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The Effect of Otitis Media with Effusion on Language and Cognitive Skills in School Age Children

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ABSTRACT

Objective: Otitis media with effusion (OME) is a common condition in childhood and can interfere with cognitive development. The fact that it can be easily overlooked causes it to become chronic and has negative consequences in the long term (1). The negative consequences of OME in terms of speech and language disorders include speech sound disorders and developmental language disorders. For this purpose, cases admitted to the speech and language therapy clinic were screened for OME consecutively, and its relationship with language disorders was analyzed.

Materials and Methods: 50 children aged 8 to 10 years without mental retardation and hearing impairment were evaluated with audiology, language, repetition (non-word and sentence), and visual perceptual tests. In addition to standard language assessment, narrative samples were obtained and analyzed which is considered a descriptive approach.

Results: 26 children were positive for OME. Children with OME scored lower on language and repetition tests. There was no significant difference between the groups with and without OME in terms of syntactic complexity, narrative skills and visual perceptual performance. The Mann-Whitney U test was used for the comparison of parameters between groups ($p<0.05$).

Conclusion: The presence of OME negatively affected language development. However, the structural complexity dimension of storytelling, complex sentence production performance, and visual perceptual skills were not affected negatively by OME. Although OME positivity is not accompanied by mental retardation and developmental delay, language development and verbal working memory may be negatively affected. OME should be routinely screened in childhood and should be addressed more closely in children with speech and language disorders.

Keywords: Otitis media with effusion, language development, speech sound disorder

INTRODUCTION

Otitis media with effusion (OME) or serous is an inflammation of the middle ear mucosa characterized by fluid accumulation in a preserved tympanic membrane and cavum tympani without signs and symptoms of acute infection (1). OME is extremely common in early childhood due to an immature immune system, frequent upper respiratory tract infections, and a shorter and more horizontal Eustachian tube than in adults (2). When OME becomes chronic, it can lead to hearing loss, cognitive dysfunction, behavioral problems, and academic failure, resulting in a reduced quality of life (3). When children with a history of chronic OME were compared with their healthy peers in terms of language development and auditory processing performance, articulation and phonemic discrimination skills were found to be negatively affected (4). Similarly, it was found that the longer the duration of the presence of OME in the cavum tympani, the more negatively expressive language skills were affected (5). The impairment of the acoustic-phonetic properties of auditory signals due to OME can lead to an incomplete and inaccurate encoding of speech sounds into phonological working memory and to the misconstruction of mental

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representations of words. Children with OME may not hear or could mis-hear short-duration and low-intensity morphemes (6). Since OME may lead to language-cognitive developmental delays, its presence in children with speech and language disorders should be investigated and its relationship with affected language areas should be demonstrated (7). For this purpose, school-age children admitted to a speech and language therapy clinic were screened consecutively for OME, and the effect of middle ear inflammation with effusion on the components of language was analyzed.

Language, as a basic expression of the human mind, is a code system that enables the emergence and transmission of thoughts and the continuity of communication between people (8). Semantic knowledge of concepts, actual use of words, and connotative/symbolic transfer of words constitute the semantic component of language (9). The syntactic/morphosyntactic side is the arrangement of words to form meaningful and regular sentences (10). Pragmatics refers to the full range of skills required for communicative purposes in the social context of language (11). Linguistic processing is closely related to executive functions such as planning, reasoning, abstraction, working memory, and inhibition (12). Turkish is a suffixal and morphologically rich language (13). Morphemes have critical importance in language comprehension and speech, and morphological processing is closely related to cognitive processes (14). The multilayered nature of language makes linguistic assessment difficult in clinical settings. Therefore, in addition to standardized tests, repetition tests (sentence and nonword repetition tests) and narrative tools that address the pragmatic dimension should be used.

The aim of this study was to draw attention to the importance of audiological evaluation and linguistic cognitive examination in school-age children to identify possible risks such as cognitive dysfunction, academic failure and social communication difficulties due to OME.

