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Vestibular Rehabilitation for Children with Sensorineural Hearing Loss

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Abstract

Background/Purpose:

Given the close anatomical relationship between the vestibular and cochlear system, children with hearing issues are at a greater likelihood to have concomitant impairments in the vestibular system and thus balance difficulties. This is especially true of children with nerve related hearing loss (sensorineural hearing loss SNHL), as opposed to issues relating to conduction through the inner ear bones and drum. This type of reduced balance sense is referred to as vestibular hypofunction (VH). Unlike adults who acquire VH, children born with VH are unlikely to complain of dizziness or visual disturbances and are often referred to as "clumsy". VH has traditionally been tested for by Vestibular Evoked Myogenic Potentials (VEMP) and Rotary Chair Testing. Unfortunately, these traditional testing methods are expensive, not readily available in the clinical setting, and do not test patients in a functional manner. Therefore, this paper seeks to examine the current literature on clinical tests including: Modified Clinical Test of Sensory Interaction in Balance (MCTSIB), Head Impulse Tests (HIT), and Dynamic Gait Index to identify children with VH within the hearing-impaired population.

Case Description

The purpose of this critical literature analysis is to examine the current evidence for identification and treatment of pediatric patients between 3-12 years old with unilateral or bilateral vestibular hypofunction (UVH or BVH respectively). Identifying specific and sensitive clinical measures in static balance, dynamic balance, and gaze stability. Followed by examination of preliminary therapeutic interventions addressing common deficits in this pediatric population. PICO: Which clinical measures (static balance, dynamic balance, or gaze stabilization) are most likely to identify vestibular impairments in 3 to 12-year-old children with sensorineural hearing loss, either directly or indirectly.

Discussion:

Children with SNHL demonstrate increased rates of vestibular hypofunction. These deficits warrant the use of valid clinical measures to assess static balance, dynamic balance, and gaze stability. The validated static balance assessment sensitive to vestibular hypofunction is the MCTSIB. Three of the four MCTSIB components: narrow base of support eyes closed, narrow base of support on foam eyes open, and narrow base of support eyes closed consistently identify impairments and should be utilized. Static examination of unilateral stance, with eyes open and closed, and dynamic balance assessment utilizing tandem walking have been shown to identify impairments, but have not been validated for vestibular hypofunction in this population. The Head Thrust Test has been validated and demonstrates high specificity for vestibular hypofunction in children with SNHL. Dynamic Visual Acuity (DVA) demonstrates sensitive to vestibular hypofunction and addresses functional gaze stability with head movement. MCTSIB, HIT, & Dynamic Visual Acuity are affordable clinical measures which can be utilized to identify vestibular hypofunction in children with sensorineural loss.

Background & Purpose

Prevalence

Increased prevalence of vestibular hypofunction has been found in pediatric populations. Pediatric patients with hearing loss have been reported to have vestibular dysfunction ranging from 30-70% of the population.[1] More specifically, many patients with Sensorineural Hearing Loss (SNHL) have previously reported deficits in horizontal semi-circular canal function, higher frequency canal function, and/or saccular deficits.[2] In turn, SNHL and vestibular hypofunction has been associated with significant motor delays.[3, 4,5,6] Fortunately, newborns are regularly screened for auditory function prior to hospital discharge.[7] Therefore, children with SNHL have potential to be identified early, screened for vestibular hypofunction, and provided intervention to improve motor development.

Given the close anatomical relationship between the cochlea and the vestibulum, within the labyrinthine system, it is not surprising that congenital, perinatal, or acquired deficits in hearing would be correlated with some dysfunction in the vestibular system. For example, acoustic trauma, vascular disorders, viral infections, genetic factors, autoimmune disorders, and ototoxic drugs are all possible sources of concomitant defictis.[8, 3]

Age of Intervention

Impairment in the vestibular system is associated with developmental gross motor and balance delays. [4] More specifically, children with bilateral vestibular loss have been shown to exhibit significant delays within the first 3 years of life, signs of effective compensation between 3-5-years old, variable deficits by 6, and potentially significant compensation by 10 years old. [3]

Therefore, this window of motor developmental growth may be ideal for effective interventional designs.

Current literature suggests adult like sway magnitude is achieved by the age of 12 years old. [9, 10, 11] Recent visual re-weighting in children suggests that younger children, from 4 and 8 years old, can recognize changes in visual amplitude/velocity and compensate for sensory conflict. These children essentially reduce the influence of inaccurate visual input, in relation to other sensory cues, maintaining static balance.[12] Children at these ages may be most developmentally appropriate for interventions which address adaptive responses to sensory conflict in relation to postural stability.

Gaze Stability

Pediatric populations with Global Developmental Delay reportedly have deficits in gaze stability. Gaze stability is the ability to maintain clear vision with head movement. [13, 14] Gaze stability is associated with the Vestibular Ocular Reflex (VOR) and rehabilitation focuses on improving oculomotor coordination in relation to active head movement. [15] To examine potential vestibular hypofunction, in relation to VOR, the Head Impulse Test and Dynamic Visual Acuity have been validated for pediatric patients with SNHL.[16] Specifically, a report of 23 children with SNHL found a motor deficit prevalence of 65.6% and a reduced dynamic visual acuity (DVA) prevalence of 15.6%. This report found children with SNHL and reduced DVA consistently scored lower on the Movement Assessment Battery for Children-2, with the greatest deficits found in the balance component. [5]

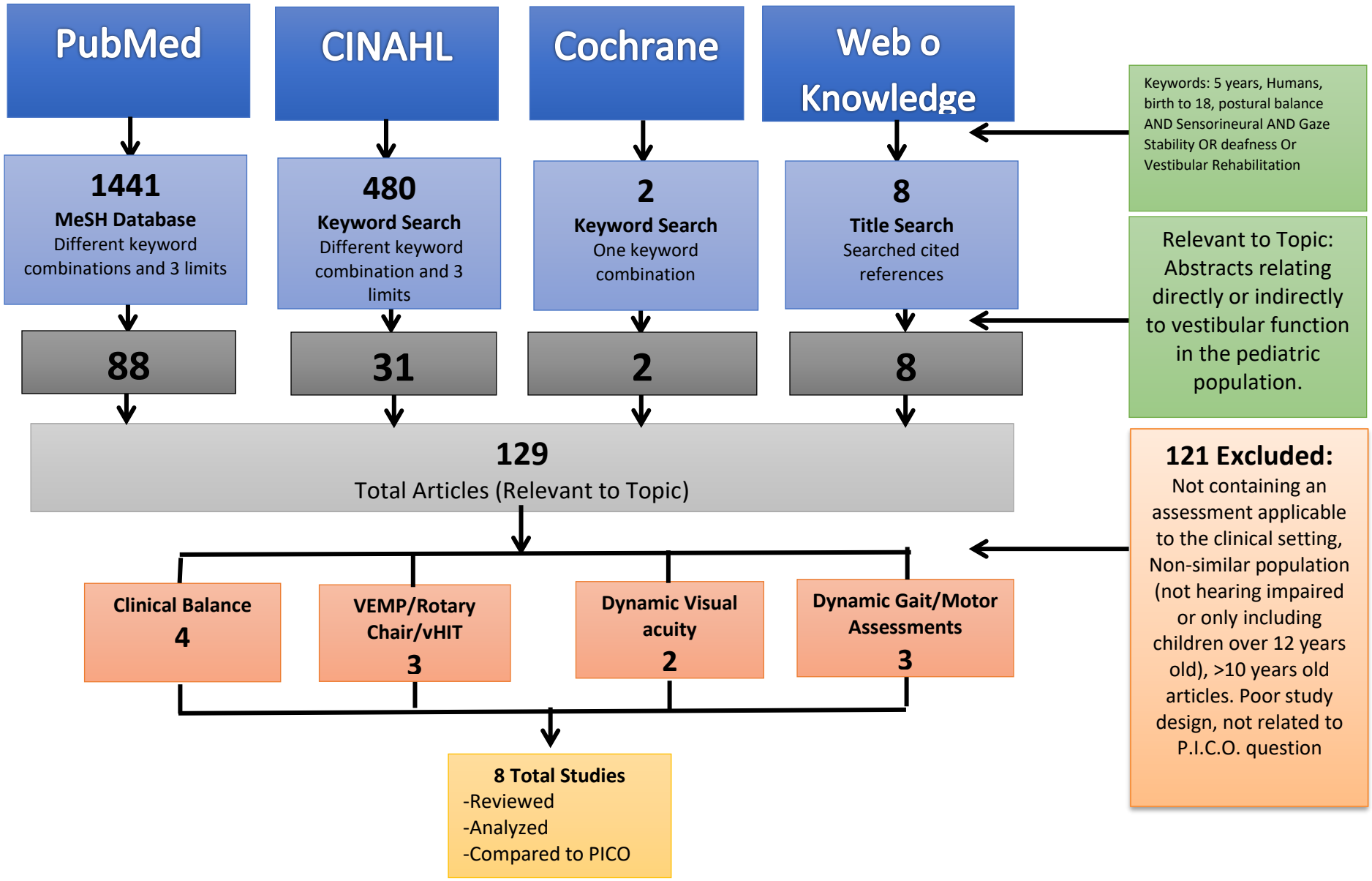
Introduction Summary

In summary, there is significant evidence that children with hearing impairment often have balance impairments. Deficits can be partially attributed to vestibular hypofunction due to its close relationship to the hearing system. The ideal age to address these deficits is not fully understood, but the potential for intervention may exist as young as three or four years old. Children at this age demonstrate the ability to differentially integrate vision, proprioception, and the vestibular system. For example, when vision is manipulated to decrease a child's sense of balance, children compensation for this misinformation by "re-weighting" the sensory influence, on successive trials, and improve static postural sway as early as four years old.[12] To complicate matters, children also move in space and different parts of the vestibular system must interact with vision and proprioception to maintain balance. For instance, head rotation stimulates the vestibular and oculomotor systems together to stabilize our vision and avoid disorientation. This process is referred to as "Gaze Stability". Given these factors, the goal of this article analysis is to examine the current evidence for assessing static balance, dynamic balance, and/or gaze stability to best identify specific impairments in children with sensorineural hearing loss.

