

The Pediatric Vestibular Symptom Questionnaire: A Validation Study

Marousa Pavlou¹, PhD, PT; Sue Whitney², DPT, PhD, NCS, ATC, FAPTA; Abdulaziz A. Alkathiry^{2,3}, PT; Marian Huett⁴, PhD, PT; Linda M. Luxon⁵, CBE BSc FRCP; Ewa Raglan⁶, MD, LRCP MRCS FRCS, FRCP; Emma L. Godfrey⁷, PhD; Doris Eva-Bamiou^{5,6,8}, MD, MSc, PhD, FRCP

Affiliations: ¹Centre of Human and Aerospace Physiological Sciences, King's College London, London, UK; ²Physical Therapy, School of Health and Rehabilitation Sciences, University of Pittsburgh, Pittsburgh, PA, USA; ³Physical Therapy, College of Applied Medical Sciences Majmaah University, Majmaah, Saudi Arabia; ⁴Department of Physiology, King's College London, London, UK; ⁵Neuro-Otology Department, National Hospital for Neurology and Neurosurgery, London, UK; ⁶Audiological Medicine Department, Great Ormond Street Hospital for Children, London, UK; ⁷Division of Health and Social Care, King's College London, London, UK; ⁸University College London Ear Institute, London, UK

Address correspondence to: Dr. Marousa Pavlou, King's College London, Centre of Human and Aerospace Physiological Sciences, Shepherd's House, Guy's Campus, London, UK SE1 1UL, marousa.pavlou@kcl.ac.uk, +44 (0) 207 848 6324.

No funding source or conflict of interest to report. Dr Pavlou wrote the first draft of the manuscript. No honorarium, grant, or other form of payment was given to anyone to produce the manuscript.

Key Words: concussion; children; dizziness

Abstract

Objectives: To develop and validate the Pediatric Vestibular Symptom Questionnaire (PVSQ) and quantify subjective vestibular symptom (i.e. dizziness, unsteadiness) severity in children. The hypothesis was that the PVSQ would discriminate between children with and without abnormal levels of vestibular symptoms. **Study Design:** 168 healthy (female n=91) and 56 children with post-concussion dizziness or a vestibular disorder (female n=32), aged between 6-17 years old, were included. The PVSQ contains questions regarding vestibular symptom frequency during the previous month. The Strength and Difficulties Questionnaire (SDQ), a brief behavioral screening instrument, was also completed. **Results:** The PVSQ showed high internal consistency (10 items; $\alpha=0.88$). A significant between-group difference was noted with higher (i.e. worse) PVSQ scores for children with vestibular symptoms ($p<0.001$); no significant differences were noted between patient groups. The optimal cut-off score for discriminating between individuals with and without abnormal levels of vestibular symptoms was 0.68 out of 3 (sensitivity 95%, specificity 85%). Emotional and hyperactivity SDQ subscale scores were significantly worse for patients compared to healthy participants ($p\leq 0.01$). A significant relationship was noted between mean PVSQ and SDQ (parent-rated version) hyperactivity and total scores for patients ($p\leq 0.01$) and the SDQ (self-rated) emotional, hyperactivity and total score ($p\leq 0.01$) in healthy controls. However, mean SDQ subscale and total scores were within normal ranges for both groups. **Conclusions:** Self-reported vestibular symptoms, measured by the PVSQ, discriminated between children presenting with vestibular symptoms and healthy controls and should be used to identify and quantify vestibular symptoms that require additional assessment and management.

INTRODUCTION

Vestibular disorders are the most common cause of dizziness in children with a prevalence of 0.7-15%. [1-3] Vestibular migraine, benign paroxysmal vertigo of childhood (a migraine precursor), post-concussion dizziness due to head trauma and viral vestibular neuritis are the most common diagnoses. [4-7] However, these disorders may often remain undiagnosed in children [8] as medical professionals may attribute symptoms to a behavioral disorder or “clumsiness”. [9, 10] This may partly be because children are often unable to express or describe their symptoms without appropriate questioning, may readily accept the symptom terminology proposed by an adult, and may demonstrate behaviors such as clinging to the parent when experiencing dizziness or vertigo. [5, 10, 11] Vestibular disorders may lead to secondary psychological symptoms and avoidance behaviors with adverse effects on educational achievement and quality of life. [12, 13] A detailed medical history, to ascertain symptoms, triggers and time course is the cornerstone of the diagnostic decision making process. [4, 5] It is therefore of the utmost importance to help a child explain his/her symptoms by providing different descriptors, in order to determine etiology and establish a diagnosis. [11] Although a number of questionnaires [14, 15] exist to assess the presence, severity, and impact of vestibular symptoms in adults, there are currently none available for the pediatric population.

