MedCrave
Step into the World of Research

Journal of Otolaryngology-ENT Research

Research Article

Open Access

CrossMark

Long-term follow-up of Egyptian adolescents and young adults with Auditory Processing Disorders (APD)

Abstract

Objective: To study the long-term follow up of young adolescents and adults formerly diagnosed with central auditory processing disorders.

Design: An Arabic version of the University of Cincinnati Auditory Processing Inventory questionnaire (UCAPI) was developed and standardized on normal Arabic speaking adolescents and adults. It was applied to patients with auditory processing disorders (APD) in order to evaluate the long-term outcome of APD subjectively. Moreover, psychophysical central auditory tests(Arabic speech in noise test, Arabic dichotic digit test, pitch pattern test, auditory fusion test and auditory memory tests were used as Objective measure for monitoring long term outcome.

Results: Standardization to the developed Arabic version of UCAPI questionnaire was done in the control group. Comparing scores of the study and control groups, independent t test showed highly statistically significant differences on all questionnaire categories. Normal composite score of psychophysical central retest results in the study group was 63.3%.

Conclusion: APD is a life-long disorder. In spite of the marked improvement of the central test results, patients show residual functional deficit as evidenced by the questionnaire. The Arabic version of UCAPI Questionnaire is a good and efficient tool diagnosing and monitoring APD in adolescents and adults.

Keywords: Auditory Processing Disorders, Auditory Tests, Pitch Pattern Test

Volume 14 Issue 2 - 2022

Somaia Tawfik,[1] Rasha Elkabarity,[1] Diana Hanna[2]

[1]Audiology Unit, ENT Department, Ain Shams University, Egypt
[2]Audiology Unit, ENT Department, Manshyet El-Bakry General Hospital, Egypt

Correspondence: Somaia Tawfik, Audiology Unit, ENT Dept, Ain Shams University, Abassia Street, Cairo, Egypt, Email dr_somaia@hotmail.com

Received: June 08, 2022 | **Published:** June 15, 2022

Introduction

Auditory processing has its roots in the mid 20th century, and much has been written about assessment of the central auditory system in the past 60 years.[1] Auditory processing disorder (APD) is defined as a deficit in the processing of auditory information. According to Canadian Interorganizational Steering Group for Speech-Language Pathology and Audiology (CISG), it is described as a generic term for hearing disorders that result from atypical processing of auditory information in the brain.[1] It is characterized by persistent limitations in the performance of auditory activities and has significant consequences. However, there is a lack of consensus regarding the nature of the disorder and there is some frustration among professionals that the term "APD" is insufficient.[2]

Because APD arises from dysfunction within the brain, and neuroplasticity enables the brain to change, auditory processing skills may improve with appropriate treatment in children whose auditory processing skills are not developing typically. With a combination of assistive and therapeutic approaches, there is growing evidence that auditory processing disorders can be effectively treated.[3] There is limited evidence to suggest that intervention for APD improves individual auditory processing abilities,[4] or that gains made in childhood transfer to adulthood.[5]

Few studies have been conducted on the long term follow- up of APD in adults. *Keith et al.*,[2] *Padilla et al.*[6] assessed the long term follow- up in adolescents and young adults who were previously diagnosed with APD. These studies showed limited evidence to suggest that APD intervention improves individual AP abilities. This indicated that long-term follow-up of auditory processing skills in children with APD have not been well-documented. *Del Zoppo et al.*[7] reported some listening and communication difficulties in children diagnosed with APD that seemed to persist into adulthood. While questionnaires are available to identify listening problems in the pediatric population, few are available for adolescent and adult populations. The University of Cincinnati Auditory Processing Inventory (UCAPI) was developed by *Keith et al.*[2] It was developed to describe the subject's profiles of listening problems in adolescents and adults. It should be noted that the UCAPI is not a diagnostic tool for listening disorders or APD; it simply documents problems of listening in a wide range of populations.[2] accordingly, this study is designed to develop Arabic version of UCAPD and apply it to APD adolescents and adults in order to assess long term outcome of APD

