ISSN 2146-6505 • EISSN 2147-1894

Indexed in Web of Science

Jarem

JOURNAL OF ACADEMIC RESEARCH IN MEDICINE

Original Investigations

VOLUME: 14 | ISSUE: 3 | December 2024

UNIVERSITY OF HEALTH SCIENCES TÜRKİYE GAZİOSMANPAŞA TRAINING AND RESEARCH HOSPITAL

galenos yayınevi

jarem.org

JAREM

JOURNAL OF ACADEMIC RESEARCH IN MEDICINE

• **Owned by on behalf of the University of Health Sciences Türkiye Gaziosmanpaşa Training and Research Hospital:** Prof. Dr. Ömer N. Develioğlu
• **Editor in Chief:** Prof. Dr. Ömer N. Develioğlu
• **Publication Type:** Periodical

JAREM

JOURNAL OF ACADEMIC RESEARCH IN MEDICINE

International Editorial Board

The previous Editor in Chief was Prof. Dr. Barış Nuhoğlu

İstanbul Yeniyüzyıl University, Gaziosmanpaşa Hospital Head of Department of Urology
(The editor-in-chief duty, which started in September 2011, was transferred to Ömer N Develioğlu in March 2016)

JOURNAL OF ACADEMIC RESEARCH IN MEDICINE

"Please refer to the journal's webpage (https://www.jarem.org/home) for "Ethical Policy", "Instructions to Authors" and "About Us".

The Journal of Academic Research in Medicine and/or its editors are members of ICMJE, COPE, WAME, CSE and EASE, and follow their recommendations. Journal of Academic Research in Medicine is indexed in Web of Science-Emerging Sources Citation Index, TÜBİTAK ULAKBİM TR Dizin, EBSCO, Gale, CINAHL, J Gate, Türk Medline, Embase and CAB International (CABI).

The journal is published online.

Owner: University of Health Sciences Türkiye Gaziosmanpaşa Training and Research Hospital

Responsible Manager: Ömer N. Develioğlu

Publisher Contact
Address: Molla Gürani Mah. Kaçamak Sk. No: 21/1
34093 İstanbul, Türkiye
Phone: +90 (530) 177 30 97 / +90 (539) 307 32 03
E-mail: info@galenos.com.tr/yayin@galenos.com.tr
Web: www.galenos.com.tr
Publisher Certificate Number: 14521

Online Publishing Date: December 2024
ISSN: 2146-6505 **E-ISSN:** 2147-1894

International scientific journal published quarterly.

JOURNAL OF ACADEMIC RESEARCH IN MEDICINE

Contents

Original Investigations

Index

DOI: 10.4274/jarem.galenos.2024.48568
J Acad Res Med 2024;14(3):90-3

Nutritional Status of Children with Cerebral Palsy

Büşra Tetik Dinçer[1], Nafiye Urgancı[2], İhsan Kafadar[3]

[1]Health Sciences University Türkiye, Şişli Hamidiye Etfal Training and Research Hospital, Clinic of Pediatrics, İstanbul, Türkiye
[2]Health Sciences University Türkiye, Şişli Hamidiye Etfal Training and Research Hospital, Clinic of Pediatrics, Division of Pediatric Gastroenterology, İstanbul, Türkiye
[3]Health Sciences University Türkiye, Başakşehir Çam and Sakura City Hospital, Clinic of Pediatrics, Division of Pediatric Neurology, İstanbul, Türkiye

Cite this article as: Tetik Dinçer B, Urgancı N, Kafadar İ. Nutritional Status of Children with Cerebral Palsy. J Acad Res Med. 2024;14(3):90-3

ABSTRACT

Objective: This study examined the nutritional parameters of children diagnosed with cerebral palsy who have lost their physical and mental function for various reasons.

Methods: A total of 130 children aged 2-18 years, diagnosed with cerebral palsy were included in the study. The nutritional characteristics of all patients were recorded, and nutritional problems were assessed. Body weight, height, and serum levels of total protein, albumin, ferritin, folic acid, alkaline phosphatase, calcium, phosphorus, magnesium, vitamin-D, and parathormone were measured.

Results: Of the 130 patients included in the study, 50% were female, and the median age was 10 (range 2-18) years. The median interquartile range (IQR) height was 130 (110-148) cm, and the median (IQR) weight was 24 (16-38) kg. In laboratory examinations, the median (IQR) vitamin-D level was 18.4 (10.5-24.9) ng/mL, with 23% (n=30) of the cases having levels below 10 ng/mL, 32% (n=42) having levels between 10-20 ng/mL, and 45% (n=58) having levels above 20 ng/mL. Albumin levels were significantly higher in female patients (p=0.002).

Conclusion: Careful monitoring of iron and vitamin-D deficiencies is necessary in children with cerebral palsy who are fed enteral formulas.

Keywords: Cerebral palsy, dysphagy, nutrition, spasticity

INTRODUCTION

Cerebral palsy (CP) is a chronic condition of movement and posture development caused by non-progressive damage to the developing fetal or infant brain, resulting in limited activity (1). Oral intake disorders and malnutrition are frequently observed in these patients because of spastic movement disorders and oropharyngeal dysphagia (2,3). In addition, due to the development of contractures and posture disorders, objective and standard measurement of parameters used in nutritional evaluation, such as height and weight, has become difficult. In these patients, protein and energy malnutrition and micronutrient deficiencies due to oral intake disorders may be observed (4,5). The frequency of increased fracture risk due to decreased bone mineral density and minimal trauma is reported to be 5-60% (2,6). In this study, the nutritional parameters of children diagnosed with CP who have lost their physical and mental function for various reasons were examined.

METHODS

A total of 130 children aged 2-18 years, diagnosed with CP, who were brought to the Pediatric Gastroenterology outpatient clinic between June 2016 and June 2017 for nutritional management were included in the study. Our study was conducted in accordance with the Declaration of Helsinki and was approved by the Health Sciences University Türkiye, Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee (decision no: 1420, date: 28.01.2020). All patients were bedridden and required care from their families. The nutritional characteristics of all patients were recorded, and nutritional problems were assessed using the Waterlow classification. No additional pathology was detected in any of the patients beyond their current condition. Body weight and height were measured using the same height meter and weighing equipment. Laboratory examinations were used to measure serum levels of total protein, albumin, ferritin, folic acid, alkaline phosphatase, calcium, phosphorus, magnesium, vitamin-D, and parathormone (PTH) using Roche AutoAnalyzer systems. The study did not include a control group.

ORCID IDs of the authors: BTD. 0009-0003-9604-201X; NU. 0000-0003-4854-507X; İK. 0000-0001-8948-4643.

Corresponding Author: Büşra Tetik Dinçer,
E-mail: buusratetik@gmail.com

Received Date: 20.07.2024 **Accepted Date:** 28.10.2024

J Acad Res Med 2024;14(3):90-3

Statistical Analysis

Statistical analysis was performed using Statistical Package for the Social Sciences® version 22.0 (IBM Corp., Armonk, NY, USA). Numbers, percentages, means, medians, etc., were used to summarize the results. The normal distribution of numerical data was assessed using the Shapiro-Wilk test. For normally distributed data, the mean and standard deviation (SD) were reported, whereas the median and interquartile range (IQR) were used for non-normally distributed data. Numerical data were compared using Student's t-test or Mann-Whitney U test according to normality. All p-values were two-tailed and were considered significant at $p<0.05$, with a confidence interval of 95%.

RESULTS

Of the 130 patients included in the study, 50% were female, and the median age was 10 (range 2-18) years. The median (IQR) height was 130 (110-148) cm, and the median (IQR) height SDs was -1.63 [-2.10-(-1.16)]. The median (IQR) weight was 24 (16-38) kg, and the median (IQR) weight SDs was -3.7 [-4.17-(-3.23)]. According to the Waterlow classification, 45 patients (34.7%) were classified as mildly malnourished. There were no significant differences in age, height, height SDs, weight, weight SDs, and Waterlow classification values between male and female patients ($p>0.05$) (Table 1).

Referring to the laboratory testing, the median (IQR) serum total protein was 7.1 (6.8-7.4) g/dL, albumin was 4.2 (3.9-4.5) mg/dL, and ferritin was 30.9 (21-48) mg/L. The median (IQR) vitamin-B12 level was 584 (422-962) pg/mL, with levels above 800 pg/mL in 13% (n=13) of the cases. The median (IQR) folic acid level was 9.1 (7-11.6) ng/mL, phosphorus was 4.4 (4-4.9) mg/dL, calcium was 9.6 (9.27-9.9) mg/dL, magnesium was 2 (1.9-2.2) mg/dL, and PTH was 35 (24.3-48.7) pg/mL. The median (IQR) vitamin-D level was 18.4 (10.5-24.9) ng/mL, with 23% (n=30) of the cases having levels below 10 ng/mL, 32% (n=42) having levels between 10-20 ng/mL, and 45% (n=58) having levels above 20 ng/mL. Albumin levels were significantly higher in female patients ($p=0.002$) (Table 2).

DISCUSSION

Feeding problems are frequently observed in children with CP. Spastic motor disorders and oropharyngeal dysphagia are common causes of these feeding issues. Enteral feeding methods, such as percutaneous endoscopic gastrostomy (PEG), can be employed, particularly in cases where dysphagia and motility disorders restrict oral intake (7). Monitoring nutrition

Table 1. Demographic features of the study population

Variables	All patients (n=130)	Female patients (n=130)	Male patients (n=130)	p-value
Age (Years, median, range)	10 (2-21)	10 (2-21)	10 (3-15)	0.909[a]
Height (Cm, median, IQR)	130 (110-148)	135 (110-149)	122 (110-148)	0.554[a]
Height SDs (median, IQR)	-1.63 [-2.10-(-1.16)]	-1.61 [-2.05-(-1.1)]	-1.66 [-2.14-(-1.2)]	0.582[a]
Weight (Kg, median, IQR)	24 (16-38)	27 (16-40)	23 (16-36)	0.452[a]
Weight SDs (median, IQR)	-3.7 [-4.17-(-3.23)]	-3.6 [-4.1-(-3.15)]	-3.8 [-4.2-(-3.27)]	0.368[a]
Waterlow classification (n, %)				
Normal	36 (27.7%)	19 (14.7%)	17 (13%)	0.923[b]
Mild	45 (34.7%)	21 (16.2%)	24 (18.5%)	
Moderate	31 (23.8%)	14 (10.8%)	17 (13%)	
Severe	18 (13.8%)	9 (6.9%)	9 (6.9%)	

[a]Mann-Whitney U test, [b]Chi-square test
cm: Centimeter, IQR: Interquartile range, kg: Kilogram, SDs: Standard deviations

Table 2. Laboratory parameters

Variables	All patients (n=130)	Female Patients	Male Patients	p-value
Total protein (g/dL, median, IQR)	7.1 (6.8-7.4)	7 (6.8-7.5)	7.1 (6.8-7.3)	0.578[a]
Albumin (mg/dL, median, IQR)	4.2 (3.9-4.5)	4.3 (4.1-4.6)	4.1 (3.7-4.4)	0.002[a]
Ferritin (mg/L, median, IQR)	30.9 (21-48)	28.1 (23-44.6)	31.3 (17.5-55)	0.665[a]
Folic acid level (ng/mL, median, IQR)	9.1 (7-11.6)	9.08 (7.15-11.88)	9.4 (6.23-11.66)	0.809[a]
Phosphore (mg/dL, median, IQR)	4.4 (4-4.9)	4.4 (3.8-5.05)	4.4 (4-4.8)	0.580[a]
Calcium (mg/dL, median, IQR)	9.6 (9.27-9.9)	9.66 (9.28-9.95)	9.58 (9.3-9.9)	0.683[a]
Magnesium (mg/dL, median, IQR)	2 (1.9-2.2)	2 (1.9-2.2)	2 (1.9-2.2)	0.166[a]
Vitamin-D (ng/mL, median, IQR)	18.4 (10.5-24.9)	17.8 (7.8-24.8)	19 (12.45-25.2)	0.355[a]
Parathormon (pg/mL, median, IQR)	35 (24.3-48.7)	36.13 (24.3-48.6)	34 (24.1-50)	0.743[a]

[a]Mann-Whitney U test, IQR: interquartile range, g: gram, mg: milligram, ng: nanogram, pg: picogram, L: liter, dL: desiliter, mL: milliliter

J Acad Res Med 2024;14(3):90-3

in these patients is challenging due to difficulties in measuring parameters such as height and weight, as well as limitations in transporting these patients to the hospital. Additionally, some studies reported that even with optimal nutritional management, the growth rate in this patient group is slower compared to that of healthy children (8).

Civan et al. (7) reported that nutritional parameters improved and the rate of major morbidity was low following PEG in children with CP. Similar findings were reported in a prospective study by Sullivan PB et al. (9). All patients in our study were fed orally and were followed up regularly. Given that their nutritional parameters remained stable, adequate nutrition can be provided orally in suitable patients. However, patients with oral intake problems can benefit from enteral nutrition methods such as PEG.

Children with CP may become underweight and suffer from protein-energy malnutrition. In addition, micronutrient deficiencies, which can exacerbate existing neurological damage, may also be observed (10). In our study, the nutritional parameters were maintained within normal limits in children who were appropriately monitored and fed enteral formulas. However, caution should be exercised in these patients due to the challenges associated with their care.

Paker et al. (11) evaluated vitamin-D levels in patients with CP. The study found that 42.9% of children with CP had low vitamin-D levels, and older patients and those on a regular diet were at higher risk of vitamin-D deficiency. Other studies on children with CP have reported that the use of anticonvulsants can also lower vitamin-D levels. Additionally, geographical regions with a high number of sunny days may have a positive effect on vitamin-D levels (12). Akpinar et al. (13) emphasized that children with CP who have high mobility limitation scores have lower vitamin-D levels, and they stressed the importance of monitoring vitamin-D levels in this patient group. In a study published by Le Roy et al. (14) in 2021, low levels of vitamin-D and ferritin were observed in children with CP, and the study emphasized the importance of micronutrient supplementation. In our study, although vitamin D levels were not compared by age among patients with CP, overall vitamin-D levels were found to be low. This deficiency may be attributed to limited sunlight exposure and the use of anticonvulsants in some patients. Additionally, the average ferritin level in our study was 14 mg/L, highlighting the importance of iron supplementation and nutritional recommendations for these children. Papadopoulos et al. (15) demonstrated that inadequate iron intake is the primary cause of iron deficiency anemia in patients with CP. According to their findings, patients are advised to undergo procedures such as endoscopy and colonoscopy following iron supplementation. In our study, ferritin levels were low in many patients, suggesting that iron supplementation should be recommended before performing invasive procedures.

Although our study's retrospective design and lack of a control group are limitations, the larger sample size compared with other studies in the literature represents a notable strength.

Study Limitations

The limitations of this study include its retrospective nature, small number of patients, and absence of a control group.

CONCLUSION

It is essential to monitor iron and vitamin-D levels in children with CP who are fed enteral formulas and to provide supplementation as needed.

Ethics

Ethics Committee Approval: Our study was conducted in accordance with the Declaration of Helsinki and was approved by the Health Sciences University Türkiye, Şişli Hamidiye Etfal Training and Research Hospital Ethics Committee (decision no: 1420, date: 28.01.2020)

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

Footnotes

Author Contributions: Surgical and Medical Practices - B.T.D., N.U., İ.K.; Concept - B.T.D., N.U., İ.K.; Design - B.T.D., N.U.; Data Collection and/or Processing - B.T.D.; Analysis and/or Interpretation- B.T.D., N.U., İ.K.; Literature Search - B.T.D.; Writing - B.T.D., N.U., İ.K.;

Conflict of Interest: The authors have no conflict of interest to declare.

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

REFERENCES

1. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl. 2007 Feb;109:8-14. Erratum in: Dev Med Child Neurol. 2007 Jun;49(6):480.
2. Apkon SD, Kecskemethy HH. Bone health in children with cerebral palsy. J Pediatr Rehabil Med. 2008;1(2):115-21.
3. Benfer KA, Weir KA, Bell KL, Ware RS, Davies PSW, Boyd RN. Oropharyngeal Dysphagia and Cerebral Palsy. Pediatrics. 2017 Dec;140(6):e20170731.
4. Schoendorfer N, Boyd R, Davies PS. Micronutrient adequacy and morbidity: paucity of information in children with cerebral palsy. Nutr Rev. 2010 Dec;68(12):739-48.
5. Carman KB, Aydın K, Kilic Aydin B, Cansu A, Direk MC, Durmus S, et al. Evaluation of micronutrient levels in children with cerebral palsy. Pediatr Int. 2022 Jan;64(1):e15005.
6. Lingam S, Joester J. Spontaneous fractures in children and adolescents with cerebral palsy. BMJ. 1994 Jul 23;309(6949):265.
7. Civan HA, Bektas G, Dogan AE, Ozdener F. Percutaneous Endoscopic Gastrostomy Feeding in Children with Cerebral Palsy. Neuropediatrics. 2021 Aug;52(4):326-332.
8. Jesus AO, Stevenson RD. Optimizing Nutrition and Bone Health in Children with Cerebral Palsy. Phys Med Rehabil Clin N Am. 2020 Feb;31(1):25-37.
9. Sullivan PB, Juszczak E, Bachlet AM, Lambert B, Vernon-Roberts A, Grant HW, et al. Gastrostomy tube feeding in children with cerebral palsy: a prospective, longitudinal study. Dev Med Child Neurol. 2005 Feb;47(2):77-85.
10. Hariprasad PG, Elizabeth KE, Valamparampil MJ, Kalpana D, Anish TS. Multiple Nutritional Deficiencies in Cerebral Palsy Compounding Physical and Functional Impairments. Indian J Palliat Care. 2017 Oct-Dec;23(4):387-392.
11. Paker N, Yavuz Mollavelioglu T, Bugdaycı D, Ones K, Bardak AN, Karacan I, Yıkıcı I, et al. Vitamin D levels in children with cerebral palsy. J Pediatr Rehabil Med. 2023;16(1):163-169.
12. Vijayakumar M, Bk A, George B, Bhatia V. Vitamin D Status in Children on Anticonvulsant Therapy. Indian J Pediatr. 2022 Jun;89(6):541-545. doi: 10.1007/s12098-021-03853-y. Epub 2021 Jul 28.

J Acad Res Med 2024;14(3):90-3

13. Akpinar P. Vitamin D status of children with cerebral palsy: Should vitamin D levels be checked in children with cerebral palsy? North Clin Istanb. 2018 Aug 8;5(4):341-347.
14. Le Roy C, Barja S, Sepúlveda C, Guzmán ML, Olivarez M, Figueroa MJ, et al. Vitamin D and iron deficiencies in children and adolescents with cerebral palsy. Neurologia (Engl Ed). 2021 Mar;36(2):112-118. English, Spanish.
15. Papadopoulos A, Ntaios G, Kaiafa G, Girtovitis F, Saouli Z, Kontoninas Z, et al. Increased incidence of iron deficiency anemia secondary to inadequate iron intake in institutionalized, young patients with cerebral palsy. Int J Hematol. 2008 Dec;88(5):495-497.

DOI: 10.4274/jarem.galenos.2024.12623
J Acad Res Med 2024;14(3):94-9

The Effect of Oral and Vaginal Misoprostol use for Cervical Ripening in Patients Undergoing Office Hysteroscopy

Havva Betül Bacak, Süleyman Salman, Fatma Ketenci Gencer, Tevfik Kaçar, Gizay Serin

University of Health Sciences Türkiye, Gaziosmanpaşa Training and Research Hospital, Clinic of Obstetrics and Gynecology, İstanbul, Türkiye

Cite this article as: Bacak HB, Salman S, Ketenci Gencer F, Kaçar T, Serin G. The Effect of Oral and Vaginal Misoprostol use for Cervical Ripening in Patients Undergoing Office Hysteroscopy. J Acad Res Med. 2024;14(3):94-9

ABSTRACT

Objective: This study aimed to evaluate the effectiveness of oral and vaginal misoprostol in reducing pain levels in patients undergoing office hysteroscopy.

Methods: The study included 225 patients scheduled for office hysteroscopy. The demographic data of the participants were collected. Using the sealed envelope method, patients were allocated into three groups of 75 each: one group received no misoprostol, the second group received oral misoprostol, and the third group received vaginal misoprostol. Oral and vaginal misoprostol (200 mcg) were administered 1 hour before the procedure. Pain levels were evaluated using visual analogue scale (VAS) scores among the groups.

Results: The pre-procedural VAS scores were significantly higher in patients who received either form of misoprostol than in those who did not receive it ($p<0.01$). The procedure duration was notably shorter for the groups receiving misoprostol ($p<0.05$). Post-procedural VAS scores were elevated in the non-misoprostol group in contrast to the misoprostol groups, with the vaginal misoprostol group showing higher scores than the oral group ($p<0.05$).

Conclusion: Our findings indicate that both vaginal and oral misoprostol administered before diagnostic hysteroscopy reduce pain and shorten the procedure duration. Further studies are necessary to determine the optimal dosage and timing for minimizing side effects while maximizing efficacy.

Keywords: Misoprostol, hysteroscopy, servical ripening

INTRODUCTION

Hysteroscopy is a minimally invasive technique used to diagnose and treat different uterine conditions, including endometrial polyps, fibroids, and uterine anomalies. During the procedure, complications such as cervical laceration, pain, excessive bleeding, infection, and uterine perforation can occur (1-3). These risks can be mitigated by preprocedural cervical ripening. Misoprostol, which is known for its cervical ripening properties, can be used for this purpose (4-6).

This study aimed to assess the effects of misoprostol on cervical ripening and its potential to reduce complications during office hysteroscopy. The impact on pain levels was assessed using the visual analogue scale (VAS).

METHODS

This randomized, controlled, single-blind, prospective study was conducted between May and September 2019 at the Health Sciences University Türkiye, Gaziosmanpaşa Taksim Training and Research Hospital. The study included 225 patients with various gynecological complaints who underwent office hysteroscopy. The Taksim Training and Research Hospital Clinical Research Ethics Committee approval was obtained (approval no: 54, date: 08.05.2019). All participants provided informed consent. The study groups were determined using the sealed envelope method, and all procedures were conducted by a single operator who was unaware of the administration of misoprostol.

Demographic data, such as age, parity, cervical length, weight, height, delivery method, procedure duration, and hysteroscopy

ORCID IDs of the authors: H.B.B.: 0000-0001-8516-5493, S.S.: 0000-0001-7090-6105, F.K.G.: 0000-0002-6076-2563, T.K.: 0009-0006-1898-1099, G.S.: 0009-0006-1036-3990

Corresponding Author: Havva Betül Bacak,
E-mail: hbbacak@hotmail.com

Received Date: 23.09.2024 **Accepted Date:** 11.12.2024

J Acad Res Med 2024;14(3):94-9

indication, were recorded. The participants were divided into three groups: no misoprostol, oral misoprostol, and vaginal misoprostol, with 75 patients in each group. Then, misoprostol (200 mcg) was administered 1 h before the procedure.

Transvaginal ultrasonography was performed using a Mindray DC-7 series ultrasound machine. Diagnostic office hysteroscopies were performed using an Olympus CV-170 series hysteroscope. Procedures were ideally scheduled for premenopausal patients postmenstruation and for menopausal patients during amenorrhea. The procedure began with the patient in the dorsal lithotomy position, using a no-touch technique to traverse the cervical canal. The uterine cavity was distended using an isotonic solution at an intrauterine pressure of 80 mmHg.

Inclusion criteria comprised patients aged 18-80 years with indications for office hysteroscopy, such as abnormal uterine bleeding, infertility, postmenopausal bleeding, and increased endometrial thickness. The exclusion criteria were age under 18 years, suspected pregnancy, active infection, severe bleeding, advanced malignancy, current intrauterine device use, cervical stenosis, vaginal septum, and uterine anomaly.

Statistical Analysis

Data analysis was conducted using SPSS software version 15 for Mac-iOS. Descriptive statistics are provided for categorical and numerical variables. For numerical variables, the mean, median, and standard deviation were used, whereas frequency and percentage were used for categorical variables. Homogeneity was assessed using the Levene test, and the Shapiro-Wilk test was used to check for normal distribution of continuous variables. One-way ANOVA and Kruskal-Wallis tests were used for group comparisons based on distribution. Pearson's chi-square test was used for categorical variables. p-value less than 0.05 was considered statistically significant.

RESULTS

Table 1 presents the demographic data of the patients and comparisons according to the administration route of misoprostol, which did not reveal any statistically significant differences between groups.

When we compared the delivery methods according to the administration route of misoprostol, there was no statistically significant difference between groups ($p>0.05$) (Table 2). Indications for hysteroscopy included endometrial polyps (54.7%), abnormal uterine bleeding (25.3%), submucosal fibroids (6.2%), infertility (4.4%), postmenopausal bleeding (4.4%), amenorrhea (3.6%), and others (0.4%) (Table 3).

Cervical canal passage time was markedly extended in the non-misoprostol group compared with the vaginal and oral groups ($p<0.05$), with no notable variation among the latter two ($p>0.05$) (Table 4).

VAS scores post-procedure were higher in the non-misoprostol group than in the misoprostol group, with higher scores in the vaginal group than in the oral group ($p<0.05$) (Table 4). Pre-procedural VAS scores were higher in patients receiving misoprostol than in those who did not ($p<0.01$), with no notable difference among the vaginal and oral groups ($p>0.05$) (Table 5).

Table 1. Comparison of demographic characteristics according to the route of misoprostol administration

Misoprostol	Absent (n=75) Mean ± SD	Vaginal (n=75) Mean ± SD	Oral (n=75) Mean ± SD	p-value
Age(years)	42±9.40	41.25±8.50	42.19±8.70	0.793
Parity	2.63±1.73	2.35±1.16	2.91±1.83	0.105
Cervical length (mm)	32.32±5.74	31.49±5.25	30.36±7.72	0.104
Body mass index	28.14±5.49	28.68±3.76	29.31±4.78	0.320

One-way ANOVA, SD: standard deviation

Tablo 2. Comparison of delivery methods according to the route of administration of misoprostol

			Misoprostol		
		Absent Frequency(%)	Vaginal Frequency(%)	Oral Frequency(%)	p-value
Delivery Method	Normal vaginal delivery	37 (49.3)	41 (54.7)	41 (54.7)	0.980
	Normal vaginal Delivery+C/ Section	13 (17.3)	10 (13.3)	11 (14.7)	0.980
	Nulliparous	18 (24)	17 (22.7)	18 (24)	0.980
	C/Section	7 (9.3)	7(9.3)	5 (6.7)	0.980
	Chi-square test				

J Acad Res Med 2024;14(3):94-9

Table 3. Indications for hysteroscopy

Indications	Frequency(%)
Endometrial Polyp	123 (54.7)
Abnormal Uterine Bleeding	57 (25.3)
Submucosal Fibroid	14 (6.2)
Infertility	10(4.4)
Postmenopausal Bleeding	10 (4.4)
Amenorrhea	8 (3.6)
Bicornuate Uterus	1 (0.4)
Habitual Abortion	1 (0.4)
Non-visible Intrauterine Device	1(0.4)

When cervical length, cervical canal passage time, and postoperative VAS score were evaluated according to the delivery method in the groups in which no misoprostol was administered, oral misoprostol was administered, and vaginal misoprostol was administered, no statistically significant differences were found between the delivery methods for any of the three parameters (p>0.05) (Table 6).

