ORIGINAL ARTICLE

Common vestibular disorders in children in Fayoum governorate: a cross-sectional study

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Abstract

Background: Vertigo in paediatric age is not a rare condition. However, a lack of awareness about causes of dizziness in children besides the absence of standard diagnostic workup often leads to unnecessary procedures in managing these cases. The purpose of this cross-sectional study was to determine the prevalence and frequency distribution of balance abnormalities in dizzy children. Additionally, the questionnaire's utility as a screening tool and its predictive accuracy are discussed. Thus, an organized strategy can be allocated to assist the diagnostic process, which is likely to eliminate unnecessary and costly evaluations.

Results: This study comprised 848 children who presented with any of the dizzy symptoms referred to the Audio-Vestibular Unit, Fayoum University Hospital. The suggested diagnosis was 23.9% of the cases suffered from otitis media either alone or combined with other diseases, while 17.6% had benign paroxysmal vertigo of childhood. Migraine patients represented 11.2% of the cases. Only 5.5% of subjects had benign paroxysmal positional vertigo. 78.3% of cases with possible diagnosis showed agreement in diagnosis by both paediatric dizziness questionnaire and the final diagnosis reached by a full assessment of the patients.

Conclusion: Diagnosing dizziness in children is challenging; nevertheless, a structured history taken in conjunction with a vestibular examination is crucial for establishing an accurate diagnosis. The questionnaire appears to be an even-handed tool for diagnosing dizzy children.

Keywords: Vertigo, Dizziness, Questionnaires, Audio-vestibular assessment, Dizzy child

Background

Dizziness is a common complaint that refers to various symptoms such as unsteadiness, imbalance, clumsiness, lightheadedness, and vertigo. Nonetheless, vertigo is a medical word that refers to a subjective or objective perception of movement that is frequently connected with vestibular system disorders [1].

Vertigo in paediatric age is not a rare condition, with about a 10% prevalence in most clinical trials; yet, young children are frequently unable to explain these different perceptions [2]. Vestibular disorders are recognized as the most common causes of dizziness in children, with a prevalence of 0.7–15%. However, the actual incidence of vertigo in the paediatric group remains underestimated due to the lack of exact clinical classification and solid diagnostic workup [3–6].

In addition to that, these disorders may often remain undiagnosed in children [7] as medical professionals may attribute symptoms to behavioural confusion or 'clumsiness' [8]; significantly, children may demonstrate behaviours such as clinging to the parent when experiencing dizziness or vertigo [9]. Above and beyond, vertigo in children constantly creates a profound sense of anxiety both in parents and physicians, leading to the excessive number of prescriptions for functional testing and imaging examinations [10].

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Accordingly, lack of awareness about causes of dizziness in children besides the absence of standard diagnostic workup often leads to unnecessary procedures in managing these cases [4]. The purpose of this cross-sectional study was to determine the prevalence and frequency distribution of balance abnormalities in dizzy children. Additionally, the questionnaire's utility as a screening tool and its predictive accuracy are discussed. Thus, an organized strategy can be allocated to assist the diagnostic process, which is likely to eliminate unnecessary and costly evaluations.

Methods
Subjects
The study design and settings
The purpose of this cross-sectional study was to determine the prevalence and frequency distribution of balance abnormalities in dizzy children. Additionally, the questionnaire's utility as a screening tool and its predictive accuracy are discussed. Thus, an organized strategy can be applied to assist the diagnostic process, which is likely to eliminate unnecessary and costly evaluations.

The study included 1007 children suffering from dizziness or vertigo. The study group underwent basic audiological and vestibular test batteries and filled in the questionnaire with their parents before testing. This study was conducted for four years, from August 2016 till February 2020, at the Audio-Vestibular Unit, University hospital.

Inclusion criteria:

1- Dizzy child presented by any following symptoms: unsteadiness, imbalance, clumsiness, light-headedness, or vertigo.
2- Age group between 6 and 18 years (females or males).

Exclusion criteria:

1- Any child who refused to complete testing (either child or guardian).
2- Any child with a known neurological disorder.

All subjects underwent

1- A thorough medical history taking: It includes a complete description of the dizziness complaint regarding frequency, duration, progression, and character. Also, precipitating and relieving factors were included. Any accompanying symptoms and medication received were documented.

2- Paediatric Dizziness Questionnaire [11]. (Shabana, M.I., Dabbous, A.O., Hosni, N.A. et al. (2012): Can scoring of symptoms in dizzy children aid the categorization of causes of dizziness for accurate referral?. Egypt J Otolaryngol 28, 214–233 https://doi.org/10.7123/01.EJO.0000418071.01257.ba) (Additional file 1).

Children and guardians filled it in. The questionnaire was developed in the light of a good knowledge of causes of childhood dizziness and with the help of previously validated questionnaires [11]: It included the following: (a) description of dizziness, (b) relevant medical history, (c) effect of dizziness on school, educational, and daily activities, (d) developmental and educational history, (e) relevant past medical history (and system review), and (f) family history. The questions were grouped into seven diagnostic categories reflecting the different systems involved in balance control, overlapping some category questions. There were 24 questions in each vestibular and neurological category; eight questions in the general classification; four questions in each of the cervical and ocular categories; six questions in the cardiovascular (CVS) category; and three questions in the psychological category. Therefore, a common denominator of 24 was used for our scoring system, with a total of 24 points for each of the seven major categories. Accordingly, the vestibular category was assigned 1 point for a 'yes' answer in each of the 24 questions and was defined as associated or not with hearing loss. The neurological category was assigned 1 point for a 'yes' answer for every 24 questions. The general category was given 3 points for a 'yes' answer for each of the eight questions. CVS category was assigned points for a 'yes' answer in each of the eight questions. The cervical category was given 6 points for a 'yes' answer for each of the four questions. The ocular category was assigned 6 points for a 'yes' answer for each of the four questions. The psychological category was given 8 points for a 'yes' answer for each of the three questions. A percentage of impairment score was obtained, and the total scoring of each system was described. The conclusions of the questionnaire were built based on the present history results of each category score, aided by any relevant data provided in the past medical or family history and system review. Thus, a conclusion was reached from the questionnaire for each child, that is, on an individual basis, which led to a particular direction in diagnosis. The referral results to different clinics were used to assess the questionnaire's ability to assign dizziness into diagnostic categories.