Methods

PICO: What clinical measures (static balance, dynamic balance, or gaze stabilization) are most likely to identify vestibular impairments in 3 to 12-year-old children with sensorineural hearing loss, either directly or indirectly. Articles were required to include clinical measures which are available in most clinical settings to assess static balance, dynamic balance, or gaze stabilization. The population these clinical measures are performed on must include children with sensorineural hearing loss. Interventional designs are preliminary and can be better addressed with appropriate outcome measures in the future. Four databases were utilized to find relevant articles. The search began by searching keywords "postural balance AND Sensorineural AND Gaze Stability OR deafness OR vestibular Rehabilitation" in PubMed and CINAHL. Filters were added to PubMed and CINAHL, including "full text", "5 years", "humans" and "birth to 18" or "All Child" to narrow down the search. Cochrane was reviewed for one keyword combination "vestibular rehabilitation" while Web of Knowledge was utilized for specific title searches attained from articles within the 121 articles previously obtained relating to balance impairment and/or vestibular impairments in the pediatric population, obtaining 8 additional articles for consideration. From the 129 total articles remaining, articles were excluded for lacking applicable clinical measures addressing balance impairment, lacking children with hearing impairment, and only including children over 12 years old. Eight relevant studies were hand chosen for analysis. See LITERATURE SEARCH STRATEGY CHART below for a diagram of this breakdown followed by ARTICLE SUMMARIES CHART giving an overall breakdown of each article chosen. The subsequent eight pages provide one-page summaries for each of the articles reviewed

Figure 1. Part I Methods: Articles Included and Excluded for Analysis



The articles below were selected to be analyzed. Refer to Appendix A for detailed article analysis worksheets.

Article #1 (Reference #28): Melo, R. (2017). Gait performance of children and adolescents with sensorineural hearing loss. *Gait and Posture, 57*, 109-114. doi:10.1016/j.gaitpost.2017.05.031

Level of evidence: 4 **PEDro Scale: 6/10**

Purpose:

To assess the gait performance of children with normal hearing (NH) in relation to sensorineural hearing loss (SNHL) utilizing the dynamic gait index.

Methods:

The Brazilian version of the Dynamic Gait Index (DGI) was performed on 48 children with SNHL and 48 matched children with normal hearing (NH). Age of subjects ranged from 7 to 18 years old.

Results:

Children with SNHL performed significantly lower on the DGI ($p < 0.001$). When stratified by age (7-10, 11-14, and 15-18 years old) mean differences between the SNHL and NH group decrease over time (7.8, 5.8, 3.8 respectively).

Critique/bottom line:

Significant impairments in dynamic gait are exhibited in children with sensorineural hearing loss, regardless of age. Although maturation may allow for compensation and decreased severity in these differences, exhibited by lower mean differences in older children. Interventional approaches to improving dynamic gait in children with SNHL will need to control for maturational improvements.

Limitations:

Specific vestibular system testing was not performed. Study lacked assessor/researcher blinding increasing the likelihood of conscious or unconscious bias.

Article #2 (Reference #30): Ebrahimi, A., Movallali, G., Jamshidi, A., Haghgoo, H., and Rahgozar, M. (2016). Balance Performance of Deaf Children With and Without Cochlear Implants. *Acta Medica Iranica*, *54*(11), 737-742. Retrieved from http://acta.tums.ac.ir/index.php/acta/article/view/5267

Level of evidence: 4 **PEDro Scale: 6/10**

Purpose:

Comparison of static and dynamic balance in children with sensorineural hearing loss (SNHL) with and without a cochlear implant (CCI).

Methods:

Cross-sectional study of children 7 to 12 years old. Subjects included 85 children with profound SNHL (>90dB), 35 of which had cochlear implants, and 60 children with typical development (TD). Static was assessed utilizing the Bruininks-Oseretsky test of Motor Proficiency (BOTMP).

Results:

Children with SNHL scored significantly lower on the BOTMP ($P<0.001$) relative to the control in all balance tasks, except Item 4 (walking forward on a line) control relative to the non-implant group ($P<0.0491$).

Critique/bottom line:

Static one leg standing activities (eyes open or eyes closed) and dynamic walking with a narrow base of support (balance beam or tandem) activities were demonstrated to be more difficult for children with SNHL to perform and may benefit from future intervention.

Limitations:

No screening procedures were utilized to assess vestibular function**.**

Article #3 (Reference #16): Christy, J., Payne, J., Azuero, A., and Formby, C. (2014). Reliability and Diagnostic Accuracy of Clinical Tests of Vestibular Function for Children. Pediatric Physical Therapy, 26(2), 180-189. doi:10.1097/pep.0000000000000039

Level of evidence: 3b **PEDro Scale: 6/11**

Purpose:

This study's purpose was to determine reliability, diagnostic values and minimum detectable change scores with 90% confidence (MDC90) for vestibular function in children with SNHL.

Methods:

Subjects included 6 to 12 year olds, 20 children with severe to profound SNHL and 23 children with typically development (TD**).**

Tests Evaluated: The Head Thrust Test, Emory Clinical Vestibular Chair test, Bucket Test, Dynamic Visual Acuity, Modified Clinical Test of Sensory Integration on Balance, and Sensory Organization Test completed twice for reliability.

Reference Standards: Rotary chair and cervical vestibular evoked myogenic potentials (cVEMP)

Results:

MCTSIB and HTT demonstrated the greatest agreement with the reference standards cVEMP and/or rotary chair test, 86% and 88% respectively. HTT demonstrating the greatest specificity at 91%. The optimal cutoff score for MCTSIB was 20 seconds for each condition. The highest clinical test sensitivities were MCTSIB and DVA both with 88%. DVA optimal cutoff score was determined to be 10 optotypes. Clinical Test specificity was highest for MCTSIB with 92%. MDC 90 for MCTSIB and DVA were determined to be 16.75 seconds and 8 optotypes respectively.

Critique/bottom line:

MCTSIB, HTT, and DVA are affordable and effective functional tests, demonstrating significant agreement with more expensive reference standards (rotary chair and cVEMP) for vestibular hypofunction. Limitations of this study includes the limited sample size of children with sensorineural hearing loss, n = 20.

Article #4 (Reference #25): Maes, L., De Kegel, A., Van Waelvelde, H., and Dhooge, I. (2014). Association Between Vestibular Function and Motor Performance in Hearing-impaired Children. *Otology and Neurotology*, *35*(10), e343-e347. doi:10.1097/mao.0000000000000597

Level of evidence: 4 **PEDro Scale: 6/11**

Purpose:

To assess balance impairment between typically developing children in relation to hearing impaired children with and without vestibular dysfunction.

Methods:

Three groups of children were included in this study, 12 children in each group matched for mean age. Normal hearing and normal vestibular function, hearing impaired and normal vestibular function, and hearing impaired and impaired vestibular function.

Vestibular system assessment: three rotational tests at 0.01, 0.05, and 0.1 Hz (horizontal canal and superior vestibular nerve function) and cVEMP (inferior vestibular nerve and saccule function).

Three clinical balance tests: Balance beam walking, one-leg hopping, and one-leg stance eyes closed.

Results:

Backward walking on balance beam was consistently effective in identifying differences between groups.

One-leg hopping: only demonstrated differences between NH+NV vs. HI +VI.

OLS EC demonstrated differences between NH and HI regardless of vestibular function.

Critique/bottom line:

Only the vestibular impaired group had a mean score below normal on all three clinical balance test indicators. With balance beam walking posteriorly being the only indicator where all vestibular impaired participants scored below normal (MQ<75), implying high sensitivity of this clinical test in this population. OLS EC was also significantly different from the control group, but vestibular impaired participants often scored above -2.00 and therefore within normal. In regard to OLS EC a significant difference did not exist between HI groups with and without VI, therefore significant deficits may exist in the hearing impaired population regardless of vestibular function.

Limitations:

Group differences between degree of hearing loss and cochlear implantation were not controlled for, both of which may have significantly impacted results.

Article #5 (Reference #24): Said, E. (2013). Clinical balance tests for evaluation of balance dysfunction in children with sensorineural hearing loss. The Egyptian Journal Of Otolaryngology, 29(3), 189. DOI: 10.7123/01.EJO.0000431452.76343.3d

Level of evidence: 4 **PEDro Scale: 4/11**

Purpose:

Assessing the balance ability of children with Sensorineural Hearing Loss (SNHL). Assessing potential differences based on age, sex, degree of SNHL, and etiology.

Methods:

Subjects included 50 children with SNHL bilaterally and 30 children with typical development. Participants were aged 5 to 15 years old.

Balance was assessed via Bruininks-Oseretsky Test of motor proficiency (BOTMP), modified Clinical Test of Sensory Interaction for Balance (mCTSIB), one-leg standing (OLS), and tandem stance.

Results:

Balance deficits in children with SNHL may be detected with: One leg standing (EO or EC), Standing on foam (EO or EC), Tandem walking EO, and tandem standing EC.

Significant age differences were detectable with OLS (EO or EC) and tandem walking on a line from the ages of 5-7, 8-10, and 11-15. Similar differences were not found in the TD group.

Significant differences relative to sex, or etiology were not found.

Critique/bottom line:

This study had a relatively high number of subjects (50 HI) relative to similar studies. This allowed them to break down subjects by age group (5-7), (8-10), and (11-15). Regardless of age children with SNHL appear to have significant deficits in balance relative to children with typical development. Although, the severity in this deficit appears to diminish with age. Benefits of any intervention should account for this maturation.

Limitations include:

Vestibular specific assessments were not reported on these patients, although VEMP was reportedly performed during a prior audiological evaluation.

Article #6 (Reference #4): Venkadesan Rajendran, Finita Glory Roy, Deepa Jeevanantham, 2013. A preliminary randomized controlled study on the effectiveness of vestibular-specific neuromuscular training in children with hearing impairment. Clinical Rehabilitation. DOI: 10.1177/0269215512462909

Level of evidence: 2b PEDro Scale: 6/11

Purpose: The purpose of this study was to evaluate the effectiveness of an exercise program including vestibular-specific neuromuscular training in children with profound hearing impairment (>90dB).

Methods: Twenty-three children were assigned to either a vestibular-specific intervention for six weeks or placed in a control group. Subjects were randomly assigned via computer-generated numbers in presealed envelops. Participants aged 6-11 with profound hearing impairment (>90dB). Patients were able to stand and walk independently.

Intensity: 45min sessions 3x/week. Exercises included eye movement exercises, e.g. visual tracking and visual fixation, balance exercises, hand eye coordination, stretching, and fundamental motor skill training.

Outcome measures included: Test of Gross Motor Development-2, postural measures (Pediatric Reach Test, One Leg Standing Balance Test, and postural sway meter), and health related quality of life (PedsQL Generic Core Scale)

Results:

Significant improvement only occurred in the intervention group over six weeks.

Motor skills: Test of Gross Motor development P =0.02, throw for distance P = 0.042, kick for distance P= 0.08, jump for distance P = 0.002, and 15-yard dash P=0.001

Postural Control: Pediatric Reach Test P =0.001, One Leg Standing Test P = 0.03, anterioposterior sway (eyes open P = 0.007, eyes closed P = 0.03), and mediolateral sway (eyes open P = 0.014, eyes closed P = 0.017)

Health-related quality of life P =0.01.

