Age-Related Static Balance Among Deaf, Hard-Hearing and Hearing Children

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ABSTRACT

This study compared static balance skill of deaf and hard-hearing children with those of normal hearing children in order to determine whether a deficit in static balance exists in deaf and hard-hearing children and to ascertain whether this deficit is age-related. The participated 206 children were divided into three groups according to the hearing level. Group (I) included 67 deaf children, group (II) included 69 hard-hearing children and group (III) included 70 hearing children. Each group included two age levels; level I age included children from 6 up to less than 9 years and level II age included children from 9 up to 12 years. Each age level included 103 children. Static balance was measured by the use of the first three items of the balance subtest of the Bruininks-Oseretsky Test of Motor Proficiency. One-way ANOVA was used to compare among the three groups for the static balance. Two-way ANOVA then was used to test the significant change in the static balance among the three groups over the two age levels. Finally, t-test was used to test the significant difference between the two tested age levels. The results showed that the mean scores for the deaf children as well as for the hard-hearing children were lower than the hearing children. The older children (level II age) had significantly higher scores than the youngest children (level I age) suggesting that the static balance deficit was age-related.
Key words: *Child development; Equilibrium; Hearing disorders; Posture; Test and measurements; Vestibular system.*

INTRODUCTION

Hearing loss is a common condition in infancy and childhood[13]. The author stated that there are two main types of hearing loss. Conductive hearing loss (CHL) is the most common type and results from an inability of the sound signals to reach the auditory nerve efficiently. It is caused by lesions in the external auditory canal, the tympanic membrane, the middle ear, or a combination of these locations (e.g., otitis media). Sensorineural hearing loss (SNHL) disorders can be divided into cochlear and retrochoclear. Cochlear disorders results from abnormalities of the inner ear. They can be genetic, acquired (e.g., meningitis), or of uncertain or mixed etiology. This type of SNHL is common in children than in adults. Retrochoclear losses involve the eighth nerve or brain stem and include a variety of degenerative and neoplastic disorders. Most causes of CHL are treatable medically or surgically, whereas most causes of SNHL are not. Hearing is generally measured from 250 to 8000 Hz in the 0- to 120 decibel (dB) range. Subject is considered as deaf when the hearing level is more than 90dB, as hard-hearing when the hearing level is between 40 to 65dB and as hearing one when the hearing level is less than 40dB.

Children who are deaf from birth or early childhood have some degree of balance impairment which intern may affect the acquisition of other motor skills or interfere with visual-perceptual-motor development and sensory integration[2,12].

Deaf problems have been defined primarily in terms of communication deficits, however, there are other associated physical problems such as balance deficit that may interfere with normal motor development and sensory integration[14]. The authors reported that damage to portions of the vestibulocochlear nerve, the presumed cause of sensorineuronal deafness, may include damage not only to the cochlear apparatus but also damage to the vestibular afferents which intern may be one possible explanation of the balance deficit.

Balance is defined as a state of action and reaction between two or more parts or organs of the body[22]. There are static as well as dynamic balance. Static balance as required for normal standing is the ability to maintain the body equilibrium in some fixed posture. Dynamic balance as required for normal walking is the ability to maintain the body equilibrium while the body is moving[7].

Bannister (1969)[1] summarized the mechanisms involved in static balance. He noted that normal standing required: 1) sufficient power in the muscles of the lower limbs and trunk to maintain the body erect, 2) normal postural sensibility to convey information concerning position, 3) normal impulses from the vestibular labyrinthine concerning position, 4) a central coordinating mechanism, the chief part of which is the vermis of the cerebellum and 5) the activity of higher centers concerned in the willed maintenance of posture.

About half of all deaf children have vestibular impairment. In as much as the vestibular apparatus triggers the vestibular reflex mechanisms that attempt to stabilize the eyes, head and body in space, impairment of this mechanism will also affect postural sensibility. Thus many deaf children have a known impairment of at least two, if not more, of the mechanisms necessary for normal static balance[19].

Early research on motor function indicated that, when deaf children were compared with children with normal hearing, the deaf children showed a deficit only in balance ability[2, 16].

Boyd (1967)[2] tested static and dynamic equilibrium in 8-, 9-, and 10-year-old boys using adaptation of the Oseretsky scale. He reported differences in static balance between deaf and normal-hearing boys at all ages and significant differences in dynamic balance between the deaf and normal-hearing boys of 9 and 10 years of age. Lindsey and O'Neal (1976)[14] showed that 8-year-old deaf children were far inferior to age-matched normal-hearing children in tasks involving both static and dynamic balance.