Scoring   Points assign to 'Yes' answers only.

Score of 100 = normal, and as score decreases, the system affection increases.

Questions with overlapping of categories assign points for each category.

Category	Number of items	Each item scores	Total Score
Vestibular	24	1	24
Neurological	24	1	24
General	8	3	24
CVS	6	4	24
Ocular	6	4	24
Psychological	3	8	24

3- Basic audiological evaluation:

- Pure tone audiometry: air conduction thresholds were tested at frequencies between 250 and 8000 Hz at octave intervals. Bone conduction thresholds were tested at frequencies between 500 and 4000 Hz, also at octave intervals with contralateral masking using narrow-band noise.
- Speech audiometry: Speech reception threshold (SRT) [12] and word discrimination scores (WDS) [13].
- Acoustic immittance testing: this included tympanometry and acoustic reflexes (ipsilateral and contralateral) using tone stimuli at 500, 1000, 2000, and 4000 Hz. The frequency of the probe used is 226 Hz.

4- Bedside examination:

a. Observing the child's gait and stance.
b. Romberg test: A Romberg test assesses the integrity of peripheral proprioception, cerebellar and vestibular functions [14].
c. Fukuda test: With unilateral vestibular lesions, this manoeuvre will elicit veering toward the affected side by more than 45°. With bilateral vestibular dysfunction, a significant forward displacement of more than 20 inches may be seen [15].
d. Dix-Hallpike positioning test: Turn the patient's head 45 degrees to one side& lay the patient supine with their head over the end of the examination bed, supporting their head with a hand on each side of the head. The result is positive if the patient develops symptoms (vertigo) and nystagmus, then repeat on the opposite side [14].
e. The head thrust test is a simple clinical manoeuvre that detects total unilateral or bilateral vestibular loss. The child fixes gaze on the nose of the examiner, who holds the child's head between their hands and then makes a very rapid (high-acceleration) 30° rotational movement to the right or left ('head thrust'), asking the child to keep the gaze fixed on the examiner's nose. When the head is rapidly turned toward the side of absent vestibular function, one or more 'catch up' saccades is observed.

Videonystagmography (VNG) VNG was performed using two-channel monocular Micromedical Mobile Eyes, where the camera can image the eye via a specialized mirror. Calibration was mandatory for accurate nystagmus recording. VNG subtests were occulography tests (smooth pursuit, saccade, and optokinetic), spontaneous nystagmus, gaze, positional, positioning, and caloric tests. The caloric test was in the following sequence: right cool, left cool, right warm, and left warm. The irrigation lasted for 40 seconds using an air caloric irrigator.

Temperatures were 25°C for cold air and 49°C for warm air; the airflow rate was maintained at 8 liters per minute. Subjects were asked to perform a mental task to maximize the response during the recording. A software algorithm was used automatically to calculate unilateral weakness, directional preponderance, and total eye velocity using standard formulae. Threshold values for caloric testing according to Bárány Society Consensus document [16]: unilateral weakness greater than (20 to 25%) is significant. Average caloric responses of a total caloric response <12°/s are diagnostic of bilateral deficiency.

Equipment:

a. Audiometry: Interacoustics AC40 calibrated according to the ISO standards.
b. Immitancemeter: Interacoustics AT235 calibrated according to the ISO standards.
c. Videonystagmography: computerized 2-channels VNG Micromedical.

The vertigo diagnoses were based on standard published criteria. For benign paroxysmal vertigo of childhood, we used *The International Classification of Headache Disorders, 2018* [17].

Diagnostic criteria:

A. At least five attacks fulfilling criteria B and C

Elghaffar *et al. The Egyptian Journal of Otolaryngology* (2022) 38:26

Page 4 of 13

B. Vertigo occurring without warning, maximal at onset and resolving spontaneously after minutes to hours without loss of consciousness

C. At least one of the following five associated symptoms or signs:

1. Nystagmus.
2. Ataxia.
3. Vomiting.
4. Pallor.
5. Fearfulness.

D. Normal neurological examination and audiometric and vestibular functions between attacks

E. Not attributed to another disorder.

Diagnostic criteria used for vestibular migraine according to The International Classification of Headache Disorders 3rd edition 2018 [17].

A. At least five episodes fulfilling criteria C and D

B. A current or history of *migraine without aura* or *migraine with aura.*

C. Vestibular symptoms of moderate or severe intensity, lasting between 5 minutes and 72 hours

D. At least half of episodes are associated with at least one of the following three migrainous features:

1. Headache with at least two of the following four characteristics:

   a. Unilateral location.
   b. Pulsating quality.
   c. Moderate or severe intensity.
   d. Aggravation by routine physical activity.

2. Photophobia and phonophobia.
3. Visual aura.

E. Not better accounted for by another ICHD-3 diagnosis or another vestibular disorder.

We required typical case medical history and a positive finding in the Dix Hallpike maneuver to diagnose benign paroxysmal positional vertigo. Vestibular neuronitis was diagnosed based on a sudden onset of severe rotatory vertigo, spontaneous horizontorotatory nystagmus, and a lack of neurologic signs that could indicate central nervous system involvement.

For Ménière's disease (MD), we used the American Academy of Otolaryngology-Head and Neck Foundation criteria, 2014 [18].

Statistical analysis

Data were collected and coded to facilitate data manipulation and double entered into Microsoft Access. Data analysis was performed using Statistical Package of Social Science (SPSS) software version 18 in windows.

Simple descriptive analysis in numbers and percentages for qualitative data, arithmetic means as central tendency measurement, standard deviations as a measure of dispersion for quantitative parametric data.

Quantitative data included in the study was first tested for normality by the One-Sample Kolmogorov-Smirnov test in each study group, then inferential statistic tests were selected.

