RESEARCH ARTICLE

MOTOR DEVELOPMENT AND POSTURAL CONTROL EVALUATION OF CHILDREN WITH SENSORINEURAL HEARING LOSS: A REVIEW OF THREE INEXPENSIVE ASSESSMENT TOOLS-PBS, TGMD-2, AND P-CTSIB

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Abstract

Objective

Sensorineural hearing loss is believed to be the result of a physiologic malfunction in the inner ear or acoustic nerve. Depending on the rapidity of progression and severity, sensorineural hearing loss can be endlessly annoying, frightening and can constitute a permanent after effect. Moreover, there is no surgical procedure that can reverse or lessen the severity of a sensorineural hearing loss. Furthermore, children with sensorineural hearing loss present with additional disabilities in 30 to 40% of the cases. Children with profound sensorineural hearing loss may exhibit abnormalities of vestibular structures, which may lead to impairment of postural control, locomotion and gait. The development of gross motor functions such as head control, sitting and walking are likely to be delayed in these children. Evaluation of motor skills and balance are the core of the pediatrician and physical therapist's expertise and practice. Knowledge of the reliable, valid and inexpensive assessment tools for measuring motor skills and balance are necessary to gauge the progression of the disease and the impact of treatment. In this review, we aim to summarize inexpensive tools such as TGMD-2, PBS, and P-CTSIB.

Keywords: Postural control, balance, motor development, evaluation, sensorineural hearing loss.

Introduction

Sensorineural hearing loss accounts for about 90% of all cases of hearing loss, and has an incidence of 2-4 per million (1, 2). It is worth to view hearing impairment as a multifaceted condition, as a variety of factors determine the effect of hearing impairment on children's development (3). Gross movement skills are necessary to move, stabilize and control body and objects at an early age when the child explores the environment. A well developed gross movement skill helps individuals to function more smoothly in the later life (4). Postural control is composed of the biomechanical motor process and the sensory organization process. Three sensory systems of visual, somatosensory and vestibular sources contribute to providing information to maintain postural control. The visual system plays a predominant role in the development of postural stability in young children while the somatosensory and the vestibular inputs dominate postural control later in life (5).

Delayed postural development is a common impairment in profoundly deaf children who are often associated with vestibular dysfunction. This can lead to defective motor development (5, 6). Rine et al repeatedly examined the balance and gross motor development of children with hearing loss and found that most of the children considerably performed poorly in both the balance and gross motor tests (7).

Physical therapists and pediatricians use different tools to document motor performance and postural control in sensorineural hearing impaired children. Most of the tools aim at a specific target group and have a specific content. Kirshner and Guyatt have described three purposes for clinical measurement: discrimination, prediction and evaluation. Discriminative measures are used to identify children with and without a particular characteristic. Predictive measures are used for screening and diagnostic purposes. Evaluative measures are used to assess changes overtime or as a result of intervention (8). In general, an assessment tool can be categorized into two major groups: norm or criterion referenced. These tests differ in their intended purposes, the way in which the content is selected and the scoring process. Norm referenced tests are designed to examine the child's performance in relation to the normative group, whereas a criterion-referenced test documents individual performance in relation to pre-determined criteria (9). A standardized test is inferred to be a norm-reference; however, criterion-referenced tests may be standardized.

Physical therapists often use published tests to ensure credibility in the assessment of children (10). Although several assessment tools exist, they are highly expensive, which minimizes their clinical utility. Knowledge of an inexpensive assessment tool for motor skills and balance measurement is mandatory for clinical practice to evaluate treatment outcomes. Hence, the purpose of this review is to introduce some inexpensive assessment tools which are used to evaluate motor skill and balance in sensorineural hearing impaired children.

Search Strategy

Computerized and manual search was done with particular focus on original articles, using the keywords or related words in different blends as the following: motor skills, balance, motor development, postural control, evaluation, deaf and sensorineural hearing loss in Pubmed and Google scholar. Sixty eight articles were selected of which 14 had the required standards.

2.1 SEARCH CRITERIA AND DATA EXTRACTION

After identification of the articles, the first selection of relevant articles was based on the titles and abstracts that addressed the assessment of balance and motor development in sensorineural hearing loss. Evidence states that in the first few months of walking, the infant steps with a wider base and a raised arm and the postural control development gradually becomes adultlike by about 5 to 7 years of age (11). Further literature also states that delayed gross motor development is evident regardless of age in children with sensorineural hearing loss (12). Hence, age group of 3 through 11 years was chosen.

