Motor Skills in Hearing Impaired Children With or Without Cochlear Implant - A Systematic Review

Vidranski, Tihomir; Farkaš, Daria

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Review

Motor Skills in Hearing Impaired Children with or without Cochlear Implant – A Systematic Review

Tihomir Vidranski and Daria Farkaš

»J. J. Strossmayer« University, Faculty of Education, Osijek, Croatia

A B S T R A C T

Hearing impairment is a major limitation in communication, and it can obstruct psychological development, development of social skills and motor development. Hearing impairment is the third most common contemporary chronic health condition, and it has become a public health problem. The effectiveness of problem solving in everyday life and in emergency situations depends greatly on the amount and quality of the motor programs. Therefore, it is evident that the normal motor development in persons with hearing impairment is essential for everyday life. The aim of this research is to analyze the available information pertaining to motor skills of hearing impaired children both with and without a cochlear implant (CI) and to analyze possibilities of influencing their motor skills. The relevant studies on motor skills of hearing impaired children both with and without CI were obtained by an extensive computer search of various databases using special keywords and extraction with respect to certain criteria, resulting in 22 studies. The overall results of this systematic review indicate that the children with hearing impairment exhibit suboptimal levels of motor skills especially balance. Very few studies compared children with hearing impairment with CI units and without CI units and the results of those studies are quite contradictory. Numerous studies have confirmed that the regular and appropriate physical exercise can improve motor skills of children with hearing impairment, especially balance. The fact that the development of motor skills is crucial for the child's interaction with the outside world, action, perception and acquisition of academic skills and other skills necessary for life shows the importance of motor skills development for children with hearing impairment.

Key words: *motor skills, basic and precise motoric, hearing impairment, cochlear implant, children*

Introduction

Hearing impairment represents a major limitation in communication, and furthermore acts as a hindrance for psychological development and development of social skills. The studies noted that the people suffering from hearing loss have a higher chance of suffering from mood disorders infrequently avoid participating in social activities, which results in underdevelopment of social relations which furthermore continues to increase the levels of psychological stress, creating a vicious circle[1]. Hearing impairment is the third most common contemporary chronic health condition, and has become a public health problem. According to the World Health Organization (WHO), more than 5% of the world population, which amounts to 360 million people, suffers from certain kind of hearing disorder. It is considered that 32 million children have some form of hearing impairment[2]. Permanent hearing damage which occurred either during the pregnancy period or immediately during or after birth occurs in 1 to 3 children per 1000 births, which makes it the most frequent form of hearing damage as opposed to other congenital forms of hearing loss[3]. As well as being a major constraint in communication, psychological and social skills development, studies have discovered that hearing impairment acts as an obstacle in the normal motor skills development[4].

Hearing impairment and motor development

Simple and complex motor skills are required to maintain the body's center of gravity above the base of support, and the development of postural and balance control is an important prerequisite for performance of common daily movements[4]. Likewise, motor development is crucial for a successful interaction of a child with the outside world – for action, perception and for the acquisition of academic and other skills necessary in life[5].

By comparing children with and without hearing loss various researches discovered that the children with hearing impairment have less developed motor skills than

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their peers without any form of hearing damage. This deficit is especially pronounced in balance[6–16]. According to some researchers, the primary cause of motor deficit, and especially balance deficit, in hearing impaired children is the damage of vestibular apparatus[17–20]. As the effectiveness of problem solving in everyday life and emergency situations greatly depends on the amount and quality of motor programs, it is evident that the importance of normal motor development in persons with hearing impairment is essential for everyday life. Therefore, the aim of this work is to systematically analyze the available information pertaining motor skills in hearing impaired children both with and without a cochlear implant (CI) and the possibilities of influencing their motor skills.