For quantitative parametric data

In-depended Student's *t*-test used to compare measures of two independent groups of quantitative data

For qualitative data

Chi-square test to compare two of more than two qualitative groups. The *p*-value ≤ 0.05 was considered the cut-off value for significance.

Results

A cross-sectional study design was implemented to assess the prevalence and frequency distribution of balance disorders in dizzy children referred to the Audio-Vestibular Unit, Fayoum University hospital and the role of questionnaire to serve as a screening tool and its accuracy to predict the diagnosis during four years from August 2016 till February 2020.

This study comprised 1007 children who presented with any of the following dizzy symptoms; unsteadiness, imbalance, clumsiness, light-headedness, or vertigo. However, 159 children refused to continue vestibular testing while conducting this study. They mainly refused to complete caloric testing and ocular motor assessment.

The study group consisted of 848 children, ranging from 6 to 18 years with a mean age of 10.86 ± 3.7 years, suffering from dizziness. They included 407 males and 441 females. Regarding sex distribution, 52% of the study group were females versus 48% males, with 30.5% showing positive family history, as shown in Table 1 excluding children who refused to continue the tests.

The description of different Peadiatric Dizziness Questionnaire items scores; first, the vestibular category the mean was (8.3 ± 3) ranged between 2 and 19, the neurological part the mean was (5.6 ± 3.7) ranged between 1 and 15, as regards general items the mean was (7.3 ± 4.9) ranged between 0 and 24, for CVS the mean was (4.2 ± 4.2) ranged between 0 and 16, for the ocular category the mean, was (3.2 ± 4.6) ranged between. Finally, for the psychological part, the mean was (3 ± 5.5) ranged

Elghaffar *et al. The Egyptian Journal of Otolaryngology*   (2022) 38:26

Page 5 of 13

Table 1 Description of demographic characters among the study group

Variables	Number ($n = 848$)	
Age (years)		
Mean /SD	10.86	3.7
Sex		
Male	407	48%
Female	441	52%
Family history		
Negative	589	69.5%
Positive	259	30.5%

Table 2 Description of differences of Pediatric Dizziness Questionnaire categories scores among the study group

Score items	Mean	SD	Range
Vestibular	8.3	3	2–19
Neurological	5.6	3.7	1–15
General	7.3	4.9	0–24
CVS	4.2	4.2	0–16
Ocular	3.2	4.6	0–24
Psychological	3	5.5	0–24
Total score	31.6	18.4	8–87

Table 3 Types of hearing loss in the study group

	study		Ears
	No.	%	
Normal	523	61.7%	1155
Unilateral CHL	68	8%	68
Bilateral CHL	143	16.9%	286
Unilateral SNHL	41	4.8%	41
Bilateral SNHL	67	7.9%	134
Bilateral mixed	6	0.7%	12
Total	848	100%	1696

Table 4 Type and degree of hearing loss in the study group

Variables ($n = 848$)	PTA results	
	Number	%
Right side hearing		
Normal	578	68.2%
Conductive	162	19.1%
Sensorineural	102	12%
Mixed	6	0.7%
Left side hearing		
Normal	577	68%
Conductive	192	22.7%
Sensorineural	73	8.6%
Mixed	6	0.7%
Degree of hearing loss on the right side ($n = 270$)		
Mild	174	64.4%
Moderate	49	18.1%
Severe	47	17.4%
Degree of hearing loss on the left side ($n=271$)		
Mild	179	66.1%
Moderate	44	16.2%
Severe	48	17.7%

between 0 and 24, as regards total score, the mean was (31.6 ± 18.4) ranged between 8 and 87 as shown in Table 2.

The basic audiological evaluation comprised both PTA & tympanometry. As for PTA results: 24.9% of the study group had conductive hearing loss, either unilateral (8%) or bilateral (16.9%), followed by 12.7% for sensorineural hearing loss, either unilateral (4.8%) or bilateral (7.9%) and 0.7% for mixed hearing loss Table 3. For the degree of hearing loss, most cases showed a mild degree of hearing loss, 64.4% on the right side versus 66.1% on the left side. Also, 18.1% of them had a moderate degree of hearing loss on the right side versus 16.2% on the left side, and 17.4% of them showed a severe degree of hearing loss on the right side versus 17.7% on the left side, as shown in Table 4. Tympanometry could not be done in 1.5% of the study group on the right side versus 2.6% on the left side. 80.9% showed type A tympanogram on the right side, versus 77.4% on the left side, type B represented 14.6% of the study group on the right side versus 16.6% on the left side, for type C tympanogram, it represented 2.9% on the right side and 3.4% on the left side as shown in Table 5.

Regarding VNG testing results: only 3.3% of cases (28 children) showed spontaneous nystagmus. Nineteen were of peripheral origin versus 9 of them of central source. Horizontal-torsional spontaneous nystagmus in peripheral vestibular disorders is suppressed by fixation. Nystagmus, purely horizontal, vertical, or torsional, usually has a central cause [19].

During conducting the positional tests (head supine, head right & head left), 83 cases only (9.8%) had nystagmus, 34 cases of them, the positional nystagmus was the only positive finding, while the remaining cases, most of them were suffering from bilateral mild conductive hearing loss; either otitis media with effusions or chronic suppurative otitis media. 62.7% of patients showed right beating nystagmus on the head left versus 37.7% showed left beating nystagmus on head right.

Elghaffar *et al. The Egyptian Journal of Otolaryngology*   (2022) 38:26

Page 6 of 13

Table 5 Frequency of different tympanometry results among the study group

Variables (n = 848)	Tympanometry results	
	Number	%
Right side tympanometry		
Not done	13	1.5%
Type A	686	80.9%
Type B	124	14.6%
Type C	25	2.9%
Left side tympanometry		
Not done	22	2.6%
Type A	656	77.4%
Type B	141	16.6%
Type C	29	3.4%

Table 7 Canal weakness among the study group

Variables (n = 848)	Caloric test assessment	
	Number	%
Normal	658	77.6%
Right canal weakness	108	12.7%
Left canal weakness	77	9.1%
Bilateral vestibular weakness	5	0.6%

Positive Dix-Hallpike test (head hanging to the right& head hanging to the left) was recorded in only 47 cases (5.54%). Torsional up-beating nystagmus on the right Dix-Hallpike in 25 cases versus torsional up-beating nystagmus on the left Dix-Hallpike in 22 cases.

