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Balance assessment in hearing-impaired children

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ABSTRACT

According to the scientific reports the postural stability is inseparably associated with hearing organ's correct functioning. The aim of the study was to evaluate the degree of disorders occurring in balance reactions in this group of children with profound hearing loss compared to their healthy peers. The study worked with a total of 228 children, including 65 who are deaf (DCH) and 163 subjects without any hearing deficits (CON) in the control group. Stabilometric measurements were performed with the use of a force distribution platform. The results indicate statistically significant differences in terms of one parameter (the total path length) recorded in the test with the eyes open and a whole range of parameters recorded when the subjects had their eyes closed (the width, height, and area of the ellipse, the total path length, and the horizontal and vertical sway). The study results showed better values of the static balance parameters in deaf children as compared to their peers without hearing disorders and the differences were particularly evident in the test with the subject's eyes closed. The results suggest significantly better processing of sensory stimuli in postural reactions particularly from propioception, and to a lesser extent, from the vision system observed in the subjects as compared to their peers in the control group.

1. Introduction

The development of normal postural reactions that oppose the force of gravity and maintain the body's balance during exercise and rest is possible due to stimulation of the labyrinth and the labyrinth's cooperation with proprioception, vision, touch, and hearing (Nakajima, Kaga, Takekoshi, & Sakuraba, 2012). Vestibular receptors receive impulses related to the position of the head in space and generate reflexes that play a key role in basic motor responses; for example maintaining head and body posture. Due to this complex process, we have, inter alia, a sense of control over the moving body and its orientation in space (Greenwald & Gurley, 2013). Hearing-related organs develop with and work in close cooperation with the vestibular system. The receptors of both systems are located in the inner ear, from which information is transmitted to

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the brainstem through cranial nerve VIII. The close neuro-anatomical relationship of these systems results in a situation in which damage to the cochlea, semicircular canals, or both, leads to vestibular dysfunction, which may be related to conditions such as balance impairment (Martin, Jelsma, & Rogers, 2012; Schwab & Kontorinis, 2011).

According to the available data, as many as 30 to 85% of children with severe or profound hearing loss have some degree of vestibular deficit (De Kegel et al., 2010; Del Pino, Femia, & Pérez-Fernándezc, 2011), which in turn interferes with the many areas of the children's development, including static and dynamic balance reactions, coordination, and the speed of performed movements (Chilosi et al., 2010).

In children, balance is inextricably linked to the mastering of basic motor skills (Fisher et al., 2005). Shah, Rao, Malawade, and Khatri (2013) reported that children with hearing impairments have balance and motor deficits that are primarily due to concomitant damage to the vestibular structures. In most hearing-impaired children, fundamental motor skills, such as the maintenance of head, sitting, and bipedal positions, develop much more slowly than in children with normal hearing (Rajendran and Finita, 2010). To master these skills, a properly developed body schema that is based on perception and experience is essential. Sensations from the skin, proprioceptive information from the muscles and joints, and motion- and gravity-related information from the vestibular system are organized, integrated, and ultimately applied during daily activities. Due to the well-organized perceptions of the body, an individual can feel the actions of any given part of the body, how those parts move, and where those parts are in space. However, when the supply of information from one of the sensory systems is limited, for example, due to the loss of hearing, the feeling of one's body within space may be affected, and result in a reduction of the maturity level of posture control (An, Yi, Jeon, & Park, 2009). Such reduced maturity levels can be particularly dangerous when the flow of information from another system, such as the visual system, is obstructed (e.g., when walking in the dark or riding a bicycle at dusk). Simultaneously, the poor postural control abilities of the deaf during childhood do not necessarily entail difficulties in the performance of everyday activities during adulthood (Kaga, 1999). Postural reactions may be well-developed in adolescence despite irregularities in the impulses received from the vestibular system due to the compensatory responses of the other systems. Therefore, it is important to examine the severities of the disorders of balance reactions that occur in hearing-impaired children and how such severities depend on the flow of information from other systems. Such evaluations may facilitate the decision to introduce measures to stimulate the relevant sensory systems as early as possible.

2. Objectives

The aim of this study was to evaluate the severities of the disorders of balance reactions that occur in a group of children with profound hearing loss relative to children with normal hearing.

3. Methods

3.1. Participants

The study examined a total of 228 children, including 65 subjects who were deaf (DCH) aged between 8 and 17, and a control group of 163 subjects without any hearing deficits aged between 8 and 16 (CON) (Table 1). This study was conducted in four schools in Rzeszów and two schools for hearing-impaired children in the Subcarpathian region of Poland. The 25 (38.46%) of participants with hearing loss been hearing impaired since birth, and 40 (61.54%) had hearing disorders acquired later.

The general criterion for inclusion in this study was the lack of neurological and orthopedic disorders. Additional inclusion criteria were, for the study group, a degree of deafness $\leq$90 dB and, for the control group, a complete lack of hearing deficits.

Exclusion criteria included: an intellectual disability and comorbid illnesses.

This study was approved by the local Bioethical Committee and performed after obtaining written consent from the children's parents.

3.2. Procedure

First, the parents of the children completed a questionnaire. The following information was acquired via questionnaire filled by parents: date of birth, illness, and degree of deafness. In the second part of the study, stabilometric measurements

Table 1
Characteristics of the subjects.

	Hearing-impaired children	Children with normal hearing
Number of subjects	65	163
Sex		
Male	46	79
Female	19	84
Age [mean ± SD]	13.4 (2.4)	11.9 (2.2)