Results suggest that the intervention has a positive effect on Motor skills, Postural Control, and QOL for 6-11 years old with profound hearing impairment. Intervention included eye movement exercises, e.g. visual tracking and visual fixation, balance exercises, hand eye coordination, stretching, and fundamental motor skill training

Critique/bottom line:

The strengths included accessible outcome measures and quality of life considerations. As well as an attempt to integrate vestibular-specific interventions including visual fixation with head

movement. A program including vestibular-specific interventions may assist in motor skill, balance, and quality of life gains.

Limitations

The limitations of this study include small sample size from one school and lack of accessor blinding. Vestibular deficits were inferred and not specifically assessed. Example protocol included stretching, ocular eye movement, and visual tracking/fixation (no head movement) without clear indication. As well, no placebo treatment was given to the control group and therefore placebo may have effected results.

Article #7 (Reference #5): Martin, W., Jelsma, J., and Rogers, C. (2012). Motor proficiency and dynamic visual acuity in children with bilateral sensorineural hearing loss. *International Journal Of Pediatric Otorhinolaryngology*, *76*(10), 1520-1525. doi:10.1016/j.ijporl.2012.07.007

Level of evidence: 4 **PEDro Scale: 5/11**

Purpose:

To determine the prevalence of motor and dynamic visual acuity impairments in children with SNHL. Secondly, to investigate any possible association between dynamic visual acuity and motor impairment.

Methods:

Cross-sectional design. A convenience sample of 32 children with SNHL were recruited from a single hearing-impaired school. A school audiologist selected children with SNHL and matched them with 32 normal-hearing children according to age and gender. Motor assessment was performed utilizing the Movement Assessment Battery for Children-2. Dynamic visual acuity was done utilizing the Lea vision chart, symbols rather than letters, created for younger children.

Results:

Reduced dynamic visual acuity is associated with SNHL ($p=0.026$). Motor performance is dependent on dynamic visual acuity and severity of SNHL ($P=0.001$). 65.6% of children with SNHL demonstrated motor impairment and 15.6% demonstrated deficits in dynamic visual acuity.

Critique/bottom line:

It's important to evaluate children with SNHL for dynamic visual acuity and motor impairments.

Limitations:

A single audiologist determined which children SNHL were appropriate and personally also selected aged matched controls.

Article #8 (Reference #23): De Kegel, A., Dhooge, I., Peersman, W., Rijckaert, J., Baetens, T., Cambier, D., and Van Waelvelde, H. (2010). Construct Validity of the Assessment of Balance in Children Who Are Developing Typically and in Children With Hearing Impairments. *Physical Therapy*, *90*(12), 1783-1794. doi:10.2522/ptj.20100080

Level of evidence: 4 **PEDro Scale: 4/11**

Purpose:

The purpose of this study is to assess the efficacy of using posturography tests and clinical balance tests to identify deficits in children with hearing impairments. Secondarily to evaluate construct validity of clinical balance tests in relation to tests of posturography.

Methods:

53 children with typical development and 23 children with hearing impairments were recruited, children aged from 6-12 years old.

Tests for posturography included mCTSIB, unilateral stance, and tandem stance. Clinical balance tests included one leg stance (eyes open and eyes closed), balance beam walking, and one-leg hopping.

Results:

Posturography: MCTSIB results EC, CEO, and CEC were the measurements which produced the greatest detectable difference ($p=0.035, 0.042, 0.014$ respectively) and effect sizes (Cohens $d = 0.64, 0.63, 0.80$ respectively). Unilateral stance also produced significant differences with $p = 0.046$ and an effect size of 0.67 (cohens D).

Clinical Balance Tests: One leg standing with eyes closed and balance beam walking demonstrated significant differences, $p = < 0.001$ and $p = 0.006$ respectively.

Critique/bottom line:

Children with profound hearing loss (on average) are likely to have static control deficits with eyes closed and unstable surface (eyes open or closed) which are detectable by posturography. Single leg standing is a static single standing test which may also demonstrate detectable deficits while walking tandem may demonstrate deficits in dynamic stability.

Limitations:

Vestibular specific assessments were not performed, e.g. VEMP and Rotary Chair. Therefore, the degree to which vestibular hypofunction is responsible for these deficits in unknown.

Discussion

Horizontal canal VOR Tests:

Dynamic Visual Acuity test (DVA) evaluates the vestibular ocular reflex (VOR) in relation to gaze stability, i.e. visual fixation w/ head movement. A difference between static and dynamic visual acuity of greater than 2 optotypes (lines) is indicative of horizontal canal hypofunction. This test has been validated in the pediatric populations as young as 3 to 6 years old and demonstrated a sensitivity of 88% in children with sensorineural hearing loss.[16, 17] On the other hand, DVA has demonstrated a lower sensitivity of 69%.[16]

The Head Impulse Test(HIT) has demonstrated a higher specificity of up to 91%, although only when examining head movement in the horizontal plane.[16] In order to assess head movement in the vertical plane the Video Head Impulse Test (vHIT) may be utilized. vHIT utilizes goggles recording eye movements while examining all six semicircular canals, but remains costly and not readily available as a clinical measure.[20] Although currently not practical, this is potentially important when considering assessment and interventional designs for improving functional dynamic visual acuity.[21]

Improvements in DVA, in adults with UVH and BVH, has been attributed to interventions designed to stimulate central reprogramming.[18] For example, adapted visual-vestibular exercises and have demonstrated DVA and reading acuity improvements in a case-study of child with acquired VH.[19] To improve upon this it is likely helpful to consider both the exact position of a person's head, to isolate specific canal function and the speed at which movement is performed, to challenge the system. For instance, when attempting to improve the accuracy of HIT in adults: a 30 degree downward pitch is commonly utilized to isolate the horizontal canal.[22] As well, although tests are commonly performed at ~ 120 degrees/sec, 150-200 degrees/sec is

reported to drop false positives from 45% to 15% during vHIT.[22] Therefore, further improvements in HIT specificity may benefit from higher rotational velocities.

In summary, when evaluating balance deficits in children with sensorineural hearing loss it's important to consider the ability to keep vision in focus while moving the head. Rotating the head side to side may be readily evaluated with Dynamic Visual Acuity while utilizing a vision chart and metronome to ensure their head is rotating at 120 degrees/sec side to side. Unlike side to side head motion, gaze stability for head movement up and down has only been successfully assessed with children using a more expensive video recording of eye movement (vHIT) which is not readily available in most clinical settings.

Posturography and Balance Assessments

The modified Clinical Test of Sensory Integration of Balance(mCTSIB) is a method of measuring postural control under 4 conditions (EO-Eyes Open, EC-Eyes Closed, CEO-Cushion Eyes Open, and CEC-Cushion Eyes Closed). MCTSIB has been shown to detect significant differences between children with typical development and those with hearing impairment. [23, 24, 16] Christy and Colleagues found a sensitivity and specificity of 88% and 92% respectively utilizing all 4 conditions and advocated for all 4 conditions to be used when testing.[16] While Kegel and Colleagues results suggested that EC, CEO, and CEC were the measurements which produced the greatest detectable difference (p=0.035, 0.042, 0.014 respectively) and effect sizes (Cohens d = 0.64, 0.63, 0.80 respectively).[23] Said and colleagues found similar results with EC, CEO, and CEC with p = 0.02, 0.04, and 0.001 respectively while the eyes open condition showed no detectable difference between groups.[24]

The Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2): Balance Subset: includes eyes open (EO), eyes closed (EC), walking forward on a line (6 steps), walking tandem (6 steps), One Leg Standing on balance beam (EO and EC), tandem standing EO on balance beam. Said and colleagues found a significant difference between children with SNHL (moderate to profound), in relation to typically developing children, for all conditions with the exceptions of standing EO and walking forward on a line EO.[24] Said and colleagues also found that OLS w/o a balance beam was significantly challenging.[24] Therefore the 4 conditions: standing EC, walking tandem, and One Leg Standing with or without balance beam (EO and EC) may be sufficiently sensitive to evaluating postural control in this population.

In relation to vestibular function, OLS EC was reported to be impaired in a population of children with SNHL with and without vestibular dysfunction and the difference was not statistically different ($p= 0.090$).[25] Therefore, deficits in postural control with eyes closed may exist regardless of specific vestibular hypofunction.

Tandem Stance: Although Said and colleagues identified tandem stance as only having a significant difference with eyes closed ($p = 0.078$) vs tandem eyes open ($p = 0.195$), 5-7 years old with hearing impairment showed significant differences with tandem eyes open as well, i.e. all 6 typical developing children passed the test while 2 of 9 hearing impaired children failed.[24] Suggesting potential for age specific guidelines in this population to identify meaningful differences in static balance.

It's important to note that the MCTSIB condition are performed with feet together.[16] Postural sway in relation to eyes open and eyes closed has been found to be the same or superior in 228 hearing impaired children who positioned their feet "no more than hip-width apart".[26] Walicka-Cuprys and colleagues citing one limitation being "lack of a standardized, reliable, validated

outcome measure for the assessment of static balance in children." This sample also included 8 to 17-year-old subjects which allows maturation to also be a significant factor.[26]

In summary, static balance is the most often evaluated form of balance in children with sensorineural hearing loss. Effective variables to evaluate stance types include narrowing base of support, reducing stability of the standing surface, and reducing visual input. To assess static balance it's helpful to consider not only making the task challenging enough, but evaluating unique ways a child's senses collaborate to maintain balance. Although the modified Clinical Test of Sensory Integration of Balance incorporates all three of these variables and has demonstrated both sensitivity and specificity in this specific population, further decreasing base of support with the addition of tandem or one leg standing may be necessary as patient's progress. In relation to more dynamic forms of balance tandem walking either on a line or balance beam has been effective in identifying impairments in this population.[23, 24, 25]

Dynamic Gait Index

Dynamic Gait Index (DGI) has demonstrated validity and reliability as a cheap and effective method of identifying adult populations with vestibular dysfunction.[18] DGI efficacy was recently increased for pediatric populations with balance impairments and sensorimotor deficits.[27,28] DGI incorporates gait with changes in speed and head movements. [28] Therefore hypothetically, these tasks could be sensitive to deficits in otolith function (linear acceleration) and semicircular function (angular velocity). Melo for instance describes children with SNHL becoming destabilized when asked to increase gait speed, as well individuals in the SNHL group often slowing or stopping to execute vertical and horizontal head movements. [28] Although promising,

vestibular testing was not performed in this study and specific associations cannot be confirmed or denied.

