan³⁶ used the ANLS to assess the nutritional literacy of 307 adolescents revealing that those who engaged in regular physical activity had higher nutritional literacy levels. Similarly Koca and Arkan⁴ utilized the ANLS and the ANHC with 467 adolescents, finding that those who participated in regular sports had higher scores across ANLS

total scores, CNL, INL, and ANHC. Consistent with these findings. In this study also showed that adolescents who engaged in physical activity had higher scores in ANLS total INL CNL and ANHC ($p<0.05$). The increase in nutrition literacy scores among physically active adolescents is thought to reflect their awareness of the role of physical activity in maintaining a healthy lifestyle.

Nutrition sleep quality and sleep duration are interconnected concepts. Poor nutrition, overnutrition, and obesity can lead to sleep-related issues.³⁷ Adolescents generally require 8-10 hours of sleep per day.³⁸ Lafci's³⁹ study found that adolescents with a daily sleep duration of 4-6 hours had lower INL levels compared to those who slept 7-9 hours or more than 10 hours. In contrast, Koca and Arkan⁴ observed that adolescents sleeping 7-12 hours daily had higher ANHC scores. In this study however no significant relationship was found between adolescents' sleep duration and their nutritional literacy or eating behavior. This lack of significant findings may be attributed to the fact that most participants had adequate sleep durations.

Technological advancements over the past two decades have led individuals to spend more time in front of screens. During adolescence the search for identity and the desire for social interaction further increase screen time. This shift has contributed to the development of unhealthy lifestyle habits, including weight gain and poor eating behaviors. Increased screen time is often associated with a higher intake of low-nutritional-value foods such as pizza, hamburgers, chips, and sugary drinks while fruit and vegetable consumption decreases.⁴⁰

A study involving 467 adolescents which assessed nutritional literacy using the ANLS and eating behavior with the same scale, found that those who watched television for less than 1 hour per day had significantly higher SNLS total scores, FNL, and INL scores.⁴ Similarly, in our study revealed that while ANLS total scores, INL, FNL, and CNL scores were similar across different screen times, adolescents who spent 1 hour or more in front of screens had significantly lower ANHC scores compared to those who did not spend time in front of screens ($p=0.01$). This suggests that higher nutritional literacy and better subheading scores may be linked to less screen time and a more conscious approach to healthy living.

Nutritional literacy encompasses the knowledge and skills required for healthy eating.⁴¹ A significant relationship exists between scores from the ANHC, which measures healthy eating behavior and the degree of healthy eating behavior; higher ANHC scores correlate with better eating habits.^{3,4} In a study assessing the nutritional literacy of 697 adolescents in Samsun using the ANLS. It was found that those who never consumed fast food had higher nutritional literacy compared to those who ate fast food once a week or Daily.³⁹ Similarly, in this study revealed that adolescents who did not consume fast food had higher ANLS total scores CNL and ANHC scores compared to those who did consume fast food ($p<0.05$). Adolescents consuming fast food three or more times a day had a lower ANHC score compared to those who never ate fast food ($p=0.03$).

Nutritional literacy which includes knowledge and the ability to make informed food choices is linked to improved dietary behaviors. Healthy nutrition during adolescence is crucial for promoting proper growth and development, and plays

a significant role in preventing chronic diseases including obesity.⁴² In this context the relationship between adolescents' height-for-age and BMI Z scores with their nutritional literacy and eating habits can provide insight into how well-informed dietary choices and behaviors correlate with physical growth and weight management. This relationship underscores the importance of nutritional literacy in fostering healthy eating practices that contribute to overall well-being and prevent obesity.

Functional nutrition literacy involves recognizing health risks obtaining information on preventive health services and utilizing these services to mitigate potential health issues.⁴³ INL refers to the process of choosing healthy foods by leveraging nutritional knowledge reflecting on ways to enhance this knowledge and implementing healthy eating practices for oneself and society.^{44,45}

In this study 17.27% of participants were slightly obese, and 20.46% were obese. However consistent with other studies.^{3,31} No significant relationship was found between BMI Z scores and ANLS total score or ANHC ($p>0.05$). Regression analysis accounting for age and gender as potential confounders also showed no significant correlation between body weight Z scores and ANLS or ANHC scores. This lack of correlation may be due to the relatively small sample size of slightly overweight and obese adolescents (37.8% of the participants, totaling 83 adolescents). Despite the absence of a positive correlation between body weight and nutritional literacy scores, adolescents who do not consume fast food had higher ANLS total scores, CNL and ANHC scores. Additionally, those who do not engage in regular physical activity had lower ANLS total scores, INL, CNL, and ANHC scores compared to those who engage in regular physical activity ($p<0.05$). These findings suggest that while body weight and nutritional literacy may not be directly correlated, healthier eating habits and regular physical activity are associated with higher nutritional literacy and better eating behavior scores.

Height assessment by age is a crucial indicator of nutritional and overall health status in children and adolescents.³⁰ During adolescence when growth and development accelerate and energy needs increase, ensuring adequate intake of nutrients such as calcium, phosphorus, copper, zinc, and vitamin D is essential for achieving optimal bone density and height for age.