Methods

Search strategy

Relevant studies on motor skills in hearing impaired children both with and without a cochlear implant were acquired through the extensive computer search of various databases (PUBMED, MEDLINE, CINHAL, EMBASE, SCOPUS, WoS, AMED, Google Scholar). The search was conducted using the following keywords: motor skills, motor abilities, motor development, precise/basic motor skills, static/dynamic balance, children with damaged hearing/hearing loss, children with sensoneural hearing impairment, children with/without a built-in CI and various other combinations of the aforementioned phrases. These databases were chosen because of their ability to provide access to medical scientific journals covering these topics.

Study selection and inclusion criteria

After the initial selection of the relevant studies with regard to the subject, a further selection was made with respect of the following criteria which studies had to meet: 1) the original scientific paper; 2) studies published in full (abstracts excluded); 3) studies published in either English or Croatian language; 4) studies up to 18 years old; 5) studies conducted on children with damaged hearing with/without a cochlear implant and without any other associated deficits (intelligence, sight, musculoskeletal system).

Data extraction

The researcher has extracted the data from each eligible article using a custom-designed manual form. The collected data included study design, study population, age of the population, sample size, battery type tests and results.

Results

Following the database search and the selection of articles according to the aforementioned criteria, 22 studies were selected as the final choice (Table 1).

TABLE 1
SUMMARY OF STUDIES

Author	Draft	Sample	No.	Age	Test battery	Results
Dummer et al.[11]	–	OS	201	4–18	TGMD	Significant difference noted between the hearing impaired children and children with no hearing impairment in motor abilities and object manipulation
Gkouvatzi et al.[23]	–	OS DOS BOS	17 17 39	6–14	BOT	Significant difference noted between the children with hearing impairment and children without hearing impairment. A significant difference noted in hearing impaired children with regard to the degree of damage
De Sousa et al.[8]	Cross-sectional	OS BOS	43 57	7–10	Balance platform	Children with hearing impairment exhibit significant oscillation of body in balance tests as opposed to children with no hearing impairment
Gheysen et al.[6]	–	OS OS+CI BOS	16 20 43	4–12	M–ABC KTK OLS	Children with hearing impairment score significantly poorer than children without hearing impairment Children with CI score significantly poorer than children with no impairment No difference between children with hearing impairment with or without CI
Carlson[22]	–	OS	48	5–10	BMAT	Degree of hearing impairment has no significant effect on motoric ability
Zwierzchova et al.[14]	–	OS	190	10–15	Eurofit	Hearing impairment effects motoric development, especially coordination
Gkouvatzi et al.[24]	Comparative study	OS DOS	17 17	6–12	BOT	Degree of hearing impairment has no significant effect on reaction speed, upper body coordination or visual motor control

Author	Draft	Sample	No.	Age	Test battery	Results
Potter et al.[15]	–	OS	34	5–9	SCSIT	Balance disorder with opened eyes noted in 44.1%, and with closed eyes in 35.3% of respondents
Hartman et al.[13]	–	OS	42	6–12	M–ABC	Percentage of children with hearing impairment with below-average results amounts to 61.9% in manual abilities, 52.4% in ball manipulation and 45.3% in balance tests
Siegel et al.[12]	Compara-tive study	OS	28	4–15	BOTMP	Children with hearing impairment score below-average with regard to benchmark values
Rine et al.[7]	–	SNHL BOS	7 6	4–5	LAP-D	Children with hearing impairment score below-average, especially in balance tests
Shaikh et al.[9]	–	OS BOZ	180 180	4–15	BOTMP	Children with hearing impairment score below-average in all basic and precise motoric tests
Winick et al.[10]	–	OS DOS BOS	892 153 686	10–17	UNIQUE test	Children with hearing impairment show poor results in flexibility and repetitive strength No differences in hand strength and running speed
Cushing et al.[21]	Cross-sectional	OS+CI BOS	41 14	4–17	BOT 2	Children with CI significantly differ from children with no impairment and benchmark values Children with connected CI show better results than children with disconnected CI units
Cushing et al.[18]	Cross-sectional	SNHL+CI	40	3–19	BOT2	Children with CI score below-average in balance tests
Jarnice[16]	Case study	OS+CI BOS	1 1	7	Balance platform	Child with a CI has significantly worse static and dynamic balance than the child with no impairment
Horn et al.[27]	Retro-spective analysis	CI	22	0–6	VABS	Precise motoric is in negative correlation with chronological age, and basic motoric is in positive correlation with chronological age
Crowe et al.[17]	–	OS+VD OS-VD BOS	22 7 13	7–13	SCSIT BOT	No significant differences noted between hearing impaired children with normal vestibular function and children with no impairment. Children with hearing impairment with associated vestibular damage score 50% worse than children with no impairment
Suarez et al.[19]	–	BOS SNHL+ VD SNHL-VD	22 8 28	8–11	Balance platform	No significant difference noted between the children with hearing impairment with normal vestibular function and children with no impairment Children with impairment and associated vestibular damage significantly differ from children with no impairment and children with impairment and normal vestibular function No difference in balance regarding connected or disconnected CI unit
Shall [20]	–	SNH -CI SNHL+CI	33 19	4–7	M–ABC	No significant difference noted between the children with hearing impairment with normal vestibular function and children with no hearing impairment Children with hearing impairment and associated vestibular damage differ significantly from children with no hearing impairment and children with hearing impairment and normal vestibular function No difference noted between the children with or without CI
Effgen[25]	Test – retest	OS	49	7–11	Balance platform	After experimental protocol an improvement in quantity of balance has been noted, but not in quality of balance
Shah et al.[26]	–	SNHL	10	6–12	TGMD PBS	Significant improvement in basic motoric and postural control is noted after the implementation of experimental protocol

