ORIGINAL ARTICLE

The Prevalence of Central Auditory Processing Disorder in Elementary School Students of Kerman, Iran

How to Cite This Article: Amizadeh M, Farahani S, Afsharmanesh J, Sharifi H, Fani Molky F. The Prevalence of Central Auditory Processing Disorder in Elementary School Students of Kerman, Iran. Iran J Child Neurol. Winter 2024; 18 (1) : 71-80

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Received: 22-Jan-2021
Accepted: 1-Jun-2022
Published: 18-Jan-2024

Abstract

Objectives

This study aimed to determine the prevalence of central auditory processing disorder (CAPD) in elementary school students in Kerman, Iran, during 2018-2019.

Materials & Methods

This cross-sectional study was conducted on 1369 elementary school students in Kerman. These students were selected by cluster sampling from different areas of Kerman and then screened using the Buffalo Model Questionnaire (BMQ). Based on the data obtained from the questionnaire, normal children were excluded from the study. Then, children with suspected central auditory processing disorder (CAPD) underwent ear exams and were excluded from the study in case of abnormal results in the tympanic membrane examination (rapture-effusion). The remaining subjects underwent peripheral audiometry evaluation, and children with abnormal audiometry were excluded from the study. Finally, the remaining children with suspicious screening results, a normal examination, and normal audiometry underwent a specific test to detect Central auditory processing disorder. Data analysis was carried out using SPSS software.

Results

One thousand three hundred sixty-nine primary school students with a mean age of 9.15 ±2.63 years enrolled in this study. 52%% of students were male. 8.03% of them had CAPD. A statistically significant relationship was found between the prevalence of CAPD and gender ($P<0.001$), place of residence ($P<0.001$), history of middle

ear inflammation (P<0.001) and history of head injury.

Conclusion

The quality of life of these students with CAPD can be improved via timely recognition of CAPD and the provision of appropriate preventive and therapeutic facilities.

Keywords: Central auditory processing disorder, Prevalence, Elementary school students, Audiometry

DOI: 10.22037/ijcn.V17 i 1. 33821

Introduction

Central auditory processing disorder (CAPD) is defined as a hearing impairment caused by impairment in the process of myelination, auditory development, temporal lobe dysfunction, and in other parts of central nervous systems (1-5). Auditory information processing is performed in the central nervous system and can affect other skills, including voice location, voice recognition, and hearing comprehension (6, 7). Undeniably, CAPD can be considered a hearing disorder despite a normal audiogram; it is a type of sensory disorder that generally impairs listening, learning, and language comprehension skills (8-13).This disorder can occur as an acquired or developmental disorder (14). Patients develop CAPD due to a specific lesion, such as head trauma, tumors, stroke, age-related functional deterioration, and infections (15). According to Simoes, the prevalence of this disorder is equal to 70% in the elderly and10-20%, in middle-aged people (16). Likewise, Geffner found a prevalence of 12% in children (17). Based on some statistics, boys suffer from this impairment more than girls (2:1) (16).

CAPD based on the Buffalo Model contains four categories: A) The tolerance-fading memory category refers to two skills commonly found together. One is the fading memory, the kid's auditory short-term memory, and the other is tolerance, the kid's ability to process language and understand speech in noise. An example of a tolerance-fading memory deficit is a poor ability to comprehend what one reads, express oneself orally, and write. B) The organization category involves sequencing errors and disorganized thinking. This also appears to be a sign of executive function and social communication deficits. Kids under this category often struggle to retrieve the words they need to respond in a conversation. C) The decoding category highlights the kid's ability to accurately and quickly process speech at the phonemic level. This has nothing to do with auditory stimuli as it only involves speech sounds. Unquestionably, the deficits in this area come from linguistic nature and poor phonemic awareness abilities. An example of decoding deficits is having trouble spelling and reading. D) The integration category may contain poor readers, kids who have trouble performing multimodal tasks, as well as

those who have trouble spelling. Furthermore, kids under this category have difficulty receiving visual and auditory information simultaneously (19). CAPD screening involves systematically evaluating auditory function and behavior. Individuals suspected of CAPD are identified through screening, carried out by a questionnaire or checklist (18). The questionnaires usually relate to the child's educational achievements, as well as listening and communication skills. Then, standard CAPD tests are performed. The standard CAPD tests include the A) Speech-In-Noise (Persian-SIN) Test , which assesses speech perceptual ability in a noisy environment, B) Staggered Spondaic Word Test (Persian-SSW) assessing the auditory perceptual ability of different words presented in both ears simultaneously (20, 21), and C) Phonemic Synthesis Test (Persian-PST) assessing the ability to combine phonemes to construct a word (22). When the result of CAPD test get positive, rehabilitation method will be proposed (23-25).