DISCUSSION

Misoprostol is an effective treatment for cervical ripening. Our study demonstrated that administering vaginal or oral misoprostol

Table 4. Evaluation of postprocedural VAS, cervical length, and passage time through the cervix according to the administration route of misoprostol

Misoprostol				
	Absent	**Vaginal**	**Oral**	**p-value**
Cervical length (mm) Median (min-max)	30(20-55)	30(23-45)	30(17-45)	p1,p2,p3=0.277
Cervical canal passage Time (sec) Median (min-max)	40(8-130)	10(1-60)	10(3-65)	p2=1, p1,p3=0.001
Postoperative VAS Score Median (min-max)	4(2-8)	2(0-8)	1(0-7)	p1,p2,p3=0.001

Kruskal-Wallis testi, Min: minimum, Max: maximum, P1: vaginal absent, P2: vaginal oral, P3: oral absent, VAS: visual analogue scale

Table 5. Preoperative VAS scores before office hysteroscopy

Preoperative VAS Score	Absent	Vaginal	Oral	p-value
Median(min-max)	0(0-0)	0(0-6)	0(0-4)	p1, p2=0.001, p3=0.360

Kruskal-Wallis testi, Min: minimum, Max: maximum, P1: vaginal absent, P2: vaginal oral, P3: oral absent, VAS: visual analogue scale

Table 6. Evaluation of VAS, cervical length, and cervical passage time based on the method of misoprostol administration and delivery mode

Misoprostol		Normal vaginal delivery	Normal vaginal delivery+C/Section	Nulliparous	C/Section	p-value
Absent	Cervical lenght(mm) Median(min-max)	30(20-42)	32(27-49)	31.5(25-42)	37(30-55)	0.058
	Cervical canal passage time(sec) Median(min-max)	40(8-115)	45(15-130)	40(10-128)	55(18-130)	0.058
	Postoperative VAS score Median(min-max)	4(2-7)	6(2-7)	5,5(2-8)	5(2-8)	1
Oral	Cervical lenght(mm) Median(min-max)	30(20-45)	28(17-42)	31(25-40)	35(31-37)	0.940
	Cervical canal passage time(sec) Median(min-max)	8(3-65)	10(5-15)	10(6-60)	13(7-15)	0.241
	Postoperative VAS score Median(min-max)	1(0-6)	3(0-5)	1(0-7)	2(0-5)	0.194
Vaginal	Cervical lenght(mm) Median(min-max)	30(23-43)	32.5(25-42)	30(24-35)	30(23-45)	0.084
	Cervical canal passage time(sec) Median(min-max)	9(1-60)	11(7-30)	12(5-19)	9(7-13)	0.083
	Postoperative VAS score Median(min-max)	2(0-7)	2.5(1-8)	2(0-6)	3(2-7)	0.474

Kruskal-Wallis testi, Min: minimum, Max: maximum, VAS: visual analogue scale

J Acad Res Med 2024;14(3):94-9

before diagnostic hysteroscopy lessened the pain associated with the procedure and also reduced the time required for completion.

In a 2017 study by Tasma et al. (7), the impact of misoprostol on pain during diagnostic hysteroscopy was assessed in 149 nulliparous premenopausal and postmenopausal women, with 74 receiving misoprostol and 75 in the placebo group. The misoprostol group received 400 mcg of oral misoprostol 24 hours before and 12 hours before the office hysteroscopy. Pain levels were evaluated using VAS scores in the misoprostol and placebo groups post-procedure. The study revealed a considerable decrease in pain in premenopausal women who received misoprostol compared with the placebo group ($p<0.05$). However, for postmenopausal women, no significant difference in VAS scores was observed between the misoprostol and placebo groups ($p>0.05$). Based on these findings, the authors recommended the use of misoprostol in premenopausal women because of its efficacy in reducing procedural pain, but cautioned against its use in postmenopausal women because of its ineffectiveness and potential side effects (7). Our findings on the effect of misoprostol on pain are consistent with those of Tasma et al. (7), although our limited postmenopausal sample size meant that the effect of misoprostol on this subgroup could not be statistically validated.

Fabiana et al. (2018) examined the impact of misoprostol on pain during diagnostic hysteroscopy in 158 postmenopausal women, with 79 receiving misoprostol and 79 receiving placebo. Participants in the misoprostol group were administered 200 mcg oral misoprostol 6 hours prior to hysteroscopy. VAS scores were used to measure pain in both groups after the procedure. The study observed no notable variation in VAS scores among the groups receiving misoprostol and placebo. in postmenopausal women ($p>0.05$). Furthermore, no difference in procedure duration was noted, although the misoprostol group experienced higher rates of side effects such as diarrhea and bleeding. The study concluded that misoprostol should not be recommended for postmenopausal women because of its ineffectiveness in reducing pain and the increased risk of side effects (8). The difference between our study and Fabiana's study might be attributed to the fact that their study included only postmenopausal women.

In 2008, da Costa et al. (9) investigated the impact of misoprostol on procedure duration and pain during diagnostic hysteroscopy in 120 postmenopausal women, with 60 women receiving oral or vaginal msoprostol and 60 women receiving placebo. Participants in the misoprostol group received misoprostol before the office hysteroscopy, and cervical passage time was measured during the procedure. The study reported that those who received misoprostol experienced significantly lower pain levels compared with the group receiving plasebo ($p<0.05$), with no significant difference in pain levels between the different misoprostol groups ($p>0.05$). The researchers concluded that misoprostol administration before office hysteroscopy effectively reduced pain severity in postmenopausal women (9). Our findings on misoprostol's effect on pain levels were in line with those of da Costa et al. (9)

Ngai et al.'s (10) 2001 study focused on the effect of misoprostol on procedure duration in diagnostic hysteroscopy among 34 postmenopausal women, with 18 in the 400 mcg oral misoprostol group and 16 in the placebo group. The group receiving misoprostol received 400 mcg of the drug 12 hours before the procedure. The study found no notable difference in procedure duration between the misoprostol and placebo groups ($p>0.05$). The authors concluded that preprocedural administration of misoprostol did not significantly affect cervical ripening in postmenopausal women (10). Our study's findings on procedure duration differed from those of Ngai et al. (10) possibly because of the extended administration time of 12 hours before the procedure and the exclusive selection of postmenopausal women as participants.

In 2008, Singh et al. (10) explored the effect of misoprostol on pain during diagnostic hysteroscopy in 100 women and divided them into a misoprostol group of 50 and a placebo group of 50. Participants assigned to the misoprostol group received 400 mcg vaginal misoprostol 6 and 4 hours prior to hysteroscopy. Pain levels were evaluated using VAS scores in both groups after the procedure. The study found that misoprostol recipients experienced significantly lower pain levels compared to those in the placebo group ($p<0.05$). The authors concluded that using misoprostol before office hysteroscopy effectively reduced pain (11). Our findings regarding the effect of misoprostol on pain were in agreement with those of Singh et al. (10).

Batukan et al. (12) investigated the effect of misoprostol on the procedure duration during diagnostic hysteroscopy in 77 premenopausal women, with 39 in the group receiving oral misoprostol and 38 in the group receiving vaginal misoprostol. Participants received 400 mcg of oral or vaginal misoprostol 6 and 4 h prior to hysteroscopy, and cervical passage time was recorded. The study reported that vaginal misoprostol resulted in significantly shorter procedure durations than the oral route ($p<0.05$). The researchers determined that vaginal administration of misoprostol was more effective for cervical ripening than oral administration in premenopausal women (12). Our findings on the effect of oral misoprostol on the procedure duration differed from those of Batukan et al. (12), potentially due to variations in the dosage and timing of drug administration.

In 2008, Waddell et al. (13) studied the effectiveness of misoprostol on pain during diagnostic hysteroscopy in 101 women: 50 in the vaginal misoprostol group and 51 in the placebo group. Participants in the misoprostol group received 400 mcg vaginal misoprostol 24 and 12 h before the hysteroscopy. Pain levels were measured using VAS scores in both groups post-procedure. The study found that misoprostol recipients experienced significantly lower pain levels than the placebo group ($p<0.05$). However, the misoprostol group experienced cramps in the pelvic region. The researchers recommended the use of misoprostol for office hysteroscopy because of its ability to reduce pain (13). Our findings on vaginal misoprostol's effect on pain were consistent with those of Waddell et al. (13).

J Acad Res Med 2024;14(3):94-9

Bastu et al. (14) examined the effect of misoprostol on pain during diagnostic hysteroscopy in 60 infertile women, with 20 in the 200 mcg misoprostol group, 20 in the 400 mcg misoprostol group, and 20 in the placebo group. Participants in the misoprostol group were administered vaginal misoprostol 12 hours before the hysteroscopy. Pain levels using VAS scores and procedure duration were assessed in the misoprostol and placebo groups post-procedure. The study reported that misoprostol recipients had significantly lower pain levels and shorter procedure durations compared with the placebo group ($p<0.05$), with no significant differences observed between the different dosage groups ($p>0.05$). The researchers concluded that vaginal misoprostol before office hysteroscopy effectively reduces pain and recommended a 200 mcg dose (14). Our findings on the effects of vaginal misoprostol on pain and procedure duration were consistent with those of Bastu et al. Since our study only used a single dosage, comparisons between different dosages were not possible.

In a 2011 meta-analysis of 17 studies, Gkrozou et al. (15) evaluated the effect of misoprostol on the procedure duration for diagnostic hysteroscopy in 707 women, with 359 in the oral or vaginal misoprostol group and 358 in the placebo group. Participants in the misoprostol group received the drug before hysteroscopy, and cervical canal passage time was measured during the procedure. The meta-analysis found that misoprostol recipients had significantly shorter procedure durations compared with the placebo group ($p<0.05$), no significant differences were observed among the various misoprostol groups ($p>0.05$).The authors advocated for the use of misoprostol before office hysteroscopy (15). Our findings regarding the impact of misoprostol on procedure duration are consistent with those reported by Gkrozou et al. (15) Furthermore, there are studies that claim to lower pain and duration with just some medications. For example, Gencer et al. (16) found that the position of Trendelenburg lithotomy reduced both the duration and pain of vaginoscopic office hysteroscopy. Another study conducted by Celik et al. (17) showed that bladder fulness by aligning the uterocervical angle reduced the pain scores of patients. These maneuvers are easy to perform and reduce pain; thus, combining misoprostol with some of these maneuvers may improve the pain scores further.

CONCLUSION

Misoprostol is a recognized agent for cervical ripening. The use of vaginal or oral misoprostol prior to diagnostic hysteroscopy effectively reduces pain and shortens the procedure duration. However, our current understanding of the biochemistry of the human cervix and the molecular mechanisms underlying cervical ripening is incomplete. Further studies are required to establish the ideal dose and timing of misoprostol for cervical ripening. Additionally, additional studies are needed to determine the most effective dosage, route of administration, and timing of misoprostol before diagnostic hysteroscopy to optimize its efficacy and minimize potential side effects.

Ethics

Ethics Committee Approval: The Taksim Training and Research Hospital Clinical Research Ethics Committee approval was obtained (approval no: 54, date: 08.05.2019).

Informed Consent: All participants provided informed consent.

Footnotes

Author Contributions: Surgical and Medical Practices - H.B.B.; Concept - H.B.B., S.S.; Design - S.S.; Data Collection and/or Processing - H.B.B., F.K.G., T.K.; Analysis and/or Interpretation - H.B.B., S.S.; Literature Search - F.K.G., T.K., G.S.; Writing - H.B.B., F.K.G., G.S.

Conflict of Interest: The authors have no conflict of interest to declare.

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

REFERENCES

1. Birinyi L, Daragó P, Török P, Csiszar P, Major T, Borsos A, et al. Predictive value of hysteroscopic examination in intrauterine abnormalities. Eur J Obstet Gynecol Reprod Biol. 2004; 115: 75-9.
2. Wortman M, Daggett A, Ball C. Operative hysteroscopy in an office-based surgical setting: review of patient safety and satisfaction in 414 cases. J Minim Invasive Gynecol. 2013; 20: 56-63.
3. Valle RF, Sciarra JJ. Current status of hysteroscopy in gynecologic practice. Fertil Steril. 1979; 32: 619-32.
4. Bisharah M, Al-Fozan H, Tulandi T. A randomized trial of sublingual misoprostol for cervical priming before hysteroscopy. J Am Assoc Gynecol Laparosc. 2003; 10: 390-1.
5. Fernandez H, Alby JD, Tournoux C, Chauveaud-Lambling A, deTayrac R, Frydman R, et al. Vaginal misoprostol for cervical ripening before operative hysteroscopy in pre-menopausal women: a double-blind, placebo-controlled trial with three dose regimens. Hum Reprod. 2004; 19: 1618-21.
6. Oppegaard KS, Nesheim BI, Istre O, Qvigstad E. Comparison of self-administered vaginal misoprostol versus placebo for cervical ripening prior to operative hysteroscopy using a sequential trial design. BJOG. 2008; 115: 663.
7. Tasma ML, Louwerse MD, Hehenkamp WJ, Geomini PM, Bongers MY, Veersema S, et al. Misoprostol for cervical priming prior to hysteroscopy in postmenopausal and premenopausal nulliparous women; a multicentre randomised placebo-controlled trial. BJOG. 2018; 125: 81-89
8. Nakano FY, Yela DA, Pinto JPL, Riegas T, Benetti-Pinto CL, Pedro AO, et al. Efficacy of misoprostol before diagnostic hysteroscopy in postmenopausal women: a randomized clinical trial. Menopause. 2018; 25: 789-94.
9. da Costa AR, Pinto-Neto AM, Amorim M, Paiva LH, Scavuzzi A, Schettini J. Use of Misoprostol Prior to Hysteroscopy in Postmenopausal Women: A Randomized, Placebo-Controlled Clinical Trial. J Minim Invasive Gynecol. 2008; 15: 67-73.
10. Ngai SW, Chan YM, Ho PC. The use of misoprostol prior to hysteroscopy in postmenopausal women. Hum Reprod. 2001; 16: 1486-8.
11. Singh N, Ghosh B, Naha M, Mittal S. Vaginal misoprostol for cervical priming prior to diagnostic hysteroscopy efficacy, safety and patient satisfaction: a randomized controlled trial. Arch Gynecol Obstet. 2009; 279: 37-40.
12. Batukan C, Ozgun MT, Ozcelik B, Aygen E, Sahin Y, Turkyilmaz C. Cervical ripening before operative hysteroscopy in premenopausal women: a randomized, double-blind, placebo-controlled comparison of vaginal and oral misoprostol. Fertil Steril. 2008; 89: 966-73.
13. Waddell G, Desindes S, Takser L, Beauchemin MC, Bessette P. Cervical Ripening Using Vaginal Misoprostol before Hysteroscopy: A Double-blind Randomized Trial. J Minim Invasive Gynecol. 2008; 15: 739-44.
14. Bastu E, Celik C, Nehir A, Dogan M, Yuksel B, Ergun B. Cervical Priming Before Diagnostic Operative Hysteroscopy in Infertile Women: A Randomized, Double-Blind, Controlled Comparison of 2 Vaginal Misoprostol Doses. Int Surg. 2013; 98: 140-4.
15. Gkrozou F, Koliopoulos G, Vrekoussis T, Valasoulis G, Lavasidis L, Navrozoglou I, et al. A systematic review and meta-analysis of randomized

J Acad Res Med 2024;14(3):94-9

studies comparing misoprostol versus placebo for cervical ripening prior to hysteroscopy. Eur J Obstet Gynecol Reprod Biol. 2011; 158: 17-23.

16. Gencer FK, Yuksel S, Kumbasar S, Babaoglu B, Kavsi B, Salman S. Trendelenburg Lithotomy Position During Vaginoscopic Office Hysteroscopy Reduces Pain and Procedure Duration. Medical Journal of Bakirkoy, 2021; 17: 298-303.
17. Celik C, Tasdemir N, Abali R, Bastu E, Akbaba E, Yucel SH, et al. The effect of uterine straightening by bladder distention before outpatient hysteroscopy: a randomised clinical trial. Eur J Obstet Gynecol Reprod Biol. 2014; 180: 89-92.

DOI: 10.4274/jarem.galenos.2024.72621
J Acad Res Med 2024;14(3):100-5

Magnetic Resonance Imaging- Defined Lumbar Paraspinal Muscle Morphometry and Lumbopelvic Parameters in Patients with Lumbar Isthmic Spondylolisthesis

Selçuk Akkaya[1], Gonca Sağlam Akkaya[2]

[1]Karadeniz Technical University, Department of Radiology, Trabzon, Türkiye
[2]Karadeniz Technical University, Department of Physical Medicine and Rehabilitation, Trabzon, Türkiye

Cite this article as: Akkaya S, Sağlam Akkaya G. Magnetic Resonance Imaging-Defined Lumbar Paraspinal Muscle Morphometry and Lumbopelvic Parameters in Patients with Lumbar Isthmic Spondylolisthesis. J Acad Res Med. 2024;14(3):100-5

ABSTRACT

Objective: Lumbar isthmic spondylolisthesis (LIS) is a mechanical process characterized by an abnormality in the pars interarticularis that results in anterior translation of the lumbar vertebra. This study aimed to evaluate the multifidus (MF) and erector spinae (ES) cross-sectional areas (CSAs) and lumbopelvic parameters in patients with LIS using magnetic resonance imaging (MRI) and to examine the association of these findings with the spondylolisthesis grade and slip percentage.

Methods: This study included 55 patients and 45 healthy individuals. The total CSA (TCSA), functional CSA (FCSA), relative CSA (rCSA), and ratios of the MF and ES muscles, lumbar lordosis angle (LLA), upper lumbar lordosis (ULLA), lower lumbar lordosis, and sacral slope angle were compared between the patient and control groups and between the spondylolisthesis grades. The correlations between these findings and the slip percentage were assessed.

Results: The functional and relative CSAs of the MF and ES muscles, MF FCSA/TCSA, and ES FCSA/TCSA were decreased in the patient group. Fatty degeneration was more pronounced in grade 2 LIS than in grade 1. ULLA was elevated in the patient group, and a weak negative correlation was observed between the slip percentage and the MF FCSA/ES FCSA ratio.

Conclusion: Patients with LIS demonstrated greater fatty degeneration in MF and ES, and increased ULLA. MRI-based assessments of ES and MF may serve as indicators of LIS progression and spinal instability. The findings of this study highlight the significance of quantitative muscle and lumbopelvic measurements, which may be beneficial in implementing exercise protocols.

Keywords: Isthmic spondylolisthesis, magnetic resonance, atrophy, multifidus, erector spinae

INTRODUCTION

Low back pain (LBP) is a prevalent and significant health issue that causes disability worldwide. It has significant socioeconomic implications because of its high prevalence and long-term morbidity. LBP has various potential causes among adults, with mechanical or non-specific causes being the most frequent. According to studies, 97% of the occurrences of mechanical LBP are caused by spinal components, such as bone, ligaments, discs, joints, nerves, and meninges (1-3).

Lumbar isthmic spondylolisthesis (LIS) is a mechanical process that causes LBP. The condition is characterized by an abnormality in the pars interarticularis that leads to anterior translation of the lumbar vertebra relative to the next caudal segment (4). The reported incidence of LIS in adult patients with LBP ranges from 3.7% to 8% in various studies. It occurs most commonly at L5-S1 and second most frequently at L4-5 (5-7). Factors contributing to the development of LIS include lumbar spine stresses that are highest at lower lumbar levels, and the facets being more coronally oriented, resulting in additional strain for the pars interarticularis at the lumbosacral junction. Moreover, the cross-sectional architecture of the pars is rather thin in the lower lumbar spine. Stress fractures may result from a congenitally dysplastic pars as well as an increase in the pressures focused across the pars with lumbar extension (8).

The paraspinal muscles (PM) are essential for maintaining the stability of the vertebral column, particularly when load-carrying is involved. Atrophy and fatty degeneration of PM can cause instability of the surrounding vertebrae, ultimately leading to LIS.

ORCID IDs of the authors: S.A. 0000-0002-6680-1156, G.S.A 0000-0001-7713-4435

Corresponding Author: Selçuk Akkaya,
E-mail: selcuk.akkaya85@gmail.com

Received Date: 13.10.2024 **Accepted Date:** 11.12.2024

J Acad Res Med 2024;14(3):100-5

Previous studies on the role of PM and several spinal pathologies have demonstrated conflicting results (9-14).

The objective of this study was to evaluate the lumbopelvic parameters, cross-sectional area (CSA) of the erector spinae (ES) and multifidus (MF) muscles, and fat infiltration level in adults with LIS. Additionally, this study aimed to assess the association between these findings and spondylolisthesis grade and slip percentage.

METHODS

Study Population

Fifty-five patients aged between 22-87 years, diagnosed with isthmic spondylolisthesis, and who underwent lumbar spine magnetic resonance imaging (MRI) in the last 12 months were included in this cross-sectional study. The exclusion criteria were the presence of neurological disease, spinal fractures, lumbosacral spinal surgery, scoliosis, and diseases that may cause sarcopenia (cancer, coronary heart disease, heart failure, thyroid/parathyroid disorders). A control group of 45 subjects similar to the patient group in terms of age and sex were enrolled in the study. The exercise status and smoking habits of all participants were noted. Based on the study of Lee et al. (9), the minimum sample size was calculated to be 90 (45 patients and 45 controls), assuming a power of 80%, a significance level (α) of 0.05, and an effect size of 0.6 for the variable of ES functional CSA. G*POWER 3.1 version (Heinrich-Heine University of Dusseldorf, Germany) was utilized to estimate the sample size. This study was approved by the Karadeniz Technical University Scientific Research Ethics Committee (IRB number: 2023/88, date: 13.07.2023).

Radiological Analysis

The degree of spondylolisthesis was determined according to the Meyerding classification of the slip, which categorizes slip severity into five grades: 0% to 25% is grade I, 25% to 50% is grade II, 50% to 75% is grade III, 75% to 100%; and grade V, greater than 100%. Axial T2-weighted MRI images were analyzed at the level of the L4 inferior endplate using the FIJI (National Institutes of Health, Bethesda, Maryland), which is an open-source image-processing software. MRI measurements were performed individually for the MF and ES muscles. The total cross sectional area (TCSA) of the muscles was measured by tracing their outlines. Functional cross-sectional area (FCSA) is the fat-free area of CSA measured by selecting a threshold signal intensity that includes only pixels within the lean muscle. The threshold for lean muscle tissue was defined by drawing six sample regions of interest (ROIs) within the lean muscle tissue of bilateral PM to avoid the inclusion of any visible pixels of fat. The maximum signal intensity obtained from the six ROIs was selected as the threshold for distinguishing lean muscle tissue from fat (Figure 1). Subsequently, the ratio of the FCSA to TCSA was calculated for the MF and ES muscles. To compensate for the influence of individual body shape, body weight, and height on the CSA of the muscles, the relative total and functional CSAs (rTCSA and rFCSA), which were defined as the ratio of the CSA of the muscles to the CSA of the L4 inferior endplate, were then obtained. The MF TCSA/ES TCSA and MF FCSA/ES FCSA ratios were also calculated.

The lumbopelvic angles were measured on T2-weighted MRI images using a Syngo.via VB60A workstation (Siemens Healthineers, Erlangen, Germany). The lumbar lordosis angle [(LLA) angle between the superior endplates of L1 and S1], upper lumbar lordosis [(ULLA) angle between the superior endplates of L1 and L4], lower lumbar lordosis [(LLLA) angle between the superior endplates of L4 and S1], and sacral slope angle [(SSA) angle between the superior endplate of S1 and the horizontal plane] were measured, as shown in Figure 2. The degree of spondylolisthesis was determined according to the Meyerding classification, and the slip percentage was recorded.

All MRI measurements were performed independently twice (with a 1-month interval) to minimize the potential for error in defining muscle margins by a radiologist with 14 years of experience. The average values of the two measurements were used for statistical analysis.

Statistical Analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences (version 23.0; IBM Inc., Armonk,

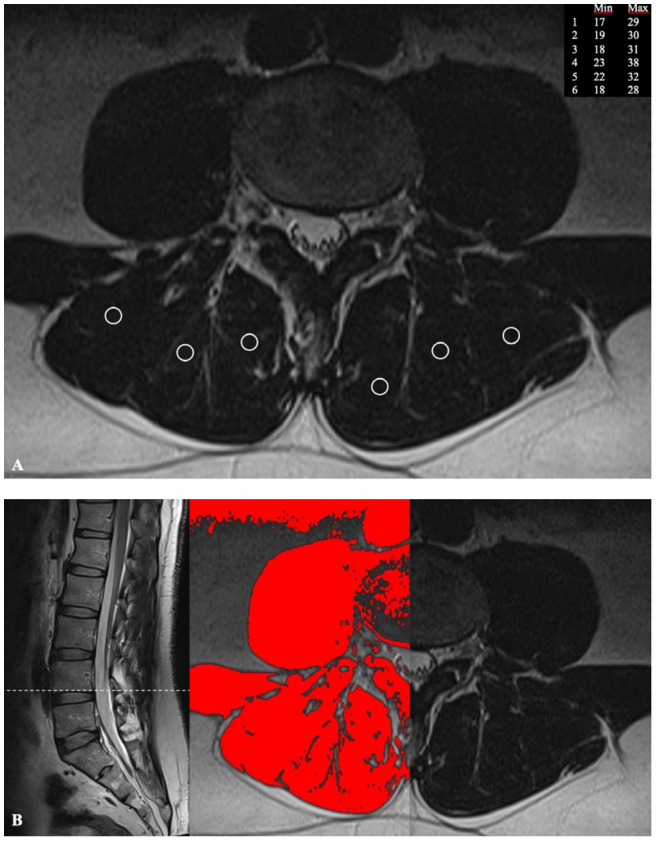

Figure 1. Quantitative paraspinal muscle measurement. (A) Selection of six different regions of interest to define upper and lower threshold limits. (B) Sagittal and axial T2-weighted magnetic resonance images showing the measurement of the total and functional cross-sectional areas of the multifidus and erector spinae muscles at the level of the L4 inferior endplate.

J Acad Res Med 2024;14(3):100-5

New York). Quantitative data were expressed as means ± standard deviation or medians and interquartile range, as appropriate. Qualitative data are presented as numbers and percentages. The Kolmogorov-Smirnov test was used to check the normality of the distribution. The variables were compared using Student's t-test, the Mann-Whitney U test, and the chi-squared test for normally distributed, non-normally distributed, and categorical variables, respectively. Statistical significance was set at p-values 0.05.

RESULTS

Demographics of Participants

A total of 55 patients (30 females, 25 males) and 45 healthy individuals (24 females, 21 males) were included in this study. The mean ages of the patient and control groups were 64.5±14.5 years and 61±5.7 years, respectively. There were no statistically significant differences between the patient and control groups in terms of gender (p=0.904), smoking status (p=0.267), exercise status (p=0.889), or age (p=0.108) (Table 1).

Radiological Characteristics

In the spondylolisthesis group, 41 patients (74.6%) had L5/S1 spondylolisthesis. Thirty-six patients (65.5%) had grade I spondylolisthesis. Table 2 lists the spondylolisthesis features of the patient group.

Comparison of the groups in terms of MF and ES muscle areas revealed that MF rFCSA, ES FCSA, ES rFCSA, MF FCSA/TCSA, and ES FCSA/TCSA were decreased in patients with spondylolisthesis compatible with an increase of fatty degeneration. ULLA was higher in the spondylolisthesis group (19.78±10.74) than in the control group (13.64±6.84). MRI measurements of the PM and lumbar lordosis are summarized in Table 3.