FNL refers to the capability to understand and utilize health services to mitigate health risks through awareness of these risks.⁴³ In this study, there was no significant relationship between height-for-age Z scores and the ANLS total score, INL, or CNL scores among adolescents with normal, tall, and very tall heights ($p>0.05$). Among the 220 participants, 10% were categorized as short or very short. Table 4,7 shows no significant differences in ANLS total score, INL, or CNL scores based on height-for-age Z scores ($p>0.05$). Additionally, ANHC scores were similar across height-for-age categories ($p>0.05$). However, the FNL score of very short adolescents was significantly lower than that of short adolescents ($p=0.002$). This finding suggests that short stature which often indicates chronic nutritional deficiencies, aligns with lower functional nutrition literacy scores. This literacy involves recognizing unhealthy foods, understanding the benefits of healthy foods, and making informed food choices.

The development of eating habits, which are established during

adolescence. plays a critical role in shaping adult dietary patterns. At age 15 eating behaviors are generally consolidated with only minor changes occurring between ages 15-18 highlighting the significance of this period for future eating habits.⁴⁶ These habits can be influenced through observation. role models. and media guidance.

Research indicates that ANHC scores tend to be lower in adolescents with poor eating habits.⁴ Good eating habits have been shown to positively impact various dimensions of nutrition literacy. European countries between 2006-2007 found that nutritional knowledge increased by approximately 2% annually accounting for socio-economic and anthropometric variables.⁴⁷

CONCLUSION

This study found that adequate nutritional literacy among adolescents may have a positive effect on their nutritional habits for this reason. It was considered necessary to provide education to adolescents in order to increase awareness of nutritional literacy.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was approved by the Kırıkkale University Faculty of Medicine Scientific Researches and Publication Ethics Board (Date: 23.03.2022, Decision No: 87606).

Informed Consent

All patients signed and free informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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The frequency of sleep disorders and their relationship with demographic factors in patients with tinnitus

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ABSTRACT

Aims: This study aimed to investigate the frequency of sleep disorders in individuals diagnosed with tinnitus and to investigate the effect of demographic factors on these disorders.

Methods: This retrospective study included 112 patients diagnosed with tinnitus between January 2018 and December 2019 at the Gazi Yaşargil Training and Research Hospital's otolaryngology clinic. The electronic files of the participants in the study were examined for sleep disorders such as insomnia, hypersomnia, inability to fall asleep, sleep terrors, sleepwalking according to ICD-9 and ICD-10 codes. The effect of demographic findings on sleep disorders were examined with multivariable regression analysis.

Result: The mean age of the study population was 38.12 ± 11.35 years and 48.21% were female. The frequency of sleep disorders was 20.5%. The female gender ratio, body mass index (BMI), smoking users and housewife ratio were higher in the group with tinnitus and sleep disorders compared to the group with isolated tinnitus. The mean age was higher in the group with isolated tinnitus compared to the group with tinnitus and sleep disorders. Advancing age (OR= 1.33, $p=0.038$) and elevated BMI levels (OR=1.55, $p=0.035$) were associated with an increased likelihood of sleep disorders, whereas male gender (OR=0.74, $p=0.038$) was associated with a decreased likelihood.

Conclusion: This study demonstrated that sleep disorders are prevalent in tinnitus patients. Advancing age and increased BMI were tied to a higher likelihood of sleep disorders in tinnitus patients, whereas male gender was linked to a reduced risk. These results indicate that demographic factors should be taken into account when managing sleep disorders in tinnitus patients.

Keywords: Hearing loss, insomnia, sleep disorders, sleep quality, tinnitus

INTRODUCTION

Tinnitus is a common clinical condition that can be seen in approximately 14% of adults and increases with age.¹ It is caused by abnormal activity within the nervous system without any internal or external acoustic stimulation.² Sounds such as ringing, hissing, whining, humming, buzzing and whistling are heard without any external sound.³ It is not fully understood how tinnitus occurs and what causes it. Although there are many models explaining the pathophysiology of tinnitus, none of them explain tinnitus in all its aspects.⁴ The main models are the peripheral model, which includes dysfunction in the auditory periphery such as cochlea or auditory nerve damage;⁵ the central model, which is caused by changes in the central auditory pathways;⁶ the gating model, which is caused by increased central auditory activity together with frontostriatal inhibitor deficiency;⁷ the somatosensory model, which explains tinnitus resulting from abnormal interactions between the auditory and somatosensory systems;⁸ and the inflammatory model, which has been emphasized recently.⁹ Many acute or chronic diseases or clinical conditions that cause changes in

vital signs can cause tinnitus with one of the above pathological patterns.⁴ We think that sleep disorders are one of these clinical conditions that may be associated with tinnitus.