The results of previous studies have shown that if CAPD is not treated, obesity can reduce functional communication and thus lead to psychological effects such as loneliness, social anxiety, depression, fear, and anger (26). Hence, the present study aims to identify CAPD for prompt treatment. Early detection and initiation of suitable rehabilitation can enhance these children's educational and social outcomes and benefit their families and the broader community. Therefore, we have undertaken this research.

Methods & Materials

This cross-sectional study was carried out on 1369 elementary school students in Kerman (South of Iran) during 2018-2019. These students were selected by cluster sampling from different areas of Kerman. This study was approved by the Ethics Committee of Kerman University of Medical Sciences with the code of ethics IR.KMU.AH.REC1396.1687.

The inclusion criteria included elementary school students living in Kerman. Exclusion criteria were as follows:1) conductive hearing loss, 2) sensory neural hearing loss, 3) cases with a lack of vision sense, and 4) cases with a history of ear surgery.

At first, all students and parents were provided with the necessary explanations, and informed consent was obtained. Besides, the Buffalo Model Questionnaire (BMQ) was used for initial screening. This questionnaire has been used in published articles on central hearing loss and has good validity(4). This questionnaire includes memory impairment, speech perception, ability to perform sequential tasks, and the like(2). Based on the responses from the questionnaire, typically developing children were not included in the study—children suspected of having CAPD first received an ear examination. If any abnormalities, such as ruptured eardrums or effusion, were observed during the tympanic membrane exam, they were subsequently excluded from the study (rapture- effusion).

The remaining subjects underwent peripheral hearing assessment using the Astra 2 device for audiometry and the Zodiac model 901 for tympanometry. Based on audiometric results, children with abnormal audiometry were excluded from the study. Finally, the remaining children who had suspected screening, a normal physical

examination and audiogram were subjected to a specific test for CAPD. Specific tests for the diagnosis of CAPD used in the present study included P-PST and P-SSW. These two tests are standardized for children in Iran based on the Buffalo CAPD model (19-21). P-SSW examines the perceptual ability to understand words presented to both ears simultaneously (19, 20). P-ST test assesses the child's ability to combine phonemes for word construction (21). Then, data analysis was carried out using SPSS.

Results

One thousand three hundred sixty-nine primary school students enrolled in this study. 52% of the participants were male. The mean age of the participants was 9.15 ±2.63 years. The prevalence of CAPD was 8.03%. In patients with CAPD, the prevalence of CAPD was significantly higher in male students than female. (P-value < 0.001).

There was a statistically significant relationship between age and CAPD students. The highest (15.45%) and the lowest (2.29%) prevalence of CAPD was observed in 10-and7-year students, respectively. 79% of parents had a high school diploma or lower. No significant relationship was observed between parental education and the prevalence of CAPD in students (P-value= 0.79). The income level of most families was reported as lower than the normal range, but there was no significant relationship between family income and CAPD (P-value= 0.49). Of the 1369 students enrolled in the study, 10 had ADHD, while none of them had CAPD. The statistical analysis showed no statistically significant relationship between ADHD and CAPD (P-value= 0.34). 5.54% of all students and 0.49% of CAPD patients had learning disorders at school. Learning disorder was statistically higher in CAPD students. (P-value= 0.001).

Table 2 demonstrates that 48% of CAPD patients had reading difficulties, but only 0.04% of all students complained. A statistically significant relationship was found between ability to read and CAPD status. (P-value<0.001) Students with CAPD have more difficulty in reading.

Table 3 demonstrates that 9.5% of all students had a history of otitis media with effusion (OME), but about 51% of students with CAPD have a history of OME. Statistical analysis showed a statistically significant relationship between OME and CAPD (P-value< 0.001). Therefore, OME history plays a magnificent role in developing CAPD.

Seven students of all students had a history of head trauma, 4 of whom had CAPD. Statistical analysis showed a significant relationship between the history of head trauma and CAPD (P-value< 0.001).

Approximately 54% of all students and 7% of patients with CAPD lived in the urban area. The prevalence of CAPD in urban and suburban students was 11.77% and 3.65%, respectively. A statistically significant relationship existed between place of residence and CAPD (P-value< 0.001). In other words, the prevalence of CAPD was higher in urban areas.