This study aimed to develop and validate a questionnaire, the Pediatric Vestibular Symptom Questionnaire (PVSQ), to identify and quantify subjective vestibular symptoms (i.e. dizziness, imbalance) in children between 6-17 years of age. A secondary study aim was to investigate the relationship between vestibular symptoms and behaviors indicative of psychological problems in healthy children and those with a vestibular disorder or concussion.

PATIENTS AND METHODS

PVSQ design

The PVSQ aimed to identify and measure the severity of common vestibular symptoms in children. The design and validation[16, 17] consisted of three main phases: i) expert panel review of initial PVSQ items; ii) pilot study to assess the validity and reliability of the PVSQ questionnaire; and iii) main validation study and collection of normative data.

An expert consensus panel comprising three consultant pediatric audio-vestibular physicians, two physical therapists and a psychologist constructed and selected questionnaire items. Items were chosen from the validated, vestibular sub-scale of the Vestibular Symptom Scale[14] and from symptoms recorded in clinic reports for children diagnosed with a vestibular disorder at the Audiological Medicine Department, Great Ormond Street Hospital (GOSH), London, UK. The 11-item questionnaire was modified (wording alterations, bigger font size) after review for ease of completion and acceptability by 10 healthy children and 5 with a vestibular disorder aged between 6-15 years old. Children answered the questionnaire based on a concrete reference period of how frequently symptoms were experienced during the previous month as this “anchors” the question, making it easier for a child to answer.[16] Each item was rated on a 0 (never) to 3 (most of the time) scale; a “don’t know” category was also included. The total score ranged from 0-33 and was normalized based on the equation: $\text{total score}/(\text{total question number} - \text{“don’t know” replies})$ to yield a score of 0-3 with higher scores indicating greater symptom severity. Ten questions are used in the normalization equation. Question 11 which asks children if their symptoms prevent activity participation, and if yes, to identify which ones, is not included in the equation. The final questionnaire is provided in Table 1.

PVSQ validation

Procedure

The study comprised of completing a) the PVSQ; b) a question set asking about migraines, frequent dizzy spells, severe stomach pain, vomiting, loss of consciousness, binocular vision or hearing difficulty, medication, and regular doctor visits (Appendix 1); and c) the Strengths and Difficulties Questionnaire (SDQ), a brief behavioral screening questionnaire for 4–17 year olds.[18, 19] The SDQ informant (4-10 years old) and self-report versions (11-17 years old) both include five subscales: emotional, conduct, hyperactivity/inattention, peer relationship problems and prosocial behavior. Subscale scores range between 0-10; the total score is the sum of the first four scales (range 0-40). The English UK and US versions (www.sdqinfo.org) were used for participants recruited in the United Kingdom and United States, respectively.

All primary school aged children in years 1 and 2 completed the PVSQ and general questions together with a parent or guardian at home, while those in year 3 and above or in secondary school completed them independently in the classroom under the standardized direction of a research team member. Children with vestibular symptoms completed the study during their clinic appointment.

Participants: Fifty-six children experiencing dizziness and/or unsteadiness symptoms due to a vestibular disorder or concussion were recruited from the Audiological Medicine Department, GOSH, or a tertiary balance center at the University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA after a complete neurological and neuro-otological examination. Inclusion criteria were a) clinical diagnosis of concussion or other pathology giving rise to vestibular

dysfunction based on clinical history and clinical examination/test findings; b) aged 6-17 years old; d) attend a mainstream school. Children with a) central nervous system involvement other than migraine or concussion; b) significant learning difficulties; or c) orthopedic deficit affecting balance and gait were excluded. Diagnostic criteria for a peripheral vestibular disorder [20], bilateral vestibular hypofunction[21], vestibular neuritis[22], migraine[23, 24] and migrainous vertigo[25] are included in the online information supplement. Post-concussion dizziness was diagnosed based on complaints of dizziness and/or balance problems on the Post-Concussion Symptom Scale or ImPACT® test.[26] All children were medical referrals to UPMC and had a clinical and functional evaluation by physiotherapists with expertise in examining and treating children with concussion.

