MORPHOFUNCTIONAL DEVELOPMENT OF CHILDREN AND ADOLESCENTS WITH DEAFNESS

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ABSTRACT
Previous studies indicated that physical fitness of deaf children and adolescents is lower compared to their hearing peers. It has been suggested that their emotional and motor development may depend on the place of residence (family home or dormitory). The aim of the study was to analyzed the relationships between morphofunctional development and psychosocial determinants in children and adolescents with deafness.
METHODS: The 54 deaf children and adolescents with severe deafness between 10-16 years of age (age 13.3±2.4 yr.) participated in the study. All of them were students of residential schools for children with deafness and were divided into two groups according to their place of residence, deaf home group (n=26) and deaf dormitory group (n=28). All subjects participated in physical performance and motor skills tests.
RESULTS: The study did not reveal any significant differences in somatic growth between children with deafness and adolescents residing in dormitories versus those in family homes. There were significant differences for physical performance variables of the deaf home compared to deaf dormitory group.
CONCLUSIONS: Family homes turned out to be better stimulators of sensory and motor functions, which underlie the development of coordination abilities, as well as vital capacity of deaf children and adolescents.

INTRODUCTION

Deafness, apart from the consequences related to conceptual and emotional development, may result in motor, coordination, balance, and sensory-motor synchronization impairment. The physical fitness of children and adolescents with deafness may be lower compared to their hearing peers and may depend on the educational process. The potential mechanism of locomotor ability impairments in deaf children may include damage to inner ear structures, i.e., the semicircular canals and vestibule, which influence dynamic and static equilibrium, respectively (Goodman 1992, 214). However, it has been suggested that decreased motor abilities were also associated with environmental factors (Dummer 1996, 400). Hearing loss during infancy and early childhood interferes with the speech and language skills and these communication difficulties may have a negative impact on the social, emotional, cognitive, and motor development (Ellis 2000, 279). The study of Ellis et al. (Elis et al. 2007, 1799) demonstrated that the emotional support and commitment of parents had an essential effect on whether a deaf child was able to participate in different forms of physical activity. It has been indicated that the physical activity and fitness of students with deaf also depend on their educational system, e.g., residential (special needs education) or mainstream schools (Butterfield 1993, 8).

We hypothesized that the environment of upbringing (i.e., place of residence and education - home or school dormitory) would have an impact on the somatic, motor abilities, and physical effort of children and adolescents with deafness. To verify this, we examined the relationships between morphofunctional development, as measured by motor skills, physical performance, and psychosocial determinants in children and adolescents with deafness.

METHODS

A group of 54 deaf children and adolescents (24 girls and 30 boys), mean age 13.3±2.4 years, participated in the study (Tab. 1). All of them were students of residential

schools for children with deafness and were divided into two groups according to their place of residence, i.e., subjects living at home (deaf home group - DHG, n=26) and those staying in a dormitory (deaf dormitory group - DDG, n=28). The medical history and data concerning deafness etiology were analyzed using questionnaires. The children health records and information about potential abnormalities associated with hearing dysfunction and the results of psychological tests were analyzed. All participants were within normal intellectual range and had no locomotor dysfunction.
The inclusion criteria included identification of the specific cause underlying hearing loss and the type of hearing loss: sensorineural or vestibular. All subjects had hearing loss of above 80 dB. The group included 28.7% with acquired hearing loss (e.g., from meningitis before the age of 2), 19.8% with inherited hearing loss, and 51.5% with congenital hearing loss (resulting from rubella or toxoplasmosis). Following the diagnosis, all participants were provided with hearing aids. The exclusion criteria included unknown etiology of deafness. All parents gave their written consent. The experiment was approved by the Ethics Committee of the Academy of Physical Education in Katowice and conformed to the standards set by the Declaration of Helsinki.
Subjects from both groups were randomly assigned to motor skills testing or physical performance testing. They were instructed to abstain from physical exercises for 24 hours before the experiment. All investigated subjects underwent bioelectrical impedance analysis (In Body Data Management System) to determine their body mass - (BM), body mass index - (BMI), percentage of body fat (% FAT), and fat free mass - (% FFM) (Tab.1).

Table 1

Age, height and body mass of deaf children

	DHG		DDG	
	Girls n=11	Boys n=18	Girls n=11	Boys n=18
Age	13.1±2.6	13.2±2.4	13.5±2.3	13.3±2.5
BV [cm]	152.9±8.5	158.7±12.2	151.2±12.5	157.5±14,0
BM [kg]	54.5±3.5	50.4±9.3	48.9±14.3	48.0±12.9
BMI	23.4±1.3	19.5±1.2	20.7±3.6	19.1±2.0
FAT[%]	30.1±6.7	14.7±3.6	21.0±8.8	13.0±2.4
FFM[%]	38.1±5.4	42.6±9.5	36.4±6.3	40.9±11.5