Different defects of CAPD were investigated in 110 CAPD patients. The most common defect was a decoding-related defect, and the least observed defect was an organization defect. (Chart 1)

Table 1: Relationship between sex and CAPD

Sex	CAPD	Test		P-value
	Healthy	Patient	Total	
Male	626 87.19%	92 12.81%	718 100%	0.001
Female	633 97.24%	18 2.76%	651 100%	
Total	1259 91.96%	110 8.04%	1369 100%	

Table 2: Relationship between reading difficulty and CAPD

Ability to Reading	CAPD	Test		
	healthy	patient	total	P value
Nnormal	1225 94.01%	78 5.99%	1303 100%	0.001
Disrupted	34 51.52%	32 48.48%	66 100%	
Total	1259 91.96%	110 8.04%	1369 100%	

Table 3: Relationship between OME and CAPD

OME	CAPD	Test		
	Healthy	Patient	Total	P value
NO history of OME	1194 96.45%	44 3.55%	1238 100%	0.001
History of OME	64 49.23%	66 50.77%	130 100%	
Total	1259 91.96%	110 8.04%	1369 100%	

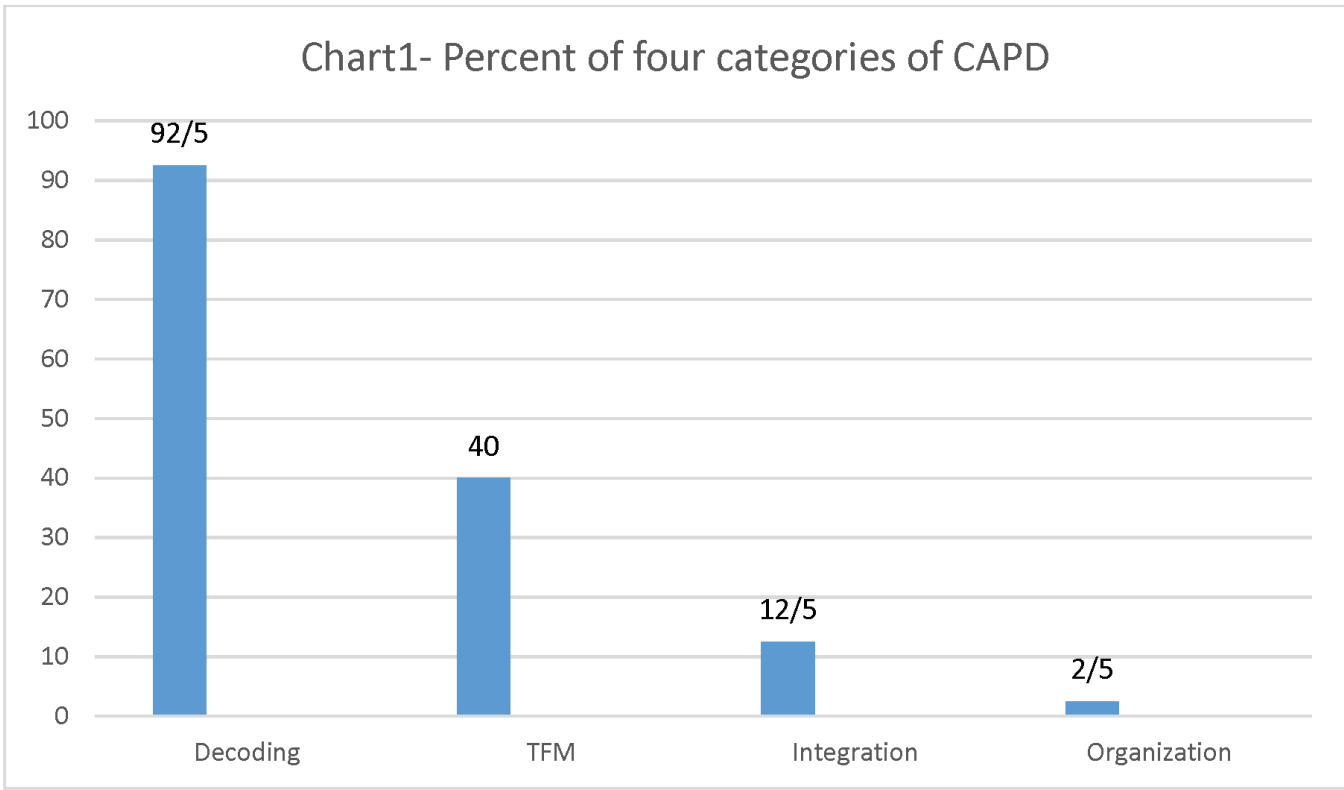

***Figure: percent** of four categories of capf*

Discussion

The present research results showed that the prevalence of CAPD was 8.03% in elementary school students in Kerman. In the Bamuie study, the prevalence of CAPD in children was 7% (27). The result of this study is not in agreement with the result of Shinn study addressing the prevalence of CAPD, which was 3% (3), and in the Pier study, the prevalence of CAPD was 3.9% (28). Additionally, Geffner et al. found that the prevalence of CAPD was about 12% (17). Such differences could be due to varied sample sizes.