There are inconsistencies in the literature regarding the improvement of balance ability with age in deaf children. Unfortunately, few previous studies systematically compared age-related changes in balance of deaf and hard-hearing children with those of a similar population of normal (hearing) children.

The purposes of this study were to compare the static balance among deaf, hard-hearing and hearing children as well as to test if there is a difference, whether it is age-related or not. The research hypotheses were: 1) when compared with hearing children, deaf and hard-hearing children would have a deficit in static balance, 2) deaf children would be inferior than hard-hearing children in tasks related to static balance and 3) the static balance deficit in deaf and hard-hearing children, if present, would diminish with age.

The significant of this study was to determine the performance level of the deaf children as well as the hard-hearing children (aging from 6 to 12 years) in static balance. This would help in designing and applying different programs that could increase their motor performance in and out of their schools.

SUBJECTS, MATERIALS AND PROCEDURES

Subjects

The subjects' distribution is shown in Table (1). The total subjects were 206 children which were divided into three groups according to the hearing level. Group I (deaf children), group II (hard-hearing children) and group III (hearing children). The number of the subjects in each group was 80 students. In group (I), 13 students were excluded as well as in group (II), 11 students were excluded because their age was more than 12 years. In group (III), 10 students were excluded because they failed to accomplish the required tests.

The hearing level of the study group was measured in decibel without the use of hearing aids. The etiology of deaf or hard-hearing was not determined. The subjects were of normal intelligence (a score of 80 or higher on a standard test of intelligence). Exclusion criteria included any neuromuscular or musculoskeletal condition, developmental delay or learning disability as identified from school record.

Table (1): Subjects distribution and places of their collection.

Subject Types (Group)	Hearing Level in dB	Age 6 : < 9 Years	Age 9 : 12 Years	Total No. of Children	Place of Collection*
Group (I) Deaf	More than 90	34	33	67	Al-Amal school
Group (II) Hard-Hearing	40 : 65	34	35	69	Primary school
Group (III) Hearing	Less than 40	35	35	70	Primary school
Total		103	103	206	

*These schools are located in Riyadh, Saudi Arabia.

Materials

The used materials were the balance subtest of the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP), stopwatch, small ball, balance beam and a tape (for eyes closure). The balance subtest of the BOTMP measures both static and dynamic balance. The subtest that measures the static balance was used.

Procedures

The test was administered in a room free from distractions. Before testing, the BOTMP pretest for arm and leg preference was administered to each subject. Each child was asked to kick a ball twice to determine the preferred leg, which was used for the first three items on the balance subtest that measure the static balance. The following three items comprise the static balance subtest in the BOTMP:

1- Subject stands on the preferred foot on a line drawn on the floor while looking at a target on the wall. Both hands are on the hips and the free (non-preferred) leg is flexed at the knee.
2- Subject stands on the preferred foot on a balance beam while looking at a target on the wall. Both hands are on the hips and the free leg is flexed at the knee.
3- Subject stands as in item 2, except with eyes closed.

In the previous items, the trial is stopped after 10 seconds and the time is then recorded.

The trial is stopped before 10 seconds if the child touches the free leg to the floor, hooks the free leg behind the supporting leg or shifts the supporting leg out of place. All subjects were tested individually. As recommended in the BOTMP handbook, subjects wore either sneakers or crepe-soled shoes without regard to the height of the shoe. All directions were explained to each child via total communication, which involves speech, sign language, body language, facial expression and demonstration. To ensure that the instructions were understood, each child was permitted to practice trial for each item. The entire battery of tests was administered once to each child.

Data Analysis

Static balance was determined by the number of seconds, up to a maximum of 10 seconds, the subject could perform in each of the three items. If the subject was unable to reach the maximum time on the first trial of each item, a second trial was permitted. As stated in the directions for the BOTMP, the highest score of the two trials was used for analysis. Raw scores were converted to point scores as described in the BOTMP manual. Point scores are used for the BOTMP in order to convert raw scores (i.e., seconds on beam) to common set of values. For an example; 9 to 10 seconds (raw score) standing on balance beam equivalent to 4 value (point score).

The total point score of static balance for each child was the summation of the point score in each of the three tested items (maximum score is 17 points and minimum score is 0).

The collected data were statistically analyzed to show the means and standard deviations of the scores in each tested item in the static balance subtest for each group. Then, a comparative study was conducted between the mean differences in the three tested groups for each tested item as well as for the total static balance score by using the one-way analysis of variance (ANOVA) to show the statistical difference at 0.05 level among as well as within the groups. In case of significance, a Scheffe's test for multiple comparisons was conducted to detect pairs of groups, significantly different at the 0.05 level.

