Age-Dynamic Balance Relationship among Deaf, Hard-Hearing and Hearing Children

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ABSTRACT

The purpose of this study was to compare dynamic balance skill of deaf and hard-hearing children with those of normal hearing children in order to determine whether a deficit in dynamic balance exists in deaf and hard-hearing children and to ascertain whether this deficit is age-related. The subjects were 206 schoolchildren who 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 years up to less than 9 years and level II age included children from 9 years up to 12 years. Each age level included 103 children. Dynamic balance was measured by the use of the last five 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 dynamic balance. Two-way ANOVA then was performed to test the significant change in the dynamic 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 dynamic balance deficit was age-related.

Key Words: *Child development; Dynamic balance; Hearing disorders; Test and measurements; Vestibular system.*

INTRODUCTION

Deaf (Hearing loss) is usually divided into two types. Conduction deafness (CD) that results from the inability of the sound signals to reach the auditory nerve efficiently. Lesions in the external auditory canal, the tympanic membrane, the middle ear, or a combination of these locations cause CD. Most causes of CD are treatable medically or surgically. Sensorineural deafness (SND) disorders that can be divided into cochlear disorders resulting from abnormalities of the inner ear (common in children) and retrochoclear losses that involve the eight nerve or brain stem and include a variety of degenerative and neoplastic disorders[13].

Because if the extreme changes in sound intensities that the ear can detect and discriminate, sound intensities are usually expressed in terms of the logarithm of their actual intensities. A tenfold increase in sound energy is called 1 bel and 0.1 bel is called 1 decibel (dB). One dB represents an actual increase in sound energy of 1.26 times. Hearing is generally measured from 250 to 8000 Hz in the 0- to 120-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[12].

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, 11].

Deaf problems are usually associated with physical problems such as balance deficit that may interfere with normal motor development and sensory integration. Damage to portions of the vestibulocochlear nerve, the presumed cause of SD, 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[14].

Balance is a complex process involving the reception and organization of sensory inputs, and the planning and execution of movement, to achieve a goal requiring upright posture[17]. It is the ability to control the center of gravity over the base of support in a given sensory environment[1].

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 balance (the ability to maintain the body equilibrium in some fixed posture) and dynamic balance (the ability to maintain the body equilibrium while the body is moving) 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 dynamic 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 dynamic balance, 2) deaf children would be inferior than hard-hearing children in tasks related to dynamic balance and 3) the dynamic 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 dynamic 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

With a target population of school-children between 6 and 12 years of age, a sample of 206 girls was drawn from three different schools in Riyadh (Al-Amal school and two primary schools). Ethical approval was obtained from each concerned school authority. After parental permission, the children were grouped 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 (Table 1).

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

Subject Types (Group)	Hearing Level in dB	6 : < 9 Years	9 : 12 Years	Total
Group (I) Deaf	> 90	34	33	67
Group (II) Hard-Hearing	40 : 65	34	35	69
Group (III) Hearing	< 40	35	35	70
Total		103	103	206

The hearing level of the each 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.

Materials

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

Procedures

The test was administered in a room free from distractions. The following five items comprised the dynamic balance subtest in the BOTMP:

1. Walking forward on walking line: The child was asked to walk forward on a line on the floor using a normal stride. Both hands were on the hips.
2. Walking forward on balance beam: The child was asked to walk forward on a balance beam using a normal stride. Both hands were on the hips.

(Items 1 and 2 were scored with a maximum of six steps. If the child placed one foot or both feet completely off the line or beam prior to six steps, the test was stopped and the number of the successful steps was recorded).

3. Walking forward heel-to-toe on walking line: The child was asked to walk forward on a line on the floor with a heel-to-toe gait. Both hands were on the hips.
4. Walking forward heel-to-toe on balance beam: The child was asked to walk forward on a balance beam with a heel-to-toe gait. Both hands are on the hips.

(Items 3 and 4 were scored with a maximum of six correct steps. A step was incorrect if one foot or both feet were placed completely off the line or beam, the heel of the front foot failed to touch the toe of the rear foot, or the toe of the rear foot was moved forward to touch the heel of the front foot).