Legend: OS – children with hearing impairment, DOS –children with partially damaged hearing, BOS –children with no hearing impairment, CI –cochlear implant, SNHL – children with sensoneaural hearing loss, VD – vestibural deficit, LAP–D – Learning Accomplishment Profile Diagnostic Edition, BOT – Bruininks – Oseretsky test of Motor Profience, TGMD – Test of Gross Motor Development, Force platform –balancing platform with a software system, M–ABC – Movement Assessment Battery for Children, KTK – Korperkoordinationstest fur Kinder, OLS – One–Leg Standing test, BMAT – Brace Motor Ability Test, PBS – Pediatric Balance Scale, EUROFIT – European Fitness Test, SCSIT – Southern California Sensory Integration Test, VABS – Vineland Adaptive Behavioral Scale

In terms of the sample of the compared respondents out of the total number of studies, six studies compared the motor skills of children without hearing impairment and children with hearing impairment[6–10,19], five studies compared the motor skills of children with hearing impairment to referent benchmark tests[11–15], four studies compared motor skills of hearing impaired children with and without a built-in CI unit[6,19,20–21], and five studies compared motor skills of hearing impaired children with or without associated vestibular damage.

In terms of the motor skills investigated out of the total number of research papers, thirteen studies investigated basic motor skills of hearing impaired children[6–7,9–11,13–14,17,22–24,26–27], seven studies investigated both basic and precise motor skills[6,9,13,17,23–24,27], eight studies tested only balance[8,12,15–16,18–19,21,25], and one study investigated only the upper limb coordination[24].

Out of a total of 22 papers, 7 studies have investigated the differences in motor skills in children with hearing impairment according to their gender[8,10–12,15,22–23], 5 studies according to age[9–12,23–24], and 5 studies investigated the effect of physical exercise on the motor skills in hearing impaired children[11,13,16,25–26].

With regard to the test battery used in the selected studies, two studies used the Test of Gross Motor Development[11,26,] seven studies used Bruininks-Oseretsky Test of Motor Proficiency[9,12,17–18,21,23–24], four studies used a software system balancing platform[8,16,19,25], three studies used Movement Assessment Battery for Children test[6,13,20], two studies used Southern California Sensory Integration Test[15,17], while the Korperkoordinationstest fur Kinder[6], One-Leg Standing Test[26], Vineland Adaptive Behavioral Scale[27], Learning Accomplishment Profile Diagnostic Edition[7], and UNIQUE[10], were used in one study respectively.