Only 8.6% of cases showed abnormal saccades (slow velocity, inaccuracy), and 8.4% showed low gain smooth pursuit and asymmetry. Finally, 8.4% of cases had low gain OPK, as shown in Table 6.

According to Bárány Society Consensus document [16]:185 cases (21.8%) had canal paresis on caloric testing: 108 patients showed right canal paresis while 77 patients showed left canal paresis as shown in Table 7. Only 5 cases showed bilateral vestibular weakness; ototoxic drugs caused two of them. One case was associated with autoimmune disease, one case was associated with cerebellar degeneration and other neurological disorders, and the last one was idiopathic. Unilateral weakness is indicative of a peripheral vestibular lesion that involves the nerve or end-organ on the side of the weakness. In many clinics, a unilateral weakness greater than 25% is significant. Average caloric responses of six degrees per second or less are consistent with a bilateral weakness.

The suggested diagnosis reached was that 23.9% (203 cases) of the cases suffered from otitis media-related dizziness either alone (94 cases) or combined with other diseases (109 cases). In comparison, 17.6% (149 cases) of the cases had benign paroxysmal vertigo of childhood. Migraine patients represented 11.2% (95 cases) of the cases. Only 5.5% of cases (47 cases) had benign paroxysmal positional vertigo, versus 4.4% of cases (37 cases) had vestibular neuritis or labyrinthitis. Less common causes as cholesteatoma, ototoxicity, perilymph fistula, enlarged vestibular aqueduct, Meniere, and labyrinthine hydrops were collectively represented in less than 3% of cases. Neurological causes represented 6.6% of cases (56 cases) as follow: epilepsy (2.2%), benign intracranial hypertension (1.4%), brain tumours (0.94%), meningitis (0.82%), Arnold Chiari malformations (0.35%), multiple sclerosis (0.12%) , stroke (0.12%) and other neurological disorders (0.59%) as shown in Table 8.

General causes as anaemia, DM, and other endocrinal disorders represented 13.9% of cases (118 cases) either alone (56 cases) or combined with other diseases (62 cases). Cardiovascular disorders were found in 3.1% of cases (26 cases) either alone (14 cases) or combined with other conditions (12 cases), while ocular disorders were found in 1.8% (15 cases) of the cases. We could not reach a possible diagnosis in 20.5% of cases (174 cases), as shown in Table 8. 20.5% of patients had unexplained dizziness, versus 79.5% had causes for dizziness as follows: 41.5% had only vestibular causes, 6.6% of them had only neurological causes, and the same percentage for general causes, followed by 1.7% for cardiovascular causes, 12.9% showed combined vestibular and neurological causes, 7.3% had connected vestibular and general causes, 1.5% for combined vestibular and ocular disorders, and finally 1.4% for the combination of vestibular and cardiovascular diseases with total percent of 23.1% for different combined causes as shown in Fig. 1.

According to the paediatric dizziness questionnaire, 36.2% of cases were diagnosed as vestibular dizziness,
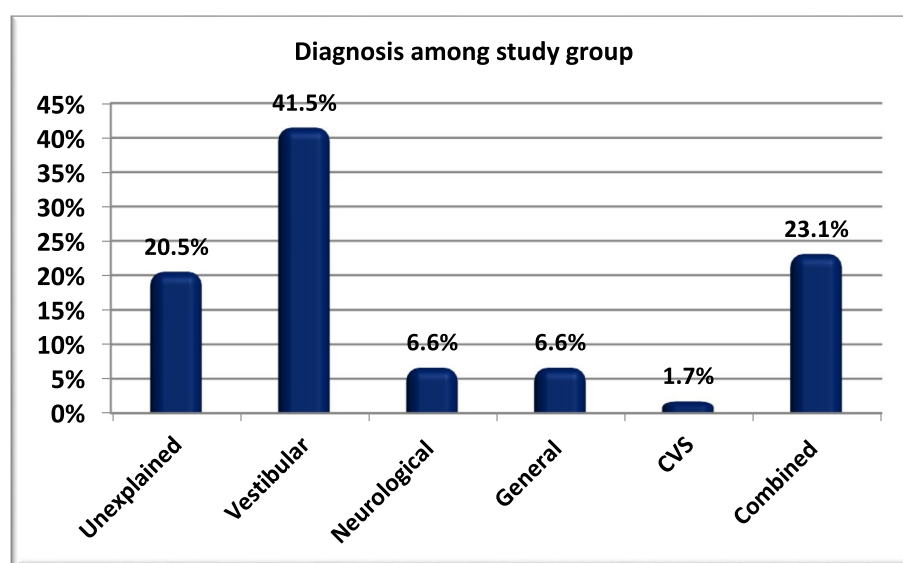
Table 6 Ocular-motor assessment among the study group

Variables	Ocular-motor assessment	
	Number	%
Saccade		
Normal	775	91.4%
Slow velocity, inaccuracy	73	8.6%
Smooth pursuit		
Normal	777	91.6%
Low gain and asymmetry	71	8.4%
OPK		
Normal	777	91.6%
Low gain and asymmetry	71	8.4%

Table 8 Diagnosis among the study group

Variables	Number (n = 848)	%
Otitis media-related dizziness	203	23.9%
Benign paroxysmal vertigo of childhood	149	17.6%
Migraine	95	11.2%
Benign paroxysmal positional vertigo	47	5.5%
Vestibular neuritis or labyrinthitis	37	4.4%
cholesteatoma	8	0.9%
ototoxicity	5	0.6%
Perilymph fistula	5	0.6%
Enlarged vestibular aqueduct	4	0.5%
Meniere or labyrinthine hydrops	3	0.35%
General	118	13.9%
Cardiovascular	26	3.1%
Ocular	15	1.8%
Epilepsy	19	2.2%
Benign intracranial hypertension	12	1.4%
Brain tumours	8	0.94%
Meningitis	7	0.82%
Arnold Chiari malformations	3	0.35%
Multiple sclerosis	1	0.12%
Stroke	1	0.12%
Other neurological disorders	5	0.59%
Unexplained	174	20.5%