MF FCSA, MF rFCSA, ES FCSA, MF FCSA/TCSA, and ES FCSA/TCSA were lower in patients with grade 2 spondylolisthesis. No significant difference was detected between grade 1 and 2 spondylolisthesis groups regarding lumbar lordosis angle (Table 4). A weak negative correlation was found between the percentage of slip and the MF FCSA/ES FCSA ratio (Table 5).

Table 1. Demographic features of the groups

		Patient group		Control group		p
		Number	%	Number	%	
Gender	Female	30	54.5	24	53.3	0.904*
	Male	25	45.5	21	46.7	
Smoking	(+)	22	40	23	51.1	0.267*
	(-)	33	60	22	48.9	
Exercise status	None	39	70.9	30	66.6	0.889*
	1-2 days/week	7	12.7	7	15.6	
	≥ 3 days/week	9	16.4	8	17.8	
Age, mean ± SD		64.5±14.5		61±5.7		0.108**

*:chi-square test, **:independent sample t-test SD: standard deviation

DISCUSSION

The paraspinal muscles directly affect the segmental stability of the lumbar spine. Thus, assessment of the CSA of these muscles is crucial for managing LBP (9,10). Previously, only a limited number of studies have investigated the role of PM in patients with spondylolisthesis. Degeneration of the PM and reduced isometric force of the lumbar spine are detected in patients with degenerative spondylolisthesis (DSL). Atrophy of the MF muscle is the most commonly observed morphometric alteration in these cases (11-14). However, the LIS has been under-investigated in terms of PM morphometry (15-17). In the present study, our findings demonstrated that the LIS group exhibited a greater degree of fat deposition in both the MF and ES than the control group, and

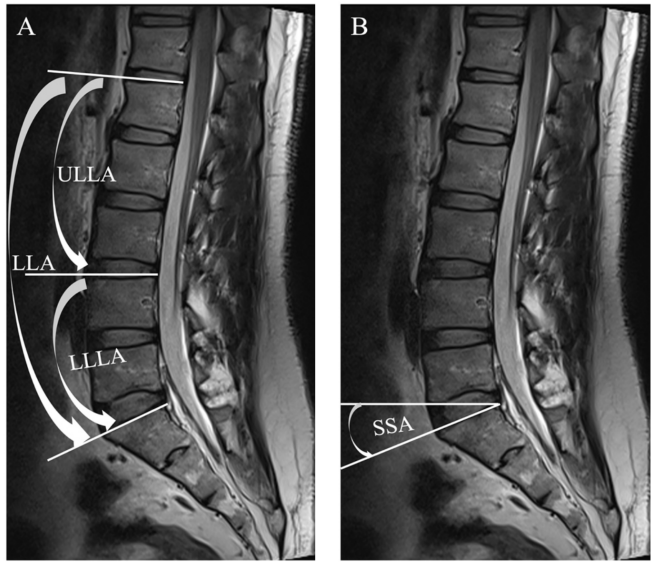

Figure 2. Measurement of lumbopelvic angles. (A) Lumbar lordosis angle (LLA) between the superior endplates of L1 and S1, upper lumbar lordosis angle (ULLA) between the superior endplates of L1 and L4, and lower lumbar lordosis angle (LLLA) between the superior endplates of L4 and S1 were measured using T2-weighted sagittal images. (B) The sacral slope angle (SSA) between the horizontal plane and the superior endplate of S1 was investigated.

Table 2. Sponylolisthesis features of the patient group

		Patient group	
		Number	%
Spondylolisthesis level	L3-4	2	3.6
	L4-5	12	21.8
	L5-S1	41	74.6
Spondylolisthesis grade	Grade 1	36	65.5
	Grade 2	19	34.5
	Grade 3	0	0
	Grade 4	0	0
Slip percentage, mean ± SD		22.73±8.63	

SD: standard deviation, L: lumbar vertebra

J Acad Res Med 2024;14(3):100-5

this difference was more pronounced among patients with grade 2 LIS compared with grade 1 LIS. A higher slip percentage was associated with MF atrophy. In addition, ULLA was increased in patients with LIS.

The relationship between DSL and PM has been investigated in several studies. Some studies on the role of PM have been conducted by measuring CSAs; however, the results have been controversial. A retrospective study included 62 female patients with DSL and evaluated the CSAs of lumbar PM and fatty degeneration. The patient group showed no significant difference in the total CSA of the MF or ES compared with the control group. Patients with DSL showed greater fat infiltration in the MF muscle and smaller FCSA. In contrast,

Table 3. Comparison of MRI parameters between the patient and control groups

Muscle and lumbar lordosis parameters	Patient group	Control group	p
LLA	57.33±12.41	52.84±11.17	0.063*
ULLA	19.78±10.74	13.64±6.84	**0.001***
LLLA	38±10.35	39.56±6.6	0.365*
SSA	46.84±9.07	44±7.92	0.103
MF TCSA (mm²)	2290.87±447.42+	2122.62±369.25+	**0.046***
MF FCSA (mm²)	1686 (794)†	1940 (564)†	0.192**
MF rTCSA	1.71±0.39+	1.69±0.37+	0.783*
MF rFCSA	1.31±0.39+	1.49±0.33+	**0.019***
MF FCSA/TCSA (%)	78.86 (20)†	90.56 (10)†	**<0.001****
ES TCSA (mm²)	3817.72±851.23+	3540.58±816.47+	0.101*
ES FCSA (mm²)	2630.76±702.69+	2955.18±780.49+	**0.031***
ES rTCSA	2.94 (1.08)†	2.73 (0.70)†	0.747**
ES rFCSA	1.87 (0.86†	2.32 (0.48)†	**0.001****
ES FCSA/TCSA (%)	69.91±14.32+	83.08±9.27+	**<0.001***
MF TCSA/ES TCSA	0.62±0.18+	0.61±0.12+	0.764*
MF FCSA/ES FCSA	0.69±0.20+	0.66±0.15+	0.423*

*: independent samples t-test, **: Mann-Whitney U test, +: mean±standard deviation, †: median (interquartile range), LLA: lumbar lordosis angle, ULLA: upper lumbar lordosis angle, LLLA: lower lumbar lordosis angle, SSA: sacral slope angle, TCSA: total cross-sectional area, FCSA: functional CSA, MF: multifidus, ES: erector spinae, r: relative

Table 4. Comparison of MRI between spondylolisthesis grades

Muscle and lumbar lordosis parameters	Grade 1	Grade 2	p
LLA	56.03±11.91+	59.79±13.29+	0.309*
ULLA	19±10.51+	21.26±11.31+	0.463*
LLLA	37.5 (9)†	41 (13)†	0.451**
SSA	45.5±8.39+	49.37±9.98+	0.134
MF TCSA (mm²)	2337.92±433.24+	2201.74±471.98+	0.287*
MF FCSA (mm²)	1958.5 (808)†	1540 (718)†	**0.042****
MF rTCSA	1.72±0.39+	1.67±0.41+	0.600*
MF rFCSA	1.41±0.32+	1.19±0.35+	**0.022***
MF FCSA/TCSA (%)	80.92 (21)†	73.87 (19)†	**0.031****
ES TCSA (mm²)	3729.35±723.25+	3984.74±1054.3+	0.294*
ES FCSA (mm²)	2872.68±620.83+	2482.35±647.5+	**0.033***
ES rTCSA	2.73 (0.95)†	3.09 (1.18)†	0.280**
ES rFCSA	1.87 (0.91)†	1.87 (0.93)†	0.608**
ES FCSA/TCSA (%)	69.99±14.39+	59.77±13.58+	**0.013***
MF TCSA/ES TCSA	0.64±0.14+	0.59±0.23+	0.338*
MF FCSA/ES FCSA	0.71 (0.28)†	0.60 (0.28)†	0.089**

*: independent samples t-test, **: Mann-Whitney U test, +: mean±standard deviation, †: median (interquartile range), LLA: lumbar lordosis angle, ULLA: upper lumbar lordosis angle, LLLA: lower lumbar lordosis angle, SSA: sacral slope angle, TCSA: total cross-sectional area, FCSA: functional CSA, MF: multifidus, ES: erector spinae, r: relative, MRI: magnetic resonance imaging

J Acad Res Med 2024;14(3):100-5

Table 5. Correlation between muscle and lumbar lordosis parameters and slip percentage

Muscle and lumbar lordosis parameters	Correlation Coefficient	p
LLA	-0.062	0.654*
ULLA	0.184	0.178*
LLLA	-0.331	0.113*
SSA	-0.092	0.502*
MF TCSA (mm²)	-0.142	0.302*
MF FCSA (mm²)	-0.120	0.382**
MF FCSA/TCSA (%)	-0.055	0.690**
MF rTCSA	-0.043	0.754*
MF rFCSA	-0.057	0.678*
ES TCSA (mm²)	0.257	0.058*
ES FCSA (mm²)	0.240	0.077*
ES FCSA/TCSA (%)	0.570	0.681*
ES rTCSA	0.172	0.209**
ES rFCSA	0.226	0.097*
MF TCSA/ES TCSA	-0.239	0.079*
MF FCSA/ES FCSA	-0.340	**0.011***

*: Pearson test, **: Spearman test, LLA: lumbar lordosis angle, ULLA: upper lumbar lordosis angle, LLLA: lower lumbar lordosis angle, SSA: sacral slope angle, TCSA: total cross-sectional area, FCSA: functional CSA, MF: multifidus, ES: erector spinae, r: relative

the ES muscle showed a large FCSA in DSL patients. These results indicate increased fat infiltration in the MF of patients undergoing DSL (18). An observational study revealed that the percentage of slip in DSL patients was not associated with MF CSA (11), whereas a case-control study showed PM hypertrophy in comparison with controls (12).

Reports on LIS and PM have yielded inconsistent results. A computed tomography study demonstrated that PM CSAs were significantly larger in patients with LIS (14). Thakar et al. (17) assessed patients who underwent posterior interbody fusion for LIS. In contrast to our results, this study demonstrated selective atrophy of the MF, whereas compensatory hypertrophy was observed in the ES. The discrepancy between our study and previous investigations may be attributable to differences in study populations. Various factors, including pain and symptom duration, pain intensity, age, race, gender, hormonal status, occupation, body mass index, and physical activity level, can potentially contribute to diverse structural changes in muscle groups. Consequently, ES compensatory hypertrophy as a protective mechanism may not be observed in all patients.

Park et al. (19) investigated the role of lumbar PM mass and slip percentage in DSL and LIS using MRI. MF CSAs were negatively correlated with slip percentage in patients with LIS, and no muscle measurements exhibited any correlation with slip percentage in the DSL group. Our study indicated that the decrease in ES and MF CSA was associated with the LIS grade, which demonstrates segmental instability. MF atrophy was more pronounced than ES atrophy in terms of the slip percentage. An additional observational study including both patients with DSL and those with LIS detected a negative correlation between slip percentage and MF CSA as well as a positive correlation between slip percentage and ES CSA (20).

Previous studies have reported that patients with DSL exhibited significantly higher segmental lumbar lordosis at the upper lumbar spine, specifically at the L1-L2 and L2-L3 levels, compared to those without DSL. This finding is consistent with our study, which revealed elevated ULLA in patients with LIS compared with healthy controls. Based on these observations, the compensatory mechanism for anterior translation of the L4 vertebral body may increase the degree of lordosis in the upper portion of the lumbar spine (21,22).

Fatty degeneration occurs with the replacement of PM tissue with adipose tissue and is considered an indicator of muscle atrophy. Unilateral back pain is linked to ipsilateral PM atrophy. The suppression of the long-loop reflex to protect damaged tissue at the symptomatic vertebral level is a potential mechanism of PM atrophy (23,24). Increased sagittal instability resulting from spondylolisthesis may lead to stretching and thinning of the paraspinal musculature, as anterior displacement of a vertebra in spondylolisthesis results in increased lumbar lordosis. This explains the structural alterations and their association with PM (19). Our results suggest that fatty degeneration and functional loss occur in the MF and ES of LIS patients. Thus, the substitution of muscular tissue with fat may influence the muscle's function, while its TCSA may remain relatively unchanged.

This study has several limitations. First, retrospective patient data did not include clinical information. Consequently, there is an absence of data regarding the reflection of fatty degeneration observed in clinical findings beyond the muscle groups. Further research will be beneficial to evaluate the clinical findings by comparing the changes in fatty degeneration in the ES and MF muscles through a prospective analysis. Second, the relationship between PM muscle measurements, symptom duration, and pain intensity was not evaluated. The strengths of this study were as follows: a matched control group was included, various MRI-based measurements were performed, and quantitative methods were used to accurately measure fat infiltration. Lumbopelvic parameters have not been addressed in previous studies. Furthermore, the results of this study indicate the importance of providing detailed descriptions of PM fatty degeneration and grading in radiology reports to plan physical therapy programs for patients with LIS. This information can also be used in follow-up examinations to monitor treatment responses and to facilitate rehabilitation.

CONCLUSION

The assessment of PM CSAs is important in patients with LIS because these muscles affect the segmental stability and control of the lumbar spine. In this study, ES and MF functional areas were decreased in patients with LIS due to fatty degeneration.

J Acad Res Med 2024;14(3):100-5

Prospective studies are needed to evaluate the clinical significance of PM fatty degeneration on pain, functionality, and exercise programs.

Ethics

Ethics Committee Approval: This study was approved by the Karadeniz Technical University Scientific Research Ethics Committee. (IRB number: 2023/88, date: 13.07.2023).

Informed Consent: Retrospective study.

Footnotes

Author Contributions: Surgical and Medical Practices - S.A.; Concept - S.A., G.S.A.; Design - S.A., G.S.A.; Data Collection and/or Processing - S.A., G.S.A.; Analysis and/or Interpretation - S.A.; Literature Search - S.A., G.S.A.; Writing - S.A., G.S.A.

Conflict of Interest: The authors have no conflict of interest to declare.

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

REFERENCES

1. Hurwitz EL, Randhawa K, Yu H, Côté P, Haldeman S. The global spine care initiative: a summary of the global burden of low back and neck pain studies. Eur Spine J. 2018; 27: 796-801.
2. Freburger JK, Holmes GM, Agans RP, Jackman AM, Darter JD, Wallace AS, et al. The rising prevalence of chronic low back pain. Arch Intern Med. 2009; 169: 251-8.
3. Chien JJ, Bajwa ZH. What is mechanical back pain and how best to treat it? Curr Pain Headache Rep. 2008; 12: 406-11.
4. Kreiner DS, Baisden J, Mazanec DJ, Patel RD, Bess RS, Burton D, et al. Guideline summary review: an evidence-based clinical guideline for the diagnosis and treatment of adult isthmic spondylolisthesis. Spine J. 2016; 16:1478-85.
5. Beutler WJ, Fredrickson BE, Murtland A, Sweeney CA, Grant WD, Baker D. The natural history of spondylolysis and spondylolisthesis: 45-year follow-up evaluation. Spine (Phila Pa 1976). 2003; 28: 1027-35; discussion 35.
6. Kalichman L, Kim DH, Li L, Guermazi A, Berkin V, Hunter DJ. Spondylolysis and spondylolisthesis: prevalence and association with low back pain in the adult community-based population. Spine (Phila Pa 1976). 2009; 34: 199-205.
7. Sakai T, Sairyo K, Takao S, Nishitani H, Yasui N. Incidence of lumbar spondylolysis in the general population in Japan based on multidetector computed tomography scans from two thousand subjects. Spine (Phila Pa 1976). 2009; 34: 2346-50.
8. Bhalla A, Bono CM. Isthmic lumbar spondylolisthesis. Neurosurg Clin N Am. 2019; 30: 283-90.
9. Lee HJ, Lim WH, Park JW, Kwon BS, Ryu KH, Lee JH, et al. The relationship between cross sectional area and strength of back muscles in patients with chronic low back pain. Ann Rehabil Med. 2012; 36: 173-81.
10. Nizard RS, Wybier M, Laredo JD. Radiologic assessment of lumbar intervertebral instability and degenerative spondylolisthesis. Radiol Clin North Am. 2001; 39: 55-71, v-vi.
11. Kalpakcioglu B, Altinbilek T, Senel K. Determination of spondylolisthesis in low back pain by clinical evaluation. J Back Musculoskelet Rehabil. 2009; 22: 27-32.
12. Nava-Bringas TI, Ramirez-Mora I, Coronado-Zarco R, Macias-Hernandez SI, Cruz-Medina E, Arellano-Hernandez A, et al. Association of strength, muscle balance, and atrophy with pain and function in patients with degenerative spondylolisthesis. J Back Musculoskelet Rehabil. 2014; 27: 371-6.
13. Wang G, Karki SB, Xu S, Hu Z, Chen J, Zhou Z, et al. Quantitative MRI and X-ray analysis of disc degeneration and paraspinal muscle changes in degenerative spondylolisthesis. J Back Musculoskelet Rehabil. 2015; 28: 277-85.
14. Ergun T, Sahin MS, Lakadamyali H. Evaluation of the relationship between L5-S1 spondylolysis and isthmic spondylolisthesis and lumbosacral-pelvic morphology by imaging via 2- and 3-dimensional reformatted computed tomography. J Comput Assist Tomogr. 2011; 35: 9-15.
15. Kader DF, Wardlaw D, Smith FW. Correlation between the MRI changes in the lumbar multifidus muscles and leg pain. Clin Radiol. 2000; 55: 145-9.
16. Danneels LA, Vanderstraeten GG, Cambier DC, Witvrouw EE, De Cuyper HJ. CT imaging of trunk muscles in chronic low back pain patients and healthy control subjects. Eur Spine J. 2000; 9: 266-72.
17. Thakar S, Sivaraju L, Aryan S, Mohan D, Sai Kiran NA, Hegde AS. Lumbar paraspinal muscle morphometry and its correlations with demographic and radiological factors in adult isthmic spondylolisthesis: a retrospective review of 120 surgically managed cases. J Neurosurg Spine. 2016; 24: 679-85.
18. Lee ET, Lee SA, Soh Y, Yoo MC, Lee JH, Chon J. Association of lumbar paraspinal muscle morphometry with degenerative spondylolisthesis. Int J Environ Res Public Health. 2021; 18(8): 4037.
19. Park JH, Kim KW, Youn Y, Kim H, Chung WS, Song MY, et al. Association of MRI-defined lumbar paraspinal muscle mass and slip percentage in degenerative and isthmic spondylolisthesis: a multicenter, retrospective, observational study. Medicine (Baltimore). 2019; 98: e18157.
20. Park HS, Kim JI, Kim KW, Cho JH, Song MY. The correlation between cross-sectional area of lumbar paraspinal muscles and spondylolisthesis: a retrospective study. Journal of Korean Medicine Rehabilitation. 2016; 26: 95-102.
21. Jun HS, Kim JH, Ahn JH, Chang IB, Song JH, Kim TH, et al. The effect of lumbar spinal muscle on spinal sagittal alignment: evaluating muscle quantity and quality. Neurosurgery. 2016; 79: 847-55.
22. Schuller S, Charles YP, Steib JP. Sagittal spinopelvic alignment and body mass index in patients with degenerative spondylolisthesis. Eur Spine J. 2011; 20: 713-9.
23. Barker KL, Shamley DR, Jackson D. Changes in the cross-sectional area of multifidus and psoas in patients with unilateral back pain: the relationship to pain and disability. Spine (Phila Pa 1976). 2004; 29: E515-9.
24. Teichtahl AJ, Urquhart DM, Wang Y, Wluka AE, Wijethilake P, O'Sullivan R, et al. Fat infiltration of paraspinal muscles is associated with low back pain, disability, and structural abnormalities in community-based adults. Spine J. 2015; 15: 1593-601.

DOI: 10.4274/jarem.galenos.2024.44153
J Acad Res Med 2024;14(3):106-14

The Effect of Post-Retirement Activity Status on Balance Functions and Quality-of-Life in Individuals Aged 65 and Over

Ahmet Alperen Akbulut[1], Gökçenur Tokgöz[2], Aslınur Taştepe[2], Simge Nur Baymaz[2], Cansel Keskin[2], Zahra Polat[1]

[1]University of Health Sciences Türkiye, Hamidiye Faculty of Health Sciences, Department of Audiology, İstanbul, Türkiye
[2]University of Health Sciences Türkiye, Hamidiye Faculty of Health Sciences, Department of Audiology, Undergraduate Program, İstanbul, Türkiye

Cite this article as: Akbulut AA, Tokgöz G, Taştepe A, Baymaz SN, Keskin C, Polat Z. The Effect of Post-retirement Activity Status on Balance Functions and Quality-of-Life in Individuals Aged 65 and Over. J Acad Res Med. 2024;14(3):106-14

ABSTRACT

Objective: This study aims to investigate the impact of working (or not working) in a job, as well as being interested in a job, exercise, sports, or other activities, on the physical conditions, balance functions, and social relations of people aged 65 and over.

Methods: A total of 64 people (mean= 68.34 years, standard deviation= 5.51) aged 65 years and older were included in this single center, cross-sectional study, with 32 in each of the active and inactive groups. After audiologic evaluation, the Physical Activity Scale for the Elderly (PASE), Short Form Health Questionnaire version-2.0 Turkish (SF-36v2), and International Falling Efficacy Scale (FES-I) were completed, followed by activities within the scope of the Senior Fitness Test (SFT) and Berg Balance Scale (BBS). Data were presented in detail and compared between the groups.

Results: Significant differences were observed between the groups in terms of PASE (z=-5.03, p<0.001), FES-I (z=-3.12, p=0.002) and BBS (z=-2.69, p=0.007) scores. There were significant differences between the groups in specific subdimensions of SF-36v2, all in favor of the active group (p<0.05). Furthermore, participants in the active group performed significantly better in all SFT areas, except SFT IV. The relationships between the BBS, PASE, FES-I, and subdimensions of SF-36v2 and SFT were analyzed and presented in detail.

Conclusion: Older adults who actively engage in a profession or occupation can maintain their balance abilities during the old age. In addition, their mental health may improve due to this active participation, which could help prevent social exclusion.

Keywords: Aging, postural balance, quality of life, accidental falls, daily activities

INTRODUCTION

The concept of "aging" is intricately linked to the inevitability of death and emerges as time progresses. Physical, biological, psychological, social, cultural, and behavioral changes all play a crucial role in it . Conversely, "elderliness" is characterized by the natural process of aging, during which vitality decreases and mortality increases. Individuals 65 years of age and older are commonly referred to as the "elderly population" in both Türkiye and worldwide (1).

An age-related challenge that often arises is difficulty in maintaining balance. Integrating the vestibular, visual, auditory, motor, and higher cerebral systems is necessary for maintaining balance. Balance issues related to aging might occur due to illnesses or as an unavoidable outcome of the normal aging process (2). Age-related degenerative changes in the peripheral and central vestibular systems lead to balance deficits, a primary concern associated with aging. Within this framework, falls and balance issues play a crucial role and necessitate the dissemination of knowledge to older adults (3).

Balance is defined as the ability to control one's center of gravity on the supporting surface in the current sensory environment. To attain the desired posture, balance necessitates not only the coordination and implementation of physical movements, but also the perception and integration of sensory information (4). Advanced neural networks and other complex systems, such as cognitive and musculoskeletal systems, can have diverse impacts on an individual's capacity to maintain balance and

ORCID IDs of the authors: A.A.A. 0000-0002-3273-6632; G.T. 0009-0004-5923-0780; A.T. 0009-0005-4670-899X; S.N.B. 0009-0008-8780-8753; C.K. 0009-0001-7022-4371; Z.P 0000-0001-8384-4302.

Corresponding Author: Ahmet Alperen Akbulut,
E-mail: a.alperenakbulut1@gmail.com

Received Date: 09.06.2024 **Accepted Date:** 11.12.2024

J Acad Res Med 2024;14(3):106-14

physical functioning (PF). Several studies have documented a decrease in vestibulo-ocular reflex function and postural stability as individuals age. Balance dysfunction is a primary contributor to reduced mobility and postural control in older individuals. It affects the capacity to sustain gait and retain control over balance during everyday tasks (5). Research has indicated that dizziness hampers daily tasks in 30% of individuals aged 70 years. Approximately 30% of elderly individuals experience at least one fall annually, whereas 15% have two or more falls. The annual fall rate for individuals aged 70 years ranged from 32% to 42%. However, for individuals aged 80 years, this rate escalates to 50% (6). Balance difficulties in older individuals can lead to serious morbidity and even mortality due to fall-related injuries, such as hip fractures. Similarly, balance problems have been linked to factors such as reduced self-confidence, reduced social interaction, and feelings of loneliness, anxiety, and embarrassment in older people (7).

Older people who regularly participate in moderate-intensity physical activity are more physically active and healthier than their sedentary counterparts in the elderly population (8). A previous study showed that older people who engage in regular physical activity at a younger age exhibit significantly greater lower body strength and dynamic balance compared to older adults who do not (9). It was also reported that elderly individuals who were physically active showed better body awareness than those who were not physically active (10).

This study specifically examines two theories: disengagement and activity. According to activity theory, an individual's aging process can be improved by replacing and maintaining relationships, responsibilities, and activities that were acquired in middle life but were lost in old age. According to this philosophy, social connections and activities are considered fundamental to life (11). The theory of disengagement, conversely, refers to the phenomenon of individuals becoming detached from society upon retirement. This process should be acknowledged as a typical occurrence that mirrors the natural progression of life (12).

This study aimed to examine the impact of daily activity, employment status after retirement, engagement in an occupation, and interest in sports and exercise on the functionality of the balance system and somatosensory functions in individuals aged 65 years and older. The objective of this study is to examine the impact of engaging in or refraining from activities in daily life on the vestibular system, drawing from the principles of activity and disengagement theories. Additionally, our goal is to examine how these individuals perceive the process of aging, the quality of their social interactions, and the level of satisfaction they derive from these interactions based on their level of activity. The hypothesis of our study posits a correlation between post-retirement employment and/or interest in a vocation and the functionality of the balancing system, as well as the endurance and integrity of the lower and upper extremities in individuals aged 65 and above. Another hypothesis in our study is that working or engaging in an activity after retirement would improve the quality of life (QoL) by promoting healthier social relationships among people aged 65 years and older.

METHODS

Participants

A total of 64 individuals participated in the study, including 21 males and 11 females in the active group [mean (M)=68.0 years, standard deviation (SD)=±5.16] and 13 males and 19 females in the inactive group (M=68.6 years, SD=±5.81) aged 65 years or older. For all participants, being 65 years of age or older, having a standardized mini-mental test score of 24 or higher, having no known or diagnosed neurological or musculoskeletal problems affecting walking and balance, having no diagnosis of hearing and balance problems, and having the physical ability to complete the scales were considered. The study excluded individuals with documented neurological diseases, physical disabilities, visual impairments, a history of orthopedic or ear-related surgeries, vestibular disease or vertigo, communication difficulties caused by psychological problems, and those who lacked the necessary coordination and cooperation to complete the scales. If any item on the scales and/or questionnaires used was left blank or incomplete, the data of those individuals were excluded. Participants were also excluded if they had pure tone average (0.5-1-2-4 kHz) of 25 dB or higher, if there was a significant decrease in hearing thresholds up to 8 kHz, if their speech discrimination score was lower than 88% in either ear, if their tympanogram showed a different type than type A, or if they had eustachian tube dysfunction.

Hearing loss was excluded as a criterion because of its association with balance problems, as highlighted in the literature. Research indicates that hearing loss, particularly sensorineural hearing loss, is linked to increased postural sway, balance impairment, and fall risk (13,14). Excluding individuals with hearing loss ensured that balance-related outcomes in this study were not influenced by auditory-vestibular system dysfunction, allowing us to isolate the effects of activity and inactivity on balance skills in the elderly population.