Three-hundred children aged between 6-17 years old were recruited from three primary and two secondary mainstream schools in the Greater London area as a healthy control group. A total of 168 questionnaires were eligible for inclusion. Exclusion criteria for the control group included a “yes” answer to questions (Appendix 1) for experiencing migraines (n=58), frequent dizzy spells (n=27), vomiting, stomach pain, and /or loss of consciousness, in addition to a neurological, psychological (n=2) or orthopedic diagnosis or infection with the human immunodeficiency virus (n=1), history of substance abuse (n=2), abnormal SDQ scores (n=14) or an incomplete PVSQ (n=2) or SDQ (n=26).

Written informed consent was obtained from all children and their parents before participating in the study. Ethical approval was obtained from the Institute of Child Health/GOSH Research Ethics Committee, London, UK and the institutional review board at the University of Pittsburgh, PA, USA.

Data Analysis

IBM SPSSv.20 (IBM Corp., Armonk, NY) was used for statistical analysis. Data are presented as mean (standard deviation). Reliability was tested using the Cronbach alpha score for total PVSQ items less one item at a time to examine whether reliability decreased when an item was excluded. Exploratory factor analysis with principal axis factoring (PAF) and Varimax orthogonal rotation to aid interpretability determined construct validity. The Kaiser criterion (eigenvalue ≥ 1) and a scree plot depicting the descending variances that account for the factors extracted in graph form was used to identify how many factors should be retained.[27] For the scree plot, factors lying before the point where eigenvalues began to drop were retained. Receiver operating curves (ROC) assessed discriminant validity in order to calculate the PVSQ's sensitivity and specificity in discriminating healthy children from those with vestibular symptoms. Mann-Whitney tests determined between-group differences for age and questionnaire data. A Chi-Squared test determined between-group gender differences. Spearman's correlation assessed the relationship between PVSQ scores, age, gender, binocular vision and SDQ scores in both groups and migraine and hearing difficulty only for children with vestibular symptoms; only significant correlations are reported. Significant results were assumed if $p \leq 0.01$.

RESULTS

Demographics

Mean age significantly differed between-groups ($U=3182$, $z=-3.931$, $p<0.001$). Compared to healthy children, those with vestibular symptoms reported hearing difficulty significantly more frequently ($U=4117$, $z=-4.935$, $p<0.001$). No between-group gender or binocular vision difficulty differences were noted. Demographic data may be found in Table 2.

Internal consistency reliability

The PVSQ obtained a Cronbach alpha score of 0.88. Item-deleted statistics showed no significant change in alpha scores (range 0.85-0.88). All items correlated significantly with the total score; a corrected total-item correlation ≥ 0.4 suggested that each item had discriminative capacity.

Factor analysis

The PAF's suitability to the ten PVSQ components was assessed prior to analysis. The correlation matrix revealed that all variables had many correlation coefficients >0.3 and the factorability of the correlation matrix was confirmed (Kaiser-Meyer-Olkin value =0.9, Bartlett's Test of Sphericity $p < 0.001$). [28] PAF analysis revealed two factors explaining 49.5% and 10.4% of the total variance (59.9%), respectively. One item ("feeling unsteady, about to lose balance") loaded onto both factors. Factor loadings of the rotated solution are presented in Table 3.

Discriminant validity and comparison between groups

The PVSQ score significantly differed between healthy children and those with vestibular symptoms ($U=444$, $z = -10.183$, $p < 0.001$; Table 4). No significant differences were noted between children diagnosed with a vestibular disorder vs. concussion. ROC analysis demonstrated that the PVSQ was able to discriminate between the two groups. The optimal cut-off score was 0.68 (out of 3) with a sensitivity of 95% and specificity of 85%. The area under the curve (with 95% confidence intervals) was 0.95 (0.92-0.99, $p < 0.001$). The ROC curve with various cut-off scores for discriminating between-groups is shown in Fig. 1.

Forty-nine (87.5%) children with vestibular symptoms replied “yes” to the question “Do any of these activities stop you doing what you want to do?” On average each child identified 4.4 (2.1) symptoms which impacted on their activity participation. The most commonly reported symptoms were headache or feeling of pressure (79.6%), a light-headed or swimmy feeling (65%), and a feeling that things are spinning or moving around (57%). Other symptoms reported as impacting on activity participation were nausea (42.9%); feeling unsteady, about to lose balance (40.8%); blurry vision, difficulty seeing things clearly and/or spots before the eyes (28.6%); unable to stand or walk without external support (28.6%); fuzzy or cotton wool feeling in the head (22.5%); unsteadiness resulting in a fall (12.2%); and/or ear pressure (8.2%).