MATERIALS AND METHODS

Participants

50 monolingual Turkish-speaking children aged 8 to 10 years (23 girls, 27 boys; mean age 8.78±0.73 years) were included in the study. Ethics committee approval and voluntary consent were obtained from Istanbul Atlas University Ethic Committee (14.03.2023-24890) and in compiance with the Declaration of Helsinki. Inclusion criterias were an absence of developmental delay and primary neurological psychiatric diagnosis, a score of 100 or above on the Wechsler Intelligence Scale for Children-Revised (WISC-R), absence of symptoms of acute otitis media, and right and left ear pure tone hearing averages within the normal range (0-15 dB).

Acute otitis media includes otorrhea of middle ear origin, otalgia, middle ear fluid or effusion, and symptoms of acute local or systemic disease (15). Acute otitis media may also present with a type B tympanogram and is not defined as OME if

Table 1. Demographical and Clinical Information of Participants

	EOM	Age	Frequency	Percentage
Age	OME-	8	10	41.7
		9	9	37.5
		10	5	20.8
		Total	24	100
	OME+	8	10	38.5
		9	12	46.2
		10	4	15.4
		Total	26	100
	OME	SSD	Frequency	Percentage
SSD	OME-	SSD+	13	54.2
		SSD-	11	45.8
		Total	24	100
	OME+	SSD+	17	65.4
		SSD-	9	34.6
		Total	26	100
	OME	LD	Frequency	Percentage
LD	OME-	LD+	1	4.2
		LD-	23	95.8
		Total	24	100
	OME+	LD+	10	38.5
		LD-	16	61.5
		Total	26	100
	OME	Gender	Frequency	Percentage
Gender	OME-	Female	11	45.8
		Male	13	54.2
		Total	24	100
	OME+	Female	12	46.2
		Male	14	53.8
		Total	26	100

OME: otitis media with effusion; OME+: Presence of otitis media with effusion; OME-: Absence of otitis media with effusion; SSD: Speech sound disorder; SSD+: Presence of speech sound disorder; SSD-: absence of speech sound disorder; LD+: Presence of language disorder; LD-: Absence of language disorder.

clinical signs of infection are present (16). Type B tympanogram with a flat curve and normal canal volume is considered diagnostic criteria of OME (17). The otolaryngologist diagnosed OME by considering the clinical examination and bilateral type B values together. Children with bilateral type B results were grouped as otitis media with effusion positive (OME+); children with bilateral type A were grouped as otitis media with effusion negative (OME-).

Participants whose equivalent test score according to the Turkish Articulation and Phonology Test (SST) was below their chronological age were diagnosed as speech sound disorder (SSD). The verbal language composite score (VLSC), obtained from the Test of Language Development-Primary-Fourth Edition Turkish Version (TOLDP-4:T) was used to determine language development. Children with very poor, weak, and below-average VLSC scores were classified as language disorder (LD+), and children with average, above-average, advanced, and very advanced VLSC scores as an absence of language disorder (LD-).

Table 1 shows the distribution of clinical and demographic data.

Instruments

Audiological Assessment

Tympanometry is a technique to determine whether the ventilation and ossicles in the middle ear are normal. Abnormal tympanometry values indicate that the patient has a problem with the middle ear. In tympanometry, the response of the eardrum to different pressures and the pressure in the middle ear are evaluated. The results of tympanometry are categorized into three categories: harmonious movement of the eardrum against different pressure values (Type A); presence of fluid in the middle ear/perforation of the membrane (Type B); and cases of negative pressure in the middle ear due to a problem in the Eustachian tube/end stage of ear infection/allergy-related obstruction (Type C) (18).

Pure tone audiometry is used to determine the degree of hearing loss by recording the thresholds at which acoustic stimuli of different intensities are heard at frequencies of 125, 250, 500, 750, 1000, 1500, 2000, 3000, 4000, 6000 and 8000 hertz. According to pure tone average results, hearing loss grades are classified as normal hearing (-10 to 15 dB), very mild (16 to 25 dB), mild (26 to 40 dB), moderate (41 to 55 dB), moderate to severe (56 to 70 dB), severe (71 to 90 dB), very severe (> 90 dB) (19).