15.1% for general causes, 10.5% for psychological causes, 5.8% for neurological causes, and a lower percentage of 3.3% for ocular and 1.7% for cardiovascular causes. For combined causes, the results were as follow 13.7% for vestibular and neurological, followed by 7.4% for vestibular and general and lower percentages 1.4%, 1.7%, 0.9%, 0.8%, 0.8%, and 0.7% for combined ocular and vestibular, general and cardiovascular, general and ocular, neurological and general, neurological and psychological, cardiovascular and ocular respectively, with a total percentage of 27.5% (233 cases) for combined causes as shown in Fig. 2.

Figure 3 showed that 47.7% of cases with unexplained dizziness were categorized as psychic patients by paediatric dizziness questionnaire, which may suggest the need for a psychiatrist to assess unexplained dizzy children. Table 9 illustrates that there is a statistically significant difference with *p*-value < 0.05 between explained and unexplained groups as regards hearing loss with a higher percentage of normal PTA on both sides among patients with unexplained dizziness and a higher percentage of conductive hearing loss on both sides among patients with possible diagnosis, most of them were due to otitis media.

Table 10 illustrates a statistically significant high mean score of different categories by paediatric dizziness questionnaire with *p*-value <0.05 among patients with unexplained dizziness.78.3% of cases with possible diagnosis showed agreement in diagnosis by both paediatric dizziness questionnaire and the final diagnosis reached by a full assessment of the patients, as shown in Table 11, which emphasizes the importance of paediatric dizziness questionnaire in the evaluation of dizzy children (Fig. 4).
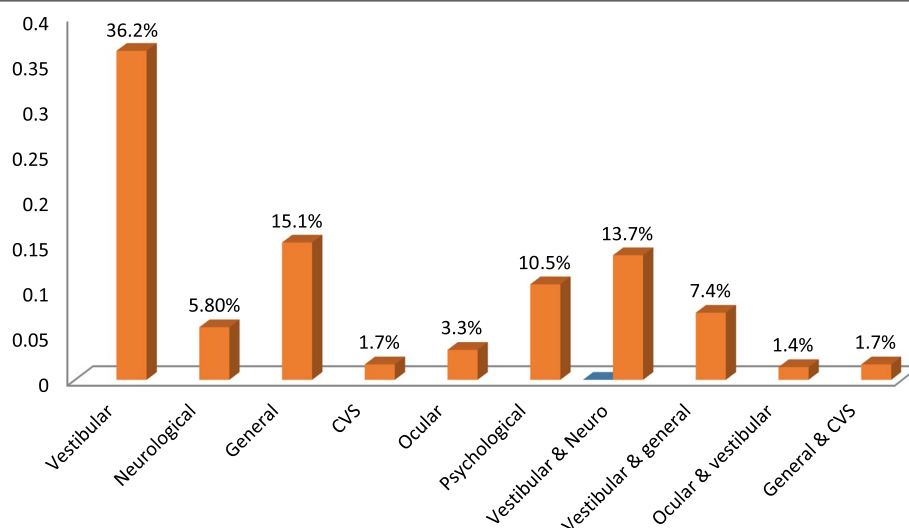

Fig. 1 Diagnosis among the study group by category

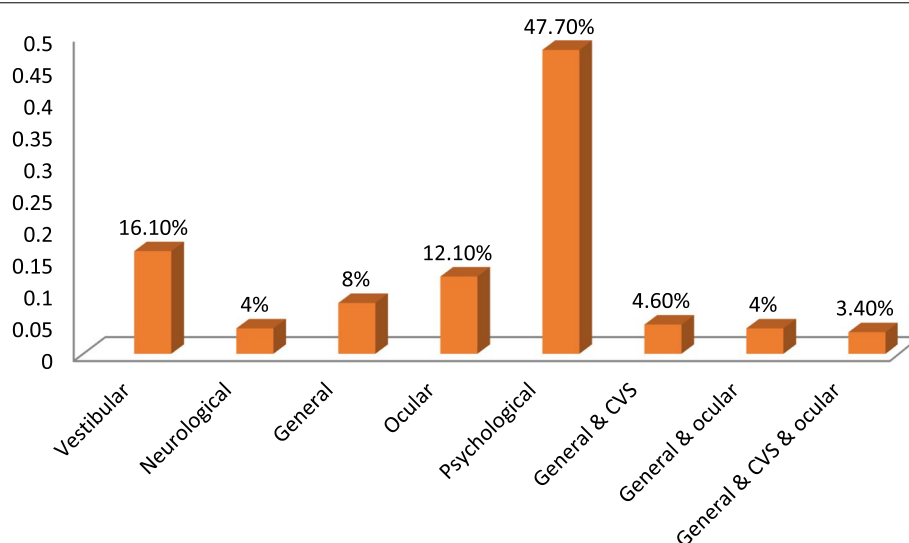**Fig. 2** Diagnosis by Pediatric Dizziness Questionnaire among the study group

Fig. 3 Diagnosis by questionnaire among clinically unexplained cases

Discussion

Vertigo is not a rare condition in the paediatric age and, although there is wide variability in published prevalence data, it approaches nearly 10% in most clinical trials [4, 5]. It is estimated that 5–10% of children have at least one episode of vertigo before the age of 10 years, with 10% having at least one attack per year; in 51.5% of cases, the intensity of vertigo halts daily activities and in 25 to 50% of cases vertigo usually associated with any form of migraine [2, 4]. In utmost clinical studies, differences in the prevalence of the single pathologies that may lead to vertigo can be perceived [10].