Materials and methods

Subjects

This study consisted of two groups, control group (to standardize the questionnaire) and study group. The control group consisted of (20) normal healthy normal young adolescents or adults (11 males & 9 females) with age range from 11 to 20 years. Criteria for inclusion were normal peripheral hearing with excellent speech discrimination scores and normal middle ears functions. They had normal language development and good scholastic achievement. The study group consisted of (20) young adolescents and adults, previously diagnosed with auditory processing disorders who attended the central auditory clinic. They were collected by reviewing all the files of the patients attending the central auditory processing clinic during the period from 2005 to 2015. The numbers of reviewed files were 303 patients and 120 were firmly diagnosed as having APD. Only a group of twenty Arabic speaking candidates participated in the study.

The average age at initial assessment was 8.5 with a range of 7-10 years. Follow -up evaluation was done at average age of 15.9

with a range of 12-19 years. The study group consisted of 14 males and 6 females. They all had APD with affection of one or more of central auditory abilities with average IQ. Criteria for exclusion were the presence of any associated neurological disorders such as epilepsy, brain malformation, and migraine as well as presence of neurodevelopmental disorders such ADHD, SLI and autism. History was taken from the study group about the previous complaints they had and the complaints at their recent follow up.

Most of them received rehabilitation (n= 14, 70%) with mean duration 11.8 month±12.6.

We have adopted the Arabic version of UCAPI questionnaire**.** The UCAPI was translated into Arabic to use it in the present study. This questionnaire was applied on the two groups: (control group) and mean, SD for every questionnaire item was obtained then applied on the (study) group.

The questionnaire includes seven demographic items about the subject's previous diagnostic, educational and occupational history. Demographic questions are not scored. Questions within the six categories contain multiple options that explore the subjects listening abilities under various conditions that are scored.

The questions fall into six categories including:

1. Listening and concentrating
2. Understanding speech
3. Following spoken instructions
4. Attention
5. Educational assistance
6. Other

Questions within the six categories contain multiple options that explore the subjects listening abilities under various conditions that are scored. The results include a total score and scores for each of the six listening categories and two general questions about hearing complaints. Subjects were asked to enter demographic data and mark the answer that best described their listening status. Responses were entered into a master Excel data sheet for analysis.

Results were plotted on a summary graph to determine the listening profile and gain an overall impression of disorders of auditory processing.

Standardization to the developed Arabic version of UCAPI of Questionnaire was done in the control group**.** Intra-observer test-retest reliability has been performed in the control group. 95% Confidence interval was done also to each questionnaire item. Basic audiological evaluation was applied to the control and study groups. It included pure tone audiometry (air conduction & bone conduction), speech audiometric and immittance test. Psychophysical Central Auditory Tests were applied only on the study group. These included speech intelligibility in noise (SPIN) test for adults,[8] to measure the ability of selective auditory attention, dichotic digits (D.D) test:[9] version I&II, pitch pattern sequence (PPS) test[10] to test for temporal ordering and sequencing ability, Auditory fusion test[11] to measure temporal resolution and auditory memory tests including: Recognition memory subtest, Memory for content subtest and memory for sequence subtest**.**[12] Every participant of the study group was subjected to test the abilities that were previously affected in their first visit to the central auditory processing clinic. Two subjects from the study group were not able to attend re-test. Their participation was maintained via questionnaires and included in the analysis.

An informed consent was taken from subjects prior to participation in the present study. The study protocol was approved by the Ethical Committee of faculty of medicine, Ain-Shams University.

Results & discussion

Both the study and the control groups were matched as regards age (15.9±2.1, 17.1±3.2 respectively). The present study showed APD was frequent in **males** more than **females** (14 males to 6 females)**.** Similarly, *Chermak & Musiek*[13] reported that APD are more frequent in males than females with a 2:1 ratio. As regards the educational level of the study group, the majority of them (N= 13, 65%) have completed preparatory school and joined high school, one participant only who have completed the high school and is studying now in college. Six subjects of the study group (30%) were delayed for one or two years due to learning difficulties. This also points to the fact that APD negatively affects scholastic achievement. Similarly, *Choi et al.*[14] concluded that auditory processing disorders could put children at greater risk for learning difficulties. This is a problem that generates a vicious circle - the poor self-concept that results from a multiple failure may lead the child with APD not to participate in classroom activities. This in turn, will have a negative effect on their ability to learn.[15]