Two-way ANOVA was then used to test the significant change in the total static balance among the three groups over the two age levels (level I included children between 6 and less then 9 years and level II included children between 9 and 12 years). Data for each tested item as well as for the total static balance were then analyzed by t-test to show the significant difference between the two tested age levels.

RESULTS

The one-way ANOVA showed a significant difference among mean balance scores for the three groups in each tested item as well as for total static balance (Table 2). A Scheffe's test for multiple comparisons showed significant differences in mean balance scores between groups I and II, I and III as well as between II and III for the total static balance (Table 3 and Figure 1). However, this test showed no significant difference between groups II and III for the third tested item.

Table (2): One-way ANOVA among the study groups for the static balance.

Source		df	SS	MS	F.ratio	P.value
Item (1)	Among Groups	2	95.3296	47.6648	60.2880*	0.000
	Within Groups	203	160.4956	0.7906		
	Total	205	255.8252			
Item (2)	Among Groups	2	314.6570	157.3285	88.0631*	0.000
	Within Groups	203	362.6682	1.7865		
	Total	205	677.3252			
Item (3)	Among Groups	2	41.5568	20.7784	14.8562*	0.000
	Within Groups	203	283.9238	1.3986		
	Total	205	325.4806			
Total Static Balance	Among Groups	2	1110.8673	555.4337	66.6318*	0.000
	Within Groups	203	1692.1812	8.3359		
	Total	205	2803.0485			

* Significant at 0.05. F.tabulated = 3.00 df: Degree of freedom.
SS: Sum of squares. MS: Mean of squares. P: Probability value.

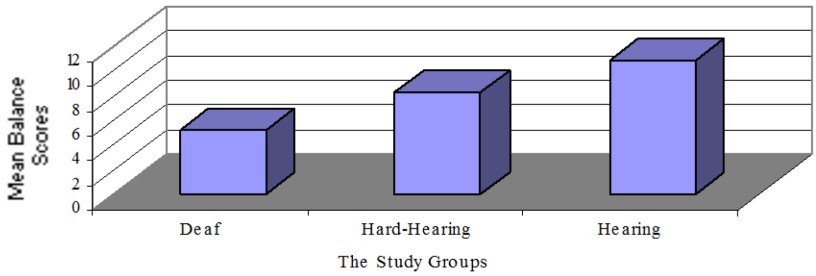

Fig. (1): Mean balance scores in the study groups for the total static balance.

Two-way ANOVA showed a significant differences among groups as well as between the tested age levels but there is no significant differences for the interaction (Table 4).

Table (3): Scheffe's test for mean balance scores of total static balance among the study groups.

Groups	Means	Groups		
		Deaf	Hard-Hearing	Hearing
Deaf	5.1194			
Hard-Hearing	8.1449	*		
Hearing	10.8143	*	*	

* Significant at 0.05. (Mean difference is considered significant if it is more than or equal 2.0416).

Table (4): Two-way ANOVA among the study groups for the static balance in the two age levels.

Source	df	SS	MS	F.ratio	F.tabulated	P.value
Among Groups	2	1110.867	555.434	78.091*	3.00	0.000
Within Groups	1	250.120	250.120	35.166*	3.84	0.000
Interaction	2	19.534	9.767	1.373	3.00	0.256
Error	200	1422.527	7.113	-------	-------	-------
Total	205	2803.049	13.673	-------	-------	-------

* Significant at 0.05. P: Probability value. df: Degree of freedom. SS: Sum of squares. MS: Mean of squares.

The t-test for independent samples used to compare balance score of level I age and level II age for each tested item as well as for the total static balance indicated a significant difference between mean balance scores of the two age levels in each item as well as for the total static balance (Table 5 and Figure 2). Table (5) and figure (2) represents that the performance of the level II age children in static balance is much better than the performance of the level I age children.

Table (5): The mean balance scores in the two age levels in each tested item and in the total static balance.

Tests	Level I Age (6:<9years)#			Level II Age (9:12years) #			t.value	P.value
	Mean	SD	SE	Mean	SD	SE		
Item (1)	2.7282	±1.190	0.117	3.3301	±0.954	0.094	-4.01*	0.000
Item (2)	3.0485	±1.762	0.174	4.0097	±1.752	0.173	-3.93*	0.000
Item (3)	1.1748	±1.070	0.105	1.8447	±1.349	0.133	-3.95*	0.000
Total Static Balance	6.9515	±3.544	0.349	9.1845	±3.522	0.347	-4.54*	0.00

Number of the subjects are 103 children. * Significant at 0.05. t.tabulated = 1.96