The study group consisted of 848 children, ranging from 6 to 18 years, with a mean age of 10.86 ±3.7 years. Regarding sex distribution, 52% of the study group were females (441 cases) versus 48% males (407 cases). In the study conducted by Farid et al. [18], the number of children included in their study was only 40 cases. Their age ranged from 6 to 12 years with a mean age of 10.25±2.18 years, and their sex distribution was 60% for females and 40% for males. On the other hand, the study of Riina et al. [2] involved 119 children, ranging from 7 months to 17 years, with a mean age of 10.9 years. Their sex distribution was 52.9% for females and 47.1% for males, and the

Table 9 Comparisons of types of hearing loss in different dizziness causes

Variables	Unexplained (*n*=174)		Explained (*n*=674)		*p*-value	Sig.
	No.	%	No.	%		
Right side hearing						
Normal	**154**	**88.5%**	**424**	**62.9%**	**< 0.05**	**S**
Conductive	**0**	**0%**	162	24%		
Sensorineural	20	11.5%	82	12.2%		
Mixed	0	0%	6	0.9%		
Left side hearing						
Normal	**154**	**88.5%**	423	62.8%	**< 0.05**	**S**
Conductive	**0**	**0%**	192	28.5%		
Sensorineural	20	11.5%	53	7.9%		
Mixed	0	0%	6	0.9%		

Table 10 Comparison of Pediatric Dizziness Questionnaire scores in different dizziness causes

Variables	Unexplained (*n* = 174)		Explained (*n* = 674)		*p*-value
	Mean	SD	Mean	SD	
Vestibular	**10.3**	3.6	7.8	2.6	**< 0.01**
Neurological	**9.7**	3.1	4.5	2.9	**< 0.01**
General	**11.1**	2.9	6.3	4.9	**< 0.01**
CVS	**9.6**	2.6	2.8	3.3	**< 0.01**
Ocular	**9.8**	3.2	1.5	3.2	**< 0.01**
Psychological	**12.5**	3.9	0.58	2.1	**< 0.01**
Total score	**62.9**	10.3	23.5	8.7	**< 0.01**

Table 11 Agreement in diagnosis by paediatric dizziness questionnaire and the final diagnosis reached by full assessment among cases with a possible diagnosis

Variables (*n* = 674)	Agreement	
	Number	%
Vestibular	259	30.5%
Neurological & vestibular	102	12%
General	56	6.6%
Vestibular & general	43	5.1%
Neurological	42	4.9%
CVS	14	1.7%
Vestibular & cardiac	12	1.4%
Total agreement	528	78.3%
Total disagreement	146	21.7%

56% for females and 54% for males. These significant differences in demographic features and the number of children included in each study may be the reason for the variations in the results.

At the beginning of the study, a full detailed structured history was taken from all the patients and their guardians, filling in the paediatric dizziness questionnaire. Structured history taking is the most important diagnostic tool. It provides information about the type and severity of the complaints and the overall disability to prevent the consequences of balance disorders by implementing early therapeutic options [21].

Regarding hearing assessment, 61.7% of cases (523 cases) had bilateral within normal peripheral hearing threshold levels, 24.9% had conductive hearing loss, either unilateral (8%) or bilateral (16.9%), followed by 12.7% for sensorineural hearing loss either unilateral (4.8%) or bilateral (7.9%) and 0.7% for mixed hearing loss. There was a statistically significant difference with a *p*-value < 0.05 between explained and unexplained groups as regards hearing loss with a higher percentage of normal PTA on both sides among patients with unexplained dizziness and a higher percentage of conductive hearing loss on both sides among patients with possible diagnos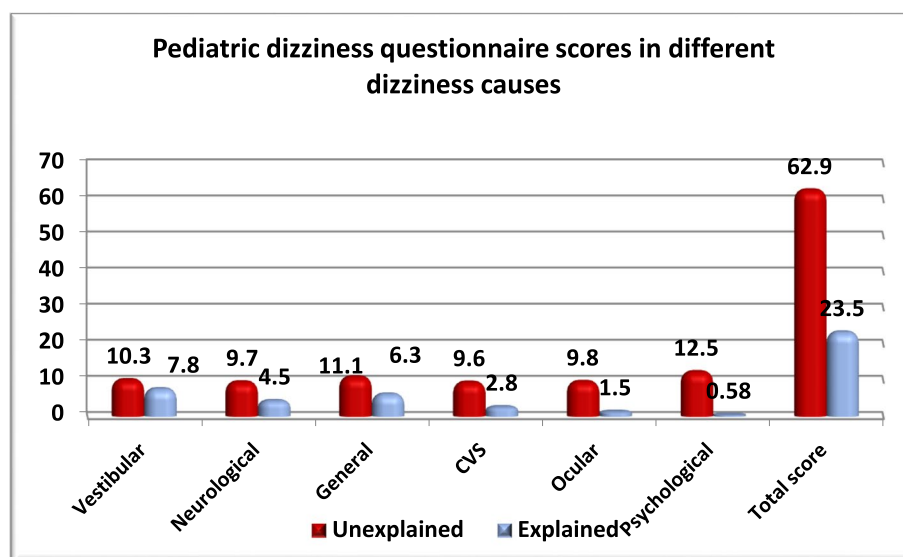is, most of them were due to otitis media. Riina et al. [2], reported that most of their patients (77%) had normal audiograms. On the other hand, Farid et al. [18], stated that only 50% of their patients had normal audiograms.