The secondary selection of articles was based on the following inclusion criteria:

a) Evaluation of the children with profound deaf/ sensorineural hearing loss
b) Age 3 – 11 years
c) Sensorineural hearing loss with or without cochlear implantation
d) Evaluation of at least one balance/motor development test in children with sensorineural hearing loss or profound hearing loss or deaf. Both diagnostic as well as intervention studies were included.
e) Articles published in English.

Data extraction was carried out by one researcher based on the above criteria. Final extraction was done by an independent rater.

Results

Various tools have been used in previous studies to detect motor impairment and balance dysfunction in deaf children (Table 1).

Table 1: Extracted research evidences

Test name	Age range (Years)	No. of Subjects	Outcome variable	Reference
BOT-2† (Balance sub set)	4-17	41 children with CI#	Static and dynamic balance	Sharon L.et al [13] 2008
BOT-2† (Balance subtest)	3-19.3	40 children with severe to profound SNHL and unilateral CI#	Static and dynamic balance	Sharon L et al(14) 2008
Posturography sensory conditions testing (SCT) PDMS **	3-8.5	21 children with SNHL	Motor development and Postural control	Rine et al(15) 2004
Force platform	8-11	36 children; 13 unilateral SNHL	Sensory organization	Suarez H et al[16] 2007
Movement Assessment Battery for Children (M-ABC) Körperkoordinationstest für Kinder (KTK) One leg standing test	4-12	36 deaf children	Motor development Balance	Gheysen F et al(17) 2008
Battery of 14 clinical test	7-13	29 children with HI *	Motor development and balance	Terry k. Crowe et al(18)1988
Children Activity Scales for Teachers (ChAS-T) Movement Assessment Battery for Children (M-ABC)	5-9	22 children with HI *, 26 children with normal hearing	Motor abilities	Engel-Yeger B et al(19) 2009
TGMD-2 §	4-18	201 deaf children	Motor skills	Dummer, G.M et al(20) 1996
Balance subset of Southern California Sensory Integration tests	5-9	34 children with SNHL ††	Static balance	Cynthia N Potter et al(21) 1984
Single-limb standing test under 4 different sensory condition	4-14	57 Profound deaf children	Sensory organization, Balance	An MH et al(22) 2009
Force platform	7-11	49 Deaf	Balance	Effgen SK et al (23)1981
BOT-2† (Balance subtest)	4.5-14.5	28 deaf children with SNHL	Balance	Siegel JC et al(24) 1991
PBS ‡ Timed Static balance test TUG test ¶	9.2±4.4	Unilateral / bilateral CI #	Balance	Jacquelyn LB et al 2010 (25)
PDMS**(Balance portion)	3.67- 7.83	11 children with CI#	Static and dynamic balance	Kleinpeter RD et al(26) 2000

Abbreviations: † Bruininks-Oseretsky test of motor proficiency, ‡Pediatric balance scale, § Test of gross motor development, ¶ Timed up and go test, # Cochlear implantation, †† Sensorineural hearing loss, * Hearing impaired, ** Peabody Developmental Motor Scales.

Table 2: Reliability, validity, assessment time and cost of few tools

Test	Cost 2010	Assessment time (Minutes)	Inter-rater reliability	Test-retest reliability	Validity
Movement-ABC	$1,094.00	20-30	ICC=0.70	ICC=0.75to 0.97	Concurrent validity with BOTMP r= 0.53 and with KTK r=0.62
PDMS- 2	$499.00	65-90	r= 0.96	r =0.89to 0.96	Construct validity with PDMS (Gross motor r=0.84, fine motor r=0.91)
TGMD- 2	$118.00	15-20	r=0.86to 0.96	r=0.91	Factor analysis: goodness of fit indexes ranging from 0.90- 0.96 (with chronological age, between groups, and subtests)
BOT- 2	Test Kit: $795.00	*80-60*	*r= 0.92to 0.99*	*r=0.86to 0.89*	*Concurrent validity with PDMS-2 r= 0.73*
KTK	548,00 €	*20*	*0.85<*	*0.85<*	*Factor analysis showed that the test evaluated dynamic body coordination and dynamic balance*
PBS	*Free*	*15-20*	*r= 0.99*	*r=0.89*	*Validity* has not yet been thoroughly tested
P-CTSIB(27)	*Free*	*20*	*r=0.99*	*r=0.99*	*Concurrent validity with BOTMP (static:0.35, dynamic:0.54, and total score:0.52)*

Discussion

Although modern assessment tools that accurately quantify motor development and postural control are available, they are still inaccessible in regular clinics due to unaffordable cost. BOT-2 is a valid and reliable tool that assesses both motor and balance skills (32). However, it is comparatively much expensive than TGMD-2 and therefore not discussed in the discussion section. Likewise, M-ABC, posturography and other tools have been ignored for the same reason. In this article, we discussed basic assessment tools: TGMD-2, PBS, and P-CTSIB, which cover motor function, balance (static and dynamic) and sensory organization.

