CLINICAL STUDY

INVESTIGATION OF AUDITORY PROCESSING PERFORMANCE AND RISKS AFFECTING ACADEMIC ACHIEVEMENT IN CHILDREN WITH OTITIS MEDIA

Emre ORHAN PhD;[1] Nuriye YILDIRIM GÖKAY PhD;[1] Türkan Özlem BAYÜLGEN Msc;[2] Hakan TUTAR MD;[3] Bülent GÜNDÜZ PhD;[1]

[1]Gazi Üniversitesi Sağlık Bilimleri Fakültesi, Odyoloji, Ankara, Türkiye [2]Ankara Üniversitesi Sağlık Bilimleri Enstitüsü, Odyoloji ve Konuşma Bozuklukları Doktora Programı, Ankara, Türkiye [3]Gazi Üniversitesi Tıp Fakültesi, Kulak Burun Boğaz Anabilim Dalı, Ankara, Türkiye

SUMMARY

Objective: Otitis media can lead to various peripheral auditory effects, including conductive hearing loss, sensorineural hearing loss, and temporary threshold shifts. While the impact of otitis media on peripheral auditory function is well-established, its effects on central auditory processing. The main purpose of this study was to examine the possible effects on auditory processing skills and academic performance at the central level due to the negativity in the transmission of auditory stimuli in children with a history of chronic otitis media with effusion.

Materials and Methods: The study included 20 children with chronic otitis media with effusion and 20 controls aged 5-12 years. The participants were administered the "Auditory Figure Ground" test, the "Dichotic Monosyllabic Word" test and the "Akademik Başarıyı Etkileyen Riskleri Tarama Ölçeği".

Results: Auditory Figure Ground and Dichotic Monosyllabic Word test scores of children with otitis media were statistically significantly lower than controls ($p<0.05$). When the subcategories of risks affecting academic success were examined, the risk scores of children with otitis media were statistically significantly higher than controls ($p<0.05$).

Conclusion: Chronic otitis media with effusion affected children's auditory processing skills and academic success. These results emphasize the importance of early diagnosis and early intervention in otitis media.

Keywords: Academic achievement, auditory processing, otitis media

ORTA KULAK İLTİHABI OLAN ÇOCUKLARDA İŞİTSEL İŞLEMLEME PERFORMANSININ VE AKADEMİK BAŞARIYI ETKİLEYEN RİSKLERİN ARAŞTIRILMASI

ÖZET

Amaç: Otitis media, iletim tipi işitme kaybı, sensörinöral işitme kaybı ve geçici eşik kaymaları gibi çeşitli periferik işitsel etkilere yol açabilir. Otitis medianın periferik işitsel fonksiyon üzerine etkisi iyi bilinmekle birlikte, merkezi işitsel işleme üzerinde etkileri vardır. Bu çalışmanın temel amacı, kronik efüzyonlu otitis media öyküsü olan çocuklarda işitsel uyaranların iletilmesindeki olumsuzluğun, merkezi düzeyde işitsel işleme becerileri ve akademik performans üzerinde olası etkilerini incelemektir.

Gereç ve Yöntem: Çalışmaya 5-12 yaş arası 20 kronik efüzyonlu otitis media hastası çocuk ve 20 kontrol dahil edildi. Katılımcılara "İşitsel Şekil Zemini" testi, "Dikotik Tek Heceli Kelime" testi ve "Akademik Başarıyı Etkileyen Riskleri Tarama Ölçeği" uygulandı.

Bulgular: Otitis medialı çocukların Auditory Figure Ground testi ve Dichotic Monosyllabic Word test puanları kontrollerden istatistiksel olarak anlamlı derecede düşüktü ($p<0,05$). Akademik başarıyı etkileyen risklerin alt kategorileri incelendiğinde, otitis medialı çocukların risk puanları kontrollerden istatistiksel olarak anlamlı derecede yüksekti ($p<0,05$).