In children with vestibular symptoms a significant relationship was noted between PVSQ scores, hearing ($r=0.47$, $p<0.001$) and binocular vision ($r=0.34$, $p=0.01$) difficulties only, whereby children with vestibular symptoms and hearing and/or binocular vision difficulty reported higher (i.e. worse) PVSQ scores.

SDQ

Significant between-group differences were noted for the self-rated version whereby children with vestibular symptoms had significantly higher scores compared to healthy children for the emotional ($U=1590$, $z=-4.329$, $p<0.001$) and hyperactivity ($U=2103$, $z=-2.47$, $p=0.01$) subscales. However, both informant and self-rated SDQ total and subscale scores were within normal ranges for healthy children, as expected based on exclusion criteria, as well as for children with vestibular symptoms, who were not excluded if they had abnormal scores ($n=10$)(Table 4). A significant relationship was noted between mean PVSQ and self-rated SDQ emotional

($r=0.24, p=0.01$), hyperactivity ($r=0.27, p<0.01$) and total ($r=0.25, p=0.01$) scores in healthy controls, whereby higher total SDQ and relevant subscale scores correlated with higher PVSQ scores. In children with vestibular symptoms, a significant positive relationship was noted between PVSQ and parent-rated SDQ hyperactivity ($r=0.93, p=0.01$) and total ($r=0.94, p=0.01$) scores.

DISCUSSION

This study presents the first pediatric vestibular symptom questionnaire for children experiencing vestibular symptoms of dizziness and/or unsteadiness. The questionnaire demonstrated properties of robust reliability, construct and discriminant validity.

When validating a questionnaire that has no other validated measure with which to compare, construct validity must be assessed by developing a hypothesis regarding the relationship of the questionnaire scores and the condition's effect on the target population.[29] With this data set, it was predicted that children with vestibular symptoms of dizziness/imbalance post-concussion or due to another vestibular disorder would demonstrate higher scores, representing significantly more severe symptoms, compared to healthy children.

The results support that the PVSQ accurately assesses vestibular symptom severity in children with vestibular symptoms. The ROC area under the curve indicates a test with “excellent accuracy” in separating those with and without abnormal levels of dizziness and/or unsteadiness.[30] The optimal cut-off score correctly identifies an abnormal level of vestibular symptoms in 95% of children and can accurately report 85% of healthy children.

Factor analysis resulted in the retention of all items organized into two subscales representing symptoms regarding ‘dizziness’ or ‘balance’. ‘Dizziness’ is a non-specific symptom while vestibular vertigo is defined as rotational, positional or recurrent dizziness with nausea, gaze and/or postural instability.[31] However, “objects turning or spinning around you” and “the sensation of turning or spinning yourself” were the most commonly reported dizziness descriptors in a pediatric study.[13] The sensation of spinning in the head with no environmental movement is common in a migraine equivalent and usually associated with headache.[11, 13, 32] In our study, 41% of children with vestibular symptoms presented with a migraine history, and items relating to headache and spinning loaded onto the ‘dizziness’ subscale. However, both children and adults with vestibular complaints report varying manifestations of dizziness [14, 33] and as expected other symptoms also loaded onto the ‘dizziness’ subscale with one PVSQ item, which loaded onto both subscales, being accepted. In the Humphriss et al[13] study, children were only asked to report “spinning dizziness” but a significant number reported “other sensations” while approximately 30% used at least three different descriptors for their dizziness.

Postural and gait instability are well documented for children with vestibular presentations.[4, 34-39] “Balance” loaded as an independent factor with three items relating specifically to postural and gait instability, feelings of unsteadiness and falls.

A Cronbach’s alpha of 0.8[40] or 0.7 for a new instrument[41, 42] is considered reliable. The PVSQ achieved a Cronbach’s alpha above these recommended values indicating high internal consistency. Alpha if item-deleted statistics (i.e. overall alpha value if that item is excluded from the calculation) and the correlation of ≥ 0.4 for all items with the total score also suggest that all

items contribute to the PVSQ's reliability. Some items might be considered to be redundant within a single score-generating screening tool in view of the strong item correlations. However, a recent report stated that numerous diverse potential symptom descriptors should be proposed when assessing children with dizziness and/or unsteadiness so that they can choose those relating to how they are feeling, which can also assist in determining etiology.[11] As children find it difficult to describe their highly variable dizziness symptoms,[5, 10, 11, 13, 43] and in view of the brevity of the PVSQ, all items were maintained.