Table 1 provides comprehensive participant information. The study sample size was calculated using G*Power. Upon determining the power of the study to be 0.80 for a significance level of $p<0.05$, it was concluded that a minimum of 32 individuals should be included in each group.

This study has been supported within the scope of the 2209-A Program conducted by TÜBİTAK, The Department of Science Fellowships and Grant Programs (Project No: 1919B012202667). All procedures in this study were approved by the Ethics Committee of the University of Health Sciences Türkiye, Hamidiye Faculty of Health Sciences (decision No: 25/22, date: 18.11.2022). All participants signed a consent form indicating their voluntary participation. All procedures were conducted in accordance with the Helsinki Declaration (as revised in 2008).

J Acad Res Med 2024;14(3):106-14

Procedures

This study had a single center, cross-sectional design. After the main researcher provided a brief explanation of the study, the eligibility criteria for individuals who wanted to voluntarily participate in the study were reviewed by all researchers. The participants in the study were divided into two groups, "active" and "inactive," according to their scores on the Physical Activity Scale for the Elderly (PASE) scale, which assesses daily physical activity status, and the information they provided about having a job or a hobby in their daily lives. Participants who reported working or volunteering for primarily sedentary tasks requiring minimal physical effort (e.g., sitting with slight arm movements) were classified as "inactive". In contrast, those whose work or volunteer activities required moderate to high levels of physical effort were classified as "active". Additionally, the average daily work hours were calculated by dividing the total work hours in the previous week by seven to standardize the evaluation of activity levels. This approach ensured a systematic and reproducible classification of physical activity status.

Collection of Data

An information form was designed to gather demographic and descriptive data, including gender, age, height, body weight, body mass index, past physical activity, employment history, current job/occupation, hours spent on the job/occupation, and daily time allocation. The Mini-Mental State Examination tool was used to assess the global cognitive functioning of the participants, and scores of 24 and above were considered normal (15). Acoustic immitancemetry, pure tone audiometry, and speech audiometry were performed to evaluate and confirm normal hearing in all participants. All participants were then asked to complete the questionnaires after audiologic evaluation, followed by activities included in the Senior Fitness Test (SFT) and Berg Balance Scale (BBS).

Pure Tone and Speech Audiometry

Using a clinical audiometer (Madsen Astera2, Otometrics; Denmark) and TDH 39 earphones (Telephonics, Farmingdale, NY), audiometric testing was conducted between 125 and 8000 Hz in a quiet room at IAC standards. The live voice was used to determine the speech discrimination score and speech reception threshold.

Acoustic Immitancemetry

A clinical tympanometry (Clarinet, Inventis; Italy) was used to perform tympanometric examination using a 226-Hz probing tone and acoustic reflex measurements.

Physical Activity Scale for the Elderly

PASE was designed to assess leisure time, housework, and work-related activities among older people (16). The validity and reliability study and cultural adaptation of the Turkish version of the scale were conducted in 2017, demonstrating its applicability to the Turkish elderly population (17). The scale consists of 12 items that evaluate the frequency, duration, and intensity of physical activities over the previous 7 days. Participation in leisure time and strengthening activities is scored based on frequency (e.g., never, 1-2 days/week, 3-4 days/week, or 5-7 days/week) and duration (e.g., less than 1 hour, 1-2 hours, 2-4 hours, or more than 4 hours). Household and work-related activities were scored as yes/no questions, while work-related activities were further quantified in terms of hours per week (16).

Table 1. Characteristics of the study groups

Characteristic		M ± SD (min-max)		Number (percentage)	
		Active group	Inactive group	Active group	Inactive group
Age (year)		68.0±5.16 (60-78)	68.6±5.81 (62-85)		
Body mass index (kg/m^2)		28.3±36.9-20.2 (3.78)	30.21±38.6-25.0 (3.52)		
Sex	Male			21 (65.6)	13 (40.6)
	Female			11 (34.4)	19 (59.4)
Education	Non-literate			2 (6.3)	7 (21.9)
	Primary school			13 (40.6)	11 (34.4)
	Middle school			7 (21.9)	4 (12.5)
	High school			6 (18.7)	5 (15.6)
	College			4 (12.5)	5 (15.6)
Chronic health status	0			17 (53.1)	14 (43.7)
	1			7 (21.9)	8 (25.0)
	2			5 (15.6)	7 (21.9)
	3			3 (9.4)	3 (9.4)
Fall status in the previous 12 months due to dizziness/vertigo	Yes			3 (9.4)	6 (18.7)
	No			29 (90.6)	26 (81.3)

M: mean, SD: standard deviation, min-max: minimum-maximum

J Acad Res Med 2024;14(3):106-14

The PASE score was calculated by multiplying the time spent on each activity or participation in an activity by empirically derived weights and summing these values across all activities. The final score ranged from 0 to 400 or more, with higher scores indicating greater physical activity levels (16).

The primary purpose of the present study was to assess work-related activities in individuals aged 65 years and older. The secondary aim was to question the participants' remaining daily activities to determine the extent of their daily physical activity using a valid scale.

Short Form Health Survey version 2.0

The SF-36v2 was used to assess the relationship between physical and mental health. The survey includes items on perceptions of change in health over the last four weeks and in the last week. A validity and reliability study of the Turkish version was conducted in 1999 (18). SF-36v2 is a survey consisting of 36 questions measuring 8 sub-dimensions of health: PF, role physical (RP), bodily pain (BP), general health (GH), vitality, social functioning (SF), role emotional (RE), and mental health. Each subdimension is rated on a scale of 0-100, with 0 indicating poor health and the lowest possible QoL score and 100 indicating good health and the highest possible QoL (19). The SF-36v2 data were analyzed using the Optum Pro Core program, which was designed to calculate the SF-36v2 survey results.

Falls Efficacy Scale International Questionnaire

The questionnaire, which was first aimed at the American public because of the region in which it was developed, was updated as FES-I to become an international questionnaire and transformed into a scale with outdoor questions (20). A Turkish validity and reliability study was conducted by Ulus et al.(21) in 2012. Questions about fear of falling (FoF) in daily activities were included in the FES-I questionnaire. In the 16-item questionnaire, the participant is expected to self-report each activity by scoring one to four on a scale from "not at all worried" (1 point) to "very worried" (4 points) (20). The FES-I questionnaire was used to investigate the effect of individuals' FoF on their active lives.

Senior Fitness Test

The SFT, developed by Rikli and Jones (22) in 1999 and first published in 2001, is a widely validated tool for assessing the physical fitness of individuals aged 60 years and older.

The assessment evaluates the critical components of functional fitness, including strength, endurance, flexibility, agility, and dynamic balance, which are essential for maintaining independence in daily activities. The SFT consists of six specific tests, each designed to measure a particular aspect of physical fitness. Lower body strength was assessed using the 30-s chair stand test, in which participants repeatedly rose from and sat down on a chair within 30 s. Upper body strength was evaluated using the 30-s arm curl test, which counts the number of bicep curls completed with weights of 5 lb (2.27 kg) for women and 8 lb (3.63 kg) for men. Aerobic endurance was measured using either the 2-min step test, which recorded the number of steps completed, or the 6-min walk test, which measured the total distance walked. Flexibility was assessed using the chair sit-and-reach test for lower body flexibility and the back scratch test for upper body flexibility. Finally, agility and dynamic balance were measured using the 8-foot up-and-go test, in which participants were required to stand up from a seated position, walk 8 feet, and return to the chair (22).

Each component of the SFT was scored individually, and normative data derived from extensive studies provided benchmarks for interpreting the results according to age and gender. The SFT is practical for both research and clinical settings, requires minimal equipment and expertise, and is well-suited for use with older adults, including those with mild cognitive impairment (22).

In this study, the SFT was used to assess how an active or inactive lifestyle impacts the physical fitness parameters of individuals aged 65 years and older, offering valuable insights into their functional abilities. The tests used to assess these parameters and included in the SFT are: 30-second chair stand test (SFT-I), 30-s arm curl test (SFT-II), 2-min step test (SFT-III), chair sit and reach test (SFT-IV), back scratch test (SFT-V), and foot up and go test (SFT-VI) (22).

Berg Balance Scale

BBS was developed to measure balance performance in the geriatric population and is often used in clinical trials to assess postural control and predict fall risk (23). Therefore, the BBS scale was used to assess the balance performance of the participants according to their lifestyle. The validity and reliability of the BBS, which has been used in many studies related to balance and falls in the elderly, was evaluated in 2008 (24). In this scale, patients are asked to perform certain activities, and the duration and/or number of repetitions are recorded. The scale consists of 14 items that are scored from 0 to 4 and sum to a total score of 0 to 56, with higher scores indicating better balance. Studies have found that low BBS scores predict the onset of the inability to perform important activities of daily living, and patients with a score of 40 or less are at high risk of falling and require appropriate referral (25).

Statistical Analysis

Statistical analyses were performed using IBM SPSS 24.0 (SPSS Inc., Chicago, IL). The descriptive statistics are reported as means and SDs for normally distributed variables and as medians and interquartile ranges for non-normally distributed variables, along with numbers and frequencies. The Shapiro-Wilk test was performed using the 95% confidence interval to test the normal distribution of the groups. The independent group t-test was used to compare normally distributed data, and the Mann-Whitney U Test was used to compare non-normally distributed data. To account for multiple comparisons in analyses involving SF-36 subscales and SFT subtests, Bonferroni correction was applied. The significance thresholds were adjusted accordingly to reduce the risk of type 1 errors. The results were considered

J Acad Res Med 2024;14(3):106-14

significant when the p-values were below the corrected threshold. The FES-I, PASE, and BBS scores were not normally distributed in the normality test; thus, correlation coefficients and statistical significance were calculated using Spearman's correlation analysis. The results were considered significant when p-0.05.

RESULTS

Participant Characteristics

The t-test revealed no significant differences in age (p>0.05) or body mass index (p>0.05) between the active and inactive groups. The chi-square test was conducted to assess whether the groups were homogeneous in terms of sex. The results did not indicate a significant difference between the groups [$\chi^2(1, N=64)=3.07$, p=0.080], suggesting that the groups were homogeneous with respect to sex.

Physical Activity and Balance Performance

According to Mann-Whitney U test, significant differences were observed between the active and inactive groups in terms of PASE (z=-5.03, p<0.001), FES-I (z=-3.12, p=0.002) and BBS (z=-2.69, p=0.007) scores (Table 2). These results remained significant after the Bonferroni correction.

Quality of Life Outcomes

To determine any group differences in SF-36v2 scores, a Mann-Whitney U test was performed. The SF-36v2 PF (z=-2.93, p=0.003), SF-36v2 RP (z=-2.67, p=0.008), and SF-36v2 BP (z=-2.98, p=0.003) showed significant differences between the active and inactive groups after Bonferroni correction (adjusted threshold: p<0.0125). However, the SF-36v2 RE subscale (z=-2.05, p=0.040) did not remain significant after correction (Table 3).

Table 2. Comparison of the active and inactive groups on the PASE, FES-I, and BBS scales

		Median (IQR)	Min;Max	Mean rank	Z-value	p-value
PASE	Active group (n=32)	224.00 (147.00)	66.00-522.00	40.17	-5.029	0.000
	Inactive group (n=32)	104.50 (60.00)	2.00-196.00	18.36		
FES-I	Active group (n=32)	17 (2.00)	16-22	18.95	-3.119	0.002
	Inactive group (n=32)	19 (4.25)	16-35	32.28		
BBS	Active group (n=32)	55.00 (4.00)	44-56	34.00	-2.690	0.007
	Inactive group (n=32)	51.00 (6.75)	21-56	22.41		

PASE: Physical Activity Scale for the Elderly, FES-I: Falls Efficacy Scale International Questionnaire; BBS: Berg Balance Scale, IQR: interquartile range
Note: Bonferroni correction was applied to account for multiple comparisons among the PASE, FES-I, and BBS scales. The corrected significance value was set as p<0.017 (α=0.05/3=0.017)

Table 3. Comparison of 8 sub-dimensions of SF-36v2 between active (n=32) and inactive (n=32) groups

		Median (IQR)	Min;Max	Mean rank	Z-value	p-value
PF	Active group	95.00 (15.00)	40.00-100.00	34.60	-2.92	0.003
	Inactive group	80.00 (30.00)	30.00-100.00	22.02		
RP	Active group	100.00 (0.00)	0.00-100.00	33.24	-2.67	0.008
	Inactive group	75.00 (75.00)	0.00-100.00	22.91		
BP	Active group	90.00 (10.00)	60.00-100.00	34.74	-2.98	0.003
	Inactive group	58.00 (55.00)	10.00-100.00	21.92		
GH	Active group	75.00 (25.00)	25.00-100.00	31.43	-1.69	0.090
	Inactive group	60.00 (37.50)	5.00-100.00	24.09		
VT	Active group	65.00 (40.00)	0.00-100.00	31.88	-1.86	0.062
	Inactive group	45.00 (47.50)	0.00-95.00	23.80		
SF	Active group	100.00 (12.00)	63.00-100.00	31.24	-1.79	0.073
	Inactive group	94.00 (37.00)	0.00-100.00	24.22		
RE	Active group	100.00 (33.00)	0.00-100.00	31.83	-2.05	0.040
	Inactive group	67.00 (75.25)	0.00-100.00	23.83		
MH	Active group	80.00 (24.00)	12.00-100.00	31.05	-1.55	0.121
	Inactive group	68.00 (25.00)	4.00-96.00	24.34		

PF: physical functioning, RP: physical role, BP: bodily pain, GH: general health, VT: vitality, SF: social functioning, RE: emotional role, MH, mental health, IQR: interquartile range
Note: Bonferroni correction was applied to account for multiple comparisons across the eight subdimensions of the SF-36v2 (PF, RP, BP, GH, VT, SF, RE, MH). The corrected significance value was set as p<0.0125 (α=0.05/4=0.0125) for the four subdimensions showing significant p-values before correction

J Acad Res Med 2024;14(3):106-14

Senior Fitness Test Results

A Mann-Whitney U test was conducted to determine any differences in SFT scores between the groups. Results showed that SFT I (z=-3.22, p=0.001), SFT III (z=-2.74, p=0.006), and SFT VI (z=-2.81, p=0.005) remained significant after Bonferroni correction (adjusted threshold: p<0.010). However, SFT II (z=-2.08, p=0.038) and SFT V (z=-2.13, p=0.032) were no longer significant (Table 4).

Gender-Based Differences

A Mann-Whitney U test was performed to determine whether the scores differed between sexes. The results indicated significant differences between male and female participants in terms of FES-I (z=-3.28, p=0.001), BBS (z=-3.82, p<0.001), PASE (z=-2.65, p=0.008), SF36 PF (z=-3.34, p<0.001), and SFT VI (z=-2.18, p=0.029), all in favor of male participants. These differences remained significant after the Bonferroni correction.

Correlation Analysis

The relationships between the BBS, PASE, FES-I, and subdimensions of SF-36v2 and SFT were analyzed, and the results are shown in Table 5. The results indicate a moderate negative correlation between FES-I and BBS (r=-0.449, p<0.01), and strong negative correlations between FES-I and the SF-36v2 sub-dimensions PF (r=-0.516, p<0.001) and GH (r=-0.560, p<0.001). Additionally, a strong positive correlation was found between BBS and PASE (r=0.504, p<0.001), while very strong positive correlations were observed between BBS and SF-36v2 subdimensions PF (r=0.638, p<0.001) and BP (r=0.476, p<0.001). Furthermore, SFT subdimensions I, II, and III showed moderate to strong positive correlations with BBS, ranging from 0.423 to 0.531, all at p<0.001. Moderate to strong correlations remained significant after Bonferroni correction.

DISCUSSION

This study investigated the effects of employment status and engagement in activities such as job involvement, exercise, and sports on the physical well-being and balance systems of adults aged 65 years and above. By incorporating the principles of activity and disengagement theories, we aimed to investigate the correlation between these elements and their impact on individuals' involvement with society and social connections, particularly in respect to the significance of maintaining an active lifestyle.

The results of our study suggest that adults aged 65 years who engage in physical activity have better balance, strength, and overall QoL compared with those who are inactive. These findings align with previous research that demonstrated the beneficial effects of physical activity on balance, muscle strength, and overall QoL in older individuals (26).

In this study, we discovered a statistically significant negative correlation between FES-I scores and SF-36v2 scores among individuals 65 years of age and older. This finding is consistent with those of earlier studies and implies that a higher FoF may be linked to a lower QoL in older people. This evidence, in our opinion, supports the theory that FoF not only causes physical restrictions but also has a significant negative influence on psychological well-being, which is crucial for overall QoL. In addition, prior studies corroborate our findings and demonstrate that FoF among older individuals has a significant influence on their emotional and physical well-being (27). Additionally, we discovered that there might be a persistent trend independent of the cultural environment when we compared our findings with those of other studies. A study conducted in Norway discovered a similar association between FoF and lower self-reported health, suggesting that this phenomenon may be prevalent

Table 4. Comparison of SFT sub-tests between active (n=32) and inactive (n=32) groups

		Median (IQR)	Min;Max	Mean rank	Z-value	p-value
SFT-I	Active group	13.00 (6.00)	7.00-21.00	35.38	-3.215	0.001
	Inactive group	9.00 (3.25)	5.00-20.00	21.50		
SFT-II	Active group	16.00 (6.00)	7.00-24.00	32.43	-2.080	0.038
	Inactive group	14.00 (5.25)	4.00-20.00	23.44		
SFT-III	Active group	186.00 (123.00)	77.00-329.00	34.19	-2.746	0.006
	Inactive group	113.50 (84.75)	0.00-274.00	22.28		
SFT-IV	Active group	-4.00 (9.00)	-16.00-0.00	28.52	-0.594	0.553
	Inactive group	-6.00 (14.62)	-29.00-0.00	26.00		
SFT-V	Active group	-12.00 (10.00)	-34.00-0.00	32.60	-2.139	0.032
	Inactive group	-18.25 (15.25)	-38.50--6.00	23.33		
SFT-VI	Active group	7.83 (1.63)	4.40-15.31	19.62	-2.819	0.005
	Inactive group	9.68 (3.23)	6.90-21.30	31.84		

SFT-I: 30-second chair stand test, SFT-II: 30-second arm curl test, SFT-III: 2-minute step test, SFT-IV: chair sit and reach test, SFT-V: back scratch test, SFT-VI: foot up and go test, IQR: interquartile range
Note: Bonferroni correction was applied to account for multiple comparisons across the six SFT sub-tests (SFT-I, SFT-II, SFT-III, SFT-IV, SFT-V, SFT-VI). The corrected significance value was set as p<0.010 (α=0.05/5=0.010) for the five sub-tests with p-values below 0.05 before correction

J Acad Res Med 2024;14(3):106-14

Table 5. Correlation analysis of the BBS, PASE, FES-I, SF-36v2 and SFT

Variables		FES-I	BBS	SFT						PASE
				I	II	III	IV	V	VI	
BBS		-0.449**	-	0.434**	0.423**	0.531***	0.120	0.266	-0.681***	0.504***
SF-36v2	PF	-0.516***	0.638***	0.557***	0.506***	0.603***	0.438***	0.184	-0.568***	0.324*
	RP	-0.451**	0.284*	0.304*	0.424**	0.422**	0.217	0.167	-0.333*	0.322*
	RE	-0.372**	0.187	0.308*	0.256	0.359**	0.258	0.078	-0.292*	0.241
	VT	-0.453**	0.436**	0.171	0.227	0.407**	0.389**	0.144	-0.354**	0.330*
	MH	-0.358**	0.388**	0.153	0.208	0.349*	0.343*	-0.032	-0.220	0.222
	SF	-0.371**	0.289*	0.315*	0.301*	0.388**	0.356**	0.152	-0.379**	0.277*
	BP	-0.461**	0.476***	0.463***	0.423**	0.503***	0.409**	0.071	-0.435**	0.339*
	GH	-0.560***	0.366**	0.256	0.232	0.269	0.204	0.119	-0.312*	0.270
PASE		-0.309*	0.504***	0.300*	0.363**	0.365*	0.044	0.435**	-0.424**	-
FES-I		-	-0.446**	-0.321*	-0.224	-0.476***	-0.178	0.028	0.385**	-0.309*

PF: physical functioning, RP: role physical, BP: bodily pain, GH: general health, VT: vitality, SF: social functioning, RE: role emotional, MH: mental health, SFT-I: 30-second chair stand test, SFT-II: 30-second arm curl test, SFT-III: 2-minute step test, SFT-IV: chair sit and reach test, SFT-V: back scratch test, SFT-VI: foot up and go test, PASE: Physical Activity Scale for the Elderly, FES-I: Falls Efficacy Scale International Questionnaire; BBS: Berg Balance Scale, SF-36v2: Short Form Health Survey version-2.0 Turkish.
Note: Bonferroni correction was applied to account for multiple correlation analyses among the BBS, PASE, FES-I, SF-36v2 sub-dimensions, and SFT sub-tests. The corrected significance values were adjusted based on the total number of pairwise correlations tested.
*p<0.05, **p<0.01, ***p<0.001

among the senior population and goes beyond national and cultural boundaries (28). We believe that this link, which has been demonstrated in the elderly Turkish population, is present in a variety of social norms and health systems.

Our study revealed a significant negative correlation between the FES-I and specific SFT items, such as the 2-minute walk test and the 30-second chair stand test. Conversely, a positive association appears to exist between the stand-and-reach test and the FES-I. These results are in line with those of Donat Tuna et al., (29) who showed that higher levels of physical activity are associated with better lower body strength and dynamics in the younger elderly population (29). Similar to Donat Tuna et al.'s (29) study on the effects of exercise on physical activity levels and lower body function, our findings suggest that an active lifestyle may have a protective effect against FoF by preserving flexibility and endurance in the lower body. These abilities are crucial for maintaining balance and physical mobility, and they may reduce the likelihood of falls and associated fear. Our research indicates that SFT not only represents physical abilities but also encompasses a psychological aspect associated with FoF. Therefore, older people who participate in physical activities may experience improvements in balance and muscle functions, which may ultimately lessen their FoF and possibly create a positive feedback cycle that encourages them to engage in activities and feel confident in their physical abilities.

Our research revealed notable relationships among PASE, FES-I, and BBS. These results support the idea that regular physical activity is linked to improved balance and reduced FoF.

The analyses of our study revealed a notable negative relationship between BBS scores and FES-I among participants in the active group. This result can be attributed to the notion that individuals who frequently participate in physical activities tend to exhibit improved muscle function and balance, thereby reducing their FoF. This implies a clear correlation between enhanced balance and decreased FoF. People who scored higher on the BBS, which evaluates balance functions, expressed less FoF. This finding is consistent with other research that emphasizes the importance of balance abilities in influencing psychological FoF (30). The enhanced proprioception, muscle strength, and reaction times of the active group may have been a result of their active lifestyle, all of which are essential components of balance maintenance. By reducing the FoF, we not only prevent actual falls but also enhance QoL. This is crucial because fear can lead to limitations in physical activities and social disengagement.

The results indicate significant disparities between the SF-36v2 and BBS scores of the active and inactive groups. This finding supports the concept that physically active elderly adults possess more robust balance systems, thereby enhancing their overall QoL. Our results are consistent with those of previous studies showing a link between increased physical activity and higher BBS scores, indicating better balance control in the elderly (31). Additionally, our findings align with research suggesting that an active lifestyle is directly related to improvements in health-related QoL, as measured by the SF-36v2 (32). Therefore, consistent with prior studies, our findings suggest that engaging in physical activity provides several health benefits that encompass various aspects of an individual's life and improves both mental and physical well-being.

J Acad Res Med 2024;14(3):106-14

Study Limitations

Our study primarily relied on BBS and questionnaires, such as PASE and FES-I, for balance assessment. While useful, these tools are subjective and may not capture the full extent of variations in balance function among elderly individuals. The inclusion of objective balance assessment methods, such as video head impulse test, videonystagmography, positional tests, and caloric tests, would have strengthened the study by providing more comprehensive and precise evaluations of the participants' balance functions.

The study population was relatively homogeneous in terms of age and health status, excluding individuals with significant neurological, musculoskeletal, or balance disorders. While necessary to control for confounding factors, this selection criterion may limit the applicability of the findings to the general elderly population. Future research should include a more diverse sample to enhance the external validity of the results.

Although the PASE provided an overview of the participants' physical activity levels, detailed information on the specific types and intensities of activities was not collected. Gaining insight into the activities that have the greatest impact on enhancing balance and QoL would be valuable. Furthermore, the potential influence of culturally specific activities, such as religious practices, cycling, and rural living, which may indirectly support physical activity, was not evaluated. Including these factors in future research could provide clearer insights into their role, particularly within the Turkish population. Future studies should also include detailed activity logs or use wearable technology to monitor and analyze activity patterns more precisely.

Additionally, the cross-sectional design of this study limits the ability to establish causal relationships between physical activity, balance, QoL, and FoF. Longitudinal studies are needed to assess the effects of changes in physical activity over time on these outcomes and to better understand the mechanisms underlying these outcomes.

By addressing these limitations, future research can build on the current study's findings, providing more robust evidence and deeper insights into the impact of physical activity on balance and QoL in elderly individuals.

CONCLUSION

Our findings suggest that elderly people who remain actively employed in a profession or occupation may be able to preserve their balancing abilities as they age. To counteract the decline associated with aging, preventive measures should be adopted, such as participating in regular physical activity programs, acquiring knowledge about health concerns, receiving nutritional assistance, implementing fall prevention techniques, enhancing social engagement, and undergoing regular health screenings. Furthermore, these measures can significantly contribute to improving balance and, consequently, the overall QoL of this population. Consequently, this could lead to reduced healthcare costs and diminished societal impact associated with balance-related conditions.

Validated instruments and questionnaires for assessing activities of daily living, hearing, balance, and cognition are an important part of geriatric assessment . Implementing a multifactor risk assessment, providing treatment for hearing impairments, engaging in regular exercise, and creating an appropriate home environment can effectively decrease the occurrence of falls resulting from unsteadiness.

Ethics

Ethics Committee Approval: All procedures in this study were approved by the Ethics Committee of the University of Health Sciences Türkiye, Hamidiye Faculty of Health Sciences (decision No: 25/22, date: 18.11.2022).

Informed Consent: All participants signed a consent form indicating their voluntary participation.

Footnotes

Author Contributions: Concept - A.A.A.; G.T.; A.T.; Design - A.A.A.; G.T.; Z.P; Data Collection and/or Processing - G.T.; A.T.; S.N.B.; C.K.; Analysis and/or Interpretation - A.A.A.; Z.P; Literature Search - A.A.A.; G.T.; A.T.; S.N.B.; C.K.; Writing - A.A.A.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Disclosure: This study has been supported within the scope of the 2209-A Program conducted by TÜBİTAK, The Department of Science Fellowships and Grant Programs (Project No: 1919B012202667).