Clinical measure conclusions, in relation to balance impairments, static balance is the most frequently utilized method to detect deficits in children with sensorineural hearing loss. Ideally static forms of balance assessment should include variable combinations eyes open vs. closed, stable vs. unstable standing surface, and eyes open vs. eyes closed as has been done specifically with the mCTSIB in to the population. Assessing static balance in this manner may elucidate which senses are most compromised or integrating least effectively. Progression of static assessment to dynamic assessment should include tandem walking. To assess the vestibular system more specifically, in relation to vision, a comparison of static visual assessment in relation to dynamic visual assessment should be performed for side to side head movement. Lastly given the fact that most children with sensorineural hearing loss are ambulatory, it is reasonable to consider the utility of a gait assessment, such as the dynamic gait index, which incorporates vestibular function into its' assessment.

Potential Treatments:

Krebs and colleagues described 3 phases for vestibular adaptation and compensation including interventions targeting standing balance, gait, and visual fixation/eye-head movements.[29] Rine and Braswell have since modified this dynamic intervention for a pediatric population with SNHL and suggest 4 categories to improve balance and motor function including: eye-hand coordination, general coordination, visual motor, and balance training.[17] Relative to general coordination findings suggests activities relative to deficits in tandem walking and one leg standing may benefit from intervention.[23, 30] Visual motor training DVA may benefit from incorporation of visual fixation with head movement progressing in eye-head speed, target size,

and background/target visual complexity. [19] Balance activities for this population will likely be challenging with eyes closed (narrow base, tandem, and single leg) and eyes open activities on unstable surfaces or single leg. [23, 24, 16, 14, 30]

Conclusion

What clinical measures (static balance, dynamic balance, or gaze stabilization) are most likely to identify vestibular impairments in 3 to 12-year-old children with sensorineural hearing loss, either directly or indirectly. Firstly, it's important to recognize that vestibular semicircular canal are stimulated with specific head positioning and movement. The Head Thrust Test(HTT) has demonstrated one of the highest specificities for vestibular hypofunction. Increased specificity is related to the test's passive rapid rotation of the head which increases vestibular input to coordinate ocular movement. Any deficits found in the Vestibulo-ocular reflex using HTT would warrant further testing utilizing Dynamic Visual Acuity to test for functional deficits in gaze stability with horizontal head movement. Although not as specific as HTT, DVA and the Modified Clinical Test of Sensory Interaction on Balance (MCTSIB) demonstrate higher sensitivity in identifying children with vestibular hypofunction. Although MCTSIB has been validated with 4 conditions, the first condition of eyes open with a narrow base of support is often not challenging enough to demonstrate significant impairments, likely being superfluous in this population. Vestibular assessment of children aged 3-12 years old with sensorineural loss should include HTT, DVA, and at least three conditions of the MCTSIB (feet together eyes closed, feet together eyes open on foam, and feet together eyes closed on foam. Gaze stability is

speed dependent and interventional approaches should include progressions of head speed while maintaining clear vision on a fixated target.

Limitations and Research Considerations

Although tandem and single leg activities are logical progressions for balancing activities in children with sensorineural hearing loss, they have not been validated to assess vestibular function directly or indirectly. Likewise, although it's important to address deficits in tandem ambulation and dynamic gait there is insufficient evidence relative to the utility of these activities as assessors of the vestibular system in this population.

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APPENDIX A

ARTICLE SUMMARIES CHART

Author	Oxford, Pedro	Purpose	Outcome Measures	Results	Accept to answer PICO
Melo 2017	4, 6/11	To assess the gait performance of children with normal hearing (NH) in relation to sensorineural hearing loss (SNHL) utilizing the dynamic gait index.	Dynamic Gait Index	Children with SNHL performed significantly lower on the DGI ($p < 0.001$). When stratified by age (7-10, 11-14, and 15-18 years old) mean differences between the SNHL and NH group decrease over time (7.8, 5.8, 3.8 respectively).	Yes
Ebrahimi 2016	4, 6/11	Comparison of static and dynamic balance in children with sensorineural hearing loss (SNHL) with and without a cochlear implant (CCI).	BOTMP	Static one leg standing activities (eyes open or eyes closed) and dynamic walking with a narrow base of support (balance beam or tandem) activities were demonstrated to be more difficult for children with SNHL to perform and may benefit from future intervention.	Yes
Christy 2014	3b, 6/11	To determine reliability, diagnostic values and minimum detectable change scores with 90% confidence (MDC90) for vestibular function in children with SNHL.	HTT DVA MCTSIB	ICC (95% CI)* DVA • 0.81 (0.66-0.90) HTT • 0.73 (0.53-0.85) MCTSIB • 0.74 (0.55-0.86) Sensitivity (95% CI)* DVA • 0.88 (0.22-0.95) HTT • 0.75 (0.25-0.89) MCTSIB • 0.88(0.22-0.95) Specificity (95% CI)* DVA • 0.69 (0.30-0.82) HTT • 0.77 (0.32-0.86) MCTSIB • 0.85 (0.32-0.90)	Yes

				DVA, HTT, and MCTSIB may be useful clinical tests in identifying children with vestibular deficits.	
Maes, 2014		To assess balance impairment between typically developing children in relation to hearing impaired children with and without vestibular dysfunction.	Rotary Chair VEMPc Balance beam backwards, one-leg hopping, and one-leg stance.	Backward walking on balance beam was consistently effective in identifying differences between groups. One-leg hopping: only demonstrated differences between NH+NV vs. HI +VI. OLS EC demonstrated differences between NH and HI regardless of vestibular function.	Yes
Rajendran, 2013	2b, 6/11	The purpose of this study was to evaluate the effectiveness of an exercise program including vestibular-specific neuromuscular training in children with profound hearing impairment (>90dB).	TGMD-2 (Motor assessment) Pediatric Reach Test One Leg Stand w/ postural sway meter. (Postural) PedsQL (Quality of Life)	Intervention has a positive effect on Motor skills, Postural Control, and QOL for 6-11 years old with profound hearing impairment. Intervention included eye movement exercises, e.g. visual tracking and visual fixation, balance exercises, hand eye coordination, stretching, and fundamental motor skill training 45 min sessions 3x/week	No
Said 2013	4, 4/11	1) Balance assessment (BOT-2, mCTSIB, OLS) of children with sensorineural hearing loss (SNHL) relative to typically developing children. 2) Prognostic value of etiological, audiological, and demographic factors to identify vestibular deficits in children.	BOT-2, MCTSIB, OLS	EC, CEO, and CEC with p = 0.02, 0.04, and 0.001 respectively Said and colleagues identified tandem stance as only having a significant difference with eyes closed (p = 0.078) vs tandem EO (p = 0.195)	Yes

Shah 2013					
Martin 2012	4, 5/11	To determine the prevalence of motor and dynamic visual acuity impairments in children with SNHL. Secondly, to investigate any possible association between dynamic visual acuity and motor impairment.	M-ABC-2 (motor assessment) DVA (dynamic visual acuity)	65.6% of children with SNHL demonstrated motor impairment and 15.6% demonstrated deficits in dynamic visual acuity. Final forward stepwise model: (1 outlier removed) 41% of M-ABC-2 results were attributed to DVA score, age, and severity of hearing loss ($r^2 = 0.41$). DVA deficit reducing M-ABC-2 score by 4.4, severity of hearing loss reducing M-ABC-2 by 3.0, and each year of age improving M-ABC-2 score by 0.3.	Yes
De Kegel 2010	4, 4/11	The purpose of this study is to assess the efficacy of using posturography tests and clinical balance tests to identify deficits in children with hearing impairments. Secondarily to evaluate construct validity of clinical balance tests in relation to tests of posturography.	Posturography (mCTSIB, unilateral-stance, and tandem stance)	**Posturography** MCTSIB results EC, CEO, and CEC were the measurements which produced the greatest detectable difference ($p=0.035, 0.042, 0.014$ respectively) and effect sizes (Cohens $d = 0.64, 0.63, 0.80$ respectively). Unilateral stance also produced significant differences with $p = 0.046$ and an effect size of 0.67 (cohens D). **Clinical Balance Tests** One leg standing with eyes closed and balance beam walking demonstrated significant differences, $p = < 0.001$ and $p = 0.006$ respectively.	Yes

Appendix B:

Article Analysis Sheets

Articles:

1. Melo, R. et. al. (2017)
2. Ebrahimi, A. et. al. (2016)
3. Christy, J. et. al. (2014)
4. Maes, L. et. al. (2014)
5. Said, E. (2013)
6. Venkadesan R, C. et. al. (2013)
7. Martin, W. et. al. (2012)
8. De Kegel, A. et. al. (2010)

Intervention – Evidence Appraisal Worksheet - #1

Citation: Melo, R. (2017). Gait performance of children and adolescents with sensorineural hearing loss. *Gait and Posture, 57*, 109-114. doi:10.1016/j.gaitpost.2017.05.031

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	This purpose of this study was to investigate the difference in dynamic gait between children with sensorineural hearing loss (SNHL) and aged matched children with normal hearing.

Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	Yes – SNHL in children is associated with increased rates of vestibular dysfunction, sensory integration, and balance impairment. Impairments may significantly impact typical development of neuromotor skills and dynamic gait.

Does the research design have internal validity?	
Appraisal Criterion	***Reader's Comments***
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Assignment- No assignment Attrition- No attrition History- No external events were mentioned Instrumentation/Testing- DGI performed by one assessor with no blinding or demonstration of intra-rater reliability. Threat to internal validity is high. Maturation- Assessment performed once, no maturation took place. Compensatory Equalization of treatments- No treatment Compensatory rivalry- subject blinding was not mentioned and it is unknown if they were kept separate. There is a threat to internal validity.

	Statistical Regression- Subjects were matched, no outliers were present.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
1. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	No treatment was performed.
2. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	Yes, groups were matched for age and sex.
3. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	It was not discussed whether participants knew they were being tested in relation to another group. Knowledge could influence how well they believed they would perform and influence their level of motivation or confidence.
4. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Assessor was not blinded, there is high risk that assessor bias may have influenced how he scored subjects.
5. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Due to hearing impairment, hearing impaired subjects were communicated to via sign language. Differences in spoken vs. signed language may

	have influenced to what degree participants understood how to perform the DGI.
6. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	No follow up. This study simply demonstrates prevalence at the time of assessment.
7. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, retest was not performed.
8. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	All participants were assessed once.

Are the valid results of this RCT important?