The percentage of children with vestibular symptoms reporting activity limitations due to their symptoms is similar to that in adults with vestibular dysfunction[31], but higher than in other child studies.[4, 13] The discrepancy in findings may be influenced by question wording differences [13] or the study population. Previous studies recruited children from the general population [4, 13] while in our study they were recruited from tertiary clinics and had a confirmed vestibular diagnosis.

PVSQ scores significantly correlate with binocular vision and/or hearing impairments, suggesting that these impairments have an additive effect on vestibular symptom severity. This is unsurprising as the relationship between hearing impairments and vestibular function[44, 45] or concussion[46, 47] is well documented while increased vertigo symptoms[48, 49] and impaired postural control[49] have been reported in children with ophthalmologic disorders but normal vestibular function. However no relationship was noted between binocular vision and PVSQ scores in healthy children which may be due to the small number of children reporting ophthalmological impairments in our sample.

Psychological issues are reported as a consequence of concussion[50, 51] and migraine[52], while approximately 50% of children with episodic vertigo[52, 53] have clinically significant SDQ scores.[53] Current findings also show significantly worse emotional and hyperactivity SDQ subscale scores for children >11 years of age with vestibular symptoms compared to healthy controls, although both groups had mean scores within normative ranges. Older children in the current study completed the self-rated SDQ version while parent data was obtained for all ages in Lee et al[53], and the SDQ score discrepancy may be due to the version completed as only a low to modest child-parent agreement has been noted.[54, 55] The tendency for higher scores in our patient cohort, in contrast to other studies in which parents were more likely to regard problems as clinically significant[54, 55] may indicate greater subclinical behavioral and emotional difficulties in our patient sample. This may increase the risk for developing psychopathology in the future [56] and children with vestibular symptoms should be screened for associated psychological symptoms.[52, 53]

A significant relationship was noted between PVSQ and self-rated SDQ scores in healthy participants and the informant version for patients. In healthy adolescents a significant correlation has been reported between multiple, recurrent subjective health complaints (i.e. headache, dizziness, backache, fatigue) and higher SDQ scores, indicating greater emotional/behavioral problems.[57] Recurrent subjective health complaints focus on re-occurring symptom frequency rather than specific diagnoses and we hypothesize that in healthy participants the relationship between PVSQ and SDQ scores may be due to the presence of subjective health complaints in a percentage of participants. It is unclear why significant correlations were noted only for the informant-rated SDQ in patients, but as it was only

completed for six participants no conclusions can be drawn. Additionally, although vestibular symptom severity directly impacts on perceived handicap, near zero correlations have been noted with anxiety.[14] Since the SDQ is designed as a behavioural screening questionnaire as opposed to measuring handicap, it is understandable that no significant relationship was noted between PVSQ and self-rated SDQ scores in the larger patient cohort.

This study does present with some limitations. Further research on test-retest reliability and responsiveness to change over time is needed to further validate the PVSQ for clinical use. In its current state, the questionnaire is not validated for children with learning disabilities. The National Centre for Research Methods state that questionnaires should be adapted for this population who experience reading and comprehension difficulties. In particular, if the aim is to ensure accuracy of answers, questions should not have more than five response options, the language should be simpler and visual images should be employed

(<http://www.pssru.ac.uk/pdf/dp2721.pdf> accessed on 12 July 2015;

<http://eprints.ncrm.ac.uk/491/1/MethodsReviewPaperNCRM-012.pdf> accessed on 12 July 2015).

Likewise, children with neurological or orthopedic deficits who may also have vestibular dysfunction but for example will also experience unsteadiness due to reasons in addition to or other than the vestibular diagnosis were excluded from the current study. This does not imply that the questionnaire cannot be used in children with a neurological disorder or orthopedic deficit, but rather in these patient cohorts answers to individual answers would need to be considered carefully in the context of the specific diagnoses and impairments present.

CONCLUSIONS

The development of the PVSQ as a reliable and valid measure provides a tool for assessing the presence and severity of subjective vestibular symptoms in children with vestibular disorders or concussion.

ABBREVIATIONS

PVSQ: Pediatric Vestibular Symptom Questionnaire; GOSH: Great Ormond Street Hospital;

UPMC: University of Pittsburgh Medical Center; SDQ: Strengths and Difficulties Questionnaire;

PAF: Principal axis factoring; ROC: Receiver operating curves

REFERENCES

- [1] Riina N, Ilmari P, Kentala E. Vertigo and imbalance in children: a retrospective study in a Helsinki University otorhinolaryngology clinic. *Arch Otolaryngol Head Neck Surg.* 2005;131:996-1000.
- [2] Bower CM, Cotton RT. The spectrum of vertigo in children. *Arch Otolaryngol Head Neck Surg.* 1995;121:911-5.
- [3] Eviatar L, Bergtraum M, Randel RM. Post-traumatic vertigo in children: a diagnostic approach. *Pediatr Neurol.* 1986;2:61-6.