REFERENCES

1. Rudnicka E, Napierała P, Podfigurna A, Męczekalski B, Smolarczyk R, Grymowicz M. The World Health Organization (WHO) approach to healthy ageing. Maturitas. 2020; 139: 6-11.
2. Özsoy G, Özsoy İ, İlçin N, Tekin N, Savcı S. Yaşlı bireylerde denge, fonksiyonel egzersiz kapasitesi ve periferal kas kuvveti arasındaki ilişki. SDÜ Sağlık Bilimleri Dergisi. 2017; 8: 28-32.
3. Gencer G, Yagmur G, İpek L, Kara DS, Uzun F, Çetin SY. Türkiye'de yaşlılarda düşme ve denge ile ilgili yapılmış çalışmaların incelenmesi. Yaşlı Sorunları Araştırma Dergisi. 2021; 14: 70-83.
4. Horak FB. Clinical assessment of balance disorders. Gait & Posture. 1997; 6: 76-84.
5. Agrawal Y, Merfeld DM, Horak FB, Redfern MS, Manor B, Westlake KP, et al. Aging, vestibular function, and balance: proceedings of a national institute on aging/national institute on deafness and other communication disorders workshop. J Gerontol A Biol Sci Med Sci. 2020; 75: 2471-80.
6. Jahn K. The aging vestibular system: dizziness and imbalance in the elderly. Adv Otorhinolaryngol. 2019; 82: 143-9.
7. Newsted D, Bale D, Armstrong M, Beyea MM, Simpson MTW, Gill SS, et al. How to identify balance disorders and reduce fall risk. J Fam Pract. 2022; 71: 20-30.
8. Raipure A, Kasatwar P. The effects of nintendo wii fit on postural balance control training in the geriatric population: a review. Cureus. 2022; 14: e31420. Published 2022 Nov 12.
9. Sarto F, Pizzichemi M, Chiossi F, Bisiacchi PS, Franchi MV, Narici MV, et al. Physical active lifestyle promotes static and dynamic balance performance in young and older adults. Front Physiol. 2022; 13: 986881. Published 2022 Aug 17.
10. Vatansever ÖM. Farklı fiziksel aktivite düzeylerindeki sağlıklı bireylerde vücut farkındalığı ile denge ve postür arasındaki ilişkinin incelenmesi: Sağlık Bilimleri Enstitüsü; 2018.
11. Havighurst RJ, Albrecht R. Older people. New York: Longmans, Green; 1953.

12. Coleman P. Cumming E, Henry W. Growing old: the process of disengagement. Basic Books, New York, 1961. (Reprint: Arno, New York, 1979, ISBN 0405 118147.). Ageing and Society. 2008; 11: 217-20.
13. Horowitz G, Ungar OJ, Levit Y, Himmelfarb M, Handzel O. The impact of conductive hearing loss on balance. Clin Otolaryngol. 2020; 45: 106-10.
14. Ciquinato DSA, Doi MY, Silva RAD, Oliveira MR, Gil AWO, Marchiori LLM. Posturographic analysis in the elderly with and without sensorineural hearing loss. Int Arch Otorhinolaryngol. 2020; 24: e496-502.
15. Güngen C, Ertan T, Eker E, Yaşar R, Engin F. Reliability and validity of the standardized Mini Mental State Examination in the diagnosis of mild dementia in Turkish population. Turk Psikiyatri Derg. 2002; 13:273-81.
16. Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale For the Elderly (PASE): development and evaluation. J Clin Epidemiol. 1993; 46: 153-62.
17. Ayvat E, Kilinç M, Kirdi N. The Turkish version of the Physical Activity Scale For the Elderly (PASE): its cultural adaptation, validation, and reliability. Turkish Journal of Medical Sciences. 2017; 47: 908-15.
18. Koçyiğit H, Aydemir Ö, Fişek G, Ölmez N, Memiş AK. Form-36 (KF-36)'nın Türkçe versiyonunun güvenilirliği ve geçerliliği. Ilaç ve tedavi dergisi. 1999; 12: 102-6.
19. Je W, Snow K, Kosinski M. SF-36 health survey: manual and interpretation guide Boston. MA, The Health Institute, New England Medical Center; 1993.
20. Yardley L, Beyer N, Hauer K, Kempen G, Piot-Ziegler C, Todd C. Development and initial validation of the Falls Efficacy Scale-International (FES-I). Age Ageing. 2005; 34: 614-9.
21. Ulus Y, Durmus D, Akyol Y, Terzi Y, Bilgici A, Kuru O. Reliability and validity of the Turkish version of the Falls Efficacy Scale International (FES-I) in community-dwelling older persons. Arch Gerontol Geriatr. 2012; 54: 429-33.
22. Rikli RE, Jones CJ. Senior fitness test manual. Human kinetics; 2013.
23. Berg K, Wood-Dauphinee S, Williams JI. The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. Scand J Rehabil Med. 1995; 27: 27-36.
24. Sahin F, Yilmaz F, Ozmaden A, Kotevoglu N, Sahin T, Kuran B. Reliability and validity of the Turkish version of the Berg Balance Scale. J Geriatr Phys Ther. 2008; 31: 32-7.
25. Downs S. The Berg Balance Scale. J Physiother. 2015; 61: 46.
26. Gerards M, Marcellis R, Senden R, Poeze M, de Bie R, Meijer K, et al. The effect of perturbation-based balance training on balance control and fear of falling in older adults: a single-blind randomised controlled trial. BMC Geriatr. 2023; 23: 305.
27. Schoene D, Heller C, Aung YN, Sieber CC, Kemmler W, Freiberger E. A systematic review on the influence of fear of falling on quality of life in older people: is there a role for falls? Clin Interv Aging. 2019; 14: 701-19. Published 2019 Apr 24.
28. Bjerk M, Brovold T, Skelton DA, Bergland A. Associations between health-related quality of life, physical function and fear of falling in older fallers receiving home care. BMC Geriatr. 2018; 18: 253. Published 2018 Oct 22.
29. Donat Tuna H, Ozcan Edeer A, Malkoc M, Aksakoglu G. Effect of age and physical activity level on functional fitness in older adults. European Review of Aging and Physical Activity. 2009; 6: 99-106.
30. Ulus Y, Akyol Y, Tander B, Durmuş D, Bilgici A, Kuru O. The relationship between fear of falling and balance in community-dwelling older people. Türk Geriatri Dergisi. 2013; 16: 260-5.
31. Dunsky A. The effect of balance and coordination exercises on quality of life in older adults: a mini-review. Front Aging Neurosci. 2019; 11: 318. Published 2019 Nov 15.
32. Aung TNN, Moolphate S, Koyanagi Y, Angkurawaranon C, Supakankunti S, Yuasa M, et al. Determinants of health-related quality of life among community-dwelling Thai older adults in Chiang Mai, Northern Thailand. Risk Manag Healthc Policy. 2022; 15: 1761-74. Published 2022 Sep 20.

DOI: 10.4274/jarem.galenos.2024.71224
J Acad Res Med 2024;14(3):115-20

A New Intraoperative Method for Controlling Electrode Placement in Cochlear Implant Surgeries: Nucleus® SmartNav System and Preliminary Results

Arzu Kırbaç[1], Merve Bayri Ulukan[2], S. Armağan İncesulu[3], Ercan Kaya[3]

[1]Eskişehir Osmangazi University, Faculty of Health Sciences, Department of Audiology, Eskişehir, Türkiye
[2]Cochlear Türkiye
[3]Eskişehir Osmangazi University, Faculty of Medicine, Department of Otolaryngology, Eskişehir, Türkiye

Cite this article as: Kırbaç A, Bayri Ulukan M, İncesulu SA, Kaya E. A New Intraoperative Method for Controlling Electrode Placement in Cochlear Implant Surgeries: Nucleus® SmartNav System and Preliminary Results. J Acad Res Med. 2024;14(3):115-20

ABSTRACT

Objective: This study aimed to evaluate electrode placement in the cochlea by analyzing data from the Nucleus® SmartNav system.

Methods: Cochlear implant (CI) surgery was retrospectively reviewed. The participants including the use of CI522 Slim Straight electrodes with anatomically normal inner ear structures were selected. Intra-operative (Intra-op) and post-operative direct graphy (X-ray imaging) results were compared to assess electrode placement in the cochlea.

Results: A total of 15 ears (4 bilateral, 7 unilateral) were evaluated. The average age of the pediatric group was 38 months (6 participants), and the average age of the adult group was 39.8 years. Intra-op SmartNav measurements obtained an average angular insertion depth of 413. 86±70.9 degrees (254-480°), a mean insertion time of 89.6s±47.05 (40-173s), and an average insertion speed of 0.65±0.54 mm/s (0.1-1.17 mm/s). In the initial placement check performed with the SmartNav system, the electrodes were placed in the appropriate position in 14 cases, and only one case had a tip fold-over (TFO). The electrode was reinserted, and a second check using the SmartNav system confirmed that TFO was not present. The SmartNav system demonstrated 100% sensitivity in determining the placement of the CI522 Slim Straight electrodes in all cases compared with direct X-ray results.

Conclusion: In cases with anatomically normal inner ear structures, the SmartNav system was determined to be an effective and reliable method for Intra-op assessment of CI electrode placement, thereby reducing the need for additional Intra-op radiological imaging.

Keywords: Hearing Loss, cochlear implant, electrode placement, SmartNav system, X-ray

INTRODUCTION

Hearing, a fundamental component of communication, can be impaired by congenital or acquired causes, and permanent hearing loss of varying degrees can occur. In severe to profound hearing loss, hearing aids are insufficient for hearing restoration, and a cochlear implant (CI) may be the only option (1,2).

CI is an electronic device designed to convert mechanical sound energy into electrical signals that are transmitted directly to the cochlea, thereby providing hearing by stimulating the auditory nerve. The device consists of an internal component (electrode array) surgically implanted into the cochlea and an external component that is activated in the post-operative (post-op) period. The CI process consists of three periods: Pre-operative period, in which it is determined whether the individual with hearing loss is a suitable candidate; ıntra-operative (Intra-op) period, in which the electrodes are placed in the cochlea by microsurgical methods by otologists specialized in CI during general anesthesia; and post-op period, in which the placed electrodes are activated by experienced audiologists (3). Additionally, the post-operation period involves CI mapping (programing) at regular intervals and auditory rehabilitation sessions. Considering all these stages, the success of a CI and the patient's benefit largely depend on the placement of the electrodes during the Intra-op period.

A misplaced electrode array during surgery may not provide the desired level of benefit in hearing and receptive speech development related and may lead to side effects, such as vertigo and facial twitching, due to electrical stimulation of the

ORCID IDs of the authors: A.K.: 0000-0003-3215-156X, M.B.U.: 0000-0002-5835-8182, S.A.İ.: 0000-0001-8467-5950, E.K.: 0000-0002-9961-0313.

Corresponding Author: Arzu Kırbaç,
E-mail: arzukirbac@gmail.com

Received Date: 02.12.2024 **Accepted Date:** 09.12.2024

wrong area (4). To prevent inappropriate electrode placement, some measurements are made by audiologists during the intra-op period (3). These tests can give an idea about the placement, but in cases in which a clear decision cannot be reached, the placement and position of the electrode array is tried to be determined with fluoroscopy, X-ray, or computerized tomography (CT) during surgery. Among these, X-ray is the most commonly used. If an issue with electrode placement is identified during these evaluations, the electrodes can be removed from the cochlea, repositioned, or replaced before completing the surgical procedure. However, the mentioned portable imaging methods may not always be available in clinics or operating rooms. Even if they are available, it might affect the waiting times, prolong surgery time, increase workload, and increase radiation exposure for both patients and staff. In cases where intra-op imaging is not performed due to the above-mentioned or different reasons, post-op imaging may reveal issues that necessitate revision or reimplantation surgeries. In addition, in some cases, tip fold-over (TFO) in the electrode array may not be determined during surgery. TFO is very important because it negatively affects low-frequency hearing, causes trauma to the cochlea, and causes an inflammatory response, which can disrupt the function of the implant throughout the entire cochlea, thus negatively affecting the functionality of the implanted device (5,6).

There is a need for new methods that can reduce the need for radiological evaluation during CI surgery and that can be an addition or alternative to traditional audiological tests. The SmartNav system is a new measurement method that is designed to verify the appropriate placement of the electrode array in the cochlea, thanks to the sound processor placed wirelessly inside the ear during surgery. In addition to traditional measurements (e.g., impedance testing, stapedius reflex testing, and electrically evoked compound action potentials), SmartNav reportedly assesses the angular insertion depth, insertion speed, and consistency of insertion speed during electrode placement (7). It has also been claimed that it determines whether there is a TFO by performing a placement check test after electrode placement is completed (5).

The present study aimed to examine intra-op SmartNav system data and post-op direct X-ray results to evaluate the location and position of electrodes placed in an anatomically normal cochlea during CI surgeries.

METHODS

In this study KTO-Karatay University Rectorate Dean of the Faculty of Medicine Non-Drug and Non-Medical Device Research Ethics Committee Presidency (approval no: 2024/034, date: 26.09.2024), the CI surgeries performed at the ENT department of our tertiary care hospital were retrospectively examined. Cases with anatomically normal inner ear structures and in which Cochlear® CI522 Slim Straight electrodes were placed during surgery were identified through file scanning. Among these cases, a tablet-based mobile Nucleus® SmartNav system, which included new Intra-op measurements and was left to our clinic by the same company for trial purposes, was used. With this system, the angular insertion depth, placement time, and speed of insertion during the placement of the electrodes, and whether TFO occurred after the electrode placement was completed were evaluated. In order to provide information about the placement of CI electrodes in the inner ear, the post-op first-day X-ray results, which are a part of the routine process in our clinic, were compared with the SmartNav results.

Cases in which electrodes other than the CI522 electrode model were used, cases in which the SmartNav system was not used intraoperatively, or cases in which post-op X-ray was not used were excluded from the study. 15 ears that underwent CI surgery within the scope of the specified criteria were included in the study.

In our descriptive study, Microsoft Excel was used to evaluate the data obtained. For summary statistics, categorical variables (gender, etc.) were presented as frequency and percentage values, and quantitative variables (angular insertion depth, insertion of speed, insertion time) were presented as mean ± SD (minimum-maximum) values.

RESULTS

In the present study, a total of 15 operated ears were evaluated: Four bilateral (8 ears) and seven unilateral (7 ears). The mean age of the 6 individuals in the pediatric group was 38 months, and the mean age of the adults was 39.8 years. 54.5% of the participants were female (6 individuals), and 45. 5% were male (5 individuals). According to CT reports, all of the operated ears, 8 on the right and 7 on the left, had normal inner ear structures, and CI522 Slim Straight electrodes were used during the operation in all ears. According to Intra-op measurements made with SmartNav, the average angular insertion depth of the electrodes in 15 ears was 413.86°±70.9 (254-480), and the total insertion time was 89.6±47.05s (40-173), and the average insertion speed was 0.65±0.54 mm/s (0.1-1.17). In the first placement check test, it was determined that the electrode arrays were properly placed in 14 cases, and only in one case (no: 7) did TFO occur between the 22nd and 19th electrodes (located in the apical part of the cochlea). In the ear where TFO was determined, the impedance values of all electrodes were within normal limits (6-9 kΩ). In addition, neural response telemetry (AutoNRT) data were obtained from only 2 of the 22 intra-cochlear electrodes (E2 and E3, these electrodes locate in the most basal part of the cochlea).

In this case, the surgeon removed the electrodes and re-inserted them. Then, in the second placement check performed with the SmartNav system, it was confirmed that there was no TFO and that the electrode array was properly placed. In this case, the appropriate position of the electrodes was confirmed by post-op CT. The images obtained in the Intra-op SmartNav system placement check test of the case are shown in Figure 1 A.

In our study, each case was evaluated with X-ray at the first post-op day, and according to these results, the electrodes were properly

J Acad Res Med 2024;14(3):115-20

in the cochlea in all cases (Table 1). When the Intra-op SmartNav measurements and post-op X-ray results were compared one-to-one for each case, the SmartNav system showed 100% sensitivity in correctly determining the electrode array placement in 15 completed CI cases.

DISCUSSION

In the current study, we retrospectively examined CI surgeries and compared intraoperative SmartNav measurements with post-operative X-ray results. In our clinic, the SmartNav system detected TFO in one of the 15 ears and confirmed proper electrode placement in the other 14 ears. In the ear with TFO, the electrode array was removed and reinserted into the cochlea during surgery, and the absence of TFO was confirmed using the SmartNav system during surgery. Post-op traditional X-ray imaging showed no issue in the placement of electrode arrays in all ears. In the ear where SmartNav identified TFO, impedance values for all electrodes were within the normal range (6-9 kΩ). AutoNRT responses were obtained only from two electrodes located in the cochlea's most basal region (E2 and E3). Routine measurements such as impedance and NRT may fail to detect electrode TFO during surgery (5). Studies have demonstrated the inadequacy of these measurements in identifying TFO and determining which electrodes are affected (8,9). Intra-op imaging methods such as X-ray, CT, and fluoroscopy are commonly used to detect electrode TFO. X-ray is preferred due to its quick procedure and minimal radiation exposure. In our routine clinical practice, X-ray radiography is typically used to assess the TFO, followed by electrode removal and reinsertion based on radiological results. Radiologic imaging and traditional telemetry measurements will then be performed to ensure the correct placement of the electrode array. On the other hand, we were able to detect and visually confirm the absence of TFO using the SmartNav system within a short time after reinsertion in our case (Figure 1 B). This method verified that the electrode array was properly placed in the cochlea without the need for imaging modalities that have the potential to significantly extend operating room time and without exposure to radiation. The SmartNav system determines the TFO by using the transimpedance matrix (TIM) algorithm (10). During the TIM measurements, electrode voltage telemetry is used to analyze the Intra-op status of the electrode array. This technology measures the electrical current between the intracochlear and extracochlear electrodes and the voltage of the intracochlear electrodes to determine the position of the electrodes. These repeated measurements generate a TIM that can detect potential misplacement or TFO. These studies validated the TIM algorithm as an effective screening tool for identifying electrode TFO (10,11).

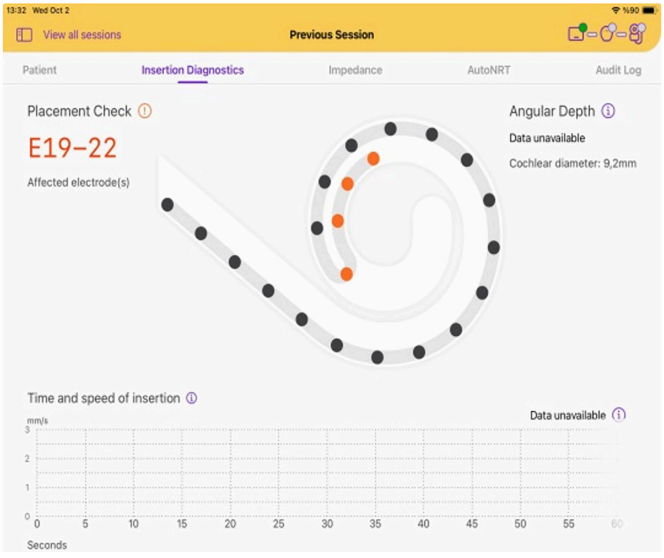

Figure 1 A. Initial placement placement check showing tip fold-over in the electrode array (involving electrodes 22, 21, 20, and 19)

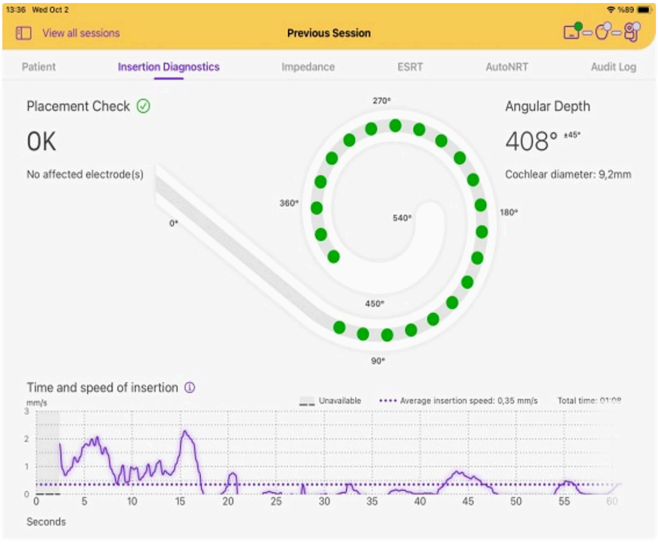

Figure 1 B: Second placement check showing all electrodes properly positioned

In a study involving different model electrodes (Slim Modiolar/CI632, Slim Straight/CI622, Contour Advance/CI612), it was reported that the Intra-op X-ray and SmartNav system correctly detected appropriate electrode placement in 47 ears and TFO in 3 ears, and the SmartNav system provided guidance in the placement of the electrode array in CI surgeries. In addition, the SmartNav system was reported to provide guidance in repositioning electrode arrays during CI surgeries (5). Kelsall et al. (12) reported that 113 out of 116 ears with slim modiolar electrodes (CI632) had proper electrode placement with Intra-op fluoroscopy and 107 with SmartNav, and 2 ears had TFO detected in the electrode array with both imaging and SmartNav, and the electrodes were then successfully repositioned. The researchers also reported that in one case, SmartNav placement could not be performed due to inconsistency in the radio frequency (RF) connection. They detected TFO only via imaging during surgery, and in a total of 4 cases, they could not perform a placement check test with SmartNav due to RF interruption (12). All SmartNav

Table 1. Demographic characteristics and clinical results

Case no	Gender	Age	Operation side	Ear	Electrode type	Cochlear anatomy	SmartNav angular depth (°)	SmartNav total insertion time (s)	SmartNav average speed of insertion (mm/s)	SmartNav Intra-op placement check-1	SmartNav Intra-op placement check-2	Post-op X-ray report
1	F	39 years	Unilateral	Right	CI522	Normal	447°	88	0.36	Normal	-	Normal and full insertion
2	F	1 year 4 m	Bilateral	Left	CI522	Normal	437°	70	2.2	Normal	-	Normal and full insertion
3	F	1 year 4 m	Bilateral	Right	CI522	Normal	451°	170	0.14	Normal	-	Normal and full insertion
4	M	20 years	Unilateral	Left	CI522	Normal	415°	67	0.61	Normal	-	Normal and full insertion
5	M	6 years 2 m	Bilateral	Left	CI522	Normal	254°	108	0.92	Normal	-	Normal and full insertion
6	M	6 years 2 m	Bilateral	Right	CI522	Normal	362°	58	0.44	Normal	-	Normal and full insertion
7	F	35 years	Unilateral	Right	CI522	Normal	408°	68	0.35	E22-E19 Tip fold-over	Normal	Normal and full insertion
8	M	1 year 2 m	Bilateral	Left	CI522	Normal	474°	68	0.5	Normal	-	Normal and full insertion
9	M	1 year 2 months	Bilateral	Right	CI522	Normal	476°	163	0.69	Normal	-	Normal and full insertion
10	M	4 years 6 m	Unilateral	Right	CI522	Normal	386°	62	0.1	Normal	-	Normal and full insertion
11	F	70 years	Unilateral	Right	CI522	Normal	400°	47	1.12	Normal	-	Normal and full insertion
12	M	4 years 4 m	Unilateral	Left	CI522	Normal	274°	128	0.44	Normal	-	Normal and full insertion
13	F	35 years	Unilateral	Left	CI522	Normal	480°	173	0.12	Normal	-	Normal and full insertion
14	F	1 year 6 months	Bilateral	Left	CI522	Normal	468°	40	1.17	Normal	-	Normal and full insertion
15	F	1 year 6 months	Bilateral	Right	CI522	Normal	476°	40	0.69	Normal	-	Normal and full insertion

CI: cochlear implant, M: male, F: female, s: seconds, °: degrees, mm/s: millimeters per second, m: month, E: electrode

tests were completed without any problems in 14 ears at our clinic. However, measurements were performed by manually applying light pressure to the sound processor to compensate for an inconsistent RF connection that we thought was related to the thickness of the scalp in a very overweight adult patient (the skin flap over the temporo-parietal area could not be measured). A stable RF connection is required to complete the tests in the SmartNav system, and the thickness of the scalp has been noted as a parameter that should be considered, especially in adults.

Atraumatic insertion of the electrode array via the round window into the cochlea can preserve residual hearing and improve auditory performance (13). Factors such as surgical approach, electrode model, steroid use, and insertion speed contribute to atraumatic insertion (14-17). The insertion speed directly affects the inner ear structures; faster speeds are associated with increased force and potential damage (18,19). To minimize risks such as membrane rupture, scalar translocation, and TFO, slower insertion speeds are recommended. Although no standard method exists for evaluating insertion speed during routine surgeries, experimental and robot-assisted insertions have enabled these measurements (17). The SmartNav system estimates insertion speed in real-time, providing graphical feedback during the insertion. The average speed and total time are displayed at the end of the insertion. This real-time feedback on insertion speed allows the surgeon to adjust the electrode insertion speed instantly while also providing a training effect that enhances surgical skills through repetition (20). In our study, the average insertion speed was 0.65 mm/s (range: 0.1-1.17 mm/s), which is consistent with the results of Concheri et al. (20), who reported an average insertion speed of 0.64 mm/s (range: 0.23-1.24 mm/s) in 65 implanted ears with CI632 electrodes. Interestingly, researchers reported that no correlation was found between electrode placement speed and

J Acad Res Med 2024;14(3):115-20

pure tone audiometry results or word recognition scores with CI. Due to the limited number of our cases, the relationship between electrode placement speed and hearing thresholds with CI could not be evaluated. However, we believe that it would be useful to investigate the possible effect of electrode placement speed on hearing thresholds in future studies. Another important parameter is the angular insertion depth of the electrode array, both in terms of protecting the inner ear structures (21) and in terms of providing an idea about possible translocations of the electrodes between scales (22). The only real-time method to observe the angular insertion depth is Intra-op fluoroscopy. Considering the disadvantages of fluoroscopy, such as prolonged surgery time and radiation, SmartNav can be an alternative treatment. The SmartNav system angularly evaluates the Intra-op electrode insertion depth and provides real-time visual and auditory feedback (7,23). In our study, the average angular insertion depth was 413. 86° (range: 274-480°) for 15 ears. Cooper et al. (5) reported a mean depth of 307.45° (standard deviation 36.42°) in 50 ears, including nine with inner ear anomalies. Our study included only individuals with anatomically normal inner ear structures. The difference in inner ear structures may have caused the angular insertion depth measured during surgery to differ.

TFO, which affects low-frequency hearing by folding in the apical region, can impair the implant's function across the cochlea due to associated trauma (9). Therefore, detecting TFO during surgery is critical to avoiding repeat surgeries, additional anesthesia, and adverse auditory outcomes. Our results indicate that Intra-op SmartNav findings demonstrated 100% sensitivity in accurately determining the placement of the CI522 Slim Straight electrode array within the cochlea compared with post-op X-ray imaging results.

This clinical study demonstrated that the SmartNav system is an effective and reliable method for Intra-op electrode placement checks in an anatomically normal cochlea, thereby reducing the need for radiologic imaging. However, further research is needed to evaluate its efficacy and reliability in CI surgeries involving patients with inner ear anomalies.

CONCLUSION

This clinical study demonstrated that the SmartNav system is an effective and reliable method for Intra-op electrode placement checks in an anatomically normal cochlea, thereby reducing the need for radiologic imaging. However, further research is needed to evaluate its efficacy and reliability in CI surgeries involving patients with inner ear anomalies.

Ethics

Ethics Committee Approval: In this study KTO-Karatay University Rectorate Dean of the Faculty of Medicine Non-Drug and Non-Medical Device Research Ethics Committee Presidency (approval no: 2024/034, date: 26.09.2024)

Informed Consent: Retrospective study.