Sonuç: Efüzyonlu kronik otitis media çocukların işitsel işleme becerilerini ve akademik başarısını etkilemiştir. Bu sonuçlar otitis mediada erken tanı ve erken müdahalenin önemini vurgulamaktadır.

Anahtar Sözcükler: Akademik başarı, işitsel işlemleme, otitis media

INTRODUCTION

Otitis media, characterized by middle ear inflammation, is a common childhood ailment associated with various auditory and cognitive sequelae[1]. Otitis media can lead to various peripheral auditory effects, including conductive hearing loss, sensorineural hearing loss, and temporary threshold shifts[2]. These peripheral effects contribute to the overall auditory challenges experienced by children with otitis media. While the impact of otitis media on peripheral auditory function is well-established, its effects on central auditory processing (CAP) have gained increasing attention in recent years[3]. Potential mechanisms underlying CAP deficits in children with otitis media include neural plasticity, auditory deprivation, and the impact of chronic otitis media on the developing auditory system[4]. Chronic inflammation and recurrent

Corresponding Author: Emre ORHAN PhD. Gazi Üniversitesi Sağlık Bilimleri Fakültesi, Odyoloji, Ankara, Türkiye, E-mail: emreorhan9494@gmail.com

Received: 27 December 2024, accepted for publication: 12 January 2025

Cite this article: Orhan E., Yıldırım Gökay N., Bayülgen T. Ö., Tutar H., Gündüz B.. Investigation Of Auditory Processing Performance And Risks Affecting Academic Achievement In Children With Otitis Media. KBB-Forum 2025;24(1):013-019

infections may disrupt the normal maturation of auditory pathways, contributing to CAP deficits.

The neurobiological mechanisms underlying CAP deficits in otitis media involve the intricate interplay of neural structures responsible for auditory processing. Chronic inflammation and recurrent infections may disrupt the normal maturation of auditory pathways, affecting synaptic pruning, myelination, and neurotransmitter release[5]. Chronic otitis media can lead to periods of auditory deprivation, impacting the development and plasticity of central auditory pathways. The brain's ability to adapt to changing sensory input may be compromised, affecting the integration and interpretation of auditory stimuli[5,6]. The developing auditory system is particularly susceptible to disruptions caused by otitis media. Critical periods of auditory development may coincide with recurrent episodes of middle ear inflammation, influencing the refinement of neural circuits involved in central auditory processing[5,7]. When previous studies on this subject were examined, it has been revealed that it negatively affects verbal memory, dichotic listening skills, and long-term binaural hearing performance[8]. Although not specifically otitis media, a study investigating long-term binaural auditory processing in conductive hearing loss as a general title revealed that the process was negatively affected due to listening impairment and inadequate access to the stimulus[9]. The main purpose of this study was to examine the possible effects on auditory processing skills and academic performance at the central level due to the negativity in the transmission of auditory stimuli in children with a history of chronic otitis media with effusion.

MATERIAL and METHODS

This study was approved by the Gazi University Non-Interventional Clinical Research Ethics Committee (Decision No. 2021/515).

The study group (n=20) in the research sample was randomly selected from children diagnosed with chronic otitis media with effusion (10 male, 10 female). The participants were selected from patients between the ages of 5-12, without any additional disabilities, with no etiology of hearing loss other than otitis media, and with typical development. The control group (n=20) was selected from volunteer individuals in the same age group with no hearing loss, no previous ear infection/operation (10 male, 10 female), and no additional disabilities and typical development. Descriptive informations of the participants were shown in Table 1.