- [4] Niemensivu R, Kentala E, Wiener-Vacher S, Pyykko I. Evaluation of vertiginous children. *Eur Arch Otorhinolaryngol*. 2007;264:1129-35.
- [5] Wiener-Vacher SR. Vestibular disorders in children. *Int J Audiol*. 2008;47:578-83.
- [6] Balatsouras DG, Kaberos A, Assimakopoulos D, Katotomichelakis M, Economou NC, Korres SG. Etiology of vertigo in children. *Int J Pediatr Otorhinolaryngol*. 2007;71:487-94.
- [7] Erbek SH, Erbek SS, Yilmaz I, Topal O, Ozgirgin N, Ozluoglu LN, et al. Vertigo in childhood: a clinical experience. *Int J Pediatr Otorhinolaryngol*. 2006;70:1547-54.
- [8] Jahn K, Langhagen T, Schroeder AS, Heinen F. Vertigo and dizziness in childhood - update on diagnosis and treatment. *Neuropediatrics*. 2011;42:129-34.
- [9] McCaslin DL, Jacobson GP, Gruenwald JM. The predominant forms of vertigo in children and their associated findings on balance function testing. *Otolaryngol Clin North Am*. 2011;44:291-307, vii.
- [10] Casselbrant ML, Mandel EM. Balance disorders in children. *Neurol Clin*. 2005;23:807-29, vii.
- [11] Rine RM, Wiener-Vacher S. Evaluation and treatment of vestibular dysfunction in children. *NeuroRehabilitation*. 2013;32:507-18.
- [12] Physicians RCo. Hearing and balance disorders: achieving excellence in diagnosis and management. Report of a working party. London: RCP; 2008.
- [13] Humphriss R, Hall A, May M, Macleod J. Balance ability of 7 and 10 year old children in the population: results from a large UK birth cohort study. *Int J Pediatr Otorhinolaryngol*. 2011;75:106-13.
- [14] Yardley L, Masson E, Verschuur C, Haacke N, Luxon L. Symptoms, anxiety and handicap in dizzy patients: development of the vertigo symptom scale. *J Psychosom Res*. 1992;36:731-41.
- [15] Jacobson GP, Newman CW. The development of the Dizziness Handicap Inventory. *Arch Otolaryngol Head Neck Surg*. 1990;116:424-7.
- [16] Bell A. Designing and testing questionnaires for children. *J Res Nurs*. 2007;12:461-9.
- [17] Jackson C FA. Designing and analysing questionnaires and surveys: a manual for health professionals and administrators. London: Whurr 2000.

- [18] Goodman R. The Strengths and Difficulties Questionnaire: a research note. *J Child Psychol Psychiatry*. 1997;38:581-6.
- [19] Goodman R, Meltzer H, Bailey V. The Strengths and Difficulties Questionnaire: a pilot study on the validity of the self-report version. *Eur Child Adolesc Psychiatry*. 1998;7:125-30.
- [20] Eagger S, Luxon LM, Davies RA, Coelho A, Ron MA. Psychiatric morbidity in patients with peripheral vestibular disorder: a clinical and neuro-otological study. *J Neurol Neurosurg Psychiatry*. 1992;55:383-7.
- [21] Kim S, Oh YM, Koo JW, Kim JS. Bilateral vestibulopathy: clinical characteristics and diagnostic criteria. *Otol Neurotol*. 2011;32:812-7.
- [22] Sekitani T IY, Noguchi T, Inokuma T. Vestibular neuritis:epidemiological survey by questionnaire in Japan. *Acta Oto-Laryngologica (Suppl)*. 1993;503:9-12.
- [23] Society HCS-CotIH. The International Classification of Headache Disorder, 2nd ed. *Cephalalgia*.24:1-160.
- [24] Lima MM, Padula NA, Santos LC, Oliveira LD, Agapejev S, Padovani C. Critical analysis of the international classification of headache disorders diagnostic criteria (ICHD I-1988) and (ICHD II-2004), for migraine in children and adolescents. *Cephalalgia*. 2005;25:1042-7.
- [25] Lempert T, Olesen J, Furman J, Waterston J, Seemungal B, Carey J, et al. Vestibular migraine: diagnostic criteria. *J Vestib Res*. 2012;22:167-72.
- [26] Maroon JC, Lovell MR, Norwig J, Podell K, Powell JW, Hartl R. Cerebral concussion in athletes: evaluation and neuropsychological testing. *Neurosurgery*. 2000;47:659-69.
- [27] Bryman A, Cramer, D. . *Quantitative Data Analysis with SPSS Release 8 for Windows. A Guide for Social Scientists*. London: Routledge; 1999.
- [28] Kaiser HF. An index of factorial simplicity. *Psychometrika*. 1974;39:31-6.
- [29] Streiner DL NG. *Health Measurement Scales: A Practical Guide to Their Development and Use*. New York, NY: Oxford University Press; 2008.