The analysis of motor skills was performed through the assessment of the following tasks of the Eurofit test battery (Eurofit 1988): maintenance of static balance - (SB; proprioceptive system function), plate tapping (PLT; speed of limb movement), forward trunk bending in sitting position, i.e., sit-and-reach (SAR; flexibility test), standing broad jump (SBJ; explosive strength), hand grip (HGR; static strength), sit-ups (SUP; trunk strength), and bent arm hang (BAH; functional strength). Target jumping (kinesthetic differentiation; KD), marching to the goal (space orientation; SO), standing broad jump forwards and backwards (movement adjustment and movement combining; MA), and catching a falling stick (speed of reaction; SR) were also assessed.
The physical performance of children with deafness was investigated using the anaerobic (Wingate Test) and aerobic exercise test (Monark 829, Sweden) (Bar-Or 1987, 381). Vital capacity (VC) of all investigated children was measured with standard spirometry (PonyGraphic 3.7, Cosmed, Italy). The experimental procedures were explained to each child with deafness in sign language by their regular schoolteacher.
All statistical calculations were performed using STATISTICA v 7.1. The verification of compatibility with normal distribution was performed using the Shapiro-Wilk test. The numerical distribution and percentage distribution were calculated for discrete variables. In order to define the effect of the social environment on somatic characteristics, motor abilities and physical effort, standardization of the dependent variables was performed separately in two groups in relation to gender and age. On the basis of standardized values, the above variables were determined separately for both groups characterized by different

environments of upbringing (DHG and DDG groups). Analysis of variance (ANOVA) was complemented by post hoc analysis or the Student's t-test.

RESULTS

There was a tendency towards the lower values of the somatic profile among children and adolescents living in the dormitory (DDG) (profile reversal) compared to DHG. However, no statistically significant relationship was found between the somatic features and the environment of upbringing (DHG/DDG) (Tab. 2).

Table 2

Comparative analysis with the use of Students' t-test for separate components of somatic profile (mean standardization) and physiological parameters with respect to upbringing environment (family home: DHG, dormitory DDG)

Somatic & Physiological Parameters	DHG	DDG	T	P
Body height	0,06	-0,05	0,50	0,61
Body mass	0,21	-0,18	1,68	0,09
BMI	0,18	-0,16	1,47	0,14
FAT	0,06	-0,05	0,49	0,62
FFM	-0,06	0,05	-0,49	0,62
VC	0.28	-0.24	2.26	**0.02***
PWC_{170}	-0.17	0.14	-1.33	0.18
VO_2	-0.16	0.13	-1.22	0.22
MAP	-0.16	0.13	-1.21	0.22
$P\bar{x}$	-0.18	0.15	-1.42	0.15
ROF	0.05	-0.04	0.41	0.67
TPP	0.18	-0.15	1.43	0.15
TMP	-0.19	0.16	-1.52	0.13

**p<0,05 statistical significant (VC) - vital capacity, (PWC170) - maximal aerobic power, (VO2max) - maximal oxygen uptake, (MAP) - maximal anaerobic power, ($P\bar{x}$) - mean anaerobic power , (ROF) - rate of fatigue, (TPP) - time to peak power, (TMP) - time of maintaining maximal power. p<0,05 statistical significant*

The place of residence (family home/dormitory) was proposed as an environmental and upbringing factor that might affect the development of motor abilities. The study revealed statistically significant differences in coordination abilities (kinesthetic differentiation, motor adjustment, and reaction time) in favour of the DHG participants (Tab. 3).

Table 3

Comparative analysis by means of t-student test for individual components in the profile of motor abilities with respect to upbringing environment (family home: DHG, dormitory DDG)

Motor Ability	DHG	DDG	t	p
static strength (HGR)	0.08	-0.07	0.68	0.49
flexibility (SAR)	-0.06	0.05	-0.47	0.64
speed of limb movement (PLT)	0.055	-0.05	0.42	0.67
trunk strength (SUP)	-0.14	0.12	-1.06	0.29
functional strength (BAH),	-0.17	0.15	-1.40	0.16
explosive strength (SBJ)	-0.03	0.03	-0.24	0.81
static Balance (SB)	0.06	-0.05	0.53	0.59
kinesthetic differentiation (KD)	0.31	-0.28	2.61	**0.012***
space orientation (SO)	0.09	-0.08	0.76	0.45
movement adjustment and movement combining (MA)	0.46	-0.41	4.11	**0.001***
speed of reaction (SR)	0.38	-0.33	3.21	**0.002***

**p<0,05 statistical significant*

There were significant correlation between vital capacity (VC) and education and environment factors of upbringing (Tab. 2). The residents of dormitories exhibited lower vital capacity compared to deaf children residing in their family homes. The analysis of physical performance profiles revealed that the obtained (maximal oxygen uptake) VO_2max (ml/kg/min), physical work capacity PWC170, maximal and mean anaerobic power (MAP, $P\bar{x}$) were lower in children and adolescents from family homes compared to their peers living in a dormitory. However, the difference was not statistically significant.

Hearing loss in the early stages of child development causes voice disorders which refers to problems in communication and educational process. The investigations on the effect of environmental factors carried out by Ellis (2007, 1815) and Liberman (2004, 286) showed the significance of the educational environment for the development of deaf children. The authors emphasized the role of physical activity in the stimulation of somatic and motor development. However, the present study has not confirmed a statistically significant effect of educational environment on the somatic development of deaf children and adolescents. Thus, our results do not confirm the hypothesis of a strong although varied effect of environmental factors on the level of motor fitness abilities (Dummer 1996, 400).

Several deaf studies have emphasized the environmental contribution to motor development (Ellis 2001,139; Żebrowska 2006, 443). It was hypothesize that the lack of differences in motor abilities between children with deafness and their hearing peers