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Motor Skills in Hearing Impaired Children

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Abstract

The aim of this review is to give information about the current situation of hearing-impaired children in terms of motor skills and their differences from hearing children in the light of the studies conducted in the last 20 years and to draw attention to the importance of physical education and sports for motor skill development in hearing-impaired children. With this aim, in this systematic review study, Google Scholar, Ulakbim/TR Index, and the Council of Higher Education (YÖK) Thesis Search Center databases were searched with Turkish and English keywords in order to reach the studies on motor skills of hearing-impaired children. The studies were screened according to the inclusion and exclusion criteria and 25 studies were included in the study. From the findings obtained, it was concluded that hearing-impaired children lag behind their hearing peers in terms of balance and some motor skills, but supporting these children with physical education and sports lessons in schools and physical activities outside of school in accordance with their needs would make significant contributions to their physical and motor development. For this reason, it is important to plan and conduct physical education and sports lessons in schools for hearing-impaired children in accordance with their needs.

Keywords: Motor skills, hearing-impaired children, physical education

1. Introduction

People use senses to perceive the world around them and interact with other people. The sense of hearing enables people to experience the world through sound. Inability to hear sounds as well as someone with normal hearing is defined as hearing impairment (WHO, 2023). According to this definition, hearing impairment can be considered as only related to an inability to process sound. Therefore, one can expect that it does not affect the capacity for physical activity or hearing impaired people can participate in physical activities without any limitations (Barboza et al., 2015; Hoffman et al., 2010). However, although a deaf or hearing-impaired individual may look like a person without any disability, hearing impairment negatively affects different developmental areas of the child and brings along a number of secondary issues with it.

Development in children can be examined in four areas: physical, emotional, mental, and motor (Gallahue et al., 2012). These developmental areas interact with each other. In other words, one area that is affected negatively can negatively affect other areas. Accordingly, hearing impairment may negatively affect emotional, cognitive, and motor development. It is known that individuals with partial or complete hearing loss have difficulties in learning their mother tongue, pursuing primary education, participating in age-appropriate activities, and performing most of the tasks required in daily life (WHO, 2023). Studies have shown that hearing impairment, especially in infancy and early childhood, negatively affects speech and language skills, and accordingly, emotional, social, cognitive, and academic developments are also affected negatively (Mavilidi et al., 2018; Peterson & Siegal, 1995). These children also show delays in physical development compared to their hearing peers (Engel-Yeger & Weissman, 2009; Horak et al., 1988; Melo et al., 2017; Rine et al., 2000; Wiegersma & Vander, 1983) and have some physiological differences (Shavel et al., 2021; Veena et al., 2015). In particular, they are reported to have higher pulsation rates and lower blood pressure levels than hearing people, and they have lower lung capacity due to their lack of voice utilization (Shavel et al., 2021; Veena et al., 2015). In addition, due to their body's decreased ability to cope with hypoxic states, their physical performance level is limited (Shavel et al., 2021; Sit et al., 2007).

In terms of motor development and balance, it has been shown in many studies that hearing-impaired children show lower performance than their hearing peers (Gheysen et al., 2008; Güven & Bal, 1992; Schmidt, 1985; Suarez et al., 2007; Rajendran & Roy, 2011; Rine et al., 1996; 2000; 2004; Vidranski & Farkaš, 2015; Wiegersma & Van der Velde, 1983). It has been reported that hearing loss negatively affects the vestibular and

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kinesthetic senses and accordingly, hearing-impaired children face many problems in terms of balance and motor skills compared to their hearing peers (Goodman & Hopper, 1992; Rajendran & Roy, 2011). In addition to sensorineural hearing loss, these problems are even more severe in children with vestibular disorders due to damage to the vestibular structures in the inner ear (Engel-Yeger & Weissman, 2009; Rine et al., 1999; 2000; 2004).

Balance and postural control are the foundation of all movement. Similarly, basic motor skills are necessary for children's interaction with the world and all kinds of movements, as well as mental skills, attention span, and social skills (Gallahue et al., 2012). For this reason, it is important to determine the current status of hearing-impaired children in terms of motor skills compared to their hearing peers and the areas where they lag behind in order to provide guidance for the preparation of appropriate intervention and educational programs.