Appraisal Criterion	*Reader's Comments*
9. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI** **c. Include effect size with p-values and CI** **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	Children with SNHL performed significantly lower on the DGI ($p < 0.001$). When stratified by age (7-10, 11-14, and 15-18 years old) mean differences between the SNHL and NH group decrease over time (7.8, 5.8, 3.8 respectively).
10. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	

	Deficits in pediatric patients with SNHL 7-18 years old may be detectible with the dynamic gait index.
11. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	This is the first time DGI has been utilized for this population. MID will still need to be established for a pediatric population.

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
12. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	The DGI as an outcome measure is available and affordable in all settings.
13. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	Inclusion of age range included 12-18 year old children which are older than the population being specifically addressed. Although this study stratified by age which increased its utility.
14. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Yes, identification of functional deficits outweighs the risk of falling if the patient is contact-guard during the test.
15. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No, intervention was performed.
16. Are there any threats to external validity in this study?	Yes, results may not be generalizable to younger children than 7. Also, there may be fundamental differences between Brazilian and American Sign Language which influenced results and the utility of DGI as an outcome measure outside of the region it was tested.

What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
1. Summarize your findings and relate this back to clinical significance	Significant impairments in dynamic gait are exhibited in children with sensorineural hearing loss, regardless of age. Although maturation may allow for compensation and decreased severity in these differences, exhibited by lower mean differences in older children. Interventional approaches to improving dynamic gait in children with SNHL will need to control for maturational improvements.

Intervention – Evidence Appraisal Worksheet - #2

Citation: Ebrahimi, A., Movallali, G., Jamshidi, A., Haghgoo, H., and Rahgozar, M. (2016). Balance Performance of Deaf Children With and Without Cochlear Implants. *Acta Medica Iranica*, *54*(11), 737-742. Retrieved from http://acta.tums.ac.ir/index.php/acta/article/view/5267

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	**Comparison of static and dynamic balance in children with sensorineural hearing loss (SNHL) with and without a cochlear implant (CCI).**
Literature Relevant background presented?	Vestibular deficits are reportedly present in 20-70% of children with SNHL. The severity of

A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	cochlear loss and cochlear implantation itself may be risk factors for increased rates of vestibular deficit. Some contradictory evidence has been published in relation to static and dynamic balance in children with SNHL. Therefore, it is important to continue assessing this population of children (with and without implantation), determining if implantation is also a meaningful variable.

Does the research design have internal validity?

Appraisal Criterion	*Reader's Comments*
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Assignment- No assignment Attrition- No attrition History- No external events were mentioned. Instrumentation/Testing- BOTMP is a norm referenced and standardized test. Assessor was not blinded and intra-rater reliability was not determined. Threat to internal validity is high. Maturation- Assessment performed once, no maturation took place. Compensatory Equalization of treatments – No treatment was performed. Compensatory rivalry – subjects were tested individually and unlikely to have been competing.

	Statistical Regression – Subjects had matched controls; no outliers were present.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
17. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	No treatment was performed
18. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	Aged matched controls were included in this study which is important given the possibility of age specific differences in balance. Sex ratio was not matched and could potentially impacted results, although no significant differences is currently highlighted between males and females in the literature.
19. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	No, treatment was provided.
20. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Yes, assessors were not blind which is a significant risk to internal validity.
21. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Yes, all participants was described as being managed equally.

22. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	No follow up. This study simply demonstrates prevalence at the time of assessment.
23. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, no retest was performed.
24. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	All participants were assessed once.

Are the valid results of this RCT important?

Appraisal Criterion	*Reader's Comments*
25. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI** **c. Include effect size with p-values and CI** **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	Children with SNHL scored significantly lower on the BOTMP ($P<0.001$) relative to the control in all balance tasks, except Item 4 (walking forward on a line) control relative to the non-implant group ($P<0.0491$). No test of differences was performed for demographics.

26. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	Items on the BOTMP may be useful in assessing static and dynamic balance in children with SNHL, with the exception of item 4 (walking forward on a line).
27. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	This evidence can still be utilized, this is the first time BOTMP has been utilized for this population. MID will still need to be established for a pediatric population.

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
28. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	The BOTMP is an outcome measure which is readily available and affordable.
29. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	Yes, 7-12 years old children with SNHL covers a significant percentage of the population being investigated.
30. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Yes, identification of functional deficits outweighs the risk of falling if the patient is contact-guard during the test.
31. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No, intervention was performed.
32. Are there any threats to external validity in this study?	Yes, the results of this study may not be generalizable to younger children than 7.

What is the bottom line? What pedro score would you give this trial?

Appraisal Criterion	*Reader's Comments*

2. Summarize your findings and relate this back to clinical significance	Static one leg standing activities (eyes open or eyes closed) and dynamic walking with a narrow base of support (balance beam or tandem) activities were demonstrated to be more difficult for children with SNHL to perform and may benefit from future intervention.

Intervention – Evidence Appraisal Worksheet - #3

Citation: Christy, J., Payne, J., Azuero, A., and Formby, C. (2014). Reliability and Diagnostic Accuracy of Clinical Tests of Vestibular Function for Children. Pediatric Physical Therapy, 26(2), 180-189. doi:10.1097/pep.0000000000000039

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	This study's purpose was to determine reliability, diagnostic values and minimum detectable change scores with 90% confidence (MDC90) for vestibular function in children with SNHL.
Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	30-100% of children with SNHL are reported to have deficits in vestibular function. Impairments in vestibular function may adversely affect motor function, postural control, and gaze stability. Gap in knowledge: Affordable, valid, and reliable testing tools are needed to appropriately identify and treat this population. Vestibular test reliability, sensitivity, and specificity have not been widely evaluated in children.

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Does the research design have internal validity?	
Appraisal Criterion	***Reader's Comments***
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History**	Assignment- No assignment

➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Attrition – No attrition History – No external events were mentioned. Instrumentation/Testing: test-retest was completed for reliability 4 hours to 7 days later. Variability in the re-testing time is a potential threat to validity. Maturation: 7 days between retest is a short enough period that maturation is unlikely to have played a significant effect. Reference standards were performed within 1 month which is a short enough duration for significant maturation effects. Compensatory Equalization of treatments: No Treatment was performed. Compensatory rivalry: The study did not mention if subjects were separated to prevent competition between the children. Statistical Regression: No outliers were mentioned.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
33. Did the investigators randomly assign subjects to treatment groups?	No treatment was performed

a. **If no, describe what was done** b. **What are the potential consequences of this assignment process for the study's results?**	
34. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? a. **If they were not similar – what differences existed?**	Age is an important factor which was not significantly different between groups, although the TD group did have a slightly higher mean age and range of ages. Sex and Ethnicity were reported. With a greater percentage of males in the SNHL group and a greater percentage of white ethnicity reported in the TD group.
35. Did the subjects know to which treatment group they were assign? a. **If yes, what are the potential consequences of the subjects' knowledge for this study's results**	No treatment was provided.
36. Did the investigators know who was being assigned to which group prior to the allocation? a. **If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Yes, assessors were not blind which is a significant risk to internal validity.
37. Were the groups managed equally, apart from the actual experimental treatment? a. **If not, what are the potential consequences of this knowledge for the study's results?**	Yes, the tests were reportedly performed the same on all participants.
38. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? a. **If not, what are the potential consequences of this knowledge for the study's results?**	No treatment was performed. Retest performed between 4hrs to 7 days later.
39. Did all the subjects originally enrolled complete the study? a. **If not how many subjects were lost?** b. **What, if anything, did the authors do about this attrition?** c. **What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Of the 20 children with SNHL, one 6-year-old girl refused to complete the referenced standard tests. It is worth mentioning that she demonstrated significant impairment in horizontal canal function, i.e. DVA and HTT scores, and the reason she refused to complete the reference standard tests was not elaborated on.
40. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)?	The clinical test data for the girl who refused to complete reference standards was still utilized in the test-retest analysis. Although not explicitly

a. If not, what did the authors do with the data from these subjects? **b. If the data were excluded, what are the potential consequences for this study's results?**	stated, her data appeared to have been excluded when comparing clinical tests to reference standards, e.g. Table 3.

Are the valid results of this RCT important?

Appraisal Criterion	*Reader's Comments*
41. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI** **c. Include effect size with p-values and CI** **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	ICC (95% CI)* DVA • 0.81 (0.66-0.90) HTT • 0.73 (0.53-0.85) MCTSIB • 0.74 (0.55-0.86) Sensitivity (95% CI)* DVA • 0.88 (0.22-0.95) HTT • 0.75 (0.25-0.89) MCTSIB • 0.88(0.22-0.95) Specificity (95% CI)* DVA • 0.69 (0.30-0.82) HTT

42. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	• 0.77 (0.32-0.86) MCTSIB • 0.85 (0.32-0.90) DVA, HTT, and MCTSIB may be useful clinical tests in identifying children with vestibular deficits.
43. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	Preliminary MDC90's established • MDC90 for DVA is 8 optotypes • MDC90 for MCTSIB is 16.75 sec.

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
44. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	Yes, DVA/HTT/and MCTSIB are affordable and available.
45. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	Yes, children 6-12 years old with SNHL cover a significant percentage of the population of interest.
46. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Yes, these clinical tests are well tolerated by children and potential identify significant deficits to address.
47. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No intervention was performed.
48. Are there any threats to external validity in this study?	Yes, these findings are preliminary with a small sample and only cover children 6-12 years old. These clinical tests may not be appropriate for younger pediatric patients.

What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
3. Summarize your findings and relate this back to clinical significance	MCTSIB, HTT, and DVA are affordable and effective functional tests, demonstrating significant agreement with more expensive reference standards (rotary chair and cVEMP) for vestibular hypofunction.

Intervention – Evidence Appraisal Worksheet - #4

Citation: Maes, L., De Kegel, A., Van Waelvelde, H., and Dhooge, I. (2014). Association Between Vestibular Function and Motor Performance in Hearing-impaired Children. *Otology and Neurotology*, *35*(10), e343-e347. doi:10.1097/mao.0000000000000597

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly?	To assess balance impairment between typically developing children in relation to hearing impaired children with and without vestibular dysfunction.

Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	
Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	Children with SNHL often demonstrate deficits in vestibular function and children with SNHL also typically demonstrate static and dynamic balance deficits. This study sought to link and further investigate this concept by comparing clinical balance performance between hearing impaired children with and without vestibular deficits.

Does the research design have internal validity?	
Appraisal Criterion	***Reader's Comments***
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Assignment- No assignment to treatment. Attrition- No attrition History- No external events were mentioned Instrumentation/Testing- Intra-rater and inter-rater reliability were not assessed for the examiners and is a threat to internal validity.

	For clinical balance tests practice trials were not explicitly mentioned and therefore it's unknown if this had any effect on performance. Maturation- No re-testing was performed, maturation is unlikely to have played a significant role. Compensatory Equalization of treatments- No treatment was performed. Compensatory rivalry- The study did not mention if subjects were separated to prevent competition. Statistical Regression- No outliers were mentioned.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
49. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	No treatment was performed
50. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	All three groups were matched for age. Hearing impaired groups were matched for etiology, had similar degree of hearing loss, and similar in hearing devices.