All subjects in the study and control groups had bilateral normal peripheral hearing with excellent speech discrimination & normal middle ear function. The audiogram provides insight as to the sensitivity of the auditory system to simple stimuli, but that is of little value in providing information about other aspects of auditory function, such as suprathreshold processes such as discrimination, word recognition, and understanding speech in noise, temporal processing, binaural processing and other complex acoustic processes.[16] Standardization of the developed Arabic version of UCAPI Questionnaire was done in the control group. Intra-observer test-retest reliability has been performed in the control group, Alpha (Cronbach) Reliability analysis to validate the Arabic version of UCAPI questionnaire. The questionnaire was highly reliable in all categories. However, educational assistance and general questions could not be tested for reliably because they had the same scores at retest. This means that all categories & total scores of the questionnaire had good reliability, denoting that it can be applied in assessment and monitoring of APD as it is reliable and consistent or perhaps there is a learning effect such that subjects learn how to take the test.

Arabic version of UCAPI applied on the control group showed mean, SD and range in different questionnaire categories (Table 1). 95% Confidence interval also was done for determination any abnormality in the different questionnaire categories. Accordingly, scores above this 95% confidence interval were considered abnormal.

Table 1 Mean (x), standard deviation (SD), range and 95% CI of the scores of questionnaire items in the control group

Questionnaire categories	Mean	SD	Range		95% CI
			Min.	Max.	
Listening	11.4	2.4	8.0- 14.0		10.3- 12.5
Understanding speech	3	0.8	2.0- 4.0		2.6- 3.3
Following instructions	4.2	0.7	3.0- 5.0		3.8- 4.5
Attention	4.7	1	3.0- 7.0		4.2- 5.2
Educational assistance	4	0	4.0- 4.0		
Others	15.5	1.2	13.0- 17.0		14.9- 16
General questions	2	0	2.0- 2.0		
Total score	44.7	3.5	39.0- 52.0		43- 46.3

Comparing scores of both groups, independent t test showed elevated means in the study group with a highly statistically significant difference on all questionnaire categories (Table 2). Similarly, *Keith et al.*[2] reported that the majority of subjects had total UCAPI scores in the range of 30 to 69. Most of the study group has exceeded the 95% CI and have abnormal scores except for Listening category, 60% only had abnormal scores. This reflects poor performance of APD group. *Keith et al.*[2] also reported that persons with histories of difficulty learning through listening and poor performance on standardized tests of auditory processing, showed abnormal total and subtest findings on the UCAPI.

Table 2 Mean (X), standard deviation (SD), t-test and p value of the Arabic questionnaire scores in the study and the control groups

Questionnaire Categories	Group	Mean	SD	Range		t	P Value	Sig.
				Min.	Max.			
Listening	Study	16.7	6.6	8.0 -	28.0	3.37	0.002	HS
	Control	11.4	2.4	8.0 -	14.0			
Understanding speech	Study	4	1	2.0	6.0	3.8	0.001	HS
	Control	3	0.8	2.0 -	4.0			
Following instructions	Study	6	1.1	4.0 -	8.0	6.32	<0.001	HS
	Control	4.2	0.7	3.0 -	5.0			
Attention	Study	8.4	2.2	4.0 -	10.0	6.79	<0.001	HS
	Control	4.7	1	3.0 -	7.0			
Educational assistance	Study	9.6	3.5	4.0 -	16.0	7.09	<0.001	HS
	Control	4	0	4.0 -	4.0			
Others	Study	28.1	5.4	18.0 -	36.0	10.27	<0.001	HS
	Control	15.5	1.2	13.0 -	17.0			
General questions	Study	6	2.2	2.0 -	10.0	7.96	<0.001	HS
	Control	2	0	2.0 -	2.0			
Total score	Study	78.8	15.5	51.0 -	104.0	9.6	<0.001	HS
	Control	44.7	3.5	39.0 -	52.0			

The study group subjects were evaluated for the long-term effect of APD (Figure 1). The means of present scores were higher than the past scores across all central test results denoting significant improvement. However, for SPIN test, the improvement in mean average scores was not significant.