Examining the literature on disabilities it is seen that studies on motor skills and sports have an important place. Regarding the motor skills of hearing-impaired people, there are studies on the comparison of hearing-impaired people with hearing people, on monitoring the motor development of hearing-impaired people, the effects of factors such as cochlear implants, and the degree and cause of hearing loss on motor development and the implementation of exercise and sports programs for the development of motor skills. In Turkey, the number of studies on disabilities, including those on motor skills and sports, has increased especially after the year 2000 (Ciğerci, 2011; Gültekin, 2012; Kalan, 2007).

There are review studies in the literature on the motor performance of the hearing-impaired (Goodman & Hopper, 1992; Rajendran & Roy, 2011). These studies present the results of studies conducted in different countries until the start of the year 2000. The aim of this study is to provide information about the current motor skills of hearing-impaired children and their differences from hearing children in the light of the studies conducted in the last 20 years in the literature, including the studies conducted in Turkey, and to draw attention to the importance of physical education and sports in terms of motor skill development in hearing-impaired children. Thus, in addition to providing an up-to-date and comprehensive national and international literature review on the basic motor skills of hearing-impaired children, the study will contribute to all relevant persons and institutions, especially physical education teachers, administrators, program developers, and those working in the field of rehabilitation, who are responsible for the education of hearing-impaired children, in terms of understanding the current situation and needs of hearing-impaired children regarding their motor skill performances and providing information that they will take as a basis for preparing appropriate programs for them.

2. Method

In this study, based on the studies conducted from the start of the year 2000 up to May 2023, it is aimed to reveal the current situation of hearing-impaired people in terms of their motor skills and their differences from hearing people. For this purpose, this study is a systematic review study carried out in accordance with the qualitative approach. A systematic review is defines as the process of gathering and synthesizing data from the studies suitable for the purpose of the research within the framework of predetermined inclusion and exclusion criteria (Yılmaz, 2021).

In order to collect data for this study, the Google Scholar, Ulakbim/TR Index, and the Council of Higher Education (YÖK) Thesis Search Center databases were searched in Turkish and English using various combinations of the keywords "hearing impairment/loss", "deaf", "motor skills/performance", "balance" and "postural control". In addition, the reference lists of the selected articles were examined to identify further appropriate publications. In the screening results, the language of the studies (Turkish or English), access to the abstract or full text, being conducted with humans, having children and adolescents as the sample group, not including intervention, and being published after the year 2000 were taken as the inclusion criteria. As a result, 25 studies that met the specified criteria were found.

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3. Findings

As a result of the literature review, 25 studies that fit the specified criteria have been identified. Information about these studies is summarized in Table 1 below. Among these studies, there are 11 studies on balance skills, 9 studies on both motor and balance skills, 2 studies on physical fitness and balance, 1 study on fine motor skills (Kamel et al., 2021), 1 study on walking (Melo, 2017), and 1 study on motor skills (Gkouvatzi, 2010).

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Table 1. Studies on Motor Skills and Balance in the Hearing Impaired since the Year 2000

Author (Year)	Aim	Sample	Method	Conclusion
		MOTOR SKILLS		
Kamel et al. (2021)	To examine the effect of sensorineural hearing loss on fine motor skills	200 children and adolescents with sensorineural hearing loss aged between 7-18 years old. They were compared with the values of 200 hearing children equivalent in terms of age and gender	Bruininks-Oseretsky Motor Skills Test .	In terms of fine motor precision and fine motor integration, children with hearing loss performed significantly lower than the hearing children. Sensorineural hearing loss affects fine motor skills.
Shavel et al. (2021).	To determine the physical characteristics of hearing-impaired children and to develop a physical education program to correct these characteristics.	72 deaf children and 28 hearing children aged between 6-10 years old.	Summative and formative pedagogical experimentation, medical and biological methods (blood pressure, electrocardiography, echocardiography, pulse measurement, physical work capacity test, measurement of catecholamines according to the Matlina method (1972), anthropometry and statistical methods).	Deaf children are weaker than hearing children in terms of physical performance and postural control. Their lung capacity and respiratory system functions are low Adrenaline and noradrenaline secretion is 2-3 times lower than hearing peers. This leads to impaired movement coordination and poor physical performance.
Stepanchenko et al. (2020).	To determine the psychomotor disorders of hearing-impaired children and the level of motor learning compared to hearing children.	94 children with hearing loss (51 hard-of-hearing and 43 deaf) and 54 hearing children aged between 7-8 years old.	A total of 10 tests based on Bernstein's theory of movement formation. The tests are as follows: static motor coordination (1 test), dynamic motor coordination (3 tests), performance speed (2 tests), motor memory and movement coordination (2 tests), and purposeful movement (2 tests).	Significant developmental delay was found in deaf and hard-of-hearing children in terms of all measured characteristics. It was concluded that hearing impairment may lead to problems manifested by motor learning and developmental delays.
Melo (2017)	To compare the gait performance of sensorineural hearing-impaired and hearing children and adolescents	48 deaf and 48 hearing children and adolescents aged between 7-18 years old.	Dynamic Gait Index (Castro et al., 2006)	The hearing impaired performed very poorly in terms of gait compared to the hearing. Performance decreased as the degree of hearing loss increased.
Gültekin	To compare the	30 hearing impaired	Body mass index,	Hearing impaired people