The "Auditory Figure Ground Test (AFG)" developed by Yalçınkaya and his colleagues in 2002 was applied to evaluate the auditory processing skills of the participants[10-12]. This test was applied in a quiet environment, (with Sennheiser HD206 over-the-ear headphones), by presenting a sound file from the computer, at a comfortable listening level above the threshold (by subjectively asking the participant whether they could hear the presented stimuli easily). In the AFG test, monosyllabic words were presented in speech noise called "speech babble". These words were created phonetically balanced and were included in the standard form of the test. Monosyllabic words were presented 8 dB above the noise level, with a signal-to-noise ratio of + 8. 25 words were presented to each of the right and left ears, and the participant was asked to repeat the words he/she heard. The percentages of correctly repeated words for each ear were analyzed[10-14]. There are two lists of 25 phonetically balanced words in the "Dichotic monosyllabic word test (DMW)". These words were presented simultaneously to each ear and the child was asked to repeat the word presented to only one ear. The number of words repeated correctly was recorded as the score for that ear. The scores were recorded separately for the right and left ears[11,15-20].

To subjectively evaluate the academic success of the participants; the "Screening Instrument For Targeting Educational Risk (S.I.F.T.E.R)" scale, originally developed by Anderson and his colleagues, was adapted as the "Akademik Başarıyı Etkileyen Riskleri Tarama Ölçeği (ABERTÖ)" by Yalçınkaya and his colleagues[21-24]. This scale included subheadings such as academic, attention, communication, class participation and school behavior and a total of 15 items. The scale items included questions about the student's success in class compared to his/her peers under the academic heading, his/her reading level, the student's

ability to sustain attention compared to his/her classmates under the attention heading, the student's vocabulary and language skills compared to his/her peers under the communication heading, and finally, the student's participation in class, completing homework on time and behavioral patterns compared to his peers under the classroom participation and school behavior headings. A 5-point Likert-type (5: upper, 1: lower) scoring system was used for the scale's scoring. The total scores obtained from each subheading of the scale were analyzed separately[22-24].

Statistical Analysis

SPSS (version 25) program was used in the analysis of the findings, and firstly the missing data and normal distributions of the data were examined. Normality assumptions were examined with Kolmogorov-Smirnov and Shapiro-Wilk Tests and histogram graphics, and all data met the parametric test conditions. Descriptive statistics of the data were presented as mean and standard deviation. DMW, AFG and ABERTO subparameter findings of the control and study groups were analyzed with "independent sample t-test". Correlation analyses were performed with "Pearson correlation analysis". Type 1 error level was determined as 0.05.

RESULTS

The scores of the study group on the Dichotic Monosyllabic Word test were statistically significantly lower compared to the controls. In addition, the scores of the study group on the Auditory Figure Ground test were statistically significantly lower compared to the controls. The findings of DMW and AFG tests were presented in Table 2.

When the subscales of ABERTÖ (attention, class participation, communication, and overall score) were analyzed, the sub-scale scores of the study group were statistically significantly lower compared to the control group. The subscale findings of ABERTÖ were presented in Table 3

While statistically significant positive correlations were observed between left ear AFG scores and ABERTÖ subscales of attention, communication and overall scores, no significant correlation was observed between class participation and left ear AFG scores (Table 4). Statistically significant positive correlations were observed between right ear AFG scores and all ABERTÖ subscales (Table 4).

While statistically significant positive correlations were observed between the left ear and right ear DMW scores and the ABERTÖ subscales of attention, class participation and overall scores, no significant correlation was observed between the communication subscale and DMW scores (Table 5).

Table 1: Descriptive informations of the participants

	Participants (n=40)		
	Controls (mean±sd) (n=20)	Study Group (mean±sd) (n=20)	p
Age	8.9±1.9	9±1.6	0.86
Duration of otitis media	3.8±1.6		
Pure Tone Average	9.2±2.9	21.8±3.4	<0.001

Table 2: Findings of DMW and AFG tests

	Study Group (n=20)	Controls (n=20)	p
	Mean±sd	Mean±sd	
DMWleft	17,15±2,18	19,2±1,7	0,002
DMWright	17,75±2,55	19,65±1,78	0,01
AFGleft	20,15±1,46	21,65±1,98	0,01
AFGright	21,10±1,80	23±2,02	0,003

DMW; Dichotic Monosyllabic Word, AFG; Auditory Figure Ground.