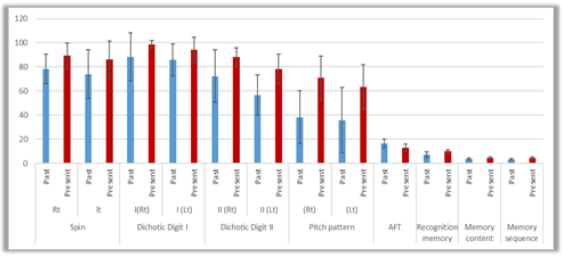

Figure 1 Bar chart representing the changes between past and present central auditory test results in the study group.

This improvement in the present study may be due to the effect of maturation of auditory pathway. Similarly, *Eggermont et al.*[17] reported that the normal development of the central auditory system, or thalamo-cortical maturation, follows a similar course to the maturation of AP skills.

Moreover, this improvement may be due to the effect of auditory training programs. There is emerging evidence that well-conceived AT programs can improve higher auditory function. *Musiek et al.*[18] illustrated that neural plasticity is demonstrated when the auditory system is trained and improves its function. This plasticity evolves because there are neurons held in reserve for these purposes or because synaptic endings are growing and making new connections. Similarly, *Padilla et al.*[6] reported improvements across all SCAN-3 subtests including Filtered Words, Competing Words, and Competing Sentences. However, for AFG (listening to speech in presence of background noise), the improvement in average scores was not significant. Similarly, they reported that those improvements in SCAN-3 Subtest were due to the effect of maturation of auditory pathway or may be due to the effect of training. The lack of significant improvement for AFG over several years suggests that the most common difficulty in auditory processing tends to persist among the children who have been diagnosed with APD. Accordingly, AFG is one of the tough abilities that need proper remediation duration which wasn't achieved in the subjects of the present study.

Despite the noticed improvement of recent central test scores, many APD subjects showed abnormal central auditory test results as shown by (Tables 3&4). Some of the study group reached normal test values. Others showed some improvement but still didn't reach normal scores. Since all subjects of the study group started with an initial diagnosis of APD, there was a reduction in the number of subjects with APD diagnosis from 100% to 36.7% (Table 5). This means that 36.7% of APD patients continue to have residual deficits in auditory skills. *Padilla et al.*[6] showed that 81% of children still present impairments in auditory processing areas several years after the initial APD diagnosis. The higher percentage of *Padilla et al.*[6] may be due to including either isolated APD affection or APD associated with other co-morbidities. While the present study included isolated APD.

The effect of the rehabilitation on the outcome of APD was assessed using the Mann-Whitney T Test and Spearman's Correlation. Neither the rehabilitation nor duration of training was statistically correlated with the subjective or objective outcome tests ($p > 0.5$) in the present study. This may be due to irregular course of rehabilitation received in most of the study group. A study by *Spyridakou et al.*[19] reported that intervention in children with AP difficulties has not been shown to transfer into adulthood. Also, *Baran*[5] speculated that compensatory intervention strategies developed in childhood may be less effective in adulthood, as affected individuals face changing environments with varying communication demands.

There was no obvious or direct effect of rehabilitation on the questionnaire scores (Table 6). Actually, the questionnaire couldn't

assess the effect of rehabilitation but could only detect the problem. However, *Keith et al.*[2] reported that none of the subjects who had been enrolled in SCAN retest had remediation programs that were specific to their APD.