(2012).	physical fitness levels of hearing impaired and hearing children.	(17 girls -13 boys) and 27 hearing students aged between 9-15 years old	body fat percentage, body density, sit-stand flexibility, standing long jump, grip strength, flamingo balance, active jump, squat jump and reaction time tests	showed lower performance than their hearing peers in balance, strength, power and reaction time determination tests.
Ciğerci et al. (2011)	To compare hearing impaired and hearing children in terms of some physiological and motoric characteristics	11 volleyball players and 27 hearing sedentary and 9 hearing-impaired volleyball players and 20 hearing-impaired sedentary students between the ages of 9 and 15 years old who regularly play sports at school or in club teams	Eurofit test battery Illinois agility test Height and body weight	Hearing impairment negatively affects some motoric characteristics such as standing long jump, reaction time, balance paw strength, agility, and anaerobic power.
Livingstone and McPhillips (2011)	To determine motor skill disorders in hearing impaired children.	25 deaf children aged between 6-12 years old, 26 hearing children of the same IQ level and 27 hearing children of the same age.	Movement Assessment Battery for Children (MABC) The Wechsler Nonverbal Scale of Ability The Brown Attention-Deficit Disorder Scale The NeuroCom Balance Master system	Hearing impaired children showed significant motor impairments. These impairments were particularly pronounced in tasks related to balance. In activities requiring the use of multiple sensory systems, deaf children with cochlear implants are at greater risk of motor delay.
Gkouvatzi et al. (2010).	Comparison of motor performance of the hearing impaired in relation to reaction time, visual-motor control and upper limb coordination.	7 deaf and 17 hard-of-hearing children aged between 6-14 years old. Comparisons were made by gender and age (7-8, 9-10, 11-12, 13-14).	Bruininks-Oseretsky Motor Skill Test	No significant difference was found between the deaf and the hard-of-hearing. There was an improvement in motor skills according to age. No difference was found in terms of gender.

Engel-Yeger and Weissman (2009)	To compare hearing-impaired and hearing children in terms of motor skills and self-efficacy perception.	22 deaf and 26 hearing children aged between 5-9 years old	Children Activity Scales for Teachers Movement Assessment Battery for Children	Hearing impaired children performed lower than hearing children in terms of motor skills, but statistically significant differences were found only in dynamic and static balance skills. No statistically significant differences were found in gross motor skills (ball skills) or manual skills. There were also no statistically significant differences among children with cochlear implants or hearing aids.
Gheysen et al. (2008)	Comparison of the motor development of deaf (with and without cochlear implant) and hearing children	36 deaf (20 with implants) and 43 hearing children aged between 4-12 years old	Motor skills: Movement Assessment Battery for Children Gross motor coordination: Körperkoordinationstest für Kinder Balance: standing on one leg	Deaf children were found to lag behind in terms of motor and balance skills compared to hearing children. There was no difference between the balance skills of deaf children with and without cochlear implants. In the backward walking test, deaf children without implants performed better than those with implants.
Kalan. (2007)	To compare hearing-impaired and hearing children in terms of motor development and physical fitness.	Children with profound hearing loss (15) and hearing children (15) aged between 7-14 years old	Posturography assessment: Neurocom Smart Balance Master posturography device For physical fitness: static balance, ball throwing, 20m run, sit-ups and sit-stand tests Motor function assessment: GMFM test battery	Deaf children showed gross motor developmental delay and had lower posture scores. Hearing impaired children showed lower performance in static balance, ball throwing, 20m run and sit-ups tests compared to hearing children.
Horn et al. (2006)	Determining fine and gross motor skills in children with prelingual hearing loss	22 children and infants under 5 years of age with prelingual hearing loss.	Vineland Adaptive Behavioral Scales (VABS).	In contrast to gross motor skills, children with prelingual hearing loss show a decline in fine motor skills as they get older, even after cochlear implantation.