Sleep disorders are an important clinical condition that can affect human health and quality of life, and their frequency increases with obesity, chronic diseases and sedentary lifestyle.¹⁰⁻¹² Insomnia, hypersomnia, inability to fall asleep, sleep terror, sleepwalking, obstructive sleep apnea, central sleep apnea are some of these important sleep disorders.¹³ Poor quality, insufficient or irregular sleep affects the endocrine, gastrointestinal, cardiovascular, nervous and cognitive functions of the human body.¹⁴⁻¹⁷ Sleep disorders can be observed with a high frequency of 25 - 77% in people with tinnitus.¹⁸ It has been reported that insomnia can be seen in approximately 50% of those with serious tinnitus.¹⁹ In addition to insomnia, tinnitus can also be seen with a significant frequency in cases of sleep bruxism, respiratory sleep disorders and obstructive sleep apnea.²⁰

In the light of this information, this study aimed to investigate

the frequency of sleep disorders in individuals diagnosed with tinnitus and to investigate the effect of demographic factors on these disorders.

METHODS

Following the principles set forth in the Declaration of Helsinki, this retrospective study was conducted at the Diyarbakır Gazi Yaşargil Training and Research Hospital Otolaryngology Clinic from January 2018 and December 2019. The study received approval from the Gazi Yaşargil Training and Research Hospital Ethics Committee (21.07.2023 - No: 483). The need for informed consent was waived under the approval of the local ethics committee due to the retrospective design.

A total of 368 patients diagnosed with tinnitus were evaluated for eligibility according to the research criteria. Inclusion criteria included patients being between 18 and 55 years old and without any comorbidities. The age range of 18-55 years was chosen to focus on adult patients and to minimize the influence of age-related confounding factors such as presbycusis and higher prevalence of sleep disorders in the elderly.²¹⁻²⁴ Patients with a recent history of ear infection, ear surgery or trauma, any history of comorbidities, and those with incomplete data were excluded from the study. Following the exclusion criteria, 112 patients diagnosed tinnitus were included in the study.

The electronic files of the participants in the study were examined for sleep disorders such as insomnia, hypersomnia, inability to fall asleep, sleep terrors, sleepwalking according to ICD-9 and ICD-10 codes. The hospital's electronic information system and patient files were used to gather demographic and clinical data.

Statistical Analysis

All data were analyzed with IBM SPSS Statistics for Windows 20.0 (IBM Corp., Armonk, NY, USA). Numerical data determined to be normally distributed based on the results of Kolmogorov-Smirnov tests are given as mean and standard deviation (SD) values while non-normally distributed variables are given as median (min-max). For comparisons between groups, Student t-test and Mann-Whitney U test for two group. Categorical variables are given as numbers and percentages, and inter-group comparisons were conducted with Chi-square and Fisher exact tests. The effect of the parameters on sleep disorders was evaluated using multivariable logistic regression analysis. $P < 0.05$ was considered statistically significant.

RESULTS

The mean age of the study population was 38.1 ± 11.4 years and 48.21% were female. Sleep disorders (insomnia, hypersomnia, inability to fall asleep) were detected in 23 of these cases (20.5%). Eight of the patients diagnosed with sleep disorders had depression and anxiety diagnoses made in the psychiatry clinic. Clinical and demographic findings of the study population are summarized in Table 1.

The study population was divided into two groups: those diagnosed with isolated tinnitus and those with sleep disorders along with tinnitus. Comparative demographic findings of the groups are summarized in Table 2. The female gender ratio (60.9% vs. 38.2%, $p=0.006$, respectively), body mass index (BMI) (28.7 ± 3.9 vs. 25.2 ± 2.4 , $p=0.010$, respectively), smoking users (47.8% vs. 37.1%, $p=0.042$, respectively) and housewife ratio (34.8% vs. 15.7%, $p=0.035$, respectively) were higher in the group with tinnitus and sleep disorders compared to the

group with isolated tinnitus. The mean age (42.2 ± 13.2 vs. 34.3 ± 9.1 years, $p=0.019$, respectively) was higher in the group with isolated tinnitus compared to the group with tinnitus and sleep disorders (Table 2). It was determined that 57.1% of women with insomnia were housewives.

Table 1. Demographic data of patients

Variables	All population n=112
Age, year	38.1 ± 11.4
Gender, n (%)	
Female	48 (42.9)
Male	64 (57.2)
BMI, kg/m ²	27.2 ± 3.3
Housewife, n (%)	22 (19.6)
Smoking, n (%)	44 (39.3)
Sleep disorders, n (%)	
No	89 (79.5)
Yes	23 (20.5)
Depression / anxiety, n (%)	8 (7.1)
Duration of diseases, week	
Tinnitus	27.3 ± 12.6
Sleep disorder	20.6 ± 10.2

Data are mean $\pm$ standard deviation or number (%). Abbreviations: BMI: Body mass index

Table 2. Distribution of demographic characteristics according to the presence of sleep disorders in tinnitus patients