	Demographics are unlikely to have had a significant impact on results.
51. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	No treatment was provided
52. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Yes, assessors were not blinded. This is a significant risk to internal validity.
53. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Yes, the tests were reportedly performed the same on all participants.
54. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	No follow up was performed.
55. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, all subjects were assessed.
56. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	Yes, all subjects were analyzed.
Are the valid results of this RCT important?	
Appraisal Criterion	
57. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI**	Backward walking on balance beam was consistently effective in identifying differences between groups. (NH +NV) > (HI + NV) > (HI + VI)

c. Include effect size with p-values and CI **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	One-leg hopping: only demonstrated differences between NH+NV vs. HI +VI. (p= 0.003) OLS EC demonstrated differences between NH and HI regardless of without or with vestibular impairment (0.001 and <0.001).
58. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	Only the vestibular impaired group had a mean score below normal on all three clinical balance test indicators. With balance beam walking posteriorly being the only indicator where all vestibular impaired participants scored below normal (MQ<75), implying high sensitivity of this clinical test in this population. OLS EC was also significantly different from the control group, but vestibular impaired participants often scored above -2.00 and therefore within normal. In regard to OLS EC a significant difference did not exist between HI groups with and without VI, therefore significant deficits may exist in the hearing impaired population regardless of vestibular function.
59. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	N/A

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?	
Appraisal Criterion	***Reader's Comments***
60. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	No intervention performed.
61. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	Yes the majority, subjects were between the ages of 3 yr 8 mo – 12 yr 11 mo. Only subjects older than 12 yr were beyond the ages of interest.
62. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Yes, it is essential to determine which clinical tests identify impairments to develop effective treatments. Subjects at risk of falling must always be guarded.
63. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No intervention was performed.
64. Are there any threats to external validity in this study?	Findings from 36 subjects recruited from one referral center at one period of time, may only be generalizable to other subjects from that referral center at that time.
What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
4. Summarize your findings and relate this back to clinical significance	Children with SNHL and vestibular deficits are likely to have dynamic balance deficits detectable by walking backwards on balance beam. Significant deficits in one-leg standing eyes closed and one-leg hopping are more likely to be detected if children have vestibular dysfunction as well.

Intervention – Evidence Appraisal Worksheet - #5

Citation: Said, E. (2013). Clinical balance tests for evaluation of balance dysfunction in children with sensorineural hearing loss. The Egyptian Journal Of Otolaryngology, 29(3), 189. DOI: 10.7123/01.EJO.0000431452.76343.3d

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	3) Balance assessment (BOT-2, mCTSIB, OLS) of children with sensorineural hearing loss (SNHL) relative to typically developing children. 4) Prognostic value of etiological, audiological, and demographic factors to identify vestibular deficits in children.
Literature	• Introduces close relationship between vestibule and cochlea within the labyrinth

Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	system and the plausibility of trauma causing concomitant damage. • Goes on to discuss the vestibular systems significance to balance and importance for typical motor development. Discusses communication challenges for children with SNHL including speech/language skills, social development, and academic performance. Discusses typical motor challenges including balance, dynamic coordination, reaction times, and speed of movements. • Cites 4-6 years of age as critical for intervention to alleviate motor deficits. • Discusses the potential for sensory redistribution(compensation) via enhanced visual and somatosensory input. • Discusses the current lack of vestibular deficit identification relative to limited effective measures/procedures to utilize clinically.

Does the research design have internal validity?

Appraisal Criterion	*Reader's Comments*
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Assignment- No assignment Attrition- No attrition History- No external events were mentioned. Instrumentation/Testing- No test-retest was performed. Only one practice trial was allowed for each test, testing is unlikely to have had a significant effect on results. Maturation- Participants were only tested once, no maturation took place within the study. Compensatory Equalization of treatments- No treatments were performed.

	Compensatory rivalry-: The study did not mention if subjects were separated to prevent competition between the children. Statistical Regression- No outliers were mentioned.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
65. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	No treatment was performed.
66. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	Age (5-7:8-10, 11-15) TD group: 6:13:11 SNHL group: 12: 15: 23 Relative ratios were reported which were different. Mean age and SD for demographics were not reported. This is a significant threat to validity.

67. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	No treatment was performed
68. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Yes, assessors were not blind which is a significant risk to internal validity.
69. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Yes, the tests were reportedly performed the same on all participants.
70. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	No follow-up were performed.
71. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, all subjects completed assessment.
72. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	Yes, all subjects were analyzed.

Are the valid results of this RCT important?

Appraisal Criterion	*Reader's Comments*
73. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI**	**EC, CEO, and CEC** with p = 0.02, 0.04, and 0.001 respectively

c. **Include effect size with p-values and CI** d. **Include ARR/ABI and RRR/RBI with p-values and CI** e. **Include NNT and CI**	Said and colleagues identified tandem stance as only having a significant difference with eyes closed (p = 0.078) vs tandem EO (p = 0.195)
74. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	**Balance deficits in children with SNHL may be detected with: One leg standing (EO or EC), Standing on foam (EO or EC), Tandem walking EO, and tandem standing EC.**
75. Do these findings exceed a minimally important difference? a. **If not, will you still use this evidence?**	SNHL group was compared against the Typically developing group. Cutoff being defined as 2SD below the typically developing mean.

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
76. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	Yes, these outcome measures are affordable and readily available.
77. Are the study subjects similar to your patient/ client? a. **If not, how different? Can you use this intervention in spite of the differences?**	Children from 6-12 years old with SNHL cover a significant percentage of the population of interest. Subjects from 12 to 15 are not part of the target population, but findings do highlight potential for significant maturational effects on balance within populations of children with SNHL which was not seen in children with typical development
78. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Yes, identification of functional deficits outweighs the risk of falling if the patient is contact-guard during the test.

79. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No, intervention was performed.
80. Are there any threats to external validity in this study?	Yes, results may not be generalizable to younger children than 5.
What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
5. Summarize your findings and relate this back to clinical significance	**Balance deficits in children with SNHL may be detected with: One leg standing (EO or EC), Standing on foam (EO or EC), Tandem walking EO, and tandem standing EC.** **Maturation may reduce the severity of these deficits over time to some extent and must be taken into consideration when evaluating the efficacy of potential interventions**

Intervention – Evidence Appraisal Worksheet - #6

Citation: Rajendran, V., and Roy, F. (2011). An overview of motor skill performance and balance in hearing impaired children. *Italian Journal Of Pediatrics*, *37*(1), 33. doi:10.1186/1824-7288-37-33

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	The stated purpose of this study was to evaluate vestibular-specific neuromuscular training on motor skills, balance, and health-related quality of life in children with hearing impairment. On the other hand, vestibular specific exercises such as gaze stability appeared to be only one aspect of the intervention program which was not effectively separated from other interventional approaches including balance, gross motor, hand-eye coordination and stretching.
Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic.	Highlighted pervious research introduced problems recently correlated with hearing impairment including deficits in communication, balance, gross motor, decreased quality of life. More specifically citing a recent systemic review which suggested an association between hearing

Describe the justification of the need for this study	impairment, vestibular impairments, and diminished quality of life. Gaps in current knowledge and Clinical importance: The effects of vestibular-specific neuromuscular training on motor, balance, and QOL had not been previously studied.

Does the research design have internal validity?	
Appraisal Criterion	***Reader's Comments***
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	**Assignment** Randomized controlled-trail with computer randomized allocation and presealed envelops. Experimental group n =11 and control n=10. **Attrition**: No attrition reported in this study. **History**: No specific concurrent events were mentioned. **Instrumentation/Testing**: Intra-rater reliability in diagnosing and re-evaluation was never stated. **Accessors** were not blinded and knew which group the subjects were in. **Maturation**: All participants were between the ages of 6-11. Significant maturation effects within 6weeks are unlikely, i.e. the control group did not have any significant changes in this time period.

	Compensatory Equalization of treatments: Treatment was not provided to the control group. Neither therapists nor examiners were blinded. **Compensatory rivalry**: Subjects were recruited from a single deaf school increasing the likelihood that they communicated regularly. **Statistical Regression**: Mann-Whitney U-test was used to analyze between group variables. Non-parametric testing was used because of the small sample size.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
81. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	Yes, random subject assignment was computer generated.
82. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	Gender: Male:Female • Control group (6:4) and intervention (8:3) Ages both Mean (range) • Control: 8.1 (6-11) • Intervention: 7.5 (6-11)

	Weight: Mean (range) • Control: 25.6 (18-32) • Intervention: 24.5 (17.5-33) Height: mean (range) • Control: 115.3 (106-122) • Intervention: 113.2 (104-124)
83. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	Subjects were in the same school and either receiving the intervention or not. The experimental group could have shared knowledge about intervention activities at school which had the potential to improve control outcomes.
84. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Computer generated random assignment and presealed envelops were used to prevent allocation bias.
85. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	No, the control group was not provided any type of placebo treatment. The possibility of intervention group improvements being based on placebo are possible, especially in relation to subjective measures such as quality of life. On the other hand, measures of balance and motor skills are less likely to be influenced by perception alone.
86. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	This study had no follow-up and therefore any effects of treatments may not have a lasting effect.
87. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, there was no attrition in this study.
88. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	Yes, all subjects were analyzed.

Are the valid results of this RCT important?	
Appraisal Criterion	***Reader's Comments***
89. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI** **c. Include effect size with p-values and CI** **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	• (Test of Gross Motor Development *P* = 0.02; throw for distance *P* = 0.042; kick for distance *P* = 0.08; jump for distance *P* = 0.001; 15-yard dash *P* = 0.001), • postural control measures (Pediatric Reach Test *P* = 0.001; One Leg Standing Test *P* = 0.03; and anteroposterior sway (eyes open *P* = 0.007, eyes closed *P* = 0.03); mediolateral sway (eyes open *P* = 0.014, eyes closed *P* = 0.017) and health-related Significant improvement only occurred in the intervention group over six weeks. Motor skills • Test of Gross Motor development P =0.02 • Throw for distance P = 0.042 • Kick for distance P= 0.08 • Jump for distance P = 0.002 • 15-yard dash P=0.001 Postural Control • Pediatric Reach Test P =0.001 • One Leg Standing Test P = 0.03 • Anterioposterior sway (eyes open P = 0.007, eyes closed P = 0.03) • Mediolateral sway (eyes open P = 0.014, eyes closed P = 0.017) Health-related quality of life P =0.01

90. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	Results suggest that the intervention has a positive effect on Motor skills, Postural Control, and QOL for 6-11 years old with profound hearing impairment. Intervention included visual tracking and visual fixation, balance exercises, hand eye coordination, stretching, and fundamental motor skill training
91. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	Yes, patients demonstrate statistically significant change which was not observed in the control group.