Zwierzchowska et al. (2004).	To determine the physical fitness levels and coordination skills of deaf children	Deaf children aged between 6-18 years old	Eurofit (1989) Test battery	The effect of hearing loss on coordination was significant in all age groups. The effect of the cause of deafness (lesion) on coordination skills was significant. No difference was found according to gender. Hearing loss has a significant effect on coordination skill level. Hearing loss may lead to motor coordination impairment.
		BALANCE		
Ebrahimi et al. (2017).	To compare hearing impaired children with hearing children in terms of postural control.	30 children with sensorineural hearing loss and 37 hearing children aged between 7-12 years old.	Bruininks-Oseretsky Motor Skills Test	Deaf children had lower postural control than hearing children.
Melo et al. (2017)	To compare children with sensorineural hearing loss with their hearing peers in terms of static and dynamic performance.	48 students with sensorineural hearing loss and 48 hearing students aged between 7-18 years old	Romberg, Romberg-Barré and Fournier tests for static equilibrium Unterberger test for dynamic balance	Static and dynamic balance changes were observed more in children with hearing loss compared to hearing children. It has been stated that this change may be related to the inadequacy of sensory organization with the effect of the vestibular system.
Akyüz et al. (2016)	To examine the balance abilities of children with congenital or acquired hearing impairment.	13 hearing-impaired children aged between 14-18 years old	Measurements were made with the Technobody PK 252 Prokin device, standing on both feet, with eyes open and shut.	Hearing impairment negatively affects the balance and movement system. In both groups, open-eye balance performance was significantly better than closed-eye balance performance.
Ebrahimi et al. (2016)	To determine the balance performance of deaf children with or without cochlear implants	145 children aged between 7-12 years old (85 with congenital or acquired bilateral profound sensorineural hearing loss; 60 hearing) In the hearing loss group; 50 without	Bruininks-Oseretsky Motor Skills Test	The total motor and balance skill scores of the group with hearing loss, especially the implanted group, were significantly lower than the hearing group. The non-implant group scored significantly higher than the implant group except for one

		cochlear implant, 35 with unilateral cochlear implant		skill (standing blindfolded on the selected foot on the balance board). Children with hearing loss, especially those with cochlear implants, are at risk of motor and balance impairment.
Ayanniyi et al. (2014)	Comparison of hearing impaired and hearing children in terms of static and dynamic balance performances	80 hearing-impaired and 80 hearing students aged between 8-17 years old	Standing on one leg test Functional reach test	The hearing impaired showed significantly lower static balance performance than the hearing. There was no difference between the groups in terms of dynamic balance performance.
Melo et al. (2015)	To evaluate hearing impaired and hearing peers in terms of postural control and to determine the effect of gender, age and degree of hearing loss on postural control.	48 students with sensorineural hearing loss and 48 hearing students aged between 7-18 years old	Balance Error Scoring System (Riemann et al., 1999)	Children with hearing loss showed significantly lower performance in terms of postural control. As the degree of hearing loss increases, postural control performance weakens.
Melo et al. (2012)	To compare hearing impaired and hearing children in terms of balance and walking performance.	44 students with sensorineural hearing loss and 44 hearing students aged between 7-17 years old	Tinetti Balance and Mobility test (Tinetti, 1986) Timed Up and Go Test (Podsiadl et al., 1991)	Hearing impaired students scored lower than hearing students, but the difference between the groups was not statistically significant.
Tan et al. (2011).	To compare the balance control of hearing impaired and hearing children.	A deaf and a hearing child, both 7 years old	Balance tasks	The balance performance of the hearing-impaired child was weaker than that of the hearing child.
de Sousa et al. (2012).	To describe postural control behavior in children with advanced sensorineural hearing loss	43 deaf and 57 hearing children aged between 7-10 years old	Force platform (AccuSway Plus)	Hearing impaired children showed lower performance in terms of postural control/balance than their hearing peers. No difference was found according to gender. Hearing impaired children may have a special sensory organization disorder, therefore early diagnosis and intervention is important.
Cushing et al. (2008)	Evaluation of static and dynamic balance skills of hearing-	Sensorineural hearing impaired and 14 hearing	Bruininks-Oseretsky Motor Skills Test 2	Static and dynamic balance performance of children with cochlear