Table 3 Normal versus abnormal present results of SPIN, Dichotic digit test and Pitch pattern sequence test

Test	Side	Present results	
SPIN (n=9)	Right	Normal Abnormal	3(33.3%) 6(66.7%)
	Left	Normal Abnormal	4(44.4%) 5(55.6%)
Dichotic digit test (n=13)			
I	Right	Normal Abnormal	10(76.9%) 3(23.1%)
	Left	Normal Abnormal	10(76.9%) 3(23.1%)
II	Right	Normal Abnormal	11(84.6%) 2(15.4%)
	Left	Normal Abnormal	10(76.9%) 3(23.1%)
Pitch pattern sequence (n=18)	Right	Normal Abnormal	11(61.1%) 7(38.9%)
	Left	Normal Abnormal	8(44.4%) 10(55.6%)

Table 4 Normal versus abnormal present results of auditory fusion and auditory memory tests

Test	Present results	
Auditory fusion	Normal	6(54.5%)
Test (n=11)	Abnormal	5(45.5%)
Memory tests (n=14)		
Recognition memory	Normal	6(42.9%)
	Abnormal	8(57.1%)
Memory for content	Normal	8(57.1%)
	Abnormal	6(42.9%)
Memory for sequence	Normal	8(57.1%)
	Abnormal	6(42.9%)

Table 5 Composite present score of central test results in the study group

Composite score	Mean (x)	SD	Median	Min- Max
Normal score	63.30%	27.1	63.5	25.0- 100.0%
Abnormal score	36.70%	27.1	36.5	0.0- 75.0%

Table 6 Correlation between the composite score of rehabilitation and total score of the questionnaire by Person correlation

	Total score of Questionnaire		
Composite score of rehabilitation	r	P value	Sig.
	-0.02	0.9	NS

In an attempt to illustrate the importance of questionnaires in monitoring the long-term follow up of APD patients, we have correlated our study central test results to questionnaire scores. The results showed an inverse relationship between UCAPI and central test results. That is, the higher the UCAPI score indicating problems of listening, the lower (poorer) the central test results indicating the presence of auditory processing disorder. Similarly, *Keith et al.*[2] reported that The results indicated an inverse relationship between UCAPI and SCAN-3:A test results.

Person correlation was done to study the correlation between the questionnaire scores & the duration of APD among the study group. There was no correlation between duration of APD & scores of questionnaire items except for Listening category.

In an attempt for analysis of the degree of improvement in the study group, they were classified to: Totally improved 4 subjects (22,2%) with normal APD scores **(group A)** & partially or not improved 14 subjects (77.8%) **(group B),** (Table 7). All of the following findings should be interpreted cautiously due to the limited sample number. A plotted profile was done for the two groups, the following criteria were observed: all of them had age range of seven to ten years at first diagnosis. **Group A** members had a single ability affection, despite **group B** had multiple ability affection. No one of **group A** failed at school. **Group B** had major number of complaints as learning difficulties, attention problems, memory problems and language problems. However, **group A** had learning difficulties as a major complaint. **Group A** didn't report any SPIN test abnormalities at their first diagnosis with APD. All patients in both groups had temporal processing disorders. Almost all **group B** had abnormal pitch pattern sequence followed by auditory memory test in 92%. This reflects presence of two affected abilities or even more that can hinder the efficacy of therapy and needs longer durations of training to be considered.[20,21]

Table 7 Profile of patients who improved versus who partially or not improved in the study group

Personal history	Totally improved group A (N=4) 22.2%	Partially/ not improved group B (N=14) 77.8%
Range of age at first diagnosis	7-10 years	7-10 years
(Previous C/O)		
Learning difficulties	+++	+++
Attention problems	+	+++
Memory problems	+	+++
Language problems	++	+++
Failed years in education	-----	+++

All members of **group A** received rehabilitation for temporal processing ability while **group B** didn't. Number and percent of patients in **group B** who received remediation programs were less than received number. *Tawfik et al.*[22] reported consistent long-term improvement for periods more than 6 months up to 4 years following auditory training. Accordingly, it is recommended to apply AT programs regularly for sufficient period of time so that APD patients can have better outcome. It is also crucial to counsel patients to accomplish AT programs regularly and intensively. All of the improved subjects received temporal processing training denoting efficacy of temporal processing training in improving APD outcome. A study by *Maggu et al.*[23] highlighted that temporal pattern training not only resulted in an improvement in process that was directly targeted (temporal patterning) but also in a process that was not directly targeted (auditory memory & sequencing).

Independent-Samples T test was performed to compare between the two groups as regards questionnaire scores. All means for questionnaire categories were higher in **group B** than **group A with** statistically significant differences in listening, following instructions, attention and the total score as shown by Table 9.