The Paediatric Balance Scale (PBS) is a modification of the berg balance scale that tests the functional balance skills of children ages five to fifteen. The test is comprised of 14 items that are relevant to everyday tasks, and each is given a score from 0 to 4, with a higher number indicating better performance. In order to administer the test, the examiner requires a height adjustable bench, a chair with a back and arm support, a stopwatch, 1 inch masking tape, a 6 inch high step stool, a chalkboard eraser, a ruler or yardstick, and a small level (28). The individual items had a small variation when analyzed using the Kappa Coefficient (k = 0.87 to 1.0), Spearman Rank Correlation Coefficient (r = 0.89 to 1.0), and high interrater reliability (0.997). The interrater reliability was also high between live sessions (0.996) and videotaped sessions (0.944).

The Test of Gross Motor Development (TGMD)-2 is a norm referenced measure of common gross motor skills, used to identify children with mild, moderate as well as severe impairments. The test includes two subsets: locomotor and object control. The test encompasses 12 skills, six for each subset - Locomotor: run, gallop, hop, leap, horizontal jump and slide; Object control: striking a stationary ball, stationary dribble, kick, catch, overhand throw and underhand roll. When the performance is correct, a score of one is marked, and incorrect performances are scored zero. There are no partial scores. The child is asked to perform every item twice. The two trials are summed together to get the total score for each performance. Higher scores indicate better performance. Reliability coefficients for the locomotor subtest average 0.85, the object control subtest average 0.88 and the gross motor composite average 0.91. Standard error of measurement is 1 at every age interval for both subtests and 4 or 5 for the composite score at each age interval (31).

The Paediatric Clinical Test of Sensory Interaction and Balance (P-CTSIB) is a timed test that was developed for systematically testing the influence of visual, vestibular, and somatosensory input on standing balance (29, 30). This test is inexpensive and requires minimal equipment. It measures sensory system effects on stationary standing postural control. The following six conditions are tested to find out the postural control triad pathology; (i, ii, iii) Standing on floor with eyes open, eyes closed, and with dome (eyes open, but the vision stabilized), (iv, v, vi) Standing on foam with eyes open, eyes closed, and with dome (eyes open, but the vision stabilized). Conditions five and six check the influence of vestibular system on balance. For all six conditions, the subject is instructed to stand quietly, with arms comfortably across the waist, feet together, for as long as possible, up to 30 seconds.

In conclusion, Simple clinical measures such as PBS, TGMD-2 and P-CTSIB can reliably evaluate motor skills and balance dysfunction in children with sensorineural hearing loss. These tools are easy for a pediatrician and physical therapist to administer and do not require expensive equipment, making them more practical. These tests do not require a long duration to administer and are short enough so that a child will not exhaust before its completion. These tests are also advantageous for obtaining data about patient performance before and after therapy. These tools are serviceable to measure motor skills and balance in clinical setting, where expensive tools are not affordable.

Authors Contribution

Both authors contributed to the conception of the study and were involved in writing, revising and approving the final draft of the manuscript.

Conflict of interest

None.

The following web link may help the reader to find more information about the above mentioned assessment tools:

1. http://www2.pef.uni-lj.si/srp- gradiva/tgm.pdf
2. http://www.proedinc.com/customer/productView.aspx?ID=1776
3. http://onlinelibrary.wiley.com/doi/10.1097/00005537-199803000-00002/full
4. http://web.missouri.edu/~proste/tool/vest/CTSIB.pdf
5. http://www.pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=PAa58000&Mode=summary
6. http://www.pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=015-8541-308&Mode=summary
7. http://www.cafyd.com/ruizlass2003.pdf
8. http://www.pearsonassessments.com/HAIWEB/Cultures/en-us/Productdetail.htm?Pid=076-1618-21X&Mode=summary
9. http://www.sw2.k12.wy.us/uploadfl/test-summaries-new.pdf
10. http://www.dizziness-and-balance.com/testing/posturography.html
11. http://www.vestibular.org/vestibular-disorders/diagnostic-tests/posturography-cdp.php
12. http://www.testzentrale.de/programm/korperkoordinationstest-fur-kinder.html

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