	impaired children with and without cochlear implants	children aged between 4-17 years old		implants is lower than their hearing peers Having an implant gives children an advantage in balance tests.
Wong et al. (2013)	To determine the balance performance of hearing-impaired children.	28 children aged between 6-11 years old (6 unilateral, 22 bilateral hearing loss)	Bruininks–Oseretsky Motor Skills Test Pediatric Functional Reach Test (FRT) Pediatric Version of Clinical Test for Sensory Interaction of Balance (P-CTSIB) Test of Postrotary Nystagmus (PRN)	The balance performance of hearing-impaired children is significantly lower.
Zwierzchowska (2008)	To investigate whether hearing impairment has an effect on motor development in children and adolescents	190 deaf children between the ages of 10 and 15 years old	Eurofit test battery	There was a correlation between coordination skills and the degree and cause of hearing loss.
Suarez et al. (2007)	To determine postural control skills in children with advanced hearing loss and cochlear implants.	36 children with sensorineural hearing loss (13 children with unilateral cochlear implants) and 22 hearing children aged between 8-11 years old	Postural control test	There was no difference between children with normal vestibular response and hearing children. Postural control performance of children with low vestibular response was lower than that of hearing children with normal vestibular response.
Yağcı et al. (2004)	To compare hearing impaired and hearing children in terms of balance skills and to determine the effects of hearing impairment on balance skills	181 deaf and 79 hearing children aged between 10-13 years old	Lowett's manual muscle testing method for lower extremity, abdominal and back muscle strength. Static and dynamic balance abilities were measured on moving and immobile surfaces (Flamingo Balance Test).	Deaf children have lower dynamic and static balance abilities and muscle strength than hearing children. Children with congenital hearing impairment had the lowest performance.

As can be seen from the table, the studies analyzed focused mostly on balance among motor skills in hearing-impaired people. Balance is defined as the adaptation to the composition of the body against gravity during rest or movement (Gökmen et al., 1995). The ability to maintain a static posture (sitting, standing) is defined as static balance and the ability to maintain a dynamic posture (walking) is defined as dynamic balance (Gallahue et al., 2012). Both static and dynamic balance are important for and necessary to perform movement. In the studies,

overall, static balance assessment included one-leg-standing, balance beam standing and heal-too-toe standing, while abilities like jumping over rope, balance beam walking, squatting, kicking and hopping were assessed for dynamic balance.

In the table, there are 11 studies comparing hearing-impaired children and adolescents with their hearing peers in terms of balance performance. In these studies, comparisons were made in terms of postural control, dynamic balance, and static balance. In general, the common result obtained in studies comparing the motor skills of hearing-impaired and hearing children and adolescents is that the balance skills of hearing-impaired children and adolescents are significantly weaker than hearing children and adolescents (Gheysen et al., 2008; Ebrahimi et al., 2017; Wong et al., 2013).

Ebrahimi et al. (2017) compared children with sensorineural hearing loss aged between 7-12 years old with their hearing peers in terms of postural control and found that hearing children had better performance. Similarly, Melo et al. determined that children with hearing loss performed significantly lower than hearing children in terms of dynamic and static balance skills (2014) and postural control (2017) in their study with children with sensorineural hearing loss aged between 7-18 years old.

Similar results were found in studies conducted in Turkey regarding balance skills. Yağcı et al. (2004), who applied static and dynamic balance tests to 181 children with congenital and acquired hearing impairment and 79 hearing children, found that hearing-impaired children showed lower performance than hearing children in terms of both dynamic and static balance skills and muscle strength, and the lowest performance belonged to children with congenital hearing impairment. They concluded that hearing impairment has a negative effect on balance and movement abilities. Similarly, Akyüz et al. (2016) examined the static balance levels of 13 hearing-impaired children aged between 14-18 years old and reported that hearing impairment negatively affected the balance and movement system. As a result of the measurements carried out with children with congenital and acquired hearing impairment that involved standing on both feet with their eyes open and closed, it was determined that the balance performance involving open eyes was better than the balance performance involving closed eyes in both groups. From this, they concluded that the presence of visual data positively affects the balance performance in hearing-impaired people, and the removal of visual stimuli from the environment leads to a decline in balance performance (Akyüz et al., 2016; Lindsey & O'Neal, 1976).

A different finding related to balance performance was reported by Ayanniyi et al. (2014). In their study with hearing-impaired and hearing children aged between 8-17 years old, the researchers reported that there was a significant difference in favor of hearing children in terms of static balance performance, but there was no difference in terms of dynamic balance performance.