Moreover, there is a statistically significant difference with a *p*-value <0.05 between explained and unexplained groups as regards hearing loss with a higher percentage of normal PTA on both sides among patients with unexplained dizziness and a higher percentage of conductive hearing loss on both sides among patients with possible diagnosis, most of them were due to otitis media.

study conducted by Lee et al. [20], involved 411 children, with their age ranging from 9 months to 18 years, with a mean age of 12.9 years, and their sex distribution was

Fig. 4 Agreement in diagnosis by paediatric dizziness questionnaire and the final diagnosis reached by full assessment among cases with a possible diagnosis

In the current study, otitis media-related dizziness was reported by 203 children (23.9%), either alone (11.1%-94 cases) or combined with other diseases such as DM, thalassemia, sickle cell anaemia, cardiovascular and respiratory disorders (12.85%- 109 cases). However, most were recurrent middle ear infections or chronic middle ear effusion. Riina et al. also found that (OME) is one of the most common causes of balance disturbance in children. They also reported that children with OME are more visually dependent on balance than healthy children. Bhandari and Gowasami [22] reported that otitis media and middle ear effusions are the most common causes of vestibular disturbances in children. Otitis media shows apparent symptoms of infection, which makes diagnosis very easy. So, most researchers exclude otitis media from the differential diagnosis of vertigo in children. Peripheral vestibular abnormalities were noted in 34% of children with otitis media with effusions in our study group (69 cases), especially in post head shaking and positional tests. Opposing our results, Said et al. [23], reported peripheral vestibular abnormalities in 64% (32 cases) of children with bilateral OME. On the other hand, Engel-Yeger et al. [24], found no significant abnormalities in VNG testing. This disparity in the results of VNG in children may reflect the lack of normative data for children. Moreover, children do not tolerate sitting still with their heads stabilized long enough for the examination to be carried out.

Accordingly, the audiological evaluation must be considered in all dizzy children since otitis media with effusion is a common condition that causes an imbalance in children.

In our current study, vertigo diagnosis was based on standard published criteria, detailed history, laboratory tests, imaging studies, and consultation documents from other specialties: neurology, ophthalmology, cardiology, haematology, and endocrinology. The most common causes of dizziness in children encountered were otitis media that represented (23.9%—- 203 cases) either alone (11.1%—94 cases) or combined with another disease (12.85%—109 cases), followed by benign paroxysmal vertigo of childhood (17.6%—149 cases) and vestibular migraine (11.2%—95 cases). Similar findings were obtained in the study conducted by Riina et al., two on 119 children with a primary complaint of vertigo. Benign paroxysmal vertigo of childhood (BPVC) accounted for 19.3% of cases, followed by vestibular migraine 14.3% of cases and otitis media-related dizziness 10.1% of cases. Choung et al. [25], identified BPVC as the second most common cause of vertigo in children (25.5%) after migraine (30.9%). Ravid et al. [26] had similar findings (16% vs. 39%). Balatsouras et al., five recorded BPVC in 16.7%, and migraine in 20.4%. Niemensivu et al., three and Ozeki et al. [27], suggested that benign paroxysmal vertigo is closely linked to migraine and could be interpreted as a migraine precursor. According to Lee et al. [20], BPVC and vestibular migraine are the leading causes of dizziness among children and adolescents, and the incidence of disease by age shows uneven distributions. BPVC was the most common in the preschool age group, followed by vestibular migraine, whereas, in the school-age group, BPVC and vestibular migraine were equally common. Vestibular migraine was the most common in adolescents.

Elghaffar *et al. The Egyptian Journal of Otolaryngology* (2022) 38:26

Page 11 of 13

In the current study, 52.4% of cases of vestibular migraine and benign paroxysmal vertigo of childhood had a positive family history of migraine in first-degree relatives (128 cases out of 244 cases). Lateef et al. [28], also reported that a family history of migraine is the most potent and reliable risk factor for migraine, with a two- to three-fold more significant risk of migraine among relatives of migraine patients than controls. Family history of disorders should be considered for clinical assessment and treatment decisions and identifying migraine underlying genetic factors.

Although McCaslin et al. [8] found that migraine involvement of the brainstem and vestibular pathways may be responsible for the incidence of periodic vestibular symptoms in a wide range, it is not precisely known the pathogenesis of vestibulopathy and its association with migraine. Dizziness could be caused by symmetrical brainstem involvement, whereas an asymmetrical one could cause true vertigo.

Abnormal vestibular findings detected in our migraine patients in this study were positional nystagmus, post-head-shaking nystagmus, unilateral peripheral vestibular hypofunction as well as ocular motor abnormalities. The results revealed peripheral and central vestibular involvement, but it was challenging to draw a sharp distinction between the two possibilities. Similarly, Espinosa et al. [29] also found that migrainous vertigo may consist of both peripheral and central impairment. Central spontaneous nystagmus and ocular-motor abnormalities could only be explained by internal auditory artery ischemia, but it may manifest infarction in the anterior inferior cerebellar artery territory. Therefore, it is speculated that migraine and stroke are not just comorbid conditions. Nevertheless, instead, migraine is possibly an independent cerebrovascular risk factor, particularly among young people [30].

In terms of vestibular testing, 159 children refused to continue. They primarily declined to complete caloric testing and oculomotor evaluation, highlighting the importance of exploring alternatives to VNG. Caloric testing gave 22.4% abnormal results, but it proved to be one of the most challenging tests in our study group. Most children moved a lot during caloric tests, making it difficult for the physician to complete it correctly. Salami et al. [31], reported these apparent difficulties in performing a standard adult procedure of VNG on children. On the other hand, positional & positioning tests did not give a high percentage of abnormalities (positional test 9.8%, positioning test 5.5%), but they contribute either to exclude or reach a diagnosis.

In the present study, we found only 4.4% of cases diagnosed as vestibular neuritis or labyrinthitis suspected from the history and canal paresis on VNG testing. Our finding agrees with Ralli et al., [32],who stated that vestibular neuritis rarely affects children below ten years. Choung et al. [25], reported that vestibular neuritis caused vertigo in only 2% of 52 paediatric patients. Ravid et al. [26], reported 14% of their 62 paediatric patients. The difference in results may be attributed to the variability of the number of cases.

We also found only 5 cases suspected with perilymph fistula as concluded from history and + ve fistula test done while all vestibular function tests were normal. This finding agreed with Erberk et al. [33], who found that perilymphatic fistula (PLF) is rarely seen in children, probably because of underestimation of this finding.