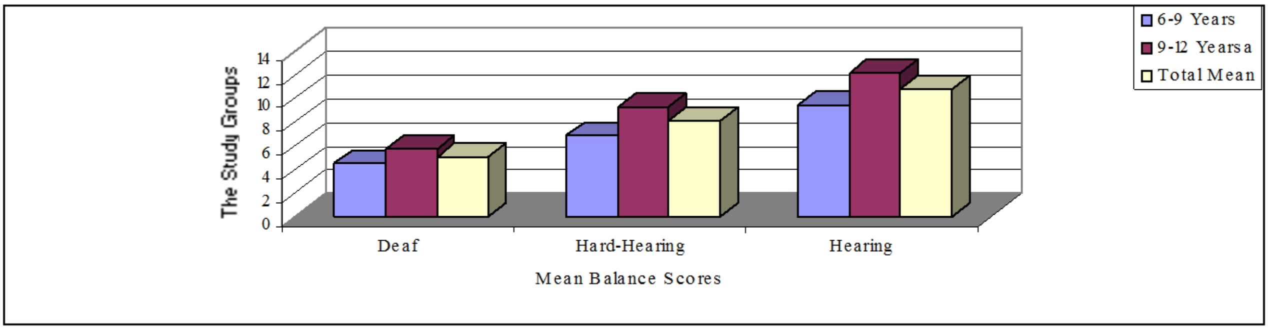

Fig. (2): Mean balance scores in the study groups in each age level for total static balance.

DISCUSSION

A balance deficit in hard-hearing and deaf children have been demonstrated in some previous studies such as studies performed by Lindsey and O'Neal (1976)[14]. In order to examine age-related changes in static balance ability in both hard-hearing and deaf children, there is a need first to determine whether the expected balance deficit was present in the sample of this study. This deficit was found when a comparison was made among the three study groups. There was significant differences in the mean static balance scores between the deaf and hard–hearing children, between the deaf and hearing children as well as between the hard-hearing and hearing children. These results are supported by the work of Siegel et al., (1991)[20] who compared balance skills of hearing-impaired children with those of hearing children using the balance subtest of the BOTMP. They found that the mean score for the hearing-impaired children was lower than the standard score.

Gayle and Pohlman (1990)[11] found that there was a difference of 57.8% in number of trials for successful completion of static balance in favor of the hearing children. They reported that over-all balance in deaf children was significantly inferior to the balance in hearing children. The authors mentioned that these differences may aid those working with deaf children in physical education.

Only in item (3) in the static balance subtest of the BOTMP, there was no significant difference between hard-hearing and hearing children. This may be attributed to the closed eyes in item (3) and vision is one of the requirement for both static and dynamic balance. These results come in agreement with studies done by Travis (1945)[24] who reported a decline in the performance of the study sample in both static and dynamic balance when the test was performed with closed eyes. Dickinson and Leonard (1967)[5] reported the importance of vision for body balance. Dickinson (1968)[4] stated that the lower balance ability seen in deaf and hard-hearing children may be due the disturbed proprioception reported in those children and the person compensates for the deficit in the proprioception by the use of vision. Gallahue (1982)[9] as well as Potter and Silverman (1984)[17] indicated that in order to compensate for balance deficits, deaf children use other sensory systems such as proprioception, kinesthesia and vision. The same idea was supported by Diener et al., (1984)[6] who stated that proprioceptive input from skin, pressure and joint receptors of the foot is of importance for the compensation of rapid displacement and plays a significant role when the platform moves at low frequencies.

The results of this study reported that the hearing children performance in static balance was greater than the deaf and hard-hearing children as well as the performance of the hard-hearing children was greater than the deaf children. This may be attributed to the hearing sense which is very important for keeping static balance. This result agrees with Galley and Forster (1987)[10] and Lindsey and O'Neal (1976)[14] who found that deaf children performed more poorly in static and dynamic balance skills than hearing children. Furthermore, the elimination of visual input on static balance tasks increased the difficulty for the deaf more than for the hearing children.

Moreover, the results of this study reported an improvement in all items of the static balance subtest as well as in the total static balance with age in all of the study groups. These findings agree with the work done by Sinbel (1985)[21] who reported greater performance of the older children (8 and 9 years) in static balance than the younger children (6 and 7 years). This may be due to that balance requires the contribution of the muscles of the foot that are still not completely developed in the young children. These results also agree with Rabti (1988)[18] who gave an exercises program for 3 months aiming to improve static balance of both deaf and normal hearing children. The author reported an improvement of the static balance in all study groups especially those older normal children. Wang and Chen (1999)[25] reported that weight and muscle strength which increase with chronological age, are the effective predictors on estimating balance score. However, Siegel et al., (1991)[20] reported that no difference between the subjects balance scores and the balance subtest standard scores was found among the age groups suggesting that the balance deficit was not age-related.