- [30] Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. *Clin Chem*. 1993;39:561-77.
- [31] Neuhauser HK, von Brevern M, Radtke A, Lezius F, Feldmann M, Ziese T, et al. Epidemiology of vestibular vertigo: a neurotologic survey of the general population. *Neurology*. 2005;65:898-904.
- [32] Batu ED, Anlar B, Topcu M, Turanli G, Aysun S. Vertigo in childhood: a retrospective series of 100 children. *Eur J Paediatr Neurol*. 2015;19:226-32.
- [33] Niemensivu R, Pyykko I, Wiener-Vacher SR, Kentala E. Vertigo and balance problems in children--an epidemiologic study in Finland. *Int J Pediatr Otorhinolaryngol*. 2006;70:259-65.
- [34] O'Reilly R, Morlet T, Pazuniak M, Greywood J, Levi J. Vestibular and balance testing in childhood migraine. *Laryngoscope*. 2012;122 Suppl 4:S93-4.
- [35] Casselbrant ML, Redfern MS, Furman JM, Fall PA, Mandel EM. Visual-induced postural sway in children with and without otitis media. *Ann Otol Rhinol Laryngol*. 1998;107:401-5.
- [36] Maes L, De Kegel A, Van Waelvelde H, Dhooge I. Association between vestibular function and motor performance in hearing-impaired children. *Otol Neurotol*. 2014;35:e343-7.
- [37] Gagnon I, Forget R, Sullivan SJ, Friedman D. Motor performance following a mild traumatic brain injury in children: an exploratory study. *Brain Inj*. 1998;12:843-53.
- [38] O'Reilly RC, Greywoode J, Morlet T, Miller F, Henley J, Church C, et al. Comprehensive vestibular and balance testing in the dizzy pediatric population. *Otolaryngol Head Neck Surg*. 2011;144:142-8.
- [39] Alsalaheen BA, Mucha A, Morris LO, Whitney SL, Furman JM, Camiolo-Reddy CE, et al. Vestibular rehabilitation for dizziness and balance disorders after concussion. *J Neurol Phys Ther*. 2010;34:87-93.
- [40] Field A. *Discovering statistics using SPSS*. London: Sage; 2009.
- [41] DeVellis R. *Scale Development: theory and applications*. Newbury Park: Sage; 1991.
- [42] DeVon HA, Block ME, Moyle-Wright P, Ernst DM, Hayden SJ, Lazzara DJ, et al. A psychometric toolbox for testing validity and reliability. *J Nurs Scholarsh*. 2007;39:155-64.

- [43] Miyahara M, Hirayama M, Yuta A, Takeuchi K, Inoki T. Too young to talk of vertigo? *Lancet*. 2009;373:516.
- [44] O'Reilly RC, Morlet T, Nicholas BD, Josephson G, Horlbeck D, Lundy L, et al. Prevalence of vestibular and balance disorders in children. *Otol Neurotol*. 2010;31:1441-4.
- [45] Choung YH, Park K, Moon SK, Kim CH, Ryu SJ. Various causes and clinical characteristics in vertigo in children with normal eardrums. *Int J Pediatr Otorhinolaryngol*. 2003;67:889-94.
- [46] Kisilevski V, Podoshin L, Ben-David J, Soustiel JF, Teszler CB, Hafner H, et al. Results of otovestibular tests in mild head injuries. *The international tinnitus journal*. 2001;7:118-21.
- [47] Lee JD, Park MK, Lee BD, Park JY, Lee TK, Sung KB. Otolith function in patients with head trauma. *Eur Arch Otorhinolaryngol*. 2011;268:1427-30.
- [48] Anoh-Tanon MJ, Bremond-Gignac D, Wiener-Vacher SR. Vertigo is an underestimated symptom of ocular disorders: dizzy children do not always need MRI. *Pediatr Neurol*. 2000;23:49-53.
- [49] Bucci MP, Le TT, Wiener-Vacher S, Bremond-Gignac D, Bouet A, Kapoula Z. Poor postural stability in children with vertigo and vergence abnormalities. *Invest Ophthalmol Vis Sci*. 2009;50:4678-84.
- [50] McCrory P, Meeuwisse WH, Aubry M, Cantu B, Dvorak J, Echemendia RJ, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. *Br J Sports Med*. 2013;47:250-8.
- [51] Joyce AS, LaBella CR, Carl RL, Lai JS, Zelko FA. The Postconcussion Symptom Scale: Utility of a Three-Factor Structure. *Med Sci Sports Exerc*. 2014.
- [52] Reale L, Guarnera M, Grillo C, Maiolino L, Ruta L, Mazzone L. Psychological assessment in children and adolescents with Benign Paroxysmal Vertigo. *Brain Dev*. 2011;33:125-30.
- [53] Lee CH, Lee SB, Kim YJ, Kong WK, Kim HM. Utility of psychological screening for the diagnosis of pediatric episodic vertigo. *Otol Neurotol*. 2014;35:e324-30.