As can be seen from the studies above, hearing-impaired children showed significantly lower performance in terms of balance than hearing children. In all of the studies analyzed in terms of static balance skills and in all of the studies except one study (Ayanniyi et al., 2014) in terms of dynamic balance skills, hearing-impaired children showed lower performance compared to hearing children.

Balance is a skill that affects movement entirely. Therefore, impairments in balance in the hearing impaired may negatively affect other motor skills. Although most of the studies in the literature on hearing-impaired people have focused on balance, there are also studies on gross motor skills, fine motor skills, and physical fitness parameters. However, the results of these studies are not as clear as those related to balance. In other words, different results are reported in the studies regarding the motor performance of the hearing impaired. In general, although there are many studies indicating that hearing-impaired people are at a lower level than hearing people in terms of motor skills (Ciğerci, 2011; Gheysen et al., 2008; Gültekin, 2012; Horn et al., 2006; Kalan, 2007; Kamel et al, 2021; Livingstone & McPhillips, 2011; Melo, 2007; Melo et al., 2012; Stepanchenko et al., 2020), there are other studies indicating that there is no significant difference in terms of some motor skills (Engel-Yeger & Weissman, 2009) or that they perform similarly (Horn et al., 2005; Kuntz et al., 2003).

In terms of gross motor skills, Kalan (2007) reported that hearing-impaired children were behind hearing children. In a study conducted with children with severe hearing loss (15) and hearing children (15) aged between 7-14 years old, the researcher found that hearing-impaired children showed a delay in gross motor development and had lower posture, static balance, ball throwing, 20m running, and sit-up test scores than hearing children. Similarly, Gheysen et al. (2008) conducted a study with deaf and hearing children aged between 4-12 years old and found that deaf children were significantly behind in terms of motor skills and balance compared to hearing children. Melo (2007) and Melo et al. (2012), who investigated the gait performance of the hearing impaired, determined that the hearing impaired showed significantly lower performance than the hearing children in their studies with children aged between 7-18 years old with sensorineural hearing loss. It was also reported that the hearing impaired were at risk of falling due to gait disturbance (Melo et al., 2012).

Studies conducted with children with hearing loss in terms of fine motor skills report that they mostly lag behind their hearing peers (Horn et al., 2006; Kamel et al., 2021). Kamel et al. (2021) compared the performance values of 200 children and adolescents with sensorineural hearing loss between the ages of 7-18years old with the results of their hearing peers in a study conducted to examine the effect of hearing loss on fine motor skills.

At the end of the study, they found that children with hearing loss performed significantly lower than hearing children in terms of fine motor precision and fine motor integration. They concluded that sensorineural hearing loss affects fine motor skills. Similarly, Horn et al. (2006), in a study conducted with children and infants under 5 years of age to determine fine and gross motor skills in children with prelingual hearing loss, found that, unlike gross motor skills, children with prelingual hearing loss showed a decline in fine motor skills with increasing age, even after cochlear implantation.

On the other hand, there are other studies reporting that there is no significant difference between hearing and hearing-impaired children in terms of motor skills or that they are similar. Engel-Yeger and Weissman (2009) conducted a study with 22 hearing-impaired and 26 hearing children aged between 5-9 years old and found that although hearing-impaired children performed lower than hearing children in terms of gross motor skills (ball skills) and manual skills, the difference was not statistically significant. In addition, they reported that there was no statistically significant difference between the motor skills of children with cochlear implants or hearing aids. In support of this result, Kutz et al. (2003) and Horn et al. (2005) also reported similar results with hearing children at the end of their studies examining the fine and gross motor skills of children and infants under 5 years of age.

Although there are few studies on the physical fitness characteristics of hearing-impaired children, these studies provide evidence that they show a delay in physical development compared to their hearing peers. In studies comparing hearing-impaired children with hearing children in terms of physical characteristics such as height, body weight, body fat percentage, muscle strength, endurance, and posture, it is reported that hearing-impaired children generally have lower scores and show a delay in physical development (Gheysen et al., 2008; Gültekin, 2012; Shavel et al., 2021; Zwierzchowska, 2008). In a study conducted by Zwierzchowska et al. (2004) with deaf children aged between 6-18 years old, they found that there was a correlation between coordination skills and the degree and cause of hearing loss. Four years later, in another study conducted to determine the physical fitness levels of 190 deaf children aged between 10-15 years old, especially the effect of hearing loss on coordination skills, they found that the effect of hearing loss on coordination was significant in all age groups (Zwierzchowska et al., 2008).