Footnotes

Author Contributions: Surgical and Medical Practices - S.A.İ.; E.K.; Concept - A.K.; M.B.U.; S.A.İ.; E.K.; Design - A.K.; M.B.U.; S.A.İ.; E.K.; Data Collection and/or Processing - A.K.; M.B.U.; S.A.İ.; E.K.; Analysis and/or Interpretation - A.K.; M.B.U.; Literature Search - A.K.; M.B.U.; Writing - A.K.; M.B.U.

Conflict of Interest: The authors have no conflict of interest to declare.

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

REFERENCES

1. İncesulu ŞA. Koklear implant endikasyonları: günümüzden geleceğe. Turkiye Klinikleri Ear Nose and Throat-Special Topics. 2012;5:52-8.
2. Granço FS, Fernandes NF, Morettin M, Costa Filho OA, Bevilacqua MC. The relationship between the speech perception and the degree of satisfaction among adult users of cochlear implants. International archives of otorhinolaryngology. 2013;17:202-7.
3. Sennaroğlu G, Batuk M, Kaya Ş. Koklear implantasyon: odyolojik değerlendirme, preoperatif, intraoperatif ve postoperatif takip. Türk Odyoloji ve İşitme Araştırmaları Dergisi. 2019;2:24-9.
4. Alnafjan F, Hasan Z, Sanli H, da Cruz MJ. Risk factors for facial nerve and other nonauditory side effects following cochlear implantation. Otology & Neurotology. 2021;42:1022-9.
5. Cooper J, Stidham KR, Morgan S, Schmelzer M, Albinus R. Utilization of SmartNav technology in cochlear implantation: optimizing efficiency in assessment of electrode placement. Cochlear Implants International. 2024:1-8.
6. Eshraghi AA, Yang NW, Balkany TJ. Comparative study of cochlear damage with three perimodiolar electrode designs. The Laryngoscope. 2003;113:415-9.
7. Cochlear TM. Nucleus®SmartNav User Guide. Version 2.0. 2024. [database on the Internet].Available from: https://mss-p-007-delivery.stylelabs.cloud/api/public/content/D1946550_6_2023-08-24?v=7a9a1c3c Accessed: 1 September 2024
8. Cosetti MK, Troob SH, Latzman JM, Shapiro WH, Roland Jr JT, Waltzman SB. An evidence-based algorithm for intraoperative monitoring during cochlear implantation. Otology & Neurotology. 2012;33:169-76.
9. Zuniga MG, Rivas A, Hedley-Williams A, Gifford RH, Dwyer R, Dawant BM et al. Tip fold-over in cochlear implantation: case series. Otology & neurotology. 2017;38:199-206.
10. Hoppe U, Brademann G, Stöver T, Ramos de Miguel A, Cowan R, Manrique M et al. Evaluation of a transimpedance matrix algorithm to detect anomalous cochlear implant electrode position. Audiology and Neurotology. 2022;27:347-55.
11. Kay-Rivest E, McMenomey SO, Jethanamest D, Shapiro WH, Friedmann DR, Waltzman SB et al. Predictive value of transimpedance matrix measurements to detect electrode tip foldover. Otology & Neurotology. 2022;43:1027-32.
12. Kelsall D, Lupo JE. Early Clinical Experience with the Cochlear™ Nucleus® SmartNav System: real-time surgical insights. Rocky Mountain Ear Center. 2022. Available from: https://escucharahoraysiempre.com/wp-content/uploads/2022/09/SmartNav-1.pdf
13. Wanna GB, Noble JH, Gifford RH, Dietrich MS, Sweeney AD, Zhang D et al. Impact of intrascalar electrode location, electrode type, and angular insertion depth on residual hearing in cochlear implant patients: preliminary results. Otol Neurotol. 2015;36:1343-8.
14. Carlson ML, Patel NS, Tombers NM, DeJong MD, Breneman AI, Neff BA et al. Hearing preservation in pediatric cochlear implantation. Otology & neurotology. 2017;38:128-33.
15. Bruce IA, Todt I. Hearing preservation cochlear implant surgery. Advances in Hearing Rehabilitation. 2018;81:66-73.
16. Snels C, IntHout J, Mylanus E, Huinck W, Dhooge I. Hearing preservation in cochlear implant surgery: a meta-analysis. Otology & Neurotology. 2019;40:145-53.
17. Kashani RG, Henslee A, Nelson RF, Hansen MR. Robotic assistance during cochlear implantation: the rationale for consistent, controlled speed of electrode array insertion. Front Neurol. 2024;15:1335994.

J Acad Res Med 2024;14(3):115-20

18. Kontorinis G, Lenarz T, Stöver T, Paasche G. Impact of the insertion speed of cochlear implant electrodes on the insertion forces. Otology & neurotology. 2011;32:565-70.
19. Rajan GP, Kontorinis G, Kuthubutheen J. The effects of insertion speed on inner ear function during cochlear implantation: a comparison study. Audiology and Neurotology. 2012;18:17-22.
20. Concheri S, Brotto D, Ariano M, Daloiso A, Di Pasquale Fiasca VM, Sorrentino F et al. Intraoperative Measurement of Insertion Speed in Cochlear Implant Surgery: A Preliminary Experience with Cochlear SmartNav. Audiol Res. 2024;14:227-238.
21. Skarzynski H, Lorens A, Matusiak M, Porowski M, Skarzynski PH, James CJ. Cochlear implantation with the nucleus slim straight electrode in subjects with residual low-frequency hearing. Ear and hearing. 2014;35:33-43.
22. Morrel WG, Holder JT, Dawant BM, Noble JH, Labadie RF. Effect of scala tympani height on insertion depth of straight cochlear implant electrodes. Otolaryngology-Head and Neck Surgery. 2020;162:718-24.
23. Strenger T, Costian N, Ortolf E, Meyermann S, Zenk J. First Experiences with the Cochlear Nucleus SmartNav System. Laryngo-Rhino-Otologie. 2023;102(S 02).

DOI: 10.4274/jarem.galenos.2024.79307
J Acad Res Med 2024;14(3):121-4

Efficacy of Medical Treatment in Primary Appendagitis Epiploica

Güven Erdoğrul, Samed Sayar, Güvenç Diner

Mersin City Training and Research Hospital, Department of General Surgery, Mersin, Türkiye

Cite this article as: Erdoğrul G, Sayar S, Diner G, Efficacy of medical treatment in primary appendagitis epiploica. J Acad Res Med. 2024;14(3):121-4

ABSTRACT

Objective: Primary appendagitis epiploica is a rare cause of abdominal pain. Generally, it can be treated conservatively, and radiological imaging is important for diagnosis. The present study aimed to report the diagnosis, treatment, and follow-up results of patients diagnosed with primary appendicitis epiploica.

Methods: This retrospective study included 31 patients diagnosed with primary appendagitis epiploica and treated medically between February 2015 and May 2021. The definitive diagnosis in all patients was made by computerized tomography (CT). The diagnosis of patients with suspected primary appendagitis epiploica on ultrasonography was confirmed by CT. The diagnosis, treatment, and follow-up results of the patients were evaluated.

Results: Of the 31 patients, 14 were female and 17 were male, with a mean patient age of 42.03±13.58 years. 10 patients were hospitalized and 21 were treated as outpatients. Inpatients stayed in the hospital for a mean of 2.8±1.03 days. Oral intake continued during hospitalization. None of the patients developed complications or were operated.

Conclusion: Primary appendagitis epiploica is a rare condition characterized by self-limiting abdominal pain. It can be treated conservatively with the correct diagnosis. Further investigation is required for recurrent cases.

Keywords: Computarized tomography, epiploic appendagitis, medical treatment

INTRODUCTION

Primary appendagitis epiploica (PAE) is a rare benign and self-limiting inflammatory disease of the epiploic appendages of the colon.

Because PAE is a clinical condition that presents with acute abdomen not requiring surgical treatment, it is very important to differentiate it from other conditions requiring urgent surgical treatment. PAE, which usually responds to conservative treatment, may lead to unnecessary laparotomies in undiagnosed cases (1-3).

It may occur in any age group, but is observed more frequently in the 4th and 5th decades. It has been reported that the risk of the disease is slightly higher in middle-aged men (4).

The appendix epiploica are pedicled appendages with a length of 0.5-5 cm and a thickness of 1-2 cm, frequently located in the sigmoid colon and ileocecal region, and contain adipose tissue covered with serosa and numbering around 100 along the entire colon (5).

The blood circulation is provided by 2 arteries coming from the colic artery branches and 1 central vein. They are susceptible to torsion and infarct development because of their pedicled structure, which allows free movement (6).

In this study, we aimed to report the diagnosis, treatment, and follow-up results of patients diagnosed with PAE.

METHODS

Ethics aprroval was obtained from the Kahramanmaraş Sütçü İmam University Medical Faculty Clinical Research Ethics Committee for this study (decision no: 02, date: 24.08.2021).

In this study, 31 patients diagnosed with PAE and treated between February 2015 and May 2021 were retrospectively evaluated. The patient data were obtained from computer records, discharge summaries, and outpatient records. When necessary, patients were interviewed, and their information was obtained. Patients were followed with 6-month intervals. Patients who did not attend the follow-up and could not be reached were excluded from the study. Patients who had other concurrent intra-abdominal pathologies with the diagnosis of PAE and whose data could not be reached were not included in the study. All risks were explained to the patients after interviewing them, and their consent was

ORCID IDs of the authors: G.E. 0000-0002-9557-7675; S.S. 0000-0001-7331-3890; G.D. 0000-0002-7732-4092

Corresponding Author: Güven Erdoğrul
E-mail: cerraherdogrul@gmail.com

Received Date: 11.11.2024 **Accepted Date:** 16.11.2024

J Acad Res Med 2024;14(3):121-4

obtained. The definitive diagnosis in all patients was made by computerized tomography (CT) (Figure 1,2). The diagnosis of patients with suspected PAE on ultrasonography (USG) was confirmed by CT. After diagnosis, patients with severe abdominal pain were hospitalized. None of the patients underwent follow-up imaging because no complications were observed. Inpatient and outpatient treatment was provided to 10 and 21 patients, respectively. Inpatients stayed in the hospital for a mean of 2.8±1.03 days. Oral intake continued during hospitalization.

No complications observed in any patient, and no surgery was performed. Patients followed in an outpatient setting were treated with ciprofloxacin, metronidazole, and anti-inflammatory drugs. The patients who required admission were treated with ceftriaxone, metronidazole, and anti-inflammatory drugs and were discharged at the end of hospitalization with ciprofloxacin, metronidazole, and oral anti-inflammatory drugs.

Statistical Analysis

Study findings were evaluated using SPSS (Statistical Package for Social Sciences) v. 21.0 statistical software. Descriptive statistical methods, such as mean, standard deviation and percentage, were used to evaluate data.

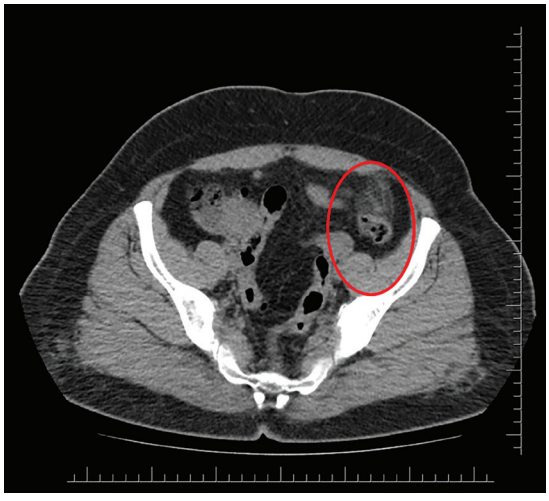

Figure 1. Image of left-sided epiploic appendagitis

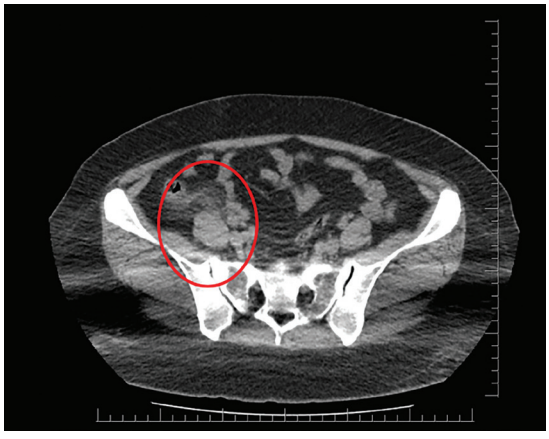

Figure 2. Image of right-sided epiploic appendagitis

RESULTS

Of the 31 patients, 14 were female and 17 were male. The mean patient age was 42.03±13.58 years. Eight patients were hospitalized. The mean duration of hospitalization was 2.62±0.74 days. Five of the hospitalized patients were female and three were male. Twenty-seven patients were admitted to the hospital with left lower quadrant pain and 4 with right lower quadrant pain. The mean white blood cell count (WBC) was 89.04±2.03 mm^3 and the mean C-reactive protein (CRP) was 17.16±12.46 mg/L. The mean follow-up duation was 43.8±21.07 months. Recurrence was observed in 4 patients (12.9%) (Table 1). Three patients were female and one was male, and 1 recurrence was observed in these 3 patients. One female patient had 2 episodes of recurrence of symptoms. In this patient, who had 3 attacks in total, sigmoid tumor was detected on colonoscopy and surgical removal was performed.

DISCUSSION

Epiploic appendages are peritoneal extensions originating from the colonic serosa, which contains adipose tissue and vascular structures (7). These structures, which are supplied by colic artery branches, are easily exposed to torsion and infarction because of the poor blood flow they receive and their pedicled structures, which allow them to move freely (5).

Although PAE can be observed in all age groups and in children, it is most commonly observed in people in their 40s and 50s, and men are affected slightly more than women (4,8).

The most commonly involved sites are the sigmoid and descending colons (3,9). Although the exact incidence of the disease is not known, it was reported to be 8.8 per million in a previous study (10).

However, diagnosis is more frequently made in patients with acute abdominal pain due to the widespread use of radiological imaging methods.

Although appendicitis, diverticulitis, acute cholecystitis, and acute gynecological diseases are also included in the differential diagnosis of PAE, they have characteristic features that can be easily distinguished by their typical locations and accompanying radiological and clinical findings (11,12).

Table 1. Patient demographics

Gender (Female/Male)	14 F/17 M
Mean age (Years)	42.03±13.58
Leukocyte average	8904±2030/mm^3
CRP average	17.16±12,46 mg/L
Follow-up period (months)	43.8±21.07
Recurrence	4 (12.9%)
Localization (L/R)	27/4

J Acad Res Med 2024;14(3):121-4

Most patients present to the emergency department due to the sudden onset of abdominal pain. It is most commonly observed in the right and left quadrants. Of the patients, 27 complained of left and right lower-quadrant pain. Nausea and vomiting can sometimes be seen in addition to abdominal pain. Physical examination findings include fever, and laboratory findings include increased WBC counts. WBC and CRP levels have been found to be high in some studies (1,13).

In our study, although the mean WBC was 8.94±2.03, 8 patients had leukocytosis. CRP levels were found to be high, with a mean of 17.16±12.46 mg/L. Historically, PAE was mostly diagnosed with laparotomy. Today, USG is an affordable and non-invasive technique for patients with suspected PAE. In Doppler USG, blood flow within the lesion was found to be absent. This imaging modality allows PAE to be differentiated from appendicitis and diverticulitis (11,14).

CT is considered to be the gold standard for diagnosis. Other lesions containing adipose tissue, acute omental infarction, mesenteric panniculitis, omental tumor (liposarcoma), fat necrosis, acute diverticulitis, and mesocolonic tumor should be considered in the differential diagnosis (14).

In our study, 7 patients were diagnosed with CT. USG was performed in 24 patients on their follow up visit. In 8 patients, CT was performed because no pathology was observed on USG. In 16 patients, although appendicitis was diagnosed by USG, it was confirmed by CT.

Although magnetic resonance imaging (MRI) is not necessary for direct diagnosis, it may be useful for determining the extent of inflammation in the surrounding mesenteric tissue. Although laparoscopy was used in selected cases, no patient required surgery (15).

The treatment of PAE remains controversial. It is argued that PAE is a self-limiting disease that can be resolved with a conservative approach using oral antibiotics and anti-inflammatory treatment (16).

However, it is also advocated that patients will recover completely only with anti-inflammatory drugs (17).

In our study, all of the patients received both antibiotics and anti-inflammatory drugs. Oral antibiotics were preferred at the outpatient setting, whereas intravenous or intramuscular antibiotics were administered in inpatien setting.

Some authors recommend early surgical intervention during treatment to prevent secondary complications and to overcome the disease quickly because early recurrence was found frequently in the patients (13).

In our study, recurrence was observed in 4 (12.9%) patients. Three patients experienced one episode of recurrence during follow-up, and one patient had 2 more episodes. A sigmoid colon tumor was detected in this patient who had appendicitis 3 times in total. The patient was subsequently operated on and discharged with recovery. When the old CT images of this patient were re-examined, no mass lesions were observed. We recommend colonoscopic examination for recurrent appendicitis. These cases of recurrent appendicitis may be a hindrance to tumor development.

CONCLUSION

PAE should be considered in the differential diagnosis of sudden-onset abdominal pain. There is no need for urgent surgery. A definitive diagnosis can be made by CT, and favorable results can be obtained with appropriate medical treatment. However, it should be kept in mind that there may be another underlying pathology in recurrent cases, and further investigations should be performed in such cases.

Ethics

Ethics Committee Approval: Ethics aprroval was obtained from the Kahramanmaraş Sütçü İmam University Medical Faculty Clinical Research Ethics Committee for this study (decision no: 02, date: 24.08.2021).

Informed Consent: Retrospective study.

Footnotes

Author Contributions: Surgical and Medical Practices - G.E.; Concept - G.E.; Design - G.E., S.S., G.D.; Data Collection and/or Processing - G.E., S.S., G.D.; Analysis and/or Interpretation - G.E., S.S., G.D.; Literature Search - G.E., S.S., G.D.; Writing - G.E., S.S., G.D.

Conflict of Interest: The authors have no conflict of interest to declare.

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

REFERENCES

1. Legome EL, Belton AL, Murray RE, Rao PM, Novelline RA. Epiploic appendagitis: the emergency department presentation. J Emerg Med. 2002;22:9-13.
2. Legome EL, Sims C, Rao PM. Epiploic appendagitis: adding to the differential of acute abdominal pain. J Emerg Med. 1999;17:823-6.
3. Tan R, Parys S, Watanabe Y. Diagnosis and management of epiploic appendagitis: a single-institution 10-year experience. Pol Przegl Chir. 2021 May 31;93:20-4.
4. Ozdemir S, Gulpinar K, Leventoglu S, Uslu HY, Turkoz E, Ozcay N, Korkmaz A. Torsion of the primary epiploic appendagitis: a case series and review of the literature. Am J Surg. 2010;199:453-8.
5. Barbier C, Denny P, Pradoura JM, Bui P, Rieger A, Bazin C, Tortuyaux JM, Régent D. Aspects radiologiques des infarctus d'appendices épiploïques [Radiologic aspects of infarction of the appendix epiploica]. J Radiol. 1998;79:1479-85.
6. Mollà E, Ripollés T, Martínez MJ, Morote V, Roselló-Sastre E. Primary epiploic appendagitis: US and CT findings. Eur Radiol. 1998;8:435-8.
7. Horton KM, Corl FM, Fishman EK. CT evaluation of the colon: inflammatory disease. Radiographics. 2000;20:399-418.
8. Toprak H, Yildiz S, Kilicarslan R, Bilgin M. Epiploic appendagitis. JBR-BTR. 2014;97:174-5.
9. Birjawi GA, Haddad MC, Zantout HM, Uthman SZ. Primary epiploic appendagitis: a report of two cases. Clin Imaging. 2000;24:207-9.
10. de Brito P, Gomez MA, Besson M, Scotto B, Huten N, Alison D. Fréquence et épidémiologie descriptive de l'appendicite épiploïque primitive par l'exploration tomodensitométrique des douleurs abdominales de l'adulte [Frequency and epidemiology of primary epiploic appendagitis on CT in adults with abdominal pain]. J Radiol. 2008;89:235-43.

J Acad Res Med 2024;14(3):121-4

11. Trovato P, Simonetti I, Verde F, Lomoro P, Vinci G, Tarotto L, Corvino F, Corvino A. Acute epiploic appendagitis: ultrasound and computed tomography findings of a rare case of acute abdominal pain and the role of other imaging techniques. Pol J Radiol. 2020;85:178-82.
12. Nejadhamzeeigilani H. The central dot sign of epiploic appendagitis. Abdom Radiol (NY). 2019;44:802-3.
13. Sand M, Gelos M, Bechara FG, Sand D, Wiese TH, Steinstraesser L, et al. Epiploic appendagitis--clinical characteristics of an uncommon surgical diagnosis. BMC Surg. 2007;1;7:11.
14. Singh AK, Gervais DA, Hahn PF, Sagar P, Mueller PR, Novelline RA. Acute epiploic appendagitis and its mimics. Radiographics. 2005;25:1521-34.
15. Vázquez-Frias JA, Castañeda P, Valencia S, Cueto J. Laparoscopic diagnosis and treatment of an acute epiploic appendagitis with torsion and necrosis causing an acute abdomen. JSLS. 2000;4:247-50.
16. Schnedl WJ, Tillich M, Lipp RW. Image of the month. Primary epiploic appendagitis. Clin Gastroenterol Hepatol. 2010;8:16.
17. Alhazmi A, de Carvalho Fischer C, Schaafs LA, Seifarth C. Appendagitis epiploica: eine seltene und nichtchirurgische Ursache abdomineller Schmerzen [epiploic appendagitis: an uncommon and nonsurgical cause of abdominal pain]. Chirurgie (Heidelb). 2023;94:954-58.

DOI: 10.4274/jarem.galenos.2024.09326
J Acad Res Med 2024;14(3):125-30

Asthmatic Patients: Is Homocysteine an Issue?

İlkay Keskinel[1], Arzu Güntürk[2], Müzeyyen Eryılmaz[3]

[1]İstanbul Okan University Faculty of Medicine, Department of Chest Diseases, İstanbul, Türkiye
[2]Florence Nightingale Hospital, Clinic of Internal Medicine, İstanbul, Türkiye
[3]Fatih Sultan Mehmet Training and Research Hospital, Clinic of Internal Medicine, İstanbul, Türkiye

Cite this article as: Keskinel İ, Güntürk A, Eryılmaz M. Asthmatic Patients: Is Homocysteine an Issue?. J Acad Res Med. 2024;14(3):125-30

ABSTRACT

Objective: Understanding the causes of asthma is crucial for developing new therapeutic modalities. Homocysteine (HCY) is an intermediate in methionine metabolism. Elevated HCY levels may indicate folate and vitamin B12 deficiencies, which are cofactors for the methylation of HCY to methionine. The relationship between hyperHCY mia and atherosclerosis is well-documented, and it is considered a cause of cardiovascular, neurodegenerative, and ocular diseases. HyperHCY mia may also cause atopy and, consequently, asthma. We aimed to evaluate the levels of HCY, vitamin B12, and folic acid in asthmatic patients and healthy adults, as well as to determine whether correlations exist between these levels and lung function, eosinophil counts, total immunoglobulin E (IgE), and eosinophilic cationic protein (ECP) levels in asthmatic subjects.

Methods: A total of 142 asthmatic patients and 36 healthy controls were enrolled in the study. Folic acid, vitamin B12, total IgE, ECP, eosinophil percentage, eosinophil counts, and HCY levels were evaluated in both groups.

Results: HCY, vitamin B12, and folic acid levels did not significantly differ between patients with asthma and controls. There was a statistically significant positive correlation (at the 0.95 confidence level) between HCY values and forced vital capacity, peak expiratory flow (PEF), and eosinophil counts in patients with asthma. Folic acid levels correlated positively only with PEF%, whereas vitamin B12 levels did not correlate with any functional parameters or atopic markers like IgE and ECP.

Conclusion: Should large-scale randomized controlled trials conclusively establish HCY as a causative factor of asthma, metabolic interventions to lower HCY levels using methyl donors could be considered alongside conventional asthma treatments.

Keywords: Homocysteine, asthma, vitamin B12, folic acid, hyperhomocysteinemia, lung functions, spirometry

INTRODUCTION

Asthma is a common chronic disease, with a prevalence of 1-18% worldwide (1). Based on data primarily from studies using the European Community Respiratory Health Survey, the asthma prevalence in Türkiye is 1.2-9.4%, whereas asthma-like symptoms are estimated to be 9.8-27.3% among adults (2). According to the World Health Organization, in 2016, asthma was responsible for 24.8 million disability-adjusted life years worldwide and caused 417,918 deaths globally. These figures highlight asthma's significant burden as a non-communicable disease, particularly in low- and middle-income countries where over 80% of asthma deaths occur. Additionally, approximately 250,000 people die annually from asthma-related complications, emphasizing the need for better management and access to treatment (3).

Homocysteine (HCY) is an intermediate in methionine metabolism. Vitamin B_{12} and folate are cofactors of the conversion of HCY to methionine through methylation (4). Hyperhomocysteinemia can develop due to deficiencies in vitamins B_{12}, B_6, and folate, defects in enzymes involved in HCY metabolism, and lifestyle factors, such as smoking and alcohol consumption (5-7). Elevated HCY levels may be associated with atherogenesis, thrombosis, cardiovascular, neurodegenerative, and ocular diseases (5,8-11). Endothelial dysfunction is the primary cause of these conditions. Increased levels of reactive oxygen species and endothelial nitric oxide within the vascular structure trigger atherogenesis through this mechanism. Additionally, some studies have suggested that HCY may contribute to the pathogenesis of these diseases by affecting inflammatory and immune cells, particularly by impairing lymphocyte function (12,13).

Asthma is a chronic inflammatory disease in which oxidative stress plays a major role in its pathogenesis (14). During HCY methylation, S-adenosylmethionine and S-adenosylhomocysteine (SAH) are produced in balanced amounts. However, if this balance

ORCID IDs of the authors: İ.K.: 0000-0003-2683-5076, A.G.: 0000-0002-1941-8699, M.E.: 0000-0002-1027-3200

Corresponding Author: İlkay Keskinel,
E-mail: ilkaykeskinel@gmail.com

Received Date: 14.09.2024 **Accepted Date:** 16.12.2024

J Acad Res Med 2024;14(3):125-30

shifts in favor of SAH, it can lead to impaired lymphocyte DNA methylation and altered gene expression (15). The DNA of lung endothelial cells may be affected by hyperhomocysteinemia.

The present study aimed to determine whether elevated HCY levels or lower levels of folic acid and vitamin B_{12} are associated with asthma. We also investigated correlations between HCY, folic acid, and vitamin B_{12} levels and lung function test parameters, as well as total immunoglobulin E (IgE), eosinophil cationic protein (ECP), eosinophil counts/mm³, and eosinophil percentage, the latter four of which can be considered atopic markers.

METHODS

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Demiroğlu Bilim University Clinical Research Ethics Committee of Helsinki (number: 44140529/29489, date: 18.07.2023). This was a retrospective, observational, and cross-sectional study. Access to patient records has been granted with the permission of the relevant chief physician's office, and this information is included in the file submitted to the ethics committee.

All patients whose files were accessed were informed about the study content and provided consent to participate. The patients' personal information will not be published, and the details in the patient files will be carefully protected and will not be shared with third parties. All patients remain anonymous, and no personal data that could identify the patients is reported in this study.