Language Assessment

TOLDP-4:T is a norm-referenced and standardized test that measures receptive and expressive language skills in children aged 4 to 8 years. It consists of 9 subtests: picture vocabulary, relational vocabulary, oral vocabulary, syntactic understanding, sentence repetition, morphological completion, word discrimination, word analysis and word articulation. By converting the raw scores of certain subtests into standard scores, the VLSC which consists of the composite score of listening, speaking, organizing, semantics, grammar, and the sum of all of them, is obtained. According to the VLSC, language development is classified as very poor (<70), poor (70-79), below average (80-89), average (90-110), above average (111-120), advanced (121-130) and very advanced (>130) (20). The reliability and validity scores of the TOLD-P:4: T has been conducted up to the age of 8 years and 11 months, and there is not yet a standardized test to assess the language development of Turkish-speaking individuals over the age of 8 years and 11 months in Turkey. 8 years and 11 months normative values were used for elder children. Since there were participants over the age of 8 years and 11 months in the study, both the VLSC score and whether there was a language disorder according to the VLSC score were categorized and a comparison was made between the groups.

Turkish Nonword Repetition Test *(*TNRT*)* performance is indexed to phonological working memory capacity and auditory attention skills. The TNRT is a practical tool used to distinguish children with developmental language disorder/risk from normally developing children. The test items are played to the participant once and then asked to repeat them. The correctly produced item is scored as 1 and the total number of correctly produced items is used as the score obtained from the test (21). In Turkey, there is no standardized test developed to determine phonological working memory capacity. Validity and reliability studies of the TNRT in Turkish-speaking school-age children are ongoing. However, there are studies comparing various disease groups and healthy subjects using TNRT in Turkish-speaking school-age children (22-23).

The Turkish Multilingual Sentence Repetition Test (LITMUS-TR) includes sentences in 5 different categories: subject-object-predicate sequences, what-whom questions, noun phrases, relative clauses, clausal adjuncts, conditional structures, and assesses morphosyntactic skills. Consisting of 30 sentences, LITMUS-TR is administered by repeating the sentence heard once. When the sentence is repeated completely correctly, it is scored as 1; otherwise, it is scored as 1 (24-25). Several studies have shown that sentence repetition tests can distinguish between children with language impairment and typical language development (26). Sentence repetition tests are therefore part of a group of language tests commonly used by clinicians to assess children's language skills. The TOLD-P:4: T includes a sentence repetition subtest, but compared to the LITMUS-TR, the sentences are longer, more complex, and contain more items. The sentences in LITMUS-TR are structured to contain a minimum of 11 and a maximum of 14 syllables and a minimum of 4 and a maximum of 6 words. In this way, the load on verbal working memory was balanced and the determinants of morphosyntactic structures on correct repetition performance were emphasized. LITMUS-TR normative studies in Turkish-speaking school-age children are ongoing.

Assessment of Speech Sound Disorder

The SST is a test that is used for screening and differential diagnosis of children with articulation and phonological problems and for which validity, reliability and standardization studies have been conducted. The Articulation Subtest measures the production of 24 phonemes in various positions in the word and the seven most common consonant phrases in Turkish in the context of picture naming. The auditory discrimination test measures the auditory-visual discrimination of 21 consonant phonemes in the smallest monosyllabic word pairs according to their phoneme position, form, and voicing/nonvoicing features. For example, the sounds /k/ and /t/ are different in terms of phoneme position and form, but they share the same in articulatory features (27).

Assessment of Narrative Skills

The Turkish version of Multilingual Assessment Instrument for Narratives-TR (MAIN) is one of the effective tools for analyzing the micro- and macrostructural features of narrative in children. By analyzing the narrative sample, it makes it possible to evaluate the semantic, morphosyntactic and pragmatic components of language. In this study, the number of complex sentences (main clause with a subordinate clause formed with a verb or inflected verb) productions interpreted in favor of syntactic maturation (28). The number of completed episodes (goal, attempt, outcome [GAO]), is considered the most effective indicator of story complexity (29).

Assessment of Visual Perceptual Motor Skills

The Bender-Gestalt Visual Motor Perception Test (BG), developed by Bender in 1938, measures the perception of visual stimuli and the ability to integrate visually perceived information into motor systems. In this test consisting of 9 drawings, each figure is placed on a separate page and it is asked to draw the pictures shown one by one in order. There is no time limit for the drawings, which are drawn sequentially using a single A4 size paper. A pencil and eraser are used for drawing. Preliminary Turkish validity and reliability studies were conducted by Ozer (30). The total score was obtained by calculating the participants' error scores. The child's drawings are scored according to the number of errors (30).