5. Stepping over response speed stick on balance beam: The child was asked to walk on a balance beam using a normal stride. Both hands were on the hips. The child stepped over a wand held by the examiner above the beam, at a height just below the

knee. (The trial was recorded as a failure if the child touched the stick firmly, swang the leg around the stick, or stepped off the beam).

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

Dynamic balance was determined in items 1 through 4 by counting the number of steps, up to a maximum of six steps, taken during each item. Item five was rated as pass or fail. If the subject was unable to reach the maximum number of steps 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., steps on a beam) to common set of values. For an example; 5 steps (raw score) walking forward on balance beam equivalent to 3 value (point score).

The total point score of dynamic balance for each child was the summation of the point score in each of the five tested items (maximum score is 15 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 dynamic 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 dynamic 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 dynamic 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 dynamic 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 dynamic 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 dynamic balance (Table 3 and Figure 1). However, this test showed non-significant differences between groups II and III for the first and the fifth tested items.

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

Source		df	SS	MS	F.ratio	P.value
Item (1)	Among Groups	2	37.1152	18.5576	65.1573*	0.000
	Within Groups	203	57.8169	0.02848		
	Total	205	94.9320	--		
Item (2)	Among Groups	2	46.5351	23.2676	71.4930*	0.000
	Within Groups	203	66.0668	0.3255		
	Total	205	112.6019	--		
Item (3)	Among Groups	2	17.2239	8.6120	23.5323*	0.000
	Within Groups	203	74.2960	0.3660		
	Total	205	91.5146	--		
Item (4)	Among Groups	2	73.0509	36.5255	50.4574*	0.000
	Within Groups	203	146.9491	0.7239		
	Total	205	220.0000	--		
Item (5)	Among Groups	2	5.2858	2.6429	11.6091*	0.000
	Within Groups	203	46.2142	0.2277		
	Total	205	51.5000	--		
Total Dynamic Balance	Among Groups	2	767.1157	383.5578	72.1416*	0.0000
	Within Groups	203	1079.2970	5.3167		
	Total	205	1846.4126	--		

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

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

Groups	Means	Groups		
		Deaf	Hard-Hearing	Hearing
Deaf	6.4776			
Hard-Hearing	9.4058	*		
Hearing	11.1714	*	*	

* Significant at 0.05. (Mean difference was considered significant if it was more than or equal 1.6304).

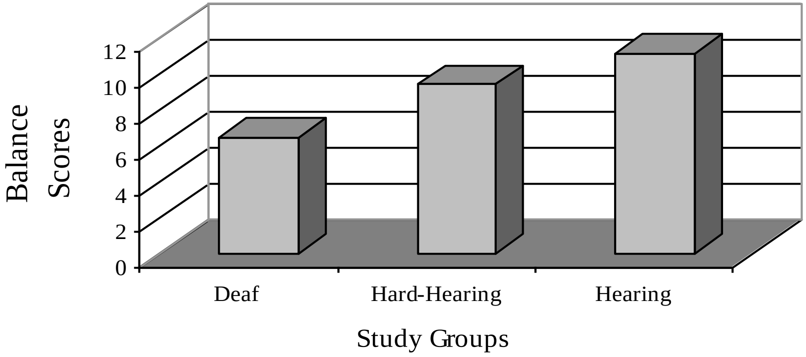

Fig. (1): Mean balance scores in the study groups for the total dynamic balance.

Two-way ANOVA showed a significant difference among groups as well as between the tested age levels but there was no significant differences for the interaction between the study groups and the tested age levels for the dynamic balance (Table 4).

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

Source	**df**	**SS**	**MS**	**F.ratio**	**F.tabulated**	**P.value**
Among Groups	2	767.116	383.558	90.120*	3.00	0.000
Within Groups	1	13.828	214.255	50.341*	3.84	0.000
Interaction	2	995.199	6.914	1.625	3.00	0.200
Error	200	851.214	4.256	-------	-------	-------
Total	205	1846.413	9.007	-------	-------	-------

* Significant at 0.05. P: Probability value. df: Degrees 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 dynamic balance indicated a significant difference between mean balance scores of the two age levels in each of the five tested items as well as for the total dynamic balance (Table 5 and Figure 2). It was detected that the performance of the level II age children in dynamic 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 total dynamic balance.