Studies supporting these results were reported by Gültekin (2012) and Ciğerci et al. (2011). Gültekin (2012) compared the physical fitness parameters of hearing-impaired and hearing children aged between 9-15 years old and reported that hearing-impaired children showed lower performance in balance, strength, power, and reaction time determination tests compared to their hearing peers. Ciğerci et al. (2011) compared hearing and hearing-impaired athletes and sedentaries in the same age group and found that hearing impairment had negative effects on balance, paw strength, reaction time, anaerobic power, standing long jump, and agility.

Similarly, Shavel et al. (2021) reported that in addition to a delay in physical development and related postural disorders in hearing-impaired primary school children, height, body weight, and chest circumference measurements were lower than their hearing peers. In addition, hearing-impaired children were found to be significantly weaker than hearing children in terms of physical performance.

As can be seen, although different results are reported in terms of gross motor skills in studies comparing hearing-impaired children and adolescents with their hearing peers, mostly hearing loos is reported to effect motor skills and physical performance.

In addition to the studies comparing hearing and hearing impaired children in the table, there are also other studies comparing the motor characteristics of deaf and hard-of-hearing children. Gkouvatzi et al. (2010) compared some motor skills of 34 deaf and hard-of-hearing children aged between 6-14 years old and found that the deaf were better at upper limb speed and dexterity than the hard-of-hearing but the difference between the groups were not statistically significant. This result was attributed to the use of sign language by the deaf. It was reported that the school attended by the hard-of-hearing students who participated in the study used verbal language in communication, not sign language. In the study, it was also noted that speed/quickness improved with increasing age. It was also reported by Melo (2017), who evaluated gait performance in the hearing impaired, that the performance decreased as the degree of hearing loss increased.

In summary, the studies presented so far have shown that hearing-impaired people are generally inferior to hearing people in terms of balance and some motor skills.

4. Discussion and Conclusion

In this study, it was aimed to determine the current situation of hearing-impaired children and adolescents in terms of motor skills based on the studies on motor skills of hearing-impaired children and adolescents after the year 2000 and to provide information to the relevant people and institutions, especially teachers and those working in the field of rehabilitation, about the differences and developments of hearing-impaired children and adolescents. The important findings of the literature review are listed and discussed in this section.

The common conclusion arrived in the studies reviewed is that hearing-impaired children and adolescents lag behind their hearing peers in terms of balance skills. In the studies, damage to the vestibular system is mostly mentioned as the main cause of lower performance in balance in the hearing impaired (Crowe & Horak, 1988;

Inoue et al., 2013; De Kegel, 2012). Studies show that 30-70% of hearing-impaired children have vestibular end organ disorders (Cushing et al., 2008), and the incidence of vestibular test abnormalities is higher in the individuals with advanced sensorineural hearing loss, and acquired deafness (meningitis) (Köroğlu & Horasanlı, 2022). There is even information that cochlear implant carries an additional risk of vestibular damage (0.33-75%) (Bayat et al., 2020; Buchman, 2004; Ibrahim, 2017; Katsiari et al., 2013; Rah et al., 2016).

Another cause of lower balance performance in the hearing impaired as indicated in the studies is related to the absence of sound input. Hearing individuals use auditory cues for postural control (Vitkovic et al., 2016). Hearing-impaired individuals also develop appropriate postural control strategies due to the need to compensate for their natural lack of balance due to the absence of sound input or to turn towards sound due to the difficulty in hearing (Thomas et al., 2018). This is seen as a reason for the prevalence of postural control disorders in the hearing impaired.

In terms of physical performance, deaf children were found to be significantly weaker than hearing children. This weakness of the hearing impaired may be related to delay in the development of the respiratory system, lungs and sympathoadrenal systems (Shavel et al., 2021; Zebrowska & Zwierzchowska, 2006). As a matter of fact, researchers report that due to the underdevelopment of the vocal system of hearing-impaired children, the delay in development in the lungs and respiratory systems and the secretion of adrenaline and nor-adrenaline are 2-3 times lower than their hearing peers, which leads to the weakness in their physical performance (Shavel et al., 2021).