Statistical Analysis

The distribution of variables was calculated by Shapiro Wilk test. Likewise, two group comparisons were performed with Student t or Mann-Whitney U tests. All data are presented as mean ± standard deviation (SD), and p-values. Statistical analyzes were performed with SPSS IBM 25.0 and p-values <0.05 were considered significant.

RESULTS

Table 2 shows the cognitive and linguistic parameters of the participants. There was no significant difference between OME+ and OME- groups according to age (p>0.05). TNRT value of OME- group was significantly higher than OME+ group (p<0.05). The LITMUS-TR value of the OME- group was significantly higher than the OME+ group (p<0.05). There was no significant difference between OME+ and OME- groups according to BG, SSD, complex sentence, and GAO (p>0.05).

Table 2. Comparison of cognitive and linguistic parameters of the participants

	OME	N	Mean	SD	Z	p
Age	OME+	26	8.77	0.71	-0.042	0.967
	OME-	24	8.79	0.779		
VLSC	OME+	26	92.46	13.189	-4.002	**0.001***
	OME-	24	108.83	10.218		
SSD	OME+	26	0.65	0.48	-0.08	**0.423**
	OME-	24	0.54	0.5		
LD	OME+	26	0.38	0.49	-2.895	**0.004***
	OME-	24	0.41	0.2		
TNRT	OME+	26	8.5	2.486	-3.911	**0.005***
	OME-	24	11.79	2.449		
LITMUS-TR	OME+	26	16.46	4.658	-4.523	**0.002***
	OME-	24	23.75	4.089		
BG	OME+	26	9.27	4.618	-1.141	0.254
	OME-	24	10.58	4.211		
Complex Sentence	OME+	26	4.08	1.129	-0.425	0.671
	OME-	24	3.92	0.929		
GAO	OME+	26	0.5	0.51	-1.147	0.251
	OME-	24	0.71	0.624		

OME: otitis media with effusion; OME+: Presence of otitis media with effusion; OME-: Absence of otitis media with effusion; SSD: Speech sound disorder; VLSC: The verbal language composite score; TNRT: Turkish Nonword Repetition Test; LITMUS-TR: The Turkish Multilingual Sentence Repetition Test; BG: The Bender-Gestalt Visual Motor Perception Test; GAO: Goal, attempt, outcome.

The VLSC value of the OME- group was significantly higher than the OME+ group (p<0.05). The LD frequency of the OME+ group was significantly higher than the OME- group (p<0.05).

DISCUSSION

Various studies have shown that unilateral hearing loss negatively affects language and cognitive functions in children. (31). Similarly, the presence of middle ear cavity effusion without hearing loss may impair the perception of

phonetic and phonological features of speech sounds (32). In our study, the presence of isolated OME without hearing loss negatively affected language skills. There is a lot of evidence that OME is comorbidity with the SSD (33). Similarly, SSD was seen with a higher frequency in OME+ cases included in this study. Since SSD is the clinical counterpart of articulation disorder and auditory discrimination problems, it can cause social communication difficulties by negatively affecting the intelligibility of the individual (34). This situation can be considered as a finding that supports the need for OME screening in cases with SSD.

In this study, school-age children with and without OME were compared in terms of language skills and visuospatial functions. BG is sensitive to measuring the level of maturation necessary for the integration of the visual perceptual process into motor skills (35). BG performance is not affected by the presence of OME. The incidence of language disorders was found to be higher in the OME+ group. However, since children older than TOLD-P:4:T normative data were included, a comparison was made according to VLSC scores. VLSC scores were found to be lower in the OME+ group. Therefore OME+ can be considered a risk factor for language disorder. Descriptive analyzes are needed due to the fact that standard language assessments are norm dependent, do not provide clues for the use of language in social contexts, and are insufficient to reveal the strong and weak language skills of children who are unfamiliar with the test or who come from different cultural/ethnic backgrounds (36). For this reason, we used MAIN-TR to assess the children's storytelling and narrative skills in terms of complex syntactic production and story complexity.