Tests	**Level I Age (6:<9years)$^{\#}$**			**Level II Age (9:12years)$^{\#}$**			**t. value**	**P. value**
	Mean	**SD**	**SE**	**Mean**	**SD**	**SE**		
Item (1)	2.2524	±0.710	0.070	2.5243	±0.624	0.061	-2.92*	0.004
Item (2)	2.0291	±0.760	0.075	2.3981	±0.676	0.067	-3.68*	0.000
Item (3)	1.7184	±0.633	0.062	2.1845	±0.622	0.061	-5.33*	0.000
Item (4)	1.6505	±0.904	0.089	2.3495	±1.045	0.103	-5.13*	0.000
Item (5)	0.3689	±0.485	0.084	0.6311	±0.485	0.048	-3.88*	0.000
Total Dynamic Balance	8.0194	±2.811	0.277	10.0874	±2.836	0.279	-5.26*	0.00

$^{\#}$ Number of the subjects is 103 children. * Significant at 0.05. SD: Standard deviation.
SE: Standard error. t. tabulated = 1.96

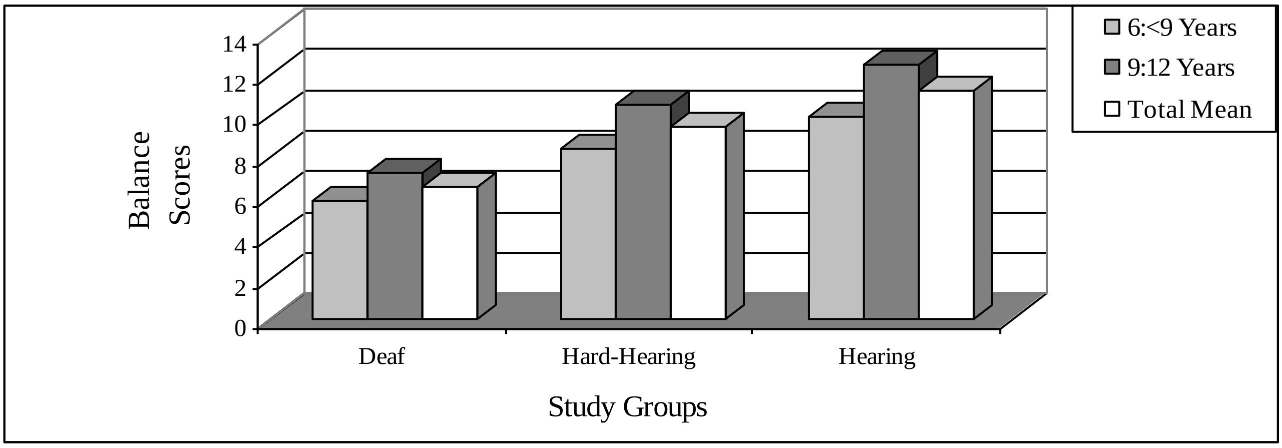

Fig. (2): Mean balance scores in the study groups in each age level for total dynamic balance.

DISCUSTION

Lindsey and O'Neal (1976)[14] stated that there is a dynamic balance deficit in deaf children. In order to examine age-related changes in dynamic 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 a significant difference in the mean dynamic 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 agree with Gayle and Pohlman (1990)[10] who reported that the over-all balance including the dynamic balance in deaf children was significantly inferior to the balance in hearing children. The results are also supported by the work of Siegel et al. (1991)[19] 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.

Gallahue (1982)[8] as well as Potter and Silverman (1984)[18] indicated that deaf children use other sensory systems such as proprioception, kinesthesia and vision in order to compensate for balance deficits. 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 revealed that the hearing children performance in dynamic balance was greater than the deaf and hard-hearing children and 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 dynamic balance. This result agrees with Galley and Forster (1987)[9] as well as Lindsey and O'Neal (1976)[14] who found that deaf children performed more poorly in static and dynamic balance skills than hearing children.