The total sample of the respondents ranged from 2 (case study) to 731, aged from infants to 18 years of age. The research design was listed in eight out of 22 studies: cross-sectional study in three studies[8,18,21], comparative analysis in two studies[12,23], and test-retest[25], retrospective analysis[27] and case study[16] in one study respectively. The summary of data from the selected works is shown in Table 1.

Discussion

The differences in motor skills between the children with hearing impairment and children with no hearing loss

The overall results of this systematic paper review have shown that the children with hearing impairment exhibit suboptimal levels of motor skills, especially in balance. The comparison of children with and without hearing impairment in almost all the studies, regardless of the test battery used, has shown significant differences in both basic and precise motor skills – the children with hearing impairment have universally achieved poorer results. The most common differences were observed in balance tests with closed eyes and one-leg balance.

Comparing children with and without hearing impairment, Gheysen[6] has noticed that the children with hearing impairment achieved poorer results in M-ABC tests, all the subtests and in total score. The most significant differences between children with and without hearing impairment were observed in the tests of balance with closed eyes, whereby the children with damaged hearing achieved worse results than their peers with no hearing damage. Furthermore, the differences, although not statistically significant, were observed in manual skills and ball manipulation, where the children with damaged hearing achieved worse results.

Rine[7] has observed significant difference in motor skills between children with and without hearing impairment, where the observed differences were particularly pronounced in balance. Children with hearing damage achieved poorer results than the children with no hearing damage. Unlike Gheysen[6], Rine[7] observed the greatest difference in the balance test with opened eyes.

De Sousa has discovered that the children with hearing impairment exhibit much greater body oscillations than the children without hearing impairment, which indicates less developed balance skills[8].

By comparison of basic and precise motor skills in children with and without hearing impairment, Shaikhi has discovered significant differences in most tests[9]. In basic motor skill tests the children with hearing impairment achieved worse results in tests of leaping, walking along the straight line, standing on one leg on a beam and in the run with a carried object, whilst the differences in ball catching and target shooting did not exhibit any significant differences. In precise motor skills the children with hearing impairment achieved worse results in object manipulation tasks, whilst the differences in drawing and strikethrough did not show any significant difference.

Furthermore, Winnick has observed that children with hearing impairment achieve worse results than the children with no hearing impairment in basic motor tests of repetitive strength and flexibility, while there was no difference in running speed and hand strength[10].

Contrary to the above studies, Suarez, using a balance platform, has noticed no difference between children with and without hearing impairment, regardless of the opened or closed eyes test[19].

Different studies have reached the same results comparing children with hearing impairment with reference values of children with no hearing impairment in certain tests as the studies carried out by comparing children with and without hearing impairment. A significant deviation of hearing impaired children has been discovered towards achieving poorer results in motor skills.

Dummer has, after comparing children with hearing impairment with benchmark tests of basic motor skills, observed that the children with hearing impairment achieve worse results in all basic motor skills and in the ability to manipulate objects[11].

Siegel, using a Bruininks-Osertesy test battery for balance assertion, has observed a significant deviation of

children with hearing impairment from the benchmark values toward the worse results[12].

Using M-ABC test battery, according to Hartman, 61.9% of the subjects achieved below-average results in manual skills, 52.4% of the subjects achieved below average results in ball manipulation and 45.3% of the subjects achieved below-average results in balance[13].

In manual ability tests respondents have achieved better results in subtests of bimanual coordination and eye-hand coordination. In ball manipulation tests they scored better in ball catching than in shooting tests, and they have achieved better results in dynamic than static balance tests.

Using Eurofit test battery, Zwierzchowska has noted significant discrepancies in children with damaged hearing from the referential values, particularly in coordination, whereby the children with damaged hearing achieved below-average results[14].

Potter, examining the static balance of children with hearing impairment, has noted that 44.1% of these children have a static balance disorder when performing balance tests with their eyes open, while the observed imbalance was noted in 33.3% of the children performing the same test with their eyes closed[15].