Variables	Sleep disorder		p
	No n=89	Yes n=23	
Age, year	34.3 ± 9.1	42.2 ± 13.2	0.019*
Gender, n (%)			
Female	34 (38.2)	14 (60.9)	0.006*
Male	55 (61.8)	9 (39.1)	
BMI, kg/m ²	25.2 ± 2.4	28.7 ± 3.9	0.010*
Housewife, n (%)	14 (15.7)	8 (34.8)	0.035*
Smoking, n (%)	33 (37.1)	11 (47.8)	0.042*

Data are mean $\pm$ standard deviation or number (%). * $p < 0.05$ indicates statistical significance
Abbreviations: BMI: Body mass index

The effect of demographic findings on sleep disorders is shown in Table 3. Advancing age (OR=1.33, 95% CI=1.09–1.72, $p=0.038$) and elevated BMI (OR=1.55, 95% CI=1.23–1.87, $p=0.035$) levels were associated with an increased likelihood of sleep disorders, whereas male gender (OR=0.74, 95% CI=0.52–0.96, $p=0.038$) was associated with a decreased likelihood.

Table 3. The effect of demographic characteristics on sleep disorders in tinnitus patients.

Variables	Univariable regression		Multivariable regression	
	OR (95% CI)	p	OR (95% CI)	p
Age, year	1.33 (1.09 - 1.72)	0.019*	1.33 (1.09-1.72)	0.038*
Gender, n (%)				
Female	Reference			
Male	0.70 (0.44 - 0.96)	0.006*	0.74 (0.52-0.96)	0.042*
BMI, kg/m ²	1.51 (1.05 - 1.97)	0.010*	1.55 (1.23-1.87)	0.035*
Housewife, n (%)	1.54 (1.10 - 1.98)	0.035*	-	-
Smoking, n (%)	1.66 (1.14 - 2.19)	0.042*	-	-
Nagelkerke R ² =0.268				

* $p < 0.05$ indicates statistical significance. Abbreviations: BMI: Body mass index, CI: Confidence interval, OR: Odds ratio

DISCUSSION

In our study, we retrospectively examined the relationship between tinnitus and sleep disorders. It was determined that there was a sleep disorder rate of 20.5% in cases with tinnitus. In tinnitus patients, sleep disorders had an independent association with increasing age, higher BMI, and gender.

The relationship between tinnitus and sleep disorders can be complex and multifaceted. Sleep disorders can trigger or exacerbate tinnitus through many different mechanisms, including deterioration of vital signs, effects on cognitive functions, and physiological changes. Tinnitus can also negatively affect sleep quality through problems such as falling asleep and staying asleep. Taking these two health problems together and determining appropriate treatment approaches will play an important role in improving the quality of life of patients.

In a population-based study conducted in Japan with 14,027 participants, tinnitus was detected in 13.3% of male cases and 10.6% of female cases. Insomnia was detected in 28.1% of males and 36.1% of females with tinnitus. In cases without tinnitus, tinnitus was detected in 18.8% of males and 21.5% of females. In males and females, the probability of insomnia was found to be 1.7 times and 1.8 times higher, respectively, in those with tinnitus compared to those without tinnitus.²⁵ In the study conducted by Wakabayashi et al.²⁶ 100 cases diagnosed with tinnitus were included in the study. In this study, sleep disorders were detected in 66% of the cases. Self-rating depression scale, and state trait anxiety inventory scores were detected higher in cases with tinnitus with sleep disorders compared to cases with isolated tinnitus. It was determined that the severity of tinnitus increased with the development of sleep disorders in these cases.²⁶ In a study conducted by Alster et al.²⁷ with 80 military personnel diagnosed with tinnitus, it was determined in the mini sleep survey they conducted that 77% of the cases may have a sleep disorder. It was determined that the cases with the highest survey scores frequently had delayed sleep, morning awakenings, mid-sleep awakenings, morning fatigue and chronic fatigue. Wakabayashi et al.'s finding of higher depression and anxiety scores in tinnitus patients with sleep disorders aligns with our results, where a significant portion of tinnitus patients with sleep disorders had psychiatric comorbidities. Similarly, Alster et al.'s work, which suggests a correlation between tinnitus and insomnia, further supports our observation of a high prevalence of sleep disorders in tinnitus patients. In a study conducted in Korea with 122 patients diagnosed with tinnitus, tinnitus handicap inventory was found to be correlated with the Pittsburgh sleep quality inventory and the Beck depression inventory.²⁸ Hébert et al.²⁹ conducted a study with 44 patients, 22 with tinnitus and 22 without tinnitus, and performed one-week sleep diaries, subjective sleep questionnaires, and one-night polysomnographic evaluations. The tinnitus group showed lower subjective sleep quality as measured by the Pittsburgh sleep quality index and sleep diaries, but no significant difference was found in objective polysomnographic sleep parameters. Quantitative non-rapid eye movement sleep analysis found lower spectral power in the delta frequency band in the tinnitus group compared to the non-tinnitus group. In a study conducted by Burgos et al.³⁰ they compared the polysomnography findings of ten cases with chronic tinnitus and sleep disorders with 20 isolated sleep disorders and 20