With regard to other motor skills, although it is generally reported that the hearing impaired perform lower than the hearing, there are also studies that report different results. These differences between the results of the studies, especially regarding the gross motor skills of the hearing impaired, may be due to the differences in the type of the scale used, the characteristics of the children in the sample, and the tasks applied. For example, Horn et al. (2005) and Kutz et al. (2003) both used the Vineland Adaptive Behavioral Scale, which is a standardized scale that measures according to the opinions of parents/caregivers. This scale is an instrument that requires interviewing children's families about children's daily routines, communication, social and motor skills. Therefore, as Horn et al. (2006) pointed out in their later study, this instrument may not provide fully objective measurements, and performance on motor tasks may be evaluated without making a distinction between gross/fine or simple/complex. Therefore, it is possible to obtain different results from more objective instruments. In addition, the age of the children participating in the study and the simplicity or complexity of the performance tasks may also be considered among the reasons for the differences between the results of the studies. Researchers have shown that age has an effect on motor skills, and even after cochlear implantation, there are developmental delays especially in fine motor skills (Schlumberger et al., 2004; Horn et al., 2006). In a study conducted with children between 5-9 years old, Schlumberger et al. (2004) reported that there was a developmental delay with increasing age, especially in complex tasks. Therefore, the differences between the ages of the samples and the scales used may have contributed to the differences between the results of the studies, especially in gross motor skills.

Although different results have been reported in the studies, in general, it is clear that hearing-impaired children need improvement in terms of motor skills. Studies have shown that delays in motor development in hearing-impaired children can be prevented and the difference between these children and their hearing peers in terms of motor skills can be minimized with physical education classes and exercise programs structured in accordance with the needs of the child (Elieyüboğlu, 2014; Eliöz et al., 2013; Hatipoğlu, 2005; Rajendran et al., 2013; Şirinkan, 2011; Yıldız & Gürsel, 2008). Such effect of physical education is mostly explained as leading hearing impaired/deaf children learn to compensate the vestibular deficit, adapt to it by using the information from other senses, which will result in improved balance and physical performance (Butterfield, 1991; Curthoys, 2000; Potter & Silverman, 1984; Rajendran et al., 2013). This also explains why vestibular response is normal in some hearing-impaired children while it is absent or very low in others as Potter & Silvermen (1984) indicate. Therefore, adding specific trainings to the physical education courses may help improve motor development and the quality of life of the hearing impaired. Langdale (1984) suggests practicing basic body movements to improve balance. It is stated that dance is an ideal activity for the hearing impaired due to its emphasis on static and dynamic balance (Hottendorf, 1989; Reber & Sherrill, 1981; Widyoseptiani & Sumanto, 2021). Especially teaching dancing to preschool children with simple and repetitive figures contributes to the development of gross motor and especially balance skills (Widyoseptiani & Sumanto, 2021). In addition, Asian exercise systems such as karate, kung fu, and tai chi, which require balance, are also recommended as they contribute to the child's awareness of his/her own body (Kasum et al., 2011).

At this point, it is clear that physical education classes carried out in accordance with the needs of the hearing impaired children with providing rich opportunities for the development of motor performance are important for the development of motor skills of these children. Although basic movements are thought to develop automatically when the child is ready, the influence of the environment on the development cannot be ignored (Gallahue et al., 2012). In addition to the child's maturation, the support from the environment, motivation,

opportunities, and, most importantly, structured physical education programs implemented consistently and regularly are necessary to ensure mastery of basic skills (Gallahue et al., 2012).

The effect of early intervention on balance disorders in hearing-impaired children is also important (Ebrahimi et al., 2017; Siegel et al., 1991). Newborn hearing screenings enable early diagnosis and treatment of hearing loss in infants (Genç et al., 2005). Early diagnosis of childhood hearing loss is vital for normal speech, language, cognitive and social development (Genç et al., 2005; Siegel et al., 1991). However, when these routine screenings do not include an assessment of balance and motor impairments, physical therapy interventions are not included in educational programs unless a significant neurological or orthopedic disorder is diagnosed. This means that the deaf child's developmental delay persists and the chance for early intervention is prevented.

As a matter of fact, it is stated that the relationship between development and disability status in early childhood has important effects on the development and later life of the individual (WHO, 2023). Therefore, physical education teachers can implement appropriate sports and exercise programs at and outside of the school, with the support of physiotherapists, if necessary, in preparing age-appropriate programs for children.

As a result, based on the studies reviewed it was determined that hearing-impaired children and adolescents lagged behind their hearing peers in terms of balance skills and performed significantly worse in terms of physical performance, and other motor skills, although there were other studies indicating that they were at the similar level. Regular participation in structured physical education and sports programs prepared according to these children's needs will significantly contribute to their physical and motor development.

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