Table 3: Findings of subscales of ABERTÖ

	Study Group (n=20)	Controls (n=20)	p
	Mean±sd	Mean± sd	
Attention	9,65±1,49	13,7±1,38	< 0,001
Class Participation	9,35±1,22	13,2±1,23	< 0,001
Communication	7,4±0,99	11,55±1,35	< 0,001
Overall	58,2±8,59	65,95±5,10	< 0,001

Table 4: Correlations between AFG and subscales of ABERTÖ

n=40		Attention	Class Participation	Communication	Overall
AFGleft	r	0.32	0.30	0.32	0.33
	p	0.043	0.057	0.042	0.033
AFGright	r	0.39	0.39	0.35	0.45
	p	0.012	0.013	0.026	0.004

AFG; Auditory Figure Ground, r; Pearson Correlation Coefficient

Table 5: Correlations between DMW and subcales of ABERTÖ

n=40		Attention	Class Participation	Communication	Overall
DMWright	r	0.45	0.45	0.17	0.40
	p	0.003	0.003	0.27	0.010
DMWleft	r	0.46	0.47	0.23	0.31
	p	0.003	0.002	0.15	0.045

DMW; Dichotic Monosyllabic Word, r; Pearson Correlation Coefficient

DISCUSSION

Otitis media is the most common otological problem caused by labiopalatine fissure. Otitis media with effusion is a disorder in which fluid accumulation in the middle ear persists for three months or longer and usually causes damage to the tympanic membrane[25]. One of the main factors in the formation of otitis media is eustachian tube dysfunction. Both the tensor veli palatini and levator veli palatini muscles are responsible for the opening of the eustachian tube[26]. Abnormal placement of the muscles that elevate and stretch the soft palate muscles causes the eustachian tube not to open sufficiently and negative pressure to form in the middle ear[27]. The first years of life are critical for hearing and speech development, and middle ear problems that occur during this period pose a risk factor for language and speech development as well as learning disabilities. Another area of critical importance at this stage is auditory processing skills[27]. Many studies in the literature emphasize that auditory processing is activated from the first interaction with sound and therefore the first years of life are critical for the development of auditory processing[28]. It is

known that otitis media with effusion occurs frequently in early childhood. In a study conducted by Khavarghazalani et. al., it was stated that children between the ages of 1 and 5 had at least one history of otitis media with effusion[7]. Otitis media with effusion can cause hearing loss of up to 40 dB, especially in low frequencies, especially in its active period. According to data obtained from animal studies; conductive hearing loss can negatively affect the structures and functions of the auditory system. For example; unilateral conductive hearing loss can affect the relative dimensions of the dendrites in the superior olivary complex[29].

It is known that the population diagnosed with otitis media has poor language development, reading and writing skills, or academic achievement, and in addition, they have shorter auditory memories compared to their normal peers[29]. In addition, it is difficult to participate in ordinary activities due to hearing loss, and behavioral problems caused by social isolation can be observed[30]. Consistent with previous studies, the ABERTÖ subtest findings proved that the children diagnosed with otitis media included in this current study had academic problems and could not easily communicate with their peers.

When the right and left ear AFG scores were examined, it was seen that the scores of the study group were significantly lower than the values of the normal group ($p<0.001$). Binaural interaction includes the acoustic signals coming to the two ears and their neural connections[31]. It should not be forgotten that many daily listening activities are in the conditions of binaural interaction, localization of acoustic stimuli and signal discrimination in noise[32]. Especially the low scores obtained from the AFG subtest implied that it may indicate difficulty in understanding speech in the presence of background noise, difficulty in determining the source of the sound in noise and difficulty in using binaural cues. In addition, it has been stated that a history of recurrent otitis media in early childhood - even after otitis media treatment - carries a high risk of causing difficulty in listening skills in background noise and weakness in auditory memory in children[27]. The scores we obtained as a result of our study support the fact that children with otitis media may have poor performance in the detection and discrimination of acoustic stimuli in the presence of noise in daily listening environments ($p<0.001$).