Moreover, the results of this study indicated an improvement in all items of the dynamic balance subtest as well as in the total dynamic balance with age in all of the study groups. These findings agree with the work done by Sinbel (1985)[20] who reported greater performance of the older children (8 and 9 years) in dynamic balance than the younger children (6 and 7 years). This may be due to the requirement of the contribution of the muscles of the foot for normal balance that are still not completely developed in the young children. These results also agree with Butterfield and Ersing (1987)[5] who studied the effect of age, sex, hearing loss and balance on the development of kicking by deaf children and found that there is an improvement in dynamic balance with aging. Moreover, Wang and Chen (1999)[22] reported that weight and muscle strength, which increase with chronological age, are the effective predictors on estimating balance score. However, Siegel et al. (1991)[19] reported that no differences between the subjects balance scores and the balance subtest standard scores were 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 dynamic 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)[7], Galley and Forster (1987)[9], Sinbel (1985)[20] and Thomas and French (1985)[21]. Butterfield and Ersing (1986)[4] examined the influence of age and the degree of hearing loss on the dynamic balance performance of hearing impaired children and youth. They found that the performance on the tasks required dynamic balance improved with chronological age. These findings were supported by Butterfield (1990)[3] who studied the effect of age on the dynamic balance in deaf children and reported an improvement in the dynamic balance with 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. 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. They found that the exercise regimen improved balance scores in the experimental group, as compared to 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, and 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 and hard-hearing children.

Conclusion

The results of this study indicated the acceptance of the three suggested hypotheses. The results indicated that there is a dynamic 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 dynamic balance. Finally, the results indicated that the dynamic balance deficit 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 dynamic balance deficit in deaf as well as hard-hearing children.

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الملخص العربي

العلاقة بين التوازن المتحرك والعمر في الأطفال الصم ، ضعاف السمع والعاديين

تهدف هذه الدراسة إلى المقارنة بين الأطفال الصم، ضعاف السمع والعاديين في التوازن المتحرك وذلك لتحديد إذا كان هناك خلل في التوازن المتحرك في الأطفال الصم وضعاف السمع ولبيان علاقة هذا الخلل (إن وجد) بالفئة العمرية للأطفال. شارك في البحث ٢٠٦ طفلة، تم تقسيمهم إلى ثلاث مجموعات على أساس مستوى السمع لديهم. اشتملت المجموعة الأولى على ٦٧ طفلة مصابة بالصمم، والمجموعة الثانية على ٦٩ طفلة مصابة بضعف السمع، والمجوعة الثالثة على ٧٠ طفلة من العاديين. احتوت كل مجموعة على مستويين من الفئات العمرية، الفئة العمرية الأولى من ٦ سنوات حتى اقل من ٩ سنوات والفئة العمرية الثانية من ٩ حتى ١٢ سنة . اشتملت كل فئة عمرية على ١٠٣ طفلة.

تم قياس التوازن المتحرك باستخدام الاختبارات الأربع الأخيرة من اختبـار التوازن الموجـود في اختبار برووننكس – اوسيريتسكى (Bruininks - Oseretsky) للمهارة الحركية.

أظهرت النتائج وجود فروق ذات دلالة إحصائية عالية بين الأطفال الصم وضعاف السمع والعاديين في التوازن المتحرك حيث كانت نتائج الأطفال الصم وضعاف السمع في اختبارات التوازن المتحرك اقل معنويا من نتائج الأطفال العاديين في نفس الاختبارات. كما أظهرت النتائج أن أداء الأطفال الأكبر سنا (الفئة العمرية الثانية) أفضل معنويا من أداء الأطفال الأصغر سنا (الفئة العمرية الأولى) وذلك في جميع الأطفال محور الدراسة. ويدل ذلك على وجود علاقة طرديـة بين التوازن المتحرك والعمر في الأطفال المصابين بالصمم وضعف السمع وأيضا الأطفال العاديين.