Data related to the study topic were obtained using a retrospective case-control study design. A total of 142 asthmatic patients (Group I) and 36 healthy controls (Group II) who visited the outpatient clinic of the Internal Diseases Department at Fatih Sultan Mehmet Training and Research Hospital between December 2023 and May 2024 were enrolled in the study.

Inclusion criteria:

- Group I: Stable asthmatic patients, both male and female, aged 18-75 years, without additional metabolic or chronic diseases, with recorded levels of folic acid, vitamin B_{12}, total IgE, ECP, eosinophil percentage, eosinophil counts/mm³, HCY levels, and spirometric test results in their files.
- Group II: Non-asthmatic individuals without any additional metabolic or chronic diseases, with recorded levels of folic acid, vitamin B_{12}, total IgE, eosinophil percentage, and eosinophil counts/mm³.

Exclusion criteria:

- Individuals younger than 18 years or older than 75.
- Individuals with any additional metabolic or chronic diseases.
- Individuals with incomplete information in their files.
- Asthma exacerbation in Group I.
- Supplementary vitamin B_{12} or folic acid.

We evaluated folic acid, vitamin B_{12}, total IgE, ECP, eosinophil percentage, eosinophil counts/mm³, and HCY levels in patients with asthma (Group I). For control subjects (Group II), we evaluated folic acid, vitamin B_{12}, and HCY levels. All subjects with asthma had lung function test results. Spirometric analysis included the evaluation of forced vital capacity (FVC), FVC% predicted, forced expiratory volume in 1 second (FEV1), FEV1% predicted, FEV1/FVC ratio, (FEV1)/FVC% predicted, forced mid-expiratory flow (FEF) (FEF25-75%), FEF 25-75% predicted, peak expiratory flow (PEF), and PEF% predicted values.

Statistical Analysis

Statistical analyses were performed using IBM Statistical Package for the Social Sciences Statistics version 26.0. Quantitative (continuous) data were presented with descriptive statistics and prevalence measures. Kolmogorov-Smirnov test was used to assess normality.

For groups with a normal distribution, the Independent Sample t-test was used to compare the means of two independent groups (k=2). For groups that did not conform to a normal distribution, the Mann-Whitney U test was applied. Categorical data were presented using descriptive statistics, including frequency values and percentages. The chi-square test was used to examine relationships between variables, frequencies, or percentages when both variables were qualitative.

To investigate the strength and direction of the relationship between two variables, the Pearson correlation coefficient was used for variables that followed a normal distribution, whereas the Spearman's correlation coefficient was used for variables that deviated from linearity. Decisions were based on test statistics at a 95% confidence level. P values below the significance level of 0.05 were considered significant.

RESULTS

In Group I, 101 patients (56.7%) were female and 41 (23.0%) were male, with a mean age of 41±13 years. In Group II, 25 patients (14.0%) were female and 11 (6.2%) were male, with a mean age of 39.0±14.0 years. According to the Pearson chi-square test, there was no statistically significant difference in gender distribution between the two groups (p=0.843). Additionally, the independent sample t-test showed no significant difference in age distribution (p=0.371). The duration of asthma in Group I was 9.5±10.2 years. All patients in Group I had mild asthma according to the global strategy for asthma management and prevention guidelines (1), and they were on low-dose inhaled corticosteroid and beta-agonist combination treatment. None of the patients had taken oral steroids or experienced an asthma attack in the previous 3 months.

The data regarding age, gender, and smoking status of the participants are presented in Table 1.

The blood work results, including eosinophil counts/mm³, eosinophil percentage, total IgE, ECP, folic acid, vitamin B_{12}, and HCY levels, are presented in Table 2.

J Acad Res Med 2024;14(3):125-30

In Group I, no significant differences were observed in HCY, folic acid, and vitamin B_{12} levels between smokers and nonsmokers with asthma (Table 3).

In Group I, folic acid levels did not correlate with eosinophil counts/mm³ (r=-0.067, p=0.451), eosinophil percentage (r=-0.034, p=0.713), total IgE levels (r=-0.034, p=0.713), or ECP levels (r=-0.034, p=0.850), according to Spearman's correlation test. However, among the lung function test parameters, only the PEF% correlated positively with the folic acid levels (r=0.196, p=0.025) (Figure 1).

In Group I, vitamin B_{12} levels were not correlated with eosinophil counts/mm³ (r=0.016, p=0.863), eosinophil percentage (r=-0.011, p=0.902), total IgE levels (r=0.046, p=0.620), or ECP levels (r=0.075, p=0.460) according to Spearman's correlation test. None of the lung function test parameters were correlated with vitamin B_{12} levels.

In Group I, HCY levels were not correlated with ECP levels (p=0.180) or total IgE levels (p=0.910). HCY levels were positively correlated with eosinophil counts/mm³ (r=0.175, p=0.042) and eosinophil percentage (r=0.198, p=0.022) (Figures 2 and 3).

HCY levels were positively correlated with FVC (r=0.182, p=0.034) and PEF (r=0.215, p=0.012) (Figures 4 and 5). Other lung function parameters were not correlated with HCY levels in Group I.

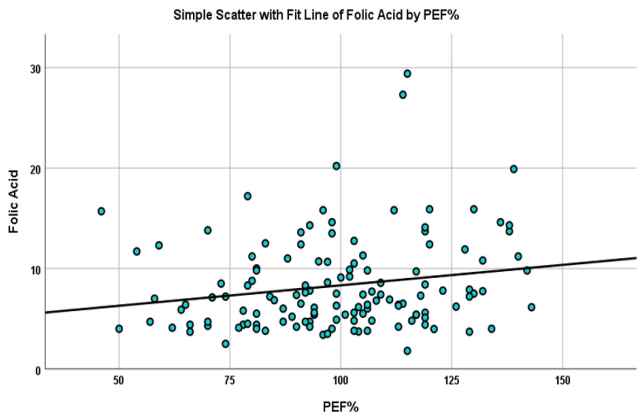

Figure 1. Correlation between folic acid levels with PEF%
PEF: peak expiratory flow

Table 1. Age, gender, and smoking status of the participants

	Group I (n=142)	Group II (n=36)	p-value
Mean age (years)	41±13	39±14	0.371*
Gender			0.843†
Female (n)	101 (56,7%)	25 (14%)	
Male (n)	41 (23%)	11 (6.2%)	
Smokers (n)	51 (28.2%)	11 (6.1%)	0.516†
Smoking duration (years)	4.8±7.9	3.7±7.1	0.381‡
Cigarettes/day	5±9	3±6	0.283‡

*Independent sample t-test, † Pearson's chi-square test, ‡ Mann-Whitney U test

Table 2. Laboratory test results of the groups

	Group I (n=142)	Group II (n=36)	p-value
Eosinophil count/mm³	246.9±204	181.4±108.4	0.108*
Eosinophil percentage (%)	3.73±2.58	2.33±1.28	0.001*‡
Total IgE (IU/mL)	139.75±186.38	9.15±5.89	0.002*‡
ECP (ng/mL)	27.29±23.95	N/A§	
Folic acid (ng/mL)	8.30±4.60	7.37±3.22	0.575*
Vitamin B12 (pg/mL)	413.5±160.6	386.7±178.7	0.256*
HCY (µmol/L)	10.16±3.04	11.08±3.38	0.115†

*Mann-Whitney U test, †Independent samples t-test, ‡statistically significant difference, § not available

Table 3. HCY, folic acid, and B_{12} levels in smokers and non-smokers with asthma

	Non-smoker asthmatic patients (n=88)	Smoker asthmatic patients (n=54)	p-value
Folic acid (ng/mL)	8.36±5.10	8.10±3.69	0.771*
Vitamin B_{12} (pg/mL)	410.2±150.8	435.4±174.4	0.435*
HCY (µmol/L)	9.83±2.99	10.86±3.52	0.064†

*Mann-Whitney U test, †Independent samples t-test

J Acad Res Med 2024;14(3):125-30

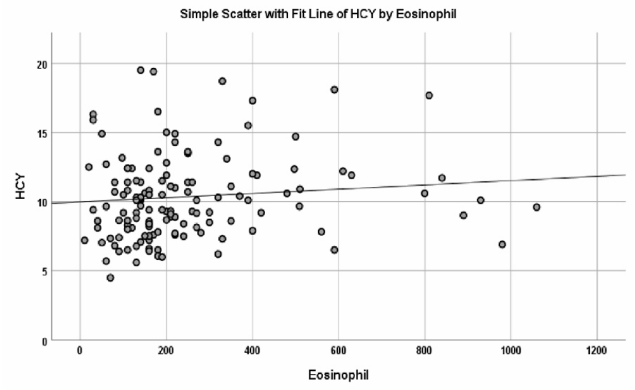

Figure 2. Correlation between HCY and eosinophil counts/mm^3
HCY: homocysteine, mm: milimetre

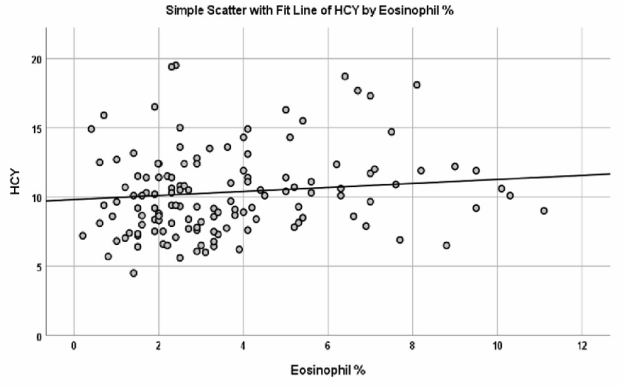

Figure 3. Correlation of HCY with eosinophil percentage
HCY: homocysteine

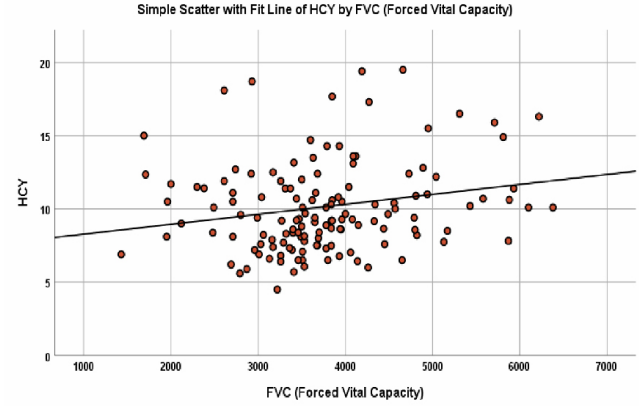

Figure 4. Correlation of HCY with FVC
HCY: homocysteine, FVC: forced vital capacity

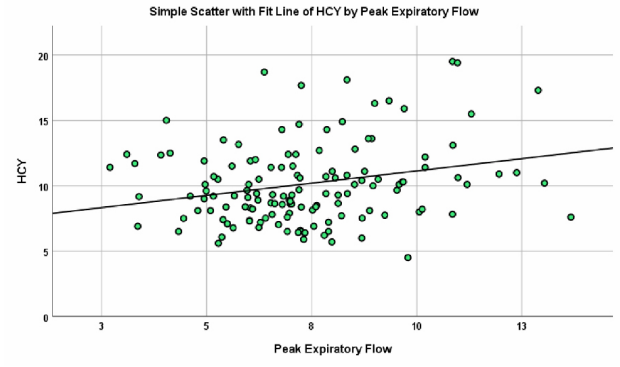

Figure 5. Correlation of HCY with PEF
HCY: homocysteine, PEF: peak expiratory flow

DISCUSSION

There are few studies in the literature that compare HCY levels and methyl donors, such as folic acid and vitamin B_{12}, in asthmatic patients with those in healthy individuals, and existing studies appear to yield conflicting results. In contrast to our findings, which indicate no difference in serum HCY levels between asthmatic and healthy individuals, Avci et al. (16) reported that HCY levels were significantly higher in asthmatic patients (10.01-30.70 µmol/L) compared with controls (7.22-12.39 µmol/L). Conversely, other studies suggest that HCY levels are significantly lower in patients with asthma compared with healthy non-asthmatic individuals (10). In their study, Abdel-Aziz et al. (15) evaluated asthmatic patients by dividing them into two groups: one with high airway bronchodilator reversibility (post-bronchodilator FEV1 ≥20%) and another with low bronchodilator reversibility. Patients in both asthmatic groups had significantly lower serum HCY levels than those in the healthy control group. Although not statistically significant, asthmatic patients with high airway bronchodilator reversibility had lower HCY levels than those with low bronchodilator reversibility. In our study, we did not subdivide the asthmatic group into high- or low-reversibility patients. Regarding IgE levels, Abdel-Aziz et al. (15) found similar serum IgE levels across all groups. Interestingly, they observed a negative correlation between HCY and IgE levels. In our cases, we did not detect a correlation between HCY levels and total IgE or ECP levels in patients with asthma. However, both eosinophil counts/mm^3 and eosinophil percentage were positively correlated with HCY levels. Additionally, we found no correlation between HCY levels and lung function parameters, except for PEF and FVC.

In a cross-sectional population-based study, Husemoen et al. (7) found no difference in plasma HCY levels between atopic and non-atopic individuals among 1,671 Danish participants aged 30-60 years. However, the methylene-tetrahydrofolate reductase (MTHFR) C677T polymorphism was more common among atopic

J Acad Res Med 2024;14(3):125-30

individuals than among non-atopic individuals. Additionally, patients with the *TT* genotype appeared to be more atopic and had higher plasma HCY levels than those with the CT or *CC* genotypes. In the same study, researchers detected a correlation between asthma and the *TT* genotype, but not with pulmonary function tests. Similarly, Thuesen et al. (17) reported that the MTHFR C677T polymorphism was associated with asthma, but not with atopy or pulmonary function. Low serum folate levels were associated with an increased prevalence of self-reported physician-diagnosed asthma, but not with lung function or atopy. In a British cohort of mothers and their children, Granell et al. (18) found no correlation between the MTHFR C677T genotype and asthma or allergy.

Based on NHANES data, Matsui and Matsui. (19) demonstrated an inverse relationship between serum folate levels and IgE levels, as well as between serum folate levels and asthma or wheezing in the past year. In a study by Thuesen et al. (20), the MTHFR C677T polymorphism was not correlated with atopy, as defined by allergen-specific IgE or ECP levels, nor with pulmonary function. However, it was associated with asthma and dyspnea. In our asthmatic population, serum folate levels correlated only with the predicted PEF percentage and not with any other functional parameters.

Consistent with our findings, Thuesen et al. (17) found that serum vitamin B_{12} levels were not associated with asthma or atopy. We did not find any correlation between vitamin B_{12} levels and lung function parameters, eosinophil counts/mm³, eosinophil percentage, total IgE, or ECP levels. Skaaby et al. (21) also did not find evidence supporting a causal relationship between vitamin B_{12} and folic acid levels and asthma, atopic markers, or hay fever. However, they did detect a positive association between serum folic acid and IgE levels.

We discussed the role of vitamin B_{12} and folic acid as methyl donors in relation to HCY and noted that these vitamins can also influence the immune system. The mechanisms by which vitamin deficiencies affect immune function are described in great detail in a review by Wintergerst et al. (22). For example, vitamin B_6 affects lymphocyte maturation, antibody formation, and T-cell activity. In patients with vitamin B_6 deficiency, Th_1 cell activity is suppressed, whereas Th_2 type response emerges (23). Katunuma et al. (24) demonstrated that vitamin B_6 supplementation suppressed Th_2 responses and IgE production. In our study, we did not assess vitamin B_6 levels.

Conclusion

Although HCY appears to play a role in many inflammation-related diseases, its relationship with asthma and atopy is not fully understood. If randomized controlled trials with large patient populations can definitively establish HCY as a causative factor of asthma, metabolic interventions to reduce HCY levels using methyl donors may be considered alongside conventional asthma treatments.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Demiroğlu Bilim University Clinical Research Ethics Committee of Helsinki on (number: 44140529/29489, date: 18.07.2023).

Informed Consent: All patients whose files were accessed were informed about the study content and provided consent to participate.

Footnotes

Author Contributions: Surgical and Medical Practices - İ.K., A.G., M.E.; Concept - İ.K., A.G., M.E.; Design - İ.K., A.G., M.E.; Data Collection and/or Processing - İ.K., A.G., M.E.; Analysis and/or Interpretation - İ.K., A.G., M.E.; Literature Search - İ.K., A.G., M.E.; Writing - İ.K., A.G., M.E.

Conflict of Interest: The authors have no conflict of interest to declare.

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

References

1. Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention, 2022. Available from: www.ginasthma.org (cited: 2023 April 22)
2. Türk Toraks Derneği: Astım Tanı ve Tedavi Rehberi 2020 Güncellemesi, 2020. (cited: 22 April 2023). Available from: URL:https://toraks.org.tr/site/sf/documents/2020/12/ 50b2903b68004d73e3ca 14d5e2589 b251023aa477 d5f257e6ce5da7b09437d24.pdf
3. World Health Organization: Asthma, 2020. (cited: 14 December 2024). Available from: https://www.who.int/news-room/fact-sheets/detail/asthma
4. Banerjee R. B12 trafficking in mammals: A for coenzyme escort service. ACS Chem Biol. 2006; 1: 149-59.
5. Kaplan P, Tatarkova Z, Sivonova MK, Racay P, Lehotsky J. Homocysteine and Mitochondria in Cardiovascular and Cerebrovascular Systems. Int J Mol Sci. 2020; 21: 7698.
6. George, AK, Majumder A, Ice H, Homme RP, Eyob W, Tyagi SC, et al. Genes and genetics in hyperhomocysteinemia and the "1-carbon metabolism": implications for retinal structure and eye functions. Can J Physiol Pharmacol. 2020; 98: 51-60.
7. Husemoen LL, Toft U, Fenger M, Jørgensen T, Johansen N, Linneberg A. The association between atopy and factors influencing folate metabolism: is low folate status causally related to the development of atopy? Int J Epidemiol. 2006; 3: 954-61.
8. Guéant JL, Guéant-Rodriguez RM, Oussalah A, Zuily S, Rosenberg I. Hyperhomocysteinemia in Cardiovascular Diseases: Revisiting Observational Studies and Clinical Trials. Thromb Haemost. 2023; 123: 270-82.
9. Sharma M, Tiwari M, Tiwari RK. Hyperhomocysteinemia: Impact on Neurodegenerative Diseases. Basic Clin Pharmacol Toxicol. 2015; 117: 287-96.
10. Ajith TA, Ranimenon. Homocysteine in ocular diseases. Clin Chim Acta. 2015; 450: 316-21.
11. Herrmann W. The importance of hyperhomocysteinemia as a risk factor for diseases: an overview. Clin Chem Lab Med. 2001; 39: 666-74.
12. Dawson H, Collins G, Pyle R, Deep-Dixit V, Taub DD. The immunoregulatory effects of homocysteine and its intermediates on T-lymphocyte function. Mech Ageing Dev. 2004; 125: 107-10.
13. Chang L, Zhang Z, Li W, Dai J, Guan Y, Wang X. Liver-X-receptor activator prevents homocysteine-induced production of IgG antibodies from murine B lymphocytes via the ROS-NF-kappaB pathway. Biochem Biophys Res Commun. 2007; 357: 772-8.
14. Kirkham P, Rahman I. Oxidative stress in asthma and COPD: antioxidants as a therapeutic strategy. Pharmacol Ther. 2006; 111: 476-94.
15. Graham IM, Daly LE, Refsum HM, Robinson K, Brattström LE, Ueland PM, et al. Plasma homocysteine as a risk factor for vascular disease. The European Concerted Action Project. JAMA. 1997; 277: 1775-81.
16. Avci E, Avci GA, Cevher SC. An independent risk factor for cardiovascular diseases in asthma: Homocysteine. Journal of Cellular Neuroscience & Oxidative Stress [Internet]. 2018; 10: 749-50.
17. Thuesen BH, Husemoen LL, Ovesen L, Jørgensen T, Fenger M, Gilderson G, et al. Atopy, asthma, and lung function in relation to folate and vitamin B(12) in adults. Allergy. 2010; 65: 1446-54.

J Acad Res Med 2024;14(3):125-30

18. Granell R, Heron J, Lewis S, Davey Smith G, Sterne JA, Henderson J. The association between mother and child MTHFR C677T polymorphisms, dietary folate intake and childhood atopy in a population-based, longitudinal birth cohort. Clin Exp Allergy. 2008; 38: 320-8.
19. Matsui EC, Matsui W. Higher serum folate levels are associated with a lower risk of atopy and wheeze. J Allergy Clin Immunol. 2009; 123: 1253-9.
20. Thuesen BH, Husemoen LL, Fenger M, Linneberg A. Lack of association between the MTHFR (C677T) polymorphism and atopic disease. Clin Respir J. 2009; 3: 102-8.
21. Skaaby T, Taylor AE, Jacobsen RK, Møllehave LT, Friedrich N, Thuesen BH, et al. Associations of genetic determinants of serum vitamin B12 and folate concentrations with hay fever and asthma: a Mendelian randomization meta-analysis. Eur J Clin Nutr. 2018; 72: 264-71.
22. Wintergerst ES, Maggini S, Hornig DH. Contribution of selected vitamins and trace elements to immune function. Ann Nutr Metab. 2007; 51: 301-23.
23. Long KZ, Santos JI. Vitamins and the regulation of the immune response. Pediatr Infect Dis J. 1999; 18: 283-90.
24. Katunuma N, Matsui A, Endo K, Hanba J, Sato A, Nakano M, et al. Inhibition of intracellular cathepsin activities and suppression of immune responses mediated by helper T lymphocyte type-2 by peroral or intraperitoneal administration of vitamin B6. Biochem Biophys Res Commun. 2000; 272: 151-5.

DOI: 10.4274/jarem.galenos.2024.10327
J Acad Res Med 2024;14(3):131-7

Wideband Absorption for Diagnosing Conductive Hearing Loss: Insights from Middle Ear Pathologies

Murat Arslan[1], Emre Ocak[2], Suna Tokgöz Yılmaz[3]

[1]Trakya University, Institute of Health Sciences, Department of Audiology, Edirne, Türkiye
[2]Ankara University Faculty of Medicine, Department of Otorhinolaryngology, Ankara, Türkiye
[3]Ankara University Faculty of Medicine, Department of Audiology, Ankara, Türkiye

Cite this article as: Arslan M, Ocak E, Tokgöz Yılmaz S. Wideband Absorption for Diagnosing Conductive Hearing Loss: Insights from Middle Ear Pathologies. J Acad Res Med. 2024;14(3):131-7

ABSTRACT

Objective: This study aimed to investigate the relationship between air-bone gap (ABG) and wideband absorbance (WBA) values in patients with conductive hearing loss resulting from four middle ear pathologies: Tympanic membrane perforation, middle ear effusion, ossicular chain discontinuity, and otosclerosis.

Methods: Air and bone conduction thresholds and WBA values were measured at 0.25, 0.5, 1, 2, and 4 kHz under ambient pressure. Correlations between ABG and WBA were analyzed in each pathology group to explore diagnostic relevance.

Results: Significant correlations were identified for specific frequencies and pathologies. In the middle ear effusion group, ABG was negatively correlated with WBA at 0.25 kHz in the right ears (r=-0.570, p=0.022), whereas a positive correlation was observed in the otosclerosis group at the same frequency (r=0.570, p=0.048). Additionally, a negative correlation was noted at 4 kHz for the left ears across all groups (r= -0.270, p= 0.034).

Conclusion: Preoperative WBA measurements provide valuable insights into middle ear function, offering diagnostic and surgical planning advantages for patients with conductive hearing loss. These findings suggest incorporating frequency-specific WBA evaluations into clinical practice can enhance the precision of middle ear pathology assessments.

Keywords: Hearing loss, middle ear pathologies, wideband tympanometry, absorbance, diagnostic audiology

Introduction

Wideband tympanometry (WBT) is a clinically valuable method for evaluating middle ear function, providing detailed insight into the diagnosis and treatment planning of conductive hearing loss. The WBT evaluates middle ear function with a transient stimulus (click or chirp) between 226 Hz and 8000 Hz and provides important information about middle ear functions (1). Because of the presence of multiple frequencies in transient stimuli, WBT is less sensitive to myogenic noise in patient movements (1-3). Comparing to traditional tympanometry, which measures at a standard 226 Hz frequency, it can provide results in a single measurement over a wide frequency range. This approach allows more specific investigation and diagnostics of middle ear problems and conductive hearing loss. The use of WBT in clinical practice can thus significantly enhance the accuracy of middle ear pathology detection and contribute to more precise treatment decisions (4-7).

Wideband absorbance (WBA), a parameter derived from WBT, measures the proportion of sound energy absorbed from the ear canal into the middle ear. This property has been found promising as a diagnostic marker, with studies indicating its ability to differentiate between various middle ear pathologies (8). Characteristic absorbance curves have been described for conditions like otosclerosis, negative middle ear pressure, middle ear effusion, ossicular chain discontinuity, excessive flaccidity or stiffness of the tympanic membrane, and perforation. These findings highlight the potential of WBA as a diagnostic marker for various stages of middle ear diseases, therefore helping with personalized treatment approaches (9).

Conductive hearing loss is a form of auditory impairment that results from pathological conditions in either the outer ear, the middle ear, or both. The condition can be caused by earwax, infection, or trauma to the external auditory canal, or by perforation of the tympanic membrane, ossicular chain discontinuity, middle ear effusion, or otosclerosis. The pure-tone audiometry test is

ORCID IDs of the authors: M.A.: 0000-0003-3827-9142, E.O.: 0000-0003-0652-2777, S.T.Y.: 0000-0002-4656-099X

Corresponding Author: Murat Arslan,
E-mail: muratarslan@trakya.edu.tr

Received Date: 28.11.2024 **Accepted Datei:** 19.12.2024

J Acad Res Med 2024;14(3):131-7

a useful tool for diagnosing conductive hearing loss (10). The diagnostic criteria include a bone conduction threshold of 20 dB HL or better and an air-bone gap (ABG) of 10 dB or more, which can range between 10 and 60 dB in conductive hearing loss (11).

Wideband acoustic absorbance measures the middle ear system's ability to absorb sound waves over a wide frequency range (8). In WBT, WBA measurements can be conducted with or without pressure, displaying absorbance results across specific frequency ranges. Non-pressure absorbance refers to measurements at ambient pressure (0 daPa), while pressure absorbance values are obtained at the peak pressure of the tympanogram (12,13).

This study addresses this gap by analyzing the relationship between ABG and WBA at specific frequencies in patients with tympanic membrane perforation, otosclerosis, middle ear effusion, and ossicular chain discontinuity. Therefore, we aimed to enhance the clinical relevance of WBA in diagnosing and managing conductive hearing loss. This investigation is novel in its focus on frequency-specific correlations across multiple pathologies, offering new perspectives on the diagnostic utility of WBA in middle ear assessments.

METHODS

Participants

The study included 78 patients (107 ears) aged 18-65 years (mean age ± SD: 38.24±12.6 years). Participants were selected based on pathological severity, which was explicitly defined in alignment with clinical diagnostic guidelines. For instance, patients with otosclerosis had an ABG ≥20 dB, which was confirmed by radiological imaging.

The inclusion criteria were as follows:

- Patients aged 18-65 years with conductive hearing loss due to
  - Tympanic membrane perforation (Griffin classification grade 2-3) (14),
  - Middle ear effusion persisting for 3 months,
  - Ossicular chain discontinuity,
  - Otosclerosis,
- Diagnosis confirmed by radiological imaging.