In dichotic tests, different stimuli are presented to both ears simultaneously, thus providing the opportunity to evaluate binaural integration skills[33]. Binaural integration assessments provide information about the brainstem, cortical lesions and corpus collosum[7,34]. Dichotic listening also provides data about the ability to combine and separate acoustic stimuli[34]. It should be noted that poor performance in these skills can be observed as difficulty in understanding and distinguishing what is said when two people speak at the same time or difficulty in hearing in the presence of background noise[31]. Similarly, Khavarghazalani et. al., stated that children with a history of otitis media had temporal processing problems due to lack of appropriate auditory development when compared to the normal group[7]. When the results of both studies and many studies in the literature are examined, it is observed that findings supporting our study are obtained.

CONCLUSION

Chronic otitis media with effusion affected children's auditory processing skills and academic success. These results emphasize the importance of early diagnosis and early intervention in otitis media. Future studies can examine more comprehensive auditory processing skills in wider age ranges and document the effects of otitis media on auditory processing skills more comprehensively.

Financial and technical support: No financial and/or technical support was received for this study.

Conflict of interest: There is no conflict of interest.

REFERENCES

1. Bluestone CD, Gates GA, Klein JO, Lim DJ, Mogi G, Ogra PL, et al. 1. Definitions, Terminology, and Classification of Otitis Media. Annals of Otology, Rhinology & Laryngology. 2002;111(3_suppl):8-18.