Syntax, the structural basis of language, is defined as the organization/sequencing of words in sentences to express thoughts, feelings, preferences, and observations in a clear, precise, and efficient way. Syntax emerges in early childhood and continues to develop throughout childhood, adolescence, and early adulthood. With development, sentence lengths increase and sentences contain more dependent clauses (37). This increase in the number of clauses embedded in the main clause (complex sentence production) and their addition to independent clauses is considered a consequence of language maturation (38). The data obtained in this study show that the presence of OME does not lead to morphosyntactic involvement in expressive language.

MAIN-TR consists of stories with pictures in which the actions of the protagonists are clearly described. The narrator has to infer the character's motivation and triggering situations by interpreting the actions in the pictures. The inclusion of statements about the purpose of the protagonist's actions (Goal), the realization of the intended action (Attempt), and the outcome of the action (Outcome) within a story section (GAO sequences) is considered a structural complexity parameter. GAO is the highest level indicator of coherent storytelling ability (39). OME has no direct effect on the ability to produce plots based on temporal and causal relationships.

Clinical Significance of Repetition Tests

Sentence comprehension tasks in standard language assessment tools require the visual-spatial perception of pictures, storing the entire sentence in working memory to reach its final meaning, and directing attentional resources to the target in order to select the picture most relevant to the meaning. In sentence repetition tests, it is accepted that the cognitive load is relatively less because there is no visual processing and semantic judgment for the repetition of the heard sentence. Therefore, sentence repetition tests are preferred in children with language impairment in order to control the reflection of cognitive dysfunctions on language as much as possible. Repetition of short sentences may not require the use of working memory and implicit grammatical acquisition. However, long sentences may exceed memory capacity. The inability to repeat the sentence exactly may not be due to morphosyntactic difficulties but to the length of the target structure (40). For this reason, the sentences in LITMUS-TR were controlled in terms of sentence length, number of phrases, number of words/ suffixes and number of syllables in each sentence (41). In our study, it was observed that the LITMUS-TR sentence repetition scores of OME+ subjects were lower. It seems that OME has a negative effect on the morphosyntactic processing needed in sentence repetition.

Nonword repetition tests can measure the capacity of phonological processing and phonological working memory, which are considered critical skills in new word acquisition. In order to repeat a meaningless word without error, acoustic representations must be formed. Similarly, when a new word is heard for the first time, acoustic signals must be stored in auditory working memory until a connection is made between the real-world referent of the word and its phonological representation (42). In the case of OME, nonword performance is becoming poor. It leads to the conclusion that OME causes difficulties in the construction and storage of phonotactic and phonological representations of auditory verbal signals. In various studies, it has been revealed that EOM negatively affects verbal working memory performance (43-44). There are no studies directly addressing the relationship between EOM and repetition tests. The low scores of the EOM+ group in the LITMUS-TR and TNRT tests may be related to the determinant role of working memory on repetition performance.

In conclusion, OME causes language impairment despite normal hearing thresholds and negatively affects morphosyntactic and phonological processing. It has no effect on storytelling skills and visual-spatial copying performance. Although OME is one of the most common clinical pictures encountered by physicians providing outpatient clinic services for children, (32) easily overlooked and negatively affects the course of development in childhood (16). Therefore, OME should be routinely screened and treatment indications should be evaluated in childhood.

Limitations

One of the key limitations was the insufficient number of participants, which might have affected the statistical power and generalizability of the findings. Additionally, due to the inability to access the previous infectious otitis media history of the OME+ group, the formation of chronic and acute OME+ subgroups was not feasible. Furthermore, although the study included participants with type B tympanometry, a recognized indicator of OME, the lack of information regarding the frequency of previous infectious otitis media in the sample remains a constraint that needs to be addressed in future research. These limitations emphasize the importance of a cautious interpretation of the results and underscore the need for larger sample sizes and comprehensive data collection in future investigations on this subject.

Ethical Approval: Ethical approval of the study was obtained from Istanbul Atlas University Local Ethics Committee (14.03.2023-24890).

Ethical Committee Approval: N/A.

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