healthy controls. In this study, it was determined that tinnitus was associated with subjective and objective sleep disorders. In a very large-scale study conducted in Taiwan using data from the Taiwan National Health Insurance Research Database, 21,798 cases diagnosed with tinnitus and 108,990 controls were included. In this study, the risk of tinnitus was found to be higher in patients with sleep disorders than in those without sleep disorders. And in the same study, the risk of tinnitus was found to be higher in patients with sleep apnea than in those without sleep apnea.³¹ In a study conducted by Koning et al.³² on 165 patients who had complaints of ringing for at least the last month and were diagnosed with tinnitus, it was determined that at least half of the patients had poor sleep quality. If we briefly review a few studies that have been done; in a study conducted by Tyler and Baker on 72 tinnitus cases, 57% had difficulty getting to sleep;³³ in a study conducted by Axelsson and Ringdahl,³⁴ 10% of cases with tinnitus had sleep difficulties; in a study conducted by Folmer et al.³⁵ on 190 tinnitus cases, 80% had sleep disturbance; 46% reported sometimes versus 33% often; in a study conducted by Lasisi and Gureje,³⁶ 52% of cases with tinnitus and 34% of those without had insomnia.

In our study, similar to many studies, the frequency of sleep disorders among patients with tinnitus was found to be 20.5%. This rate is higher than the normal population. As shown in many studies above, sleep disorders are around 10% in the healthy population. This result shows us that there is a relationship between tinnitus and sleep disorders. In our study, we found that the age of patients with tinnitus and sleep disorders was higher. We know that both sleep disorders and tinnitus increase with age.³⁷ An interesting finding, which is similar to the findings in many studies above, is that the rate of tinnitus was higher in women than in men. It was found that 57.1% of these women were housewives. This may be due to overweight status and daily fatigue. In our study, smoking was found to be higher in the group with sleep disorders and tinnitus compared to the other group. It is known that smoking negatively affects both sleep disorders and hearing physiology.^{38,39} We also found that BMI was significantly higher in the group with both tinnitus and sleep disorders. The average BMI in the group with sleep disorders and tinnitus was close to the upper limit of the overweight group. As is known, overweight and obesity cause serious sleep disorders such as obstructive sleep apnea due to the narrowing they create in the upper respiratory tract and the restriction of lung expansion in the thoracic cavity.^{40,41}

Our main limitation is that the study has a retrospective design, which limits our ability to confirm cause-and-effect relationships. Additionally, the small sample size and the fact that the study was conducted at a single center may restrict the generalizability of the findings. Another limitation to consider is that the findings related to sleep disorders were derived solely from ICD codes. This approach may not capture the full scope of sleep disturbances in tinnitus patients. Incorporating data from polysomnography or validated sleep disorder questionnaires would have provided more comprehensive and informative insights into the nature and severity of sleep disorders in this population.

CONCLUSION

In our study, 20.5% of the patients with tinnitus had insomnia. Age was found to be an independent predictor in patients with

sleep disorders along with tinnitus. Prospective clinical and experimental studies are needed to clearly understand whether tinnitus causes sleep disorders or sleep disorders cause tinnitus.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was approved by the Gazi Yaşargil Training and Research Hospital Clinical Researches Ethics Committee (Date: 21.07.2023, Decision No: 483).

Informed Consent

Because the study was designed as an animal experiments, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Things to know about tetanus

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ABSTRACT

Tetanus is a disease of the nervous system characterised by muscle spasms caused by toxins produced by an anaerobic bacterium called *Clostridium tetani* (*C. tetani*) found in soil. These muscle spasms may occur frequently in the jaw and neck but may also be generalised throughout the body. The diagnosis can be made clinically and by history. The causative agent of tetanus, *C. tetani*, produces toxins that trigger muscle contractions after contamination from saliva, faeces, contaminated products and soil. Tetanus is a disease that can be prevented by vaccination. In case of a possible tetanus risk in the patient, tetanus prophylaxis planned according to the type of injury after cleaning the wound prevents the disease.

Keywords: Tetanus, *Clostridium tetani*, diagnosis, treatment

EPIDEMIOLOGY

A significant decrease has been observed in adult and neonatal tetanus cases over the years with the vaccination of children within the scope of the Expanded Immunisation Programme implemented in our country, women in the 15-49 age group and pregnant women and military personnel within the scope of the Maternal Neonatal Tetanus Elimination Programme.¹ When the tetanus cases in our country are analysed, while a total of 550 cases were observed between 1980-1984, 77 cases were detected between 2013-2017. Although there is no data for 2018 in the records of the World Health Organization (WHO) for our country, a total of 18 cases were observed in 2019 and all of them were adult tetanus cases.² It was announced by WHO on 24 April 2009 that maternal and neonatal tetanus was eliminated in Türkiye. When neonatal tetanus cases were analysed between 2009 and 2019, two cases were observed in 2010 and one case was observed in 2014.³

PATHOGENESIS

Clostridium tetani (*C. tetani*) enters the human body through injuries that cause disruption of skin integrity. Infections that occur in the neonatal period usually occur as a result of umbilical cord procedures or transmission through the umbilical cord.