Differences in motor abilities of hearing impaired children with a built-in CI, without built-in CI and children without hearing disability

Very few studies compared hearing impaired children with and without CI unit, and the results obtained from these studies are quite contradictory and only apply to the balance tests. Some researchers have noted the existence of a difference in motor abilities of children with built-in and unincorporated CI, whereas the children with a CI achieved better results. The remaining researchers observed no differences between these groups. A possible reason for the perceived contradictions is the use of different test batteries. Unambiguous results were obtained only when comparing the children with a CI and children without hearing impairment, where the children with CI achieved significantly poorer results. Contradictions in the resulting studies indicate a need for further research, and particularly of the motor abilities which were not covered by the current studies.

Jernice, comparing a hearing impaired child with a CI and a child without hearing impairment (case study) noted that the child with a CI had a significantly worse dynamic and static balance ability than the child without hearing impairment. The only instance where the difference was not noted was the two leg standing subtest[16].

Gheysen has noted that the children with CI have significantly poorer results than the children with no hearing impairment in balance tests. Furthermore, it was noted that there were no differences in balance test results in children with and without CI, except in the walking backwards subtest, where the hearing impaired children without a CI achieved significantly better results[6].

Cushing, examining the deficit in static and dynamic balance in children with CI also noticed that these children achieve below-average results in respect to the reference value, but when the same difference was tested on children in terms of connected and disconnected CI where it was found that children with connected CI achieve significantly better results[21].

Unlike Cushing[21], Suarez[19], examining the balance of the children with CI on a balance platform has not noticed any difference between children with and without CI neither in closed eyes condition nor in open eyes condition.

Shall[20] received the same results as Suarez[19] while comparing children with hearing disability with and without a CI in a M-ABC test battery. No differences between those two groups were found in any of the subtests.

The differences in motor abilities in hearing impaired children with associated vestibular apparatus damage and hearing impaired children with no vestibular apparatus damage

Studies examining the impact of associated damage to the vestibular apparatus gave unambiguous results, which lead to the conclusion that the associated vestibular deficit has significantly less impact on the development of motor skills. The research conducted by Crowe[17] indicated that the children with hearing impairment with associated vestibular apparatus damage achieve similar results in all tests of basic and precise motoric as children with no hearing disability. Furthermore, the children with hearing disability with associated vestibular damage achieve 50 per cent worse results than children with no damage in balance tests.

Cushing[18], Suarez[19] and Shalla[20] concluded the same in their studies. Suarez[19] notes significantly poorer results in children with hearing problems associated with vestibular deficits than children with hearing impairment with no vestibular damage.

The differences between the aforementioned groups have not been noted only in the study conducted by Potter[15].

Differences in motor skills of children with hearing impairment in regard to gender and age

Observation of the gender difference in children with hearing disability in tests of strength, speed and flexibility has shown significant differences that were identical to those in the population of children without hearing disability[10–11,22]. Boys have achieved higher scores in tests of strength and speed, while girls have achieved higher scores in tests of flexibility. There were no differences in balance tests[8,12,15,23].

Differences in motor skills of children with hearing impairment according to the age have been observed in a large number of studies[9–12, 23–24]. It was noted that the motor abilities of children with hearing impairment improve with age.

Differences in motor skills of children with hearing impairment due to involvement in physical activity

The studies have confirmed that the application of adjusted physical exercise leads to a significant improvement of motor skills in the population with hearing disability. A significant improvement of all abilities, with special emphasis on the balance, which is significantly impaired in this population, has been observed.

While determining the level of basic motor skills of children with hearing impairment Dummer[11] observed that better results in motor skills tests were achieved by the children who were involved in a sports activity, as opposed to the children with hearing disability who were not involved in sports activities.

Hartman has noted the same. He noticed that the children who have been involved in sports activities achieved better results in ball manipulation test and dynamic balance test[13].

Furthermore, Effgen noted that daily fifteen-minute static balance exercises during a 10 day period improved the quantity, but not quality of balance in children with hearing impairment. In other words, balance time has increased, but it did not reduce the oscillations of the body while maintaining balance[25].