Only 3 cases (0.35%) were suspected of Meniere's disease or labyrinthine hydrops in the present study. Similar results were obtained by Ravid et al., [26], who found no cases of Meniere's in their 62 patients. Also, Balatsouras et al. [5], reported only 1 case out of 50 patients, and Erbek et al. [33], found again only 1 of their 50 paediatric patients with Meniere's disease. Collectively, VNG findings agreed with Szirmai [34], Uneri &Turkdogan [35], who stated that VNG together with history and PTA were necessary to reach a correct diagnosis.

Epilepsy represented 2.2% of cases in the current study. Similar results were obtained by Riina et al. [2], who reported only 3 cases out of 119 children. Also, Choung et al. said that seizures caused vertigo in only 2% of their 55 paediatric patients, Erbek et al. [33] found 6% of their paediatric patients with epilepsy, and Ravid et al., recorded only 3% of their patients with epilepsy. Only 8 cases (0.94%) were diagnosed with brain tumours, which was agreed with Choung et al. [25],, who reported that a CP angle tumour caused vertigo in only 2% of their 52 paediatric patients. In the same way. Brain tumours are sporadic causes of vertigo in children, with a prevalence of just around 5/100,000. Approximately 1% of all paediatric intracranial tumours are in the posterior fossa, which may cause dizziness or imbalance [16].

Cardiovascular disorders were detected in 3.1% of cases (26 cases) either alone (14 cases) or combined with other diseases (12 cases). Both occult cardiac arrhythmias and acute myocardial infarctions could manifest as dizziness. Changes in blood pressure and changes in pulse are common in adolescents. Ravid et al. [26], reported orthostatic hypotension in 9% of their 62 paediatric dizzy patients and syncope in 3% of his cases.

We found that 1.8% (15 cases) of our study group suffered from ocular problems, in agreement with Erberk et al. [33], who found that various ophthalmological disorders could appear in children due to the ongoing development of the visual system during the first decade of life. We depend mainly on history, consultation documents from an ophthalmologist, and exclusion of other causes

to reach our diagnosis. Children with vertigo and dizziness but with normal neurological findings and no apparent vestibular abnormalities after vestibular tests should undergo complete ocular testing to identify any ocular abnormality as a potential cause of vertigo and dizziness.

Other medical aetiologies that cause dizziness are diverse but primarily include hypertension, infection, hypoglycemia, and medications. Among our cases, 13.9% (118 cases) suffered from widespread systemic diseases like anaemia, DM, and other endocrinal disorders either alone (56 cases) or combined with other conditions (62 cases). The diagnosis was confirmed from their medical history reports and laboratory tests.

In our study group, 10.5% of cases (89 cases) were categorized as psychogenic dizziness by paediatric dizziness questionnaire. Similarly, Erbek et al. [33] reported that 10% of paediatric dizzy patients had 'psychogenic vertigo'. Also, six of 119 were diagnosed with psychogenic dizziness in the study of Riina et al. [2]. Depression, conversion, and somatization were identified as the most frequent causes. Historical findings indicate psychogenic disorders are the inability to attend school despite normal physical examination and observing unusual interactions with guardians (Emeriglu et al., 2004).

In the present study, we could not reach a possible diagnosis in 20.5% of cases (174 cases). Similarly, Choung et al. [25] reported that 18.2% of their paediatric dizzy patients were 'unclassified'. Such patients typically need to be followed more closely than patients with a precise diagnosis. Empirical medication trials, psychiatric consultation, and vestibular physical therapy could be valuable options.

In the current study, the diagnosis by paediatric dizziness questionnaire was agreed with the final diagnosis reached by full assessment in about 78.3% of cases with a possible diagnosis. Ravid et al. [26], also reported that the sensitivity of the questionnaire to get the correct diagnosis was 92%. Shabana et al. [11], also stated that in 75% of cases, the diagnostic categories of the questionnaire matched the diagnosis on referral. Its sensitivity in vestibular diagnosis was 88.9%. The questionnaire seems to be an appropriate tool for diagnosing dizzy children, with a scoring system that can categorize dizzy children by the systems affected. The proposed standardized questionnaire could be a good and simple diagnostic tool for children with vertigo or dizziness.

Vertigo in children could be seen due to many causes. These include trauma, infections, migraine, central nervous system disorders (usually cerebellar and brainstem), benign paroxysmal positional vertigo (BPPV), vestibular neuritis due to viral infections, and psychosomatic disorders [21].

Vertigo in children must be given adequate consideration since it can be the only symptom of a broad spectrum of diseases, including central nervous system neoplasms or inner ear pathologies. Moreover, especially in childhood, vertigo and dizziness can produce numerous prescriptions for useless and expensive testing without obtaining any help in therapeutic decision-making [10].

Children are challenging to evaluate. Not only do 'vertigo in this critical age' has a different differential diagnosis, but the affected children respond relatively well to the treatment and recover quicker than the adults. Thus, it is most important to determine whether a vestibular disorder exists in a child to prescribe the appropriate rehabilitative therapy, which can improve those children's general well-being and quality of life.

Conclusion
Diagnosing dizziness in children is challenging; nevertheless, a structured history taken in conjunction with a vestibular examination is crucial for establishing an accurate diagnosis. The questionnaire appears to be an even-handed tool for diagnosing dizzy children.

Recommendations
The proposed structured questionnaire should be incorporated in the diagnostic process of dizzy children and is likely to eliminate the need for unnecessary costly evaluation. Besides a thorough and detailed history taking, a basic audiological evaluation, a bedside examination, VNG, Video Head Impulse test, and VEMP for children to avoid dropouts found in the current study.

Supplementary Information
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Additional file 1.
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Availability of data and materials
All datasets used are available.

Elghaffar *et al. The Egyptian Journal of Otolaryngology*   (2022) 38:26

Page 13 of 13

Declarations

Ethics approval and consent to participate
The study was approved by the local research ethics board of Fayoum University on May 15th, 2016 (reference number D 86); written informed consent was obtained from all patients' guardians to participate in this work.

Consent for publication
All patients' guardians obtained
written informed consent to publish this work.

Competing interests
The authors declare they have no competing interests, no financial or non-financial conflict of interest.

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