Exclusion criteria were as follows:

- Diagnosis of sensorineural or mixed hearing loss.
- Presence of mastoid or external ear disease (e.g., cholesteatoma).
- History of otological surgery.

Study Protocol

Data Collection and Physical Examination

Demographic data such as age, gender, and medical history related to hearing loss were collected from all participants. A comprehensive physical examination was conducted by an otolaryngologist, including an otoscopic evaluation of the external auditory canal and tympanic membrane. Temporal bone computed tomography scan was used to confirm pathological severity and identify potential confounders, such as undiagnosed conditions (15).

Participant Grouping

Participants were divided into four groups according to their diagnosed middle ear pathologies:

- **Group I:** Tympanic membrane perforation (n=27 ears)
- **Group II:** Middle ear effusion (n=31 ears)
- **Group III:** Ossicular chain discontinuity (n=25 ears)
- **Group IV:** Otosclerosis (n=24 ears)

Measurement Procedures

To minimize variability and ensure consistency, all measurements were conducted in a single session for each participant. Audiological evaluations, including pure tone audiometry and WBT, were performed in a soundproof room compliant with the American National Standards Institute standards. The equipment was calibrated according to the manufacturer's instructions before each test session.

Data Management and Ethical Considerations

Data were recorded electronically and securely stored to protect participant confidentiality and to comply with data protection regulations. This study was approved by Ankara University Clinical Research Ethics Committee (decision no: 09-710-19, date: 13.05.2019). and written informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines.

Audiological Evaluation

Pure-tone Audiometry

Pure-tone audiometry was performed to determine air- and bone-conduction thresholds using the Interacoustics AC-40 audiometer. Air-conduction thresholds were measured at frequencies of 0.25, 0.5, 1, 2, 4, 6, and 8 kHz, while bone-conduction thresholds were assessed at 0.25, 0.5, 1, 2, and 4 kHz. Pure-tone thresholds for both air and bone conduction were obtained using the modified Hughson-Westlake procedure (16).

Criteria for The Diagnosis of Conductive Hearing Loss

Conductive hearing loss was diagnosed if an ABG of 10 dB or more was present at least 3 out of 5 frequencies tested (0.25, 0.5, 1, 2, and 4 kHz) (17).

Classification of ABG Amounts

The audiograms were classified into two categories based on the amount of ABG delivered at each frequency:

- **Less-ABG audiogram:** An average ABG of ≤25 dB at least 3 frequencies among 0.25, 0.5, 1, 2, and 4 kHz.

J Acad Res Med 2024;14(3):131-7

• **More-ABG audiogram:** The average ABG of ≥26 dB at the same frequencies (18).

WBT Test

WBT absorbance tests were conducted bilaterally using the Interacoustics Titan 3.5 system with the Version 3.7 Research Module (Interacoustics A/S, Denmark). Absorbance measurements were performed using a click stimulus at ambient pressure over the frequency range 226-8000 Hz. The stimulus had a duration of 2 ms, and measurements were taken at 107 frequency points with a resolution of 21.5 Hz. The intensity level was set at 94-dB peak equivalent SPL (peSPL).

The tests were conducted in a quiet room using a sealing probe to occlude the external ear canal. Participants were instructed to avoid activities such as swallowing, coughing, yawning, or talking during the test to prevent artifacts.

Statistical Analysis

Statistical analyses were performed using IBM SPSS 22.0 (SPSS Inc., Chicago, IL, USA). The normality of the numerical data was assessed using the Shapiro-Wilk test. Normally distributed variables were expressed as mean ± standard deviation, non-normally distributed variables were expressed as min-max, and categorical variables were presented as frequency (percentage).

For group comparisons, the Mann-Whitney U test was used for two groups, while the Kruskal-Wallis test and Dunn's post-hoc test with Bonferroni correction were used for three or more groups. Relationships between categorical variables were assessed using the Pearson Chi-square test or Fisher's exact test, depending on the sample size.

Correlations between ABG and WBA at various frequencies were evaluated using Pearson's or Spearman's correlations, depending on normality, with the results expressed as correlation coefficients (r) and 95% confidence intervals. Multiple regression analysis was used to analyze the ABG-WBA relationships while adjusting for confounding factors (e.g., age, pathology type, ear laterality), with interaction terms used to explore frequency-dependent effects. Statistical significance was set at $p<0.05$.

RESULTS

Participant Demographics

A total of 78 participants (107 ears) were included in the study, consisting of 51 females (68.38%) and 27 males (31.62%), with a mean age of 38.24±12.6 years (Table 1). Participants were distributed across the following four pathology groups: Tympanic membrane perforation (Group I), middle ear effusion (Group II), ossicular chain discontinuity (Group III), and otosclerosis (Group IV). No significant differences in age, gender, or ear laterality distribution were noted between the groups ($p>0.05$).

ABG Findings

The ABG was assessed at five frequencies (0.25, 0.5, 1, 2, and 4 kHz), and the trends were as follows:

• Group-specific findings:

• Group I (tympanic membrane perforation): The highest ABG was 0.25 kHz for both ears, with mean values of 30±9.4 dB in the right ear and 25.71±6.7 dB in the left ear.

• Group II (middle ear effusion): Similarly, the highest ABG was at 0.25 kHz (29.66±14.2 dB for the right ear and 29.58±12.3 dB for the left ear).

• Group III (ossicular chain discontinuity): Peak ABG occurred at 0.5 kHz, with values of 26.36±9.5 dB and 26.42±11.8 dB for the right and left ears, respectively.

• Group IV (Otosclerosis): ABG peaked at 0.5 kHz (30±11.9 dB for the right ear and 30.83±11.4 dB for the left ear; Table 2).

• **Frequency-specific trends:** Across all groups, ABG values decreased with increasing frequency, reaching their lowest values at 4 kHz.

• Gender and laterality comparisons:

• Female participants generally exhibited lower ABG values in the right ear than male participants, but the difference was not statistically significant ($p>0.05$).

• No significant differences in ABG were observed between the right and left ears in any group ($p>0.05$; Table 3).

Wideband Absorption (WBA) Findings

The WBA was measured across five frequencies, and the trends are summarized in Table 4:

• General trends:

• The absorbance was lowest at 0.25 kHz and highest at 2 kHz across all groups, consistent with known audiological patterns.

• Significant group differences were identified at 0.25 and 4 kHz (Kruskal-Wallis $p<0.05$).

• The post hoc analysis revealed that

• Middle ear effusion (Group II) had a significantly lower absorbance at 0.25 kHz than the other groups ($p=0.022$).

• Otosclerosis (Group IV) had a higher absorbance at 0.25 kHz than tympanic membrane perforation (Group I; $p=0.048$).

• Pathology-specific patterns:

• Tympanic membrane perforation and middle ear effusion show reduced absorbance at lower frequencies, reflecting impaired sound energy transfer.

Table 1. Gender and age distribution according to the groups

Groups	Age range	Mean ± SD	n		
			Male	Female	Total
Group I	18-61	38±11.2	10	11	21
Group II	19-65	37.5±14.4	9	12	21
Group III	21-47	33.1±8.9	4	14	18
Group IV	23-65	44.5±12.6	4	14	18
Total	18-65	38.24±12.6	27	51	78

SD: standard deviation

J Acad Res Med 2024;14(3):131-7

Table 2. ABG values categorized according to pathology type, frequency, and ear laterality

Frequency	Group I		Group II		Group III		Group IV	
	Right ear mean ± SD	Left ear mean ± SD	Right ear mean ± SD	Left ear mean ± SD	Right ear mean ± SD	Left ear mean ± SD	Right ear mean ± SD	Left ear mean ± SD
250 Hz	30±9.4	25.71±6.7	29.66±14.2	29.58±12.3	25±9.4	25.71±12	28.88±11.9	29.16±12
500 Hz	22.72±9	20.71±7.8	28±13.3	24.58±13.3	26.36±.9.5	26.42±11.8	30±11.9	30.83±11.4
1000 Hz	23.63±11.6	17.14±9.9	28±9.9	25.41±10.5	24.5±11.5	26.42±11.8	27.22±13.7	28.33±8.7
2000 Hz	19.09±10.6	12.14±3.9	20±13.7	18.75±11.1	22.72±10.5	24.28±10.1	17.22±11.2	15.83±6.6
4000 Hz	23.63±10.7	18.57±5.5	23.33±12.3	22.5±12.1	24.09±11.3	25.42±8	23.88±13.6	20±9.4

SD: standard deviation

Table 3. ABG groups based on sex and laterality

		Left ear		Right ear	
		n	%	n	%
Female	Less ABG	21	56.8	9	32.1
	More ABG	16	43.2	19	67.9
	Total	37	100	28	100
Male	Less ABG	11	45.8	12	66.7
	More ABG	13	54.2	6	33.3
	Total	24	100	18	100

ABG: air-bone gap

• Otosclerosis exhibited higher absorbance at low frequencies, likely due to increased middle ear stiffness.

Correlation Between ABG and WBA

The relationships between ABG and WBA were evaluated for all pathologies:

• Middle ear effusion (Group II):

• A significant negative correlation was observed between ABG and WBA at 0.25 kHz in the right ear (r=-0.570, p=0.022), suggesting reduced absorbance with increasing ABG. This is illustrated in Figure 1.

• Otosclerosis (Group IV):

• A positive correlation was noted at 0.25 kHz in the right ear (r=0.570, p=0.048), indicating that increased stiffness may enhance absorbance.

• Across All Groups:

• At 4 kHz, a significant negative correlation (r=-0.270, p=0.034) was observed in the left ear, suggesting that greater ABG values were associated with lower absorbance. This is illustrated in Figure 2.

• No statistically significant correlations were identified at other frequencies (p>0.05).

Multiple Regression Analysis

Multiple regression analysis was performed to assess the independent relationship between ABG and WBA. Age, sex, pathology type, and laterality were included as confounders based on theoretical and empirical evidence suggesting their influence on WBA. After verifying the model assumptions (linearity, independence, homoscedasticity, and absence of multicollinearity), the analysis showed that ABG was a significant predictor of WBA at 0.25 kHz (β=0.35, p=0.002) and 4 kHz (β=0.30, p=0.007). Interaction effects indicated that the strength of the ABG-WBA relationship varied according to pathology, with the strongest association observed in middle ear effusion at 0.25 kHz.

DISCUSSION

This study investigated the relationship between mean ABG and WBT absorbance values in patients with different middle ear pathologies. The findings indicate that the relationship between ABG and absorbance varies significantly depending on the specific pathology and the frequency measured, providing valuable insights into the diagnostic potential of WBT absorbance in clinical evaluations.

Key Findings and Their Interpretation

In the middle ear effusion group, a significant negative correlation was observed between ABG and absorbance at 0.25 kHz in the right ear (r=-0.570, p=0.022). This finding suggests that as the severity of middle ear effusion increases (reflected by higher ABG), the sound energy absorbance decreases, consistent with the presence of fluid in the middle ear cavity, which reduces sound transmission. This finding is consistent with previous studies that demonstrated an increase in energy reflectance in ears with middle ear effusion, particularly at lower frequencies (19,20).

In contrast, the otosclerosis group exhibited a significant positive correlation at 0.25 kHz in the right ear (r=0.570, p=0.048). This relationship indicates that increased stiffness in the middle ear system due to otosclerosis enhances sound absorbance at specific frequencies. This finding is consistent with studies by Shahnaz et al. (21) and Shahnaz and Davies. (22), which reported significantly higher energy reflectance in otosclerotic ears, particularly at low frequencies. These patterns suggest that otosclerosis induces stiffness-related changes in sound energy transfer, making WBT a useful tool for identifying such mechanical changes.

Additionally, a significant negative correlation was observed across all participants between ABG and absorbance at 4 kHz in the left ear (r=-0.270, p=0.034). This finding suggests that the ability of the middle ear to absorb sound energy diminishes with ABG levels at

Table 4. Distribution of absorbance values among the groups

Right ear						Left ear				
	Frequency	n	Mean ± SD	Min.	Max.	Frequency	n	Mean ± SD	Min.	Max.
Group I	250 Hz	7	0.216±0.25	0.043	0.775	250 Hz	11	0.107±0.07	0.04	0.25
	500 Hz	7	0.371±0.25	0.075	0.745	500 Hz	11	0.258±0.15	0.07	0.55
	1000 Hz	7	0.520±0.23	0.196	0.85	1000 Hz	11	0.526±0.23	0.21	0.86
	2000 Hz	7	0.608±0.18	0.311	0.854	2000 Hz	11	0.630±0.17	0.32	0.95
	4000 Hz	7	0.501±0.14	0.256	0.63	4000 Hz	11	0.420±0.20	0.11	0.78
Group II	250 Hz	12	0.089±0.06	0.019	0.255	250 Hz	15	0.089±0.05	0	0.23
	500 Hz	12	0.176±0.10	0.062	0.4	500 Hz	15	0.210±0.08	0.01	0.35
	1000 Hz	12	0.445±0.24	0.167	0.857	1000 Hz	15	0.540±0.22	0.01	0.96
	2000 Hz	12	0.731±0.10	0.562	0.903	2000 Hz	15	0.601±0.27	0.06	0.96
	4000 Hz	12	0.446±0.12	0.281	0.602	4000 Hz	15	0.416±0.18	0.04	0.61
Group III	250 Hz	7	0.140±0.09	0.021	0.293	250 Hz	11	0.194±0.16	0.02	0.57
	500 Hz	7	0.324±0.31	0.03	0.947	500 Hz	11	0.424±0.28	0.06	0.79
	1000 Hz	7	0.463±0.27	0.165	0.978	1000 Hz	11	0.625±0.27	0.12	0.97
	2000 Hz	7	0.671±0.11	0.478	0.79	2000 Hz	11	0.689±0.16	0.36	0.94
	4000 Hz	7	0.593±0.22	0.357	0.943	4000 Hz	11	0.474±0.17	0.19	0.69
Group IV	250 Hz	6	0.140±0.09	0.021	0.293	250 Hz	9	0.125±0.11	0	0.37
	500 Hz	6	0.324±0.31	0.03	0.947	500 Hz	9	0.256±0.22	0.07	0.72
	1000 Hz	6	0.463±0.27	0.165	0.978	1000 Hz	9	0.596±0.24	0.26	0.87
	2000 Hz	6	0.671±0.11	0.478	0.79	2000 Hz	9	0.664±0.12	0.39	0.87
	4000 Hz	6	0.593±0.22	0.357	0.943	4000 Hz	9	0.512±0.14	0.07	0.54

SD: standard deviation, min.: minimum, max.: maximum

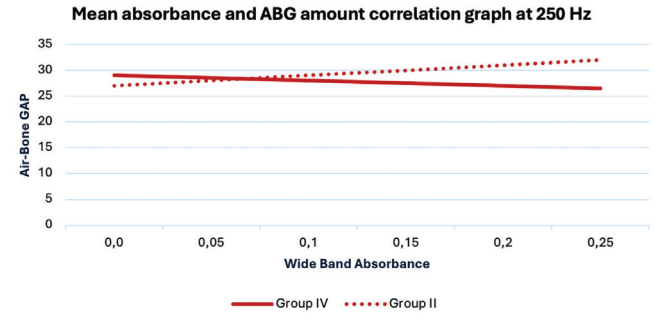

Figure 1. Scatter plot of ABG and absorbance correlation in the middle ear effusion group (0.25 kHz, right ear)
ABG: air-bone gap

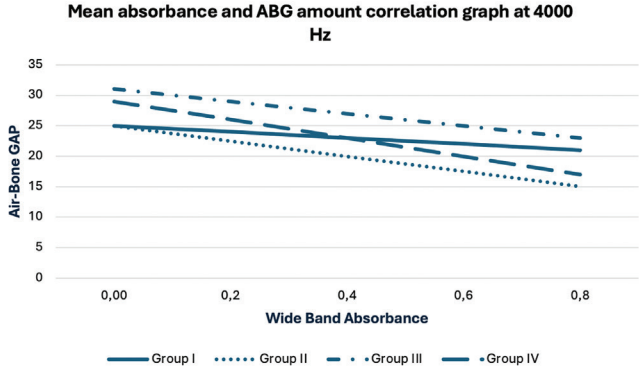

Figure 2. Scatter plot of ABG and absorbance correlation across all participants (4 kHz, left ear)
ABG: air-bone gap

higher frequencies. This result extends previous research that has predominantly focused on low-frequency changes in absorbance (23,24).

Consistency with Literature

The ABG values measured in this study for various middle ear pathologies were consistent with previously published values. Tympanic membrane perforation exhibited mean ABG values of 30.5 dB in the right ear and 25.5 dB in the left ear, consistent with the findings of Anthony and Harrison. (25). Similarly, the middle ear effusion group had an average ABG of 29 dB, which is consistent with the results reported by Dempster and Swan (26). The ABG values for ossicular chain discontinuity (mean: 25 dB) and otosclerosis (mean: 28 dB for the right ear and 29 dB for the left ear) were comparable to those reported by Ayache et al. (27).

The absorbance patterns identified in the tympanic membrane perforation and middle ear effusion groups were also consistent with the literature. Previous studies have demonstrated that low-frequency sound transmission decreases with increasing tympanic membrane perforation size (20,28,29). In our study, absorbance at

0.25 and 0.5 kHz was lower in the perforation group than in normal ear values but remained higher than at other frequencies. Similarly, the reduction in absorbance observed at frequencies below 1 kHz in the middle ear effusion group aligns with the findings of Feeney et al. (19) and Voss et al. (20), who demonstrated that middle ear fluid increases energy reflectance at low frequencies.

Interestingly, although ossicular chain discontinuity has been associated with a notch-like reduction in energy reflectance between 0.4 and 0.8 kHz (7,30), no such pattern was observed in this study. This discrepancy may be due to differences in the extent or type of ossicular chain damage among the study populations, warranting further investigation.

In otosclerosis, the reduced absorbance observed at low frequencies (0.25 and 0.5 kHz) aligns with previous findings by Nakajima et al. (31) and Feeney et al. (19), who reported elevated reflectance values at similar frequencies. This reflects the stiffness-dominated mechanics of otosclerotic ears, reinforcing the utility of WBT for detecting such changes.

Clinical Implications

The observed frequency-specific correlations between ABG and absorbance highlight the diagnostic potential of WBT absorbance measurements. Combining ABG and WBT in clinical practice may enhance the diagnostic accuracy of middle ear pathologies and provide additional insights into their severity. For instance, middle ear effusion and otosclerosis exhibit distinct absorbance trends that can guide preoperative evaluation and surgical planning.

Moreover, the universal reduction in absorbance at 4 kHz across all pathologies suggests that this frequency may serve as a general indicator of the severity of conductive hearing loss. While traditional audiometry remains the standard for evaluating hearing thresholds, WBT absorbance offers complementary information by characterizing the biomechanical properties of the middle ear.

Limitations and Future Directions of this Study

A limitation of this study was the lack of stratification by pathological severity or specific anatomical characteristics, such as the size or location of tympanic membrane perforations or the extent of ossicular damage. Future research should consider these factors to provide more detailed insights into the relationship between ABG and absorbance.

Additionally, the sample size in some pathology groups, particularly ossicular chain discontinuity, was relatively small, which may have limited statistical power. Larger studies with broader pathological representations are needed to validate these findings. Future research could also explore the application of WBT absorbance in mixed or sensorineural hearing loss to assess its diagnostic potential.

CONCLUSIONS

The observed frequency-specific correlations between ABG and absorbance highlight the diagnostic potential of WBT absorbance measurements. Combining ABG and WBT in clinical practice may enhance the diagnostic accuracy of middle ear pathologies and provide additional insights into their severity. For instance, middle ear effusion and otosclerosis exhibit distinct absorbance trends that can guide preoperative evaluation and surgical planning.

Moreover, the universal reduction in absorbance at 4 kHz across all pathologies suggests that this frequency may serve as a general indicator of the severity of conductive hearing loss. While traditional audiometry remains the standard for evaluating hearing thresholds, WBT absorbance offers complementary information by characterizing the biomechanical properties of the middle ear.

Ethics

Ethics Committee Approval: This study was approved by Ankara University Clinical Research Ethics Committee (decision no: 09-710-19, date: 13.05.2019).

Informed Consent: Written informed consent was obtained from all participants.

Footnotes

Author Contributions: Surgical and Medical Practices - M.A.; Concept - M.A.; E.O.; S.T. Y.; Design - M.A.; E.O.; S.T. Y.; Data Collection and/or Processing - M.A.; E.O.; S.T. Y.; Analysis and/or Interpretation - M.A.; E.O.; S.T. Y.; Literature Search - M.A.; Writing - M.A.

Conflict of Interest: The authors have no conflict of interest to declare.

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

References

1. Hein TAD, Hatzopoulos S, Skarzynski PH, Colella-Santos MF. Wideband Tympanometry. Advances in Clinical Audiology. 2017.
2. Prieve BA, Vander Werff KR, Preston JL, Georgantas L. Identification of conductive hearing loss in young infants using tympanometry and wideband reflectance. Ear Hear. 2013; 34: 168-78.
3. Tharpe AM, Seewald R. Comprehensive handbook of pediatric audiology. Plural publishing. 2016.
4. Gümüş B, Torun Topçu M. Wide Band Acoustic İmmitancemetry. Medeniyet Med J. 2018; 33: 126-31.
5. Huang GT, Rosowski JJ, Peake WT. Relating middle-ear acoustic performance to body size in the cat family: measurements and models. J Comp Physiol A. 2000; 186: 447-65.
6. Stinson MR, Shaw EA, Lawton BW. Estimation of acoustical energy reflectance at the eardrum from measurements of pressure distribution in the human ear canal. J Acoust Soc Am. 1982; 72: 766-73.
7. Voss SE, Allen JB. Measurement of acoustic impedance and reflectance in the human ear canal. J Acoust Soc Am. 1994; 95: 372-84.
8. Hunter L, Shahnaz N. Acoustic Immitance Measures. San Diego: Plural Publishing; 2014.
9. Citation Niemczyk E, Lachowska M. Wideband tympanometry - a new method to evaluate the middle ear. Pol Otorhino Rev. 2016; 5: 65-74.
10. Moore BCJ. Cochlear hearing loss: physiological, psychological and technical issues. J Acoust Soc Am; November.
11. Naz S. Hearing Loss. BoD-Books on Demand; 2012.
12. Yigit O, Tokgoz-Yilmaz S, Tahir E, Bajin MD, Kar I, Sennaroglu L. Wideband Tympanmetry Results of Bone Cement Ossiculoplasty. Am J Otolaryngol. 2019; 40: 512-9.
13. Interacoustic. Manual. IU. Titan Instruction for Use - Geniş Band Tympanometry. 2013 [updated Revize 2 - version 09/2013].
14. Griffin WL Jr. A retrospective study of traumatic tympanic membrane perforations in a clinical practice. Laryngoscope. 1979; 89: 261-82.
15. Ocak E, Kocaöz D, Acar B, Topçuoğlu M. Radiological Evaluation of Inner Ear with Computed Tomography in Patients with Unilateral Non-Pulsatile Tinnitus. J Int Adv Otol. 2018; 14: 273-7.

J Acad Res Med 2024;14(3):131-7

16. Carhart R, Jerger JF. Preferred Method For Clinical Determination Of Pure-Tone Thresholds. Journal of Speech and Hearing Disorders. 1959; 24: 330-45.
17. Margolis RH, Wilson RH, Popelka GR, Eikelboom RH, Swanepoel de W, Saly GL. Distribution Characteristics of Air-Bone Gaps: Evidence of Bias in Manual Audiometry. Ear Hear. 2016; 37: 177-88.
18. Keefe DH, Sanford CA, Ellison JC, Fitzpatrick DF, Gorga MP. Wideband aural acoustic absorbance predicts conductive hearing loss in children. Int J Audiol. 2012; 51: 880-91.
19. Feeney MP, Grant IL, Marryott LP. Wideband energy reflectance measurements in adults with middle-ear disorders. J Speech Lang Hear Res. 2003; 46: 901-11.
20. Voss SE, Rosowski JJ, Merchant SN, Peake WT. Middle-ear function with tympanic-membrane perforations. I. Measurements and mechanisms. J Acoust Soc Am. 2001; 110: 1432-44.
21. Shahnaz N, Bork K, Polka L, Longridge N, Bell D, Westerberg BD. Energy reflectance and tympanometry in normal and otosclerotic ears. Ear Hear. 2009; 30: 219-33.
22. Shahnaz N, Davies D. Standard and multifrequency tympanometric norms for Caucasian and Chinese young adults. Ear Hear. 2006; 27: 75-90.
23. CARHART R. Clinical application of bone conduction audiometry. Arch Otolaryngol (1925). 1950; 51: 798-808.
24. Hunter LL, Tubaugh L, Jackson A, Propes S. Wideband middle ear power measurement in infants and children. J Am Acad Audiol. 2008; 19: 309-24.
25. Anthony WP, Harrison CW. Tympanic membrane perforation. Effect on audiogram. Arch Otolaryngol. 1972; 95: 506-10.
26. Dempster JH, Swan IR. The management of otitis media with effusion in adults. Clin Otolaryngol Allied Sci. 1988; 13: 197-9.
27. Ayache D, Sleiman J, Plouin-Gaudon I, Klap P, Elbaz P. Obliterative otosclerosis. J Laryngol Otol. 1999; 113: 512-4.
28. Lerut B, Pfammatter A, Moons J, Linder T. Functional correlations of tympanic membrane perforation size. Otol Neurotol. 2012; 33: 379-86.
29. Mehta RP, Rosowski JJ, Voss SE, O'Neil E, Merchant SN. Determinants of hearing loss in perforations of the tympanic membrane. Otol Neurotol. 2006; 27: 136-43.
30. Voss SE, Merchant GR, Horton NJ. Effects of middle-ear disorders on power reflectance measured in cadaveric ear canals. Ear Hear. 2012; 33: 195-208.
31. Nakajima HH, Rosowski JJ, Shahnaz N, Voss SE. Assessment of ear disorders using power reflectance. Ear Hear. 2013; 34 Suppl 1: 48S-53S.

2024 REVIEWER INDEX

Adem Atıcı
Adil Umut Zübarioğlu
Ahmet İlker Tekkeşin
Anıl Demiröz
Atılım Atılgan
Atilla Celik
Atilla Çilengir
Ayşe Çiğdem Tütüncü
Basri Çakıroğlu
Bedia Çakmakoğlu
Beray Gelmez Taş
Bülent Babaoğlu
Ceki Paltura
Çigdem Çınar
Derya Baykız
Ebru Aytekin
Ece Gültekin
Emin Uysal
Ertuğrul Altınbilek
Esme Ekizoğlu Turgut
Guzin Zeren
Gülfidan Aras
Gürsel Soybir
Hakan Öztürk
Hanife Usta Atmaca
Işıl Akgun Demir
İbrahim Halil Erdem
İbrahim Murat Bolayırlı
İmran Kurt Ömürlü
Memduha Devren Taş
Meryem Keçeli Başaran
Mine Kucur
Miraç Özalp
Mustafa Çalık
Oğuz Yılmaz
Okan Gürkan
Ozan Doğan
Ozan Volkan Yurdakul
Özkan Onuk
Reşat Dabak
Rıdvan Sivritepe
Serpil Mungan Durankaya
Sinan Uslu
Süheyl Poçan
Süleyman Salman
Şakir Delil
Tamer Atasever
Teoman Akçay
Utku Eser
Yetkin Zeki Yılmaz
Zehra Dilek Dilek Kanmaz
Zeynep Mine Coşkun Yazıcı