Shah managed to significantly improve basic motor skills in children with hearing impairment during 12 weeks exercise program (10 minutes 3 times per week)[26].

Jernice, in a hearing impaired child and a child without hearing disability case study, observed after an exercise program, has observed an improved dynamic balance in both children. The child with hearing impairment improved its results in both static equilibrium subtests, while the child without hearing impairment improved the results in only one subtest[16].

Conclusion

By the systematic review of motor skills studies of children with hearing impairments it can be concluded that those children achieve significantly poorer results than the children without hearing impairment, with a special deficit in balance tests. The results indicate that it is possible to mitigate this motoric deficit by a CI, although further research might be necessary due to discrepancies exhibited in these studies. Numerous studies have confirmed that the regular and appropriate physical exercise can improve motor skills of children with hearing impairment, especially balance. The fact that the motor skills development is crucial for the child's interaction with the outside world, action, perception and acquisition of academic skills and other skills necessary for life, shows the importance of the motor skills development in children with hearing disability. Since children with a built-in CI are capable of successful integration in mainstream education system, it is necessary to develop adjusted custom programs of physical education which will help them develop their motor skills, with special emphasis on the balance. Furthermore, it is necessary to enroll such children in appropriate sports activities in order to help them develop motor skills and encourage their psychological and social development.

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T. Vidranski

»J. J. Strossmayer« University, Faculty of Education, Cara Hadrijana 10, 31000 Osijek, Croatia
e-mail: tvidranski@foozos.hr

MOTORIČKE SPOSOBNOSTI DJECE OŠTEĆENOG SLUHA S ILI BEZ KOHLEARNOG IMPLANTATA: SUSTAVNI PREGLED

S A Ž E T A K

Oštećenje sluha predstavlja veliko ograničenje komunikacije, koje nadalje veže i prepreku u psihološkom razvoju, razvoju socijalnih vještina i motoričkom razvoju. Ono se danas ubraja u jedno od najčešćih zdravstvenih kroničnih stanja, odnosno treće po učestalosti kronično stanje, zbog čega je postalo i javno zdravstveni problem. Kako djelotvornost rješavanja različitih životnih problema sa kojima se čovjek susreće u svakodnevnu životu i tzv. urgentnim situacijama, u mnogome ovisi o količini i kakvoći motoričkih programa, vidljivo je da je važnost normalnog motoričkog razvoja osoba sa oštećenim sluhom bitno za svakodnevni život. S toga je cilj ovog rada, sustavno analizirati dostupne informacije u literature koje se odnose na motoričke sposobnosti djece oštećenog sluha koja imaju/nemaju ugrađen CI (kohlearni implantat) i mogućnost utjecaja na iste. Relevantna istraživanja o motoričkim vještinama djece oštećenog sluha sa/bez ugrađenog CI su dobivena opsežnom računalnom pretragom različitih baza podataka pomoću ključnih riječi i ekstrakcijom s obzirom na određene kriterije. U konačan izbor odabrana su 22 rada. Sveukupni rezultati ovog sistematskog pregleda radova ustanovili su da djeca oštećenog sluha pokazuju suboptimalne razine motoričkih sposobnosti, posebno izražene u ravnoteži. Vrlo mali broj istraživanja se bavio usporedbom djece oštećena sluha sa ugrađenim CI i djece oštećena sluha bez ugrađenog CI, a rezultati dobiveni tim istraživanjima su prilično kontradiktorni. Potvrđeno je brojnim istraživanjima da je redovnim i primjerenim tjelesnim vježbanjem moguće poboljšati motoričke sposobnosti djece oštećenog sluha, s posebnim naglaskom na poboljšanje ravnoteže. Kako je motorički razvoj ključan za interakciju djeteta sa vanjskim svijetom, za njegovu percepciju, akciju, za stjecanje akademskih vještina, te drugih vještina potrebnih kroz život, vidljiva je važnost razvijanja motoričkih vještina djece oštećena sluha.