When t-test was used to compare balance scores of the level I age and the level II age groups. The results showed an improvement of the static balance with aging which may be attributed to the increased in muscle strength and endurance with age. These results agree with results reported by Fisher (1988)[8], Galley and Forster (1987)[10], Sinbel (1985)[21] and Thomas and French (1985)[23]. Butterfield and Ersing (1986)[3] examined the influence of age and the degree of hearing loss on the static balance performance of hearing impaired children and youth. They found that the performance on the tasks required static balance improved with chronological age.

The finding of this study that revealed a significant balance deficit in each of the tested age level of the deaf and hard-hearing children tested strongly suggest the need for intervention prior to the time at which balance ability becomes mature. Effgen (1981)[7] and Lewis et al., (1985)[15] examined the effects on balance of an exercise regimen for young deaf children. Effgen (1981)[7] used a force platform to measure static balance before and after a 10-day exercise program in 25 deaf children, whose mean age was 9 years. She found a significant improvement in static balance following the exercise regimen. Lewis et al., (1985)[15] implemented a 6-week exercise program for 11 deaf children aged 6 through 8 years using the balance subtest of the BOTMP. The authors found that the exercise regimen improved balance scores in the experimental group, but they found no change in a control group of deaf children who did not exercise.

Although these previous studies involved formal exercise regimens, the physical education teacher can consult with the physical therapist to develop an age-appropriate physical activity program (e.g., running, jumping, gymnastics) aimed at improving balance ability. Just as early intervention appear beneficial for children with Down syndrome, cystic fibrosis and other disabling conditions, early intervention may help reduce the balance deficit in deaf children.

Conclusion

The results of this study indicated the acceptance of the three suggested hypotheses. The results indicated that there is a static balance deficit in both deaf and hard-hearing children. The results also indicated that deaf children are inferior than hard-hearing children in tasks related to static balance. Finally, the results indicated that the static balance deficit is age-related.

Further research should examine dynamic balance deficit in both deaf and hard-hearing children. More research is also required to detect whether the dynamic balance is age-related. Further true longitudinal study of maturation of balance ability would be extremely instructive, particularly if a distinction is made between children with and without vestibular dysfunction. More studies are required to determine whether early intervention will reduce the static balance deficit in deaf as well as hard-hearing children.

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الملخص العربي

العلاقة بين التوازن الثابت والعمر في الاطفال الصم، ضعاف السمع والعاديين

تهدف هذه الدراسة الى المقارنة بين الأطفال الصم ، ضعاف السمع والعاديين في التوازن الثابت وذلك لتحديد اذا كان هناك خلل في التوازن الثابت في الأطفال الصم وضعاف السمع ولبيان علاقة هذا الخلل (ان وجد) بالفئة العمرية للأطفال. شارك في البحث 206 طفل ، تم تقسيمهم الى ثلاث مجموعات على اساس مستوى السمع لديهم . اشتملت المجموعة الأولى على 67 طفل مصاب بالصمم ، والمجموعة الثانية على 69 طفل مصاب بضعف السمع ، والمجوعة الثالثة على 70 طفل من العاديين . احتوت كل مجموعة على مستويين من الفئات العمرية ، الفئة العمرية الأولى من 6 سنوات حتى اقل من 9 سنوات والفئة العمرية الثانية من 9 حتى 12 سنة . اشتملت كل فئة عمرية على 103 طفل . تم قياس التوازن الثابت باستخدام الأختبارات الثلاثة الأولى من اختبار التوازن الموجود في اختبار برووننكس – اوسيريتسكى (Bruininks - Oseretsky) للمهارة الحركية . أظهرت النتائج وجود فروق ذات دلالة احصائية عالية بين الأطفال الصم وضعاف السمع والعاديين في التوازن الثابت حيث كانت نتائج الأطفال الصم وضعاف السمع في اختبارات التوازن الثابت اقل معنويا من نتائج الأطفال العاديين في نفس الاختبارات . كما أظهرت النتائج ان اداء الأطفال الأكبر سنا (الفئة العمرية الثانية) أفضل معنويا من اداء الأطفال الأصغر سنا (الفئة العمرية الأولى) وذلك في جميع الأطفال محور الدراسة . ويدل ذلك على وجود علاقة طردية بين التوازن الثابت والعمر في الأطفال المصابين بالصمم وضعف السمع وايضا الأطفال العاديين .