2. Rovers MM, Schilder AG, Zielhuis GA, Rosenfeld RM. Otitis media. Lancet. 2004;363(9407):465-73.
3. Ertugrul O, Ozdamar OI, Ozluoglu LN. The evaluation of auditory processing skills and late latencies in children with ventilation tube history. International Journal of Pediatric Otorhinolaryngology. 2024;186:112145.
4. Haapala S, Niemitalo-Haapola E, Raappana A, Kujala T, Suominen K, Kujala T, et al. Effects of Recurrent Acute Otitis Media on Cortical Speech-Sound Processing in 2-Year Old Children. Ear and Hearing. 2014;35(3).
5. Gyawali BR, Kharel S, Giri S, Ghimire A, Prabhu P. Impact of Otitis Media With Effusion in Early Age on Auditory Processing Abilities in Children: A Systematic Review and Meta-Analysis. Ear, Nose & Throat Journal.0(0):01455613241241868.
6. Borges LR, Paschoal JR, Colella-Santos MF. (Central) auditory processing: the impact of otitis media. Clinics (Sao Paulo). 2013;68(7):954-9.
7. Khavarghazalani B, Farahani F, Emadi M, Hosseni Dastgerdi Z. Auditory processing abilities in children with chronic otitis media with effusion. Acta Otolaryngol. 2016;136(5):456-9.
8. Gan RWC, Daniel M, Ridley M, Barry JG. Quality of questionnaires for the assessment of otitis media with effusion in children. Clin Otolaryngol. 2018;43(2):572-83.
9. Graydon K, Rance G, Dowell R, Van Dun B. Consequences of Early Conductive Hearing Loss on Long-Term Binaural Processing. Ear Hear. 2017;38(5):621-7.
10. Yalçınkaya F, Belgin E. Konuşma ve lisan problemi olan ve olmayan çocukların uyarlanmış şaşırtmacalı kelime testi ile santral işitsel işlemleme performanslarının incelenmesi. Çocuk Sağlığı ve Hastalıkları Dergisi. 2003;46(3):195-202.
11. Bolulu A, Elkin N. İşitsel işlemleme, bozuklukları ve potansiyeller. Istanbul Gelisim University Journal of Health Sciences. 2019(8):816-26.
12. Keith RW. Development and standardization of SCAN-C test for auditory processing disorders in children. Journal of the American Academy of Audiology. 2000;11(08):438-45.
13. Domitz DM, Schow RL. A new CAPD battery?Multiple auditory processing assessment. 2000.
14. Schow RL, Seikel JA, Chermak GD, Berent M. Central auditory processes and test measures. 2000.
15. Turkyilmaz MD, Yilmaz S, Yagcioglu S, Yaralı M, Celik N. Computerised Turkish versions of tests for central auditory processing disorder. Journal of Hearing Science. 2012;2(1):30-5.
16. Yathiraj A, Vanaja CS. Criteria to classify children as having auditory processing disorders. American Journal of Audiology. 2018;27(2):173-83.
17. Ferreira GC, Costa MJ, editors. Variability of the dichotic sentence test in the test and retest of normal hearing adults. CoDAS; 2020: SciELO Brasil.
18. Fifer RC, Jerger JF, Berlin CI, Tobey EA, Campbell JC. Development of a dichotic sentence identification test for hearing-impaired adults. Ear and Hearing. 1983;4(6):300-5.
19. Jerger J, Martin J. Dichotic listening tests in the assessment of auditory processing disorders. Audiological Medicine. 2006;4(1):25-34.
20. Bayazıt O, Bayazıt O, Öniz A, Öniz A, Özgören M, Özgören M. Dikotik dinlemede dikkatin kulak tercihine etkisi. Dokuz Eylül Üniversitesi Tıp Fakültesi Dergisi. 2008;22(2):47-55.
21. Wilson WJ, Jackson A, Pender A, Rose C, Wilson J, Heine C, et al. The CHAPS, SIFTER, and TAPS?R as Predictors of (C) AP Skills and (C) APD. 2011.
22. Yalçınkaya F, Küçükünal IS, Özçelik ADÖ. Teachers" opinions regarding the symptoms of central auditory processing disorder in children with reading and writing difficulties. South African Journal of Education. 2020;40(2):1-9.
23. Yalçinkaya F, Türkyilmaz MD, Keith R, Harris R. THE SCAN-C (CHILDREN) IN TESTING FOR AUDITORY PROCESSING DISORDER IN A SAMPLE OF TURKISH CHILDREN. Journal of International Advanced Otology. 2015;11.
24. Anderson KL. Screening identification for targeting educational risk. Denver, Co: Educational Audiology Association. 1989.
25. Gani B, Kinshuck A, Sharma R. A review of hearing loss in cleft palate patients. International journal of otolaryngology. 2012;2012(1):548698.
26. Muntz HR. An overview of middle ear disease in cleft palate children. Facial plastic surgery. 1993;9(03):177-80.
27. Boscariol M, André KD, Feniman MR. Cleft palate children: performance in auditory processing tests. Brazilian journal of otorhinolaryngology. 2009;75(2):213-20.
28. Minardi C, Souza A, Netto MP, Ulhôa F, Feniman MR, Campos CF, et al. Auditory abilities in children with cleft lip and/or palate according to Fisher's. Acta Otorrinolaringológica Española. 2004;55(4):160-4.
29. Tucci DL, Rubel EW. Afferent influences on brain stem auditory nuclei of the chicken: effects of conductive and sensorineural hearing loss on n. magnocellularis. Journal of Comparative Neurology. 1985;238(4):371-81.
30. Kuo C-L, Lien C-F, Chu C-H, Shiao A-S. Otitis media with effusion in children with cleft lip and palate: a narrative review. International journal of pediatric otorhinolaryngology. 2013;77(9):1403-9.
31. Cameron S, Dillon H, Newall P. Three case studies of children with suspected auditory processing disorder. Australian and New Zealand Journal of Audiology, The. 2005;27(2):97-111.
32. Hornickel J, Kraus N. Objective biological measures for the assessment and management of auditory processing disorder. Current Pediatric Reviews. 2011;7(3):252-61.
33. Bellis TJ, Bellis JD. Central auditory processing disorders in children and adults. Handbook of clinical neurology. 2015;129:537-56.
34. Ma X. Comprehensive assessment of (central) auditory processing disorder in school age children with non-syndromic cleft lip and/or palate. HKU Theses Online (HKUTO). 2014.