In this research, 7-year-old children suffering from CAPD were the least (2.29%), while the children aged ten with CAPD were the most (15.45%). On the other hand, Piotr H et al. mentioned the prevalence of CAPD in children aged seven more than those aged 12 (29). These findings is not parallel to the current research. The reason can be due to distinguished tests and several cases.

The present study's results also revealed a statistically significant relationship between the prevalence of CAPD and sex. Seemingly, the prevalence of this disorder is higher in males than in females. In addition, the findings are consistent with the results of studies by Shinn et al.(3), Bamuie et al. (27), and Kats et al (30). However, it is inconsistent with the findings of Pier et al.'s research indicating that the prevalence of CAPD is equal in both sexes (28). According to the relevant reference books, the prevalence of CAPD in boys is more than double that of girls (1). likewise, Piotr H et al. reported that the prevalence of CAPD was higher in boys than girls (29).

The current research study's results also indicated a significant statistical relationship between the

prevalence of CAPD and the history of OME. These findings are parallel with the results of Bennet et al.'s study. Based on his result, 10-12% of children with CAPD had at least one period of OME at about five years of age (31).

The present study demonstrated a significant relationship between the history of head trauma and CAPD in the statistical analysis. Bregman et al. contended that 58% of patients with a history of head trauma suffered CAPD (32). Notably, the results of this study were consistent with Bergman's findings, while the sample volume of head trauma in this research was low.

The current study also showed a significant relationship between the place of residence and CAPD, suggesting that the prevalence of CAPD was higher in children living in the city than in children living in the suburbs. According to Nagao's study, the prevalence of CAPD in students in private schools was considered more than that in public schools (33). The above-mentioned findings are parallel to the current research. Notably, no reason was found for it. The reason might be that a few studies have been conducted in this field.

Correspondingly, the present study revealed a statistically significant relationship between learning disorder and CAPD, indicating that CAPD leads to learning disorder in children, and 49% of patients with CAPD had learning disorder. Selçuk Günes et al. investigated the relationship between learning disorder and CAPD. The findings revealed that children with learning disorders suffered CAPD more (34)10889D}.

Besides, a significant relationship was observed between CAPD and reading difficulty, with 29% of children with CAPD having reading difficulty. Piotr H et al. mentioned that school children with disturbed dichotic digits test (DDT) and CAPD suffered reading difficulty(29). Similarly, Kamhi stated that CAPD would be along with language and reading disorders.(35). Noticeably, this article's findings are consistent with the above-mentioned findings.

The relationship between CAPD and ADHD was investigated in the present study, but no significant relationship was reported. Meanwhile, Nagao considered ADHD as a comorbidity along with CAPD (33). According to Asma et al., the kids with ADHD suffered CAPD to a greater extent(36). Remarkably, the findings were not inconsistent with the present research. It seems crucial to mention that few kids (10 cases) underwent ADHD in this research.

Furthermore, no significant relationship was found between parental education level and family income with CAPD, which was not investigated in previous studies.

The present study also evaluated different CAPD defects that referred to decoding as the most common defect, and the least common was impairment of organization defect.

Limitation

The first limitation of the study was a considerable number of questions in the questionnaire led to little attention to the response. Another limitation was that parents filed in the questionnaire rather than students. Lack of parent's cooperation to refer to the audiometric clinic due to carrying out the test would be regarded as the last one.

In Conclusion

The results of the present study showed that the prevalence of CAPD in elementary school students of Kerman is 8.4%. The prevalence of the disorder was higher in males than females. The highest and the lowest prevalence was also seen in the ten and seven age groups. Furthermore, the results showed that a history of OME and head trauma would result in an increased incidence of CAPD. Moreover, the prevalence of this disorder was higher in students. The present study displayed the role of CAPD in reading disorders, hearing impairment, and learning disorders. The present study did not show any relationship between family income and ADHD with CAPD. Besides, further studies are needed to find out more about this disorder.

Acknowledgement

Special thanks to the Neurology Research Center, Kerman University of Medical Sciences and Kerman Department of Education for their sincere cooperation. The authors would also like to thank the Farahmand Language Center for the help. IR.KMU.AH.REC.1396.1687

Author's Contribution

Fatemeh FANI MOLKY Conceptualization, Methodology, Data collecting, Formal analysis, Investigation, Resources, writing _review & editing., Jila AFSHARMANESH :Data collecting Saeid FARAHANI MD: writing – review & editing. Hamid SHARIFI Formal analysis Maryam AMIZADEH Conceptualization, Methodology, Formal analysis, Investigation, Resources, writing – original draft, Writing – review & editing. All authors contributed to and have approved the final manuscript.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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