When anaerobic conditions are provided for the settling spores, they transform into a vegetative form. The bacteria begin to produce toxins that are spread throughout the body by blood and lymphatic flow. The toxins are retained and act in various parts of the central nervous system, including the

motor endplate, spinal cord and brain. It is effective in the sympathetic nervous system.

Tetanus toxin disrupts the neurotransmitter balance, disabling inhibitory mechanisms and leading to clinical symptoms.⁴ This leads to muscle contractions and spasms. In addition to these, seizures may be observed, and different findings may occur due to the involvement of the autonomic nervous system.⁵

Tetanospasmin toxin synthesised by *C. tetani* is a very potent neurotoxin.⁶ Tetanus toxin spreads from tissue spaces to lymphatic and vascular systems. It enters the nervous system through neuromuscular junctions and is transported to the central nervous system by retrograde axonal transport.⁷

TYPES OF CLINICS

Tetanus manifests itself with four different clinical types;⁸

- A) Generalised tetanus
- B) Localised tetanus
- C) Cephalic tetanus
- D) Neonatal tetanus

A) Generalised Tetanus

50-75% of patients present with a generalised form:⁸

-The first symptom is usually trismus or locking of the jaw. Locking in the jaw area is seen due to contractions in the masseter muscle.

-In the following period, stiffness in the neck area, difficulty in swallowing and hardening in the abdomen are observed. In addition to these, findings such as increase in temperature, sweating, increase in blood pressure, tachycardia are observed.

-Nuchal rigidity and dysphagia, condescending smile (risus sardonicus) are among the early findings of facial involvement.

-Spasms may recur frequently and may last up to a few minutes.

-Spasms may last for three to four weeks.

-Curative recovery may take months in patients.

B) Localised Tetanus

In localised forms, patients have persistent spasm of a group of muscles.⁸

-The underlying pathology is a dysfunction of the intermediate neurons that inhibit alpha neurones.

-There is no involvement of the central nervous system and therefore mortality is low.

C) Cephalic Tetanus Is a Rare Form

The features of this form are given below.^{2,8}

-It usually occurs after head trauma or otitis media.

-Presentations are seen due to cranial nerve involvement.

-Infection may remain localised or may show a tendency to spread.²

D) Neonatal Tetanus

Another form of tetanus which is rare in developed countries and frequently results in neonatal death in undeveloped countries.^{8,9}

-The infection starts with the involvement of the contaminated umbilical cord during delivery in unsanitary and unhygienic environments and progresses due to inadequate maternal immunisation.

-In the first week after birth, the baby becomes restless, feeding decreases and spasm attacks occur.

-The prognosis is poor in neonatal babies.

PHYSICAL EXAMINATION FINDINGS

-The first symptoms of tetanus are headache and muscle stiffness. It starts especially in the jaw region, spasm in the neck region, difficulty in swallowing, abdominal findings, generalised spasms and sweating are other findings.

-Fever is not detected in patients and consciousness is clear.¹⁰

-Spatula test may be performed in patients. The spatula test is a simple diagnostic bedside test involving touching the oropharynx with a spatula. Under normal conditions, this manoeuvre causes a gag reflex, and the patient tries to remove the spatula (i.e., a negative test result). However, if the patient has tetanus, they may develop a reflex spasm and bite the spatula (positive test result). The sensitivity and specificity of this test have been found to be 94% and 100%, respectively.¹¹

-Opisthotonus develops in patients as a result of contraction. While flexion is observed in the arms, extension movement is observed in the feet, periodic apnoea attacks are observed as a result of contraction of intercostal muscles and diaphragm. Rigidity may be observed in the abdominal wall.¹⁰

-Autonomic dysfunction is observed in the late stages of

the disease. In addition to hypertension and tachycardia, hypotension and bradycardia and cardiac arrest may be observed.

-Sudden tonic contractions and tetanic seizures resembling epileptic seizures may be observed. There is no loss of consciousness during these seizures. Severe pain usually occurs. The occurrence of these seizures indicates a poor prognosis. In seizures, opisthotonus state, deflection and abduction of the upper extremities and extensor movements in the lower extremities are observed.

-Abdominal contractions may mimic acute abdominal findings and patients may present to hospital with these findings. Tenderness and defence in the abdomen may be observed. It has been observed that laparotomy is performed in patients who are not diagnosed correctly.

DIAGNOSIS

The points to be considered in the diagnosis are as follows:¹²

-There is no special test for the diagnosis, the diagnosis is made under detailed anamnesis and clinical observation.

-Trismus, dysphagia, generalised rigidity and muscle spasms are among the findings that should be observed for clinical diagnosis.

-No significant changes were observed in complete blood count and biochemical values.

-Cerebrospinal fluid obtained by lumbar puncture was normal.

-No diagnostic change is observed.