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
92. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	The motor, balance, and QOL measurements in this study are widely available and affordable. Postural sway meters on the other hand may not be as readily available. Intervention activities listed in the studies online appendix require widely available/affordable material including: ball, objects, foam, and a balance beam.
93. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	Pediatric patients with hearing impairments are seen regularly for developmental delays including motor and balance issues.

94. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	The benefits of gross motor and balance activities are already widely accepted to intervene with patient's deficits. Risks are unlikely to be life threatening in this population although including unnecessary eye movement exercises can potentially reduce the effect of limited therapeutic time.
95. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	Not applicable.
96. Are there any threats to external validity in this study?	Yes, this study was done with a small population from one deaf school and therefore may not be generalizable. Pre-test results were not compared against norms to indicate subjects had clinically significant deficits in the first place.
What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
6. Summarize your findings and relate this back to clinical significance	• The strengths included accessible outcome measures and quality of life considerations. As well as an attempt to integrate vestibular-specific interventions including visual fixation with head movement. • The limitations of this study include small sample size from one school and lack of accessor blinding. Vestibular deficits were inferred and not specifically assessed. Example protocol included stretching, ocular eye movement, and visual tracking/fixation (no head movement) without clear indication. • A program including vestibular-specific interventions may assist in motor skill, balance, and quality of life gains.

Intervention – Evidence Appraisal Worksheet - #7

Citation: Martin, W., Jelsma, J., and Rogers, C. (2012). Motor proficiency and dynamic visual acuity in children with bilateral sensorineural hearing loss. *International Journal Of Pediatric Otorhinolaryngology*, *76*(10), 1520-1525. doi:10.1016/j.ijporl.2012.07.007

Intervention – Evidence Appraisal Worksheet

Is the purpose and background information sufficient?

Appraisal Criterion	*Reader's Comments*
Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	To determine the prevalence of motor and dynamic visual acuity impairments in children with SNHL. Secondly, to investigate any possible association between dynamic visual acuity and motor impairment.
Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	Impairments in the vestibular system may be misdiagnosed or not identified due to a lack of reported dizziness by children. Although there is preliminary research on vestibular hypofunction in children with SNHL and motor delays, the extent to which dynamic visual acuity relates to motor delays had not been investigated.

Does the research design have internal validity?

Appraisal Criterion	*Reader's Comments*
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Selection A convenience sample was taken with inclusion based on the opinion of one audiologist. Age and gender appropriate matched controls were selected by the same audiologist. Attrition- No attrition.

	History- No external events were mentioned. Instrumentation/Testing MABC-2 is validated and reliable test with previous ICC test-retest reliability exceeding 0.95 with a range from 0.92 to 0.98. Utilizing the pediatric DVA previous test-retest reliability was ICC = 0.84 and interrater reliability of 0.88. The average of two DVA trials were performed, testing is unlikely to have been a significant threat to validity. Maturation- Participants were only tested at one time, no maturation took place within the study. Compensatory Equalization of treatments- No treatments were performed. Compensatory rivalry- The study did not mention if subjects were separated to prevent competition. Statistical Regression- One outlier was mentioned with a residual score greater than 2 standard residuals.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***

97. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	No treatment was performed.
98. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	Yes, both groups had a mean age of 9.4 years old. 15 females and 17 males. 32 SNHL (SD 2.4, range 4.5-13.2) 32 normal hearing (SD 2.5, range 4.6-13.3)
99. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	No treatment was performed.
100. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	Yes, assessors were not blinded. This is a significant risk to internal validity.
101. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Yes, the tests were reportedly performed the same on all participants.
102. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	No follow-up was performed
103. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, all subjects were assessed.
104. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	Yes, all subjects were analyzed.

Are the valid results of this RCT important?

Appraisal Criterion	*Reader's Comments*
105. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI** **c. Include effect size with p-values and CI** **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	Reduced dynamic visual acuity is associated with SNHL (p=0.026). Motor performance is dependent on dynamic visual acuity and severity of SNHL (P=0.001). 65.6% of children with SNHL demonstrated motor impairment and 15.6% demonstrated deficits in dynamic visual acuity. The SNHL group performed worse on all components of the M-ABC-2: Manual dexterity (p = 0.011), aiming and catching (P = 0.005), and Balance (P< 0.001) Preliminary forward stepwise model: 33% of in M-ABC-2 was attributed to DVA score, age, and severity of hearing loss ($r^2 = 0.33$) Final forward stepwise model: (1 outlier removed) 41% of M-ABC-2 results were attributed to DVA score, age, and severity of hearing loss ($r^2 = 0.41$). DVA deficit reducing M-ABC-2 score by 4.4, severity of hearing loss reducing M-ABC-2 by 3.0, and each year of age improving M-ABC-2 score by 0.3. A deficit in DVA may impact a patient's balance, dexterity, and aiming/catching. Motor deficits are prevalent in children with profound SNHL

106. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	regardless of DVA and this is only one variable to consider.
107. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	N/A

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
108. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	Yes readily available and affordable, the pediatric DVA simply requires a metronome and Lea Symbol charts.
109. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	Yes, the subjects 4-12 years old with SNHL cover a significant percentage of the population of interest. Subjects 12-14 years old were also included.
110. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Yes, identifying deficits in gaze stability is a relatively quick assessment which may highlight a significant variable. No known risks.
111. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No intervention was performed.
112. Are there any threats to external validity in this study?	Although promising, a single convenience sample from one school does have significant threats to external validity.

What is the bottom line? What pedro score would you give this trial?

Appraisal Criterion	*Reader's Comments*

7. Summarize your findings and relate this back to clinical significance	Children with profound SNHL and motor impairments may have specific deficits in gaze stability with head movement. Gaze stability is potentially a significant impairment to assess and which has the potential to improve future treatment designs.

Intervention – Evidence Appraisal Worksheet - #8

Citation: De Kegel, A., Dhooge, I., Peersman, W., Rijckaert, J., Baetens, T., Cambier, D., and Van Waelvelde, H. (2010). Construct Validity of the Assessment of Balance in Children Who Are Developing Typically and in Children With Hearing Impairments. *Physical Therapy*, *90*(12), 1783-1794. doi:10.2522/ptj.20100080

Intervention – Evidence Appraisal Worksheet

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***

Study Purpose Stated clearly? Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	The purpose of this study is to assess the efficacy of using posturography tests and clinical balance tests to identify deficits in children with hearing impairments. Secondarily to evaluate construct validity of clinical balance tests in relation to tests of posturography.
Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	Postural stability is a prerequisite for motor development and may be evaluated via posturography, i.e. mCTSIB on force plate, unilateral stance, and tandem stance, or clinical balance tests, i.e. one leg standing and tandem walking. The convergent validity between posturography and clinical balance tests and the discriminant validity between static and dynamic balance tests had not previously been studied in this population.

Does the research design have internal validity?	
Appraisal Criterion	***Reader's Comments***
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History** ➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	Assignment: For initial testing, subjects were randomly assigned to either posturography or clinical balance tests. Attrition: No attrition

	History: No external events were reported. Instrumentation/Testing- For posturography 1 training trail was allowed before data collection, testing is unlikely to have impacted validity. Maturation- The duration between initial testing and final testing was not mentioned. Compensatory Equalization of treatments- Tests sessions were performed in the same quiet room for all subjects with at least one break offered to all the children. Compensatory rivalry- The study did not mention if subjects were separated to prevent competition. Statistical Regression- No outliers were mentioned.

Are the results of this therapeutic trial valid?	
Appraisal Criterion	***Reader's Comments***
113. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	No treatment was performed.
114. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	All participants were between the ages of 6-12. No elaboration on age or any other demographics were given. Matching of any kind was not mentioned. There significant potential that demographics were different.
115. Did the subjects know to which treatment group they were assign?	No treatment was performed

a. **If yes, what are the potential consequences of the subjects' knowledge for this study's results**	
116. Did the investigators know who was being assigned to which group prior to the allocation? a. **If they were not blind, what are the potential consequences of this knowledge for the study's results?**	No blinding was performed.
117. Were the groups managed equally, apart from the actual experimental treatment? a. **If not, what are the potential consequences of this knowledge for the study's results?**	Testing was reportedly performed the same for all subjects.
118. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? a. **If not, what are the potential consequences of this knowledge for the study's results?**	No follow-up took place.
119. Did all the subjects originally enrolled complete the study? a. **If not how many subjects were lost?** b. **What, if anything, did the authors do about this attrition?** c. **What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, the tests were reportedly performed the same on all participants.
120. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? a. **If not, what did the authors do with the data from these subjects?** b. **If the data were excluded, what are the potential consequences for this study's results?**	Yes, all subjects were analyzed

Are the valid results of this RCT important?

Appraisal Criterion	*Reader's Comments*
121. What were the statistical findings of this study? a. **When appropriate use the calculation forms below to determine these values** b. **Include: tests of differences? With p-values and CI** c. **Include effect size with p-values and CI**	**Posturography** MCTSIB results EC, CEO, and CEC were the measurements which produced the greatest detectable difference (p=0.035, 0.042, 0.014 respectively) and effect sizes (Cohens d = 0.64, 0.63, 0.80 respectively). Unilateral stance also

d. **Include ARR/ABI and RRR/RBI with p-values and CI** e. **Include NNT and CI**	produced significant differences with p = 0.046 and an effect size of 0.67 (cohens D). **Clinical Balance Tests** One leg standing with eyes closed and balance beam walking demonstrated significant differences, p= <0.001 and p= 0.006 respectively.
122. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	For static control EC, CEO, and CEC activities may be challenging for children with SNHL, and if posturography is available, e.g. the Neurocom at Carrie Tingley Hospital, mCTSIB may be useful as an outcome measure. Clinical Tests such as single leg standing activities may also challenge static control and be used to demonstrate improvements. As well tandem walking, e.g. on a balance beam may be useful to identify deficits for interventions to focus on.
123. Do these findings exceed a minimally important difference? a. **If not, will you still use this evidence?**	N/A

Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?

Appraisal Criterion	*Reader's Comments*
124. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	No intervention was performed.
125. Are the study subjects similar to your patient/ client? a. **If not, how different? Can you use this intervention in spite of the differences?**	Yes, children from 6-12 with SNHL are a significant portion of the population of interest. Although findings may not be generalizable to younger children.

126. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	There is relatively little risk in balancing activities if the children are properly guarded. Identifying impairments is essential to creating targeted treatments.
127. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	No intervention was performed.
128. Are there any threats to external validity in this study?	Findings may not be generalizable to younger children than 6. As well only children with bilateral hearing impairment of at least 45dB were included in this study. [more specifically mean hearing loss of 97.87 (SD27.36) in the right ear and 91.61 dB (SD 28.57) for the left ear, i.e. profound hearing loss on average]
What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
8. Summarize your findings and relate this back to clinical significance	Children with profound hearing loss (on average) are likely to have static control deficits with eyes closed and unstable surface (eyes open or closed) which are detectable by posturography. Single leg standing is a static single standing test which may also demonstrate detectable deficits while walking tandem may demonstrate deficits in dynamic stability.

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Intervention – Evidence Appraisal Worksheet - #9

Citation: Rine, R., Braswell, J., Fisher, D., Joyce, K., Kalar, K., and Shaffer, M. (2003). Improvement of motor development and postural control following intervention in children with sensorineural hearing loss and vestibular impairment. International Journal Of Pediatric Otorhinolaryngology, 68(9), 1141-1148. doi:10.1016/j.ijporl.2004.04.007

Intervention – Evidence Appraisal Worksheet

Is the purpose and background information sufficient?	
Appraisal Criterion	***Reader's Comments***
Study Purpose Stated clearly?	"The purpose of this study was to determine the effect of exercise intervention on the progressive motor development delay and postural control

Usually stated briefly in abstract and in greater detail in introduction. May be phrased as a question or hypothesis. A clear statement helps you determine if topic is important, relevant and of interest to you. Consider how the study can be applied to PT and/or your own situation. What is the purpose of this study?	impairments in children with sensorineural hearing loss(SNHL) and concurrent vestibular impairment" Testing: • Motor developmental (PDMS) • Posturography Sensory Conditions Testing (SCT) via Neurocom
Literature Relevant background presented? A review of the literature should provide background for the study by synthesizing relevant information such as previous research and gaps in current knowledge, along with the clinical importance of the topic. Describe the justification of the need for this study	Synthesizing relevant information Children with SNHL and concurrent vestibular impairment often have greater deficits in motor development, including postural deficits. 4-6 yr old critical for posture development. Gaps in knowledge Despite evidence for exercise efficacy in Adults, e.g. gaze stability, postural, and gait, w/ vestibular dysfunction, pediatric reports are scarce. Clinical Importance: "Vestibular function and postural control mechanisms were not tested, and the intervention was not focused on facilitation of adaptation and substitution, which has been shown to be efficacious for the improvement of function in adults with vestibular impairments."

Does the research design have internal validity?	
Appraisal Criterion	***Reader's Comments***
➢ **Discuss possible threats to internal validity in the research design. Include:** ➢ **Assignment** ➢ **Attrition** ➢ **History**	Assignment: The study used a random-block design to assign n=10 to the exercise group and n=11 to the placebo group. Matched for age and age equivalent score on motor development tests) Attrition: No attrition was reported in his study.

➢ **Instrumentation** ➢ **Maturation** ➢ **Testing** ➢ **Compensatory Equalization of treatments** ➢ **Compensatory rivalry** ➢ **Statistical Regression**	History: 1) Patients participated in study for 12 weeks, no significant historical variables were reported. Instrumentation/Testing: 2) SCT: Same examiner for all testing (blinded to group placement) 3) PDMS: Same examiners for all testing (blinded to group placement). 4) Good ICC established prior to actual testing. Maturation: 5) Subjects were 3-7yrs old and participated in study for 3 months, i.e. 12 week intervention. Therefore, maturation may effect results especially for younger children. 6) Maturation in relation to developmental quotient may also have an inverse relationship as evidenced by the control regressing from 0.78 (pre-test) to 0.55 (post-test) Compensatory Equalization of Treatment 7) The same research assistant provided treatment to all children either under a Physical Therapist supervision (exercise) or Audiologist supervision (placebo). Any personal bias may have influenced treatment. Compensatory rivalry 8) No information was given regarding subject knowledge/blinding regarding the other group. Statistical Regression 9) Linear model and paired t-tests for developmental quotients and raw scores. (PDMS) 10) Non-parametric Wilcoxon signed rank tests (SCT). After intervention exercise group no longer differed from normative data, signifying improvement.

Are the results of this therapeutic trial valid?

Appraisal Criterion	*Reader's Comments*
129. Did the investigators randomly assign subjects to treatment groups? **a. If no, describe what was done** **b. What are the potential consequences of this assignment process for the study's results?**	The study used a random-block design to assign n=10 to the exercise group and n=11 to the placebo group. Matched for age and age equivalent score on motor development tests) b) Limited sample size was randomized on the basis of age and developmental age, any other variables such as etiology are not controlled for.
130. Were the groups similar at the start of the trial? Did they report the demographics of the study groups? **a. If they were not similar – what differences existed?**	Gender: Females:male ratio greater in exercise group 7:3 vs. placebo 5:6. Race: Caucasian:Hispanic:Black:Indian • (3:3:3:1) exercise vs. (2:6:3:1) placebo Hearing Levels: Bilateral profound: Bilateral Severe: Severe/moderate: Profound/moderate • (6:2:2:0) exercise vs. (8:1:1:1) placebo Etiology: Premature:Cytomegalovirus:Heredity:Antibiotics:Kallman syndrome:Unknown • 2:1:3:1:0:6 exercise vs. 0:1:2:1:1:6 placebo
131. Did the subjects know to which treatment group they were assign? **a. If yes, what are the potential consequences of the subjects' knowledge for this study's results**	Only one group was a treatment while the other served as a placebo. Results may have been altered if either group believed they were in the placebo group.
132. Did the investigators know who was being assigned to which group prior to the allocation? **a. If they were not blind, what are the potential consequences of this knowledge for the study's results?**	No, the blocked-randomized design should have facilitated allocation randomly. Examiners were specifically blinded to the treatment of each group.
133. Were the groups managed equally, apart from the actual experimental treatment? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Yes, 30 min sessions 3x/week for a minimum of 30 sessions within 4 months by the same assistant was provided to both groups. Pre and post-tests were given to all participants by blinded examiners.

134. Was the subject follow-up time sufficiently long to answer the question(s) posed by the research? **a. If not, what are the potential consequences of this knowledge for the study's results?**	Subjects only demonstrated acute benefits immediately after interventions. No follow-up was provided to demonstrate long-term benefits of such interventions.
135. Did all the subjects originally enrolled complete the study? **a. If not how many subjects were lost?** **b. What, if anything, did the authors do about this attrition?** **c. What are the implications of the attrition and the way it was handled with respect to the study's findings?**	Yes, no attrition reported.
136. Were all patients analyzed in the groups to which they were randomized (i.e. was there an intention to treat analysis)? **a. If not, what did the authors do with the data from these subjects?** **b. If the data were excluded, what are the potential consequences for this study's results?**	Yes, all patients were analyzed.
Are the valid results of this RCT important?	
Appraisal Criterion	***Reader's Comments***
137. What were the statistical findings of this study? **a. When appropriate use the calculation forms below to determine these values** **b. Include: tests of differences? With p-values and CI** **c. Include effect size with p-values and CI** **d. Include ARR/ABI and RRR/RBI with p-values and CI** **e. Include NNT and CI**	Pre-test **PDMS** scores below norms ($P \leq 0.001$) **SOT** SCT-3 scores below norms ($P \leq 0.02$) Somatosensory (SCT-3 stability/SCT-1 stability) below norms: (P =0.03) • (Sway-referenced vision + fixed support)/(Eyes open + fixed support) Vision ratio (SCT-5 stability/SCT-1 stability) below norms: (P=0.05)

138. What is the meaning of these statistical findings for your patient/client's case? What does this mean to your practice?	• (Eyes closed +sway referenced support)/(Eyes open + fixed support) Post-Test PDMS raw scores significantly improved in exercise group (P = 0.004) relative to pre-test. Developmental quotient decreased in control group (Pre-test 0.78 to post-test 0.55) "developmental delay may be progressive" After post-test placebo group received exercise intervention and improved by their second post-test Raw score (P =0.001) and developmental quotient (P =0.05)
139. Do these findings exceed a minimally important difference? **a. If not, will you still use this evidence?**	Initial (A Priori) power assessment required 25 subjects in each group for sufficient power (0.80).
Can you apply this valid, important evidence about an intervention in caring for your patient/client? What is the external validity?	
Appraisal Criterion	***Reader's Comments***
140. Does this intervention sound appropriate for use (available, affordable) in your clinical setting?	Outcome measures including Rotatory Chair test and (SMART Balance Master System $80,000-$180,000) are very expensive and widely not accessible or affordable. Assessment: PDMS is cheaper and more easily accessible. Although intervention was not specifically elaborated on, anecdotally it does not require this expensive equipment and may be performed with stickers (attention/fixation), toys (attention/fixation), foam (stability), blindfolds (increase vestibular/somatosensory demand) and swings (passive angular velocity).

141. Are the study subjects similar to your patient/ client? **a. If not, how different? Can you use this intervention in spite of the differences?**	I had a patient diagnosed with developmental delay who scored significantly below norms on the PDMS-2. SNHL and vestibular system had not been specifically assessed and therefore inclusion of vestibular exercises was not necessarily warranted.
142. Do the potential benefits outweigh the potential risks using this intervention with your patient/client?	Further evaluation for vestibular exercises may have been beneficial and warranted more specific interventions to address deficits. Potential risk would likely be $1/6^{th}$ of each session being spent on ineffective exercises while the benefit may have been reaching developmental norms.
143. Does the intervention fit within your patient/client's stated values or expectations? **a. If not, what will you do now?**	Yes, the family very much wanted to meet developmental milestones. Further evaluation for vestibular exercises may have been beneficial and warranted more specific interventions to address deficits.
144. Are there any threats to external validity in this study?	Threats: The intervention is loosely theoretically defined at best, outcome measures are widely unavailable/unaffordable. Serving rural families, sometimes 1hr 1x/week is how often patients appear at an outpatient facility, e.g. Carrie Tingley Hospital. Reasonable: 30min 3x/week is a realistic expectation for an outpatient facility. Intervention principles can still be applied.
What is the bottom line? What pedro score would you give this trial?	
Appraisal Criterion	***Reader's Comments***
145. Summarize your findings and relate this back to clinical significance	Subjects with SNHL and vestibular deficits may benefit from exercises focused on hand-eye coordination, general coordination, visual motor training, and balance training which targets visual and somatosensory awareness. Including both vestibular adaptation and substitution/compensation exercises. Intensity: 30 min/day 3x/week for a minimum of 30 sessions (or 12 weeks).