Table 8 Number and percent of patients who improved versus who partially or not improved as regards central auditory testing at their first diagnosis

Central auditory tests		Totally improved group A (N=4) 22.2%	Partially or not improved group B (N=14) 77.8%
		(N), (%)	(N), (%)
SPIN	Normal	4 (100%)	5 (35.7%)
	Abnormal	0 (0.0%)	9 (64.2%)
Dichotic	Normal	2 (50%)	3 (21.4%)
	Abnormal	2 (50%)	11 (78.6%)
Pitch pattern sequence	Normal	0 (0.0%)	0 (0.0%)
	Abnormal	4 (100%)	14 (100%)
Auditory fusion	Normal	2 (50%)	5 (35.7%)
	Abnormal	2 (50%)	9 (64.2%)
Auditory memory	Normal	3 (75%)	1 (7.1)
	Abnormal	1 (25%)	13 (92.9%)

Table 9 Mean (X), standard deviation (SD), independent t-test and p value of the Arabic questionnaire scores in the **group A** and **group B**

	Group	Mean	SD	Range		t	P Value	Sig.
				Min.	Max.			
Listening	Group B	18.6	6.2	9.0- 28.0		2.54	0.022	S
	Group A	10.3	3.2	8.0-15.0				
Understanding speech	Group B	4.1	1	2.0-6.0		1.18	0.254	NS
	Group A	3.5	0.6	3.0- 4.0				
Following instruction	Group B	6.1	1.2	4.0- 8.0		0.9	0.38	HS
	Group A	5.5	0.6	5.0- 6.0				
Attention	Group B	8.9	1.8	5.0-10.0		3.01	0.008	HS
	Group A	5.8	2.2	4.0- 9.0				
Educational assistance	Group B	10.6	3.7	4.0- 16.0		1.82	0.087	NS
	Group A	7	2	4.0- 8.0				
Others	Group B	29	5.3	18.0-36.0		1.76	0.098	NS
	Group A	23.8	4.9	19.0-28.0				
General questions	Group B	6.3	2.5	2.0- 10.0		0.95	0.355	NS
	Group A	5	2	2.0- 6.0				
Total score	Group B	83.6	14.1	63.0- 104.0		3.07	0.007	HS
	Group A	60.8	7.7	51.0- 69.0				

* Statistically significant $p < 0.05$

The questionnaire scores reflected the improvement which has occurred in group A (Table 9). All means for all questionnaire categories were elevated in **group B** than **group A** with apparent difference in the total score of the questionnaire denoting poor performance on all questionnaire categories in **group B**. However, **group A** showed slightly elevated scores than the control group. This enhances the role of UCAPI questionnaire in diagnosis and monitoring of APD.[2] The present study showed that even with total improvement in behavioral central testing in **group A**, there is still functional central auditory deficit which explained why APD complaints persist in adulthood. APD has been described as a developmental disorder[24] that may be life-long disorder for some individuals.[7]

Conclusion & recommendations

Arabic version of UCAPI questionnaire is an efficient tool for subjective evaluation and monitoring of APD in adolescents &adults. Accordingly, it is recommended to implement the questionnaire routinely in APD clinic. The application of APD intensive and regular rehabilitation programs can improve long term outcome of APD. Auditory temporal processing training can improve temporal processing as well as other auditory abilities such as auditory memory. It is recommended to apply temporal remediation programs as they have global effect on the outcome. In spite of the marked improvement as evidenced by follow- up central test results, patients showed residual functional deficit evidenced by questionnaire.

Conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Acknowledgements

The authors acknowledge Professor Robert W. Keith for the UCAPI for supplying the materials of the Questionnaire.

Funding

None.