- [54] Goodman R, Ford T, Simmons H, Gatward R, Meltzer H. Using the Strengths and Difficulties Questionnaire (SDQ) to screen for child psychiatric disorders in a community sample. *Br J Psychiatry*. 2000;177:534-9.
- [55] van der Meer M, Dixon A, Rose D. Parent and child agreement on reports of problem behaviour obtained from a screening questionnaire, the SDQ. *Eur Child Adolesc Psychiatry*. 2008;17:491-7.
- [56] Roza SJ, Hofstra MB, van der Ende J, Verhulst FC. Stable prediction of mood and anxiety disorders based on behavioral and emotional problems in childhood: a 14-year follow-up during childhood, adolescence, and young adulthood. *Am J Psychiatry*. 2003;160:2116-21.
- [57] Petanidou D, Giannakopoulos G, Tzavara C, Dimitrakaki C, Kolaitis G, Tountas Y. Adolescents' multiple, recurrent subjective health complaints: investigating associations with emotional/behavioural difficulties in a cross-sectional, school-based study. *Child and adolescent psychiatry and mental health*. 2014;8:3.

Figure 1. ROC curves for various cut-off levels of the PVSQ to discriminate between healthy children and those with dizziness due to a vestibular disorder or concussion.

APPENDIX 1: General question set**We would first like to ask a few questions about you.**

1. What is your name?.....
2. How old are you?.....
3. Please circle as appropriate: Boy / Girl
4. Do you have migraines? Yes / No / Don't know
5. Do you often have dizzy spells? Yes / No
6. Do you often have terrible stomach aches? Yes / No
7. Do you often vomit? Yes / No

8. Do you have fits or faints? Yes / No
9. Can you see well with both eyes? Yes / No
10. If no, do you know why? (e.g. lazy eye, needing glasses)?.....
11. Do you have any trouble hearing? Yes/ No
12. Do you have glue ear? Yes / No / Don't know
13. Do you take any medicine? Yes / No
14. If yes, why do you take it?
15. Do you see a doctor for any reason? Yes / No
16. If yes, what is the reason? (e.g. muscles, joints, bones etc)
.....
17. Do you have a feeling of spinning lasting less than two minutes when you bend over or look up quickly or turn over in bed? Yes / No

SUPPLEMENTARY INFORMATION

Diagnostic Criteria

Diagnostic criteria for a peripheral vestibular disorder diagnosis was based on a) clinical history of sudden vertigo resolving within days to weeks and b) findings of unilateral (or bilateral) canal paresis on standard Fitzgerald-Hallpike caloric testing as measured by the duration parameter using the Jongkees formula of more than 8% in the absence of optic fixation[20] and/or direct current electronystagmography (ENG) showing the presence of unidirectional spontaneous nystagmus on gaze testing with enhancement of the response on removal of optic fixation and/or a marked directional preponderance of at least 30% on rotation testing. Bilateral vestibular

hypofunction was diagnosed based on bilateral canal paresis as above and/or reduced gain and increased phase leads during low 0.04 Hz frequency step rotation.[21] Vestibular neuritis was diagnosed based on a history of sudden onset vertigo, absence of both hearing and neurological symptoms.[22] Migraine was diagnosed based on the International Headache Society (IHS) criteria[23, 24] and migrainous vertigo on the Bárány Society and IHS criteria.[25]