-Serum muscle enzymes, especially enzymes such as creatine phosphokinase, may be increased.¹²

TREATMENT

The most successful intervention against tetanus is prevention with vaccination. Tetanus cases may show a mortal course. Developments in intensive care units, close monitoring of patients, certain pharmacological treatments have increased survival rates.

Treatment goals:¹³

1. Inhibition of toxin production
2. Neutralisation of free toxins
3. General supportive therapy: Airway control, control of muscle spasm, management of autonomic disorders

1. Inhibition of Toxin Production

Approaches for toxin inhibition are given below:¹⁴

- Wound control is important to prevent toxin production.
- The spores in the wound should be eradicated, necrotic tissue should be debrided and the wound site should be cleaned.
- Another important point for inhibiting toxin production is antibiotherapy.
- Appropriate antimicrobial therapy after appropriate debridement is an important factor in the eradication of *C. tetani*.
- Metronidazole 500 mg every 6-8 hours and penicillin-G 2-4 million units every 6 hours.
- In patients who do not respond to treatment, trimethoprim-sulfamethoxazole is used.¹⁴

2. Neutralisation of Free Toxins

Approaches for toxin neutralization are given below:¹⁵

- Human tetanus immunoglobulin (TIG) is an antiserum used for neutralisation of toxins.
- Although the optimal therapeutic dose is not clear, 500 units is recommended.
- It can be given up to 3000 to 6000 units when necessary.
- Half of the dose is administered around the wound as soon as tetanus is diagnosed. The other half is given as intramuscular administration.

3. General Supportive Therapy

Approaches for general supportive therapy are given below:¹⁶

- Diffuse muscle contractions may be life-threatening due to respiratory system failure, aspiration and exhaustion.
- The presence of the patient in a quiet and dark room without light will prevent the occurrence of muscle spasms. Benzodiazepines are traditionally used drugs which are effective against rigidity and muscle spasms.¹⁴ The most commonly used benzodiazepine is diazepam. Diazepam is used intravenously with an initial dose of 10-30 mg. Anaesthesia may be used to relieve spasms in patients who develop tolerance to benzodiazepine administration. Propofol infusion provides control of spasm and rigidity. Neuromuscular agents are used when sedation is inadequate. Vekonium and other blockers without cardiovascular effects are preferred. Neuromuscular blockers are usually administered as continuous infusion. Baclofen acts by stimulating postsynaptic GABA (gamma amino butyric acid) beta receptors. The preferred route is intrathecal. It can be given as bolus or by continuous intrathecal infusion at a dose of 1000 mcg.¹⁶

VACCINATION IN TETANUS PROPHYLAXIS

-According to the recommendation made by the American Advisory Committee on Immunisation Practices (ACIP), diphtheria, tetanus and acellular pertussis vaccines should be administered in newborns at the 2nd, 4th and 6th months, and the 4th and 5th doses should be administered at the 18th month and 4-6 years of age.¹⁷

-A booster dose for tetanus and diphtheria is recommended every ten years for correctly vaccinated individuals.¹⁷ In our country, circulars of the Ministry of Health and recommendations of the adult vaccination guide are in this direction.

TETANUS IMMUNISATION IN OUR COUNTRY

The vaccination schedule applied in our country as of 2020; it is applied as diphtheria, acellular pertussis and tetanus administered at the end of the 2nd, 4th, and 6th months. It is administered as a quintuple mixed vaccine with inactivated polio (IPV) and Haemophilus influenzae type B. The booster of the quintuple mixed vaccine is administered again in the 18th month. Quadrivalent combination vaccine with DaBT and IPV is administered at 48 months. Adult diphtheria and tetanus vaccine (Td) is administered at the age of 13.¹⁸

TETANUS VACCINE INDICATIONS AND APPLICATION METHODS

Indications and method of application are as follows:¹⁹

- It is recommended to be routinely administered in childhood.
- It is recommended to complete the vaccination of individuals who have not been vaccinated or have not been vaccinated during childhood.
- Primary vaccination in the adult period is three doses. Vaccination is performed as two doses at four-week intervals and the third dose 6 months after the second dose. If the third dose is not administered on time, it can be administered up to 12 months after the first dose.
- Since the antitoxin level decreases over the years, a booster dose is administered every 10 years in adults. It is recommended that one of these booster doses should be tetanus-diphtheria-inactivated polio (Tdap).
- Tetanus vaccine is administered to people who have not been previously vaccinated or whose previous vaccination status is unknown.
- In pregnancy, every pregnant woman is vaccinated, regardless of her vaccination status. If possible, it is recommended to administer one dose as Tdap. The most appropriate period for vaccination is 27-36 weeks of pregnancy.
- Tetanus vaccine is recommended for all healthcare workers who have not been vaccinated against tetanus before and who have the possibility of contact with infants younger than 12 months.

CONTRAINDICATIONS OF THE VACCINE

Vaccination is contraindicated in patients with severe allergic reactions after vaccination and in case of development of neurological symptoms after vaccination. In periods of moderate and severe acute illness, vaccination can be postponed until the patient recovers. Mild illnesses and breastfeeding are not contraindications for vaccination.¹⁹

SIDE EFFECTS OF THE VACCINE

- Common side effects of the vaccine after application are pain, erythema and swelling.
- It is seen to be more common locally, especially at the application site.
- Arthus, which is called local oversized pieces, may occur. This situation does not constitute a contraindication for the vaccine.¹⁹

POST-EXPOSURE PROPHYLAXIS

After the injury, immunoglobulin and vaccine should be administered according to the contamination status of the wound and the patient's vaccination calendar (Table).¹⁹

1. Clean Wounds:

- a. Surgical incisions
- b. Injuries treated within 2 hours

2. Dirty Wounds:

- a. Contaminated with dirt, faeces, soil or saliva

- b. Cut wounds
- c. Fragmentation wounds
- d. Bruise wounds
- e. Puncture wounds
- f. Frostbite and burn wounds
- g. Patients treated within 12 hours of injury

Table. Post-contact prophylaxis

Immunisation status	Clean minor injuries		Other injuries (dirty, faecal-saliva contact, incision, burn, foreign body)	
	Vaccine	Immunoglobulin	Vaccine	Immunoglobulin
Unknown or <3 doses	Yes	No	Yes	Yes
>3 doses	No (*)	No	No (**)	No
*It is administered if the last dose is >10 years.				
**It is administered if the last dose is >5 years.				
The immunoglobulin administered for prophylaxis is 250 IU.				

Where human tetanus immunoglobulin is not available, heterolog serum is used and 3000-5000 IU can be administered intramuscularly.

CONCLUSION

Tetanus is a nervous system disease characterised by muscle spasms caused by tetanospasmin toxin, a potent neurotoxin produced by an anaerobic bacterium called *C. tetani* found in soil. *C. tetani* enters the human body through injuries that cause disruption of skin integrity. There is no specific test for diagnosis, the diagnosis is made under detailed anamnesis and clinical observation. Trismus, dysphagia, generalised rigidity and muscle spasms are among the findings that should be observed for clinical diagnosis. Wound control is important to prevent toxin production. The spores in the wound should be eradicated, necrotic tissue should be debrided, and the wound site should be cleaned. The most successful intervention against tetanus is prevention with vaccination.

ETHICAL DECLARATIONS

Referee Evaluation Process

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The authors have no conflicts of interest to declare.

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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Augmented and virtual reality in medicine

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Dear Editor;

I've read the article, titled 'Exploring the competence of artificial intelligence (AI) programs in the field of oculofacial plastic and orbital surgery'¹ published in your journal, with great interest. The fact that your groundbreaking and innovative article is related to AI and large language models (LLM) prompted me to write you a letter regarding the other side of the AI spectrum, particularly augmented reality (AR) and virtual reality (VR) in medicine.

In recent years, the use of AR/VR applications has significantly increased, particularly in medical fields such as ophthalmology, plastic surgery, cardiovascular surgery, general surgery dermatology etc. and in dental medicine. The primary uses of AR/VR in medicine can be categorized into; education, surgery, and diagnostics.² These technologies hold great promise for applications across various fields, including healthcare, education, engineering, design, manufacturing, retail, and entertainment. While VR creates an immersive experience that is separate from the real world, AR overlays virtual images, fostering interaction between the user, the digital content, and their physical surroundings.

The review of current scientific literature examines the role of VR and augmented reality (AR) in the medical field. These technologies are most frequently applied in areas such as diagnostics, surgery, rehabilitation, and mental health care, offering considerable promise in enhancing patient outcomes. VR and AR have been particularly effective in managing conditions like pain, stroke rehabilitation, and neurodegenerative diseases. Although research in this area has grown rapidly, there remains a need for further refinement and standardization to maximize their potential in clinical practice.³

Pottle⁴ article explores the transformative potential of VR in medical education. VR provides immersive, interactive learning experiences that allow medical students to practice clinical skills in a simulated environment, offering an effective and resource-efficient alternative to traditional simulation methods. The technology's ability to deliver repeatable, standardized scenarios on-demand supports autonomous learning and reduces the need for faculty involvement, making it accessible to a wider range of students. Additionally, the article highlights VR's potential to

democratize medical education by overcoming geographical barriers and enhancing interprofessional learning across healthcare systems.

Carvalho's⁵ study explores the use of VR in ophthalmology education. VR has emerged as an auxiliary tool in medical education, particularly in delicate specialties like ophthalmology, where it is used for training and therapeutic simulations. The research highlights that VR applications in ophthalmology are still limited, but the technology holds significant potential. Especially in surgical training, VR simulators enable students to repeatedly practice complex procedures. As a result, VR represents a major innovation in both ophthalmology education and treatment.

In conclusion, AI and AR/VR are complementary technologies. While AI makes AR and VR applications smarter, more realistic, and interactive, AR and VR technologies effectively present the information provided by AI to the user in a visual and auditory manner. When used together, they give rise to groundbreaking applications, especially in fields such as healthcare, education, entertainment, and manufacturing.

ETHICAL DECLARATIONS

Referee Evaluation Process

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Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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