References

1. Canadian guidelines on auditory processing disorder in children and adults: Assessment and intervention. *Canadian Inter organizational Steering Group for Speech-Language Pathology and Audiology* (CISG). 2012. .
2. Keith RW, Tektas M, Ramsay K, et al. Development and standardization of the university of cincinnati auditory processing inventory (UCAPI). *Int J Audiol*. 2019;58(6):373–378.
3. Chermak GD, Musiek FE. Handbook of central auditory processing disorder: comprehensive intervention.
4. Sharma M, Purdy SC, Kelly AS. A randomized control trial of interventions in school-aged children with auditory processing disorders. *Int J Audiology*. 2012;51(7):506–518.

5. Baran JA. Managing auditory processing disorders in adolescents and adults. *Semin Hear*. 2002;23:327–335.
6. Padilla J, Morlet T, Nagao K, et al. Speech perception capabilities in children a few years after initial diagnosis of auditory processing disorder. *Proceedings of Meetings on Acoustics*. 2016;25(1).
7. Del Zoppo C, Sanchez L, Lind C. A long-term follow-up of children and adolescents referred for assessment of auditory processing disorder. *Int J Audiol*. 2015;54(6):368–375.
8. Tawfik S, Shalaby A. Development and standardization of arabic central test battery in children. *Proceedings of the XXIII World Congress of the International Association of Logopedics and Phoniatrics*. 1995;25–31.
9. Tawfik S, Weiheba H, Abdel-Maksoud A. Standardization of two binaural dichotic digits and dichotic rhyme test on normal children. 2008.
10. Pinheiro M, Musiek FE. Assessment of central auditory dysfunction: foundations and clinical correlates. *The Journal of the Acoustical Society of America.* 1987;82(3):1609–1614.
11. McCroskey RL, Keith RW. Auditory fusion test-revised: instruction and user's manual. 1996.
12. Tawfik S, El-Danasoury I, Abdel-Maksoud A, et al. Auditory attention and memory tests for children: development, standardization and application. *The Egyptian Journal of otolaryngology*. 2002;19(2):31–43.
13. Chermak GD, Musiek FE. Central auditory processing disorders: New perspectives. *Singular*. 1997.
14. Choi SM, Kei J, Wilson WJ. Learning difficulties and auditory processing deficits in a clinical sample of primary school-aged children. *International Journal of Audiology*. 2020;59(11):874–880.
15. Bellis TJ. Assessment and management of central auditory processing disorders in educational setting. from science to practice. *Singular Publishing Group*. 1996.
16. Musiek FE, Shinn J, Chermak GD, et al. Perspectives on the pure-tone audiogram. *Journal of the American Academy of Audiology*. 2017;28(7):655–671.
17. Eggermont J, Ponton CW. Auditory-evoked potential studies of cortical maturation in normal hearing and implanted children: correlations with changes in structure and speech perception. *Acta Otolaryngol*. 2003;123(2):249–252.
18. Musiek FE, Shinn J, Hare C. Plasticity, auditory training, and auditory processing disorders. *Seminars in hearing*. 2002;23(4):263–276.
19. Spyridakou C, Luxon LM, Bamiou DE. Patient-reported speech in noise difficulties and hyperacusis symptoms and correlation with test results. *The Laryngoscope*. 2012;122(7):1609–1614.
20. Tallal P, Miller SL, Bedi G, et al. Language comprehension in language-learning impaired children improved with acoustically modified speech. *Science*. 1996;271(5245):81–84.
21. Bellis TJ. Assessment and management of central auditory processing disorders in the educational setting: from science to practice. 2003.
22. Tawfik S, Mohamed Hassan D, Mesallamy R. Evaluation of long-term outcome of auditory training programs in children with auditory processing disorders. *Int J Pediatric Otorhinolaryngol*. 2015;79(12):2404–2410.
23. Maggu A, Yathiraj A. Effect of temporal pattern training on specific central auditory processes. *Student Research at AIISH Mysore.* 2011;18–27.
24. Witton C. Childhood auditory processing disorder as a developmental disorder: The case for a multi-professional approach to diagnosis and management. *Int J Audiol.* 2010;49(2):83–87.

Citation: Tawfik S,Elkabarity R,Hanna D. Long-term follow-up of Egyptian adolescents and young adults with Auditory Processing Disorders (APD). *J Otolaryngol ENT Res.* 2022;14(2):32–37. DOI: 10.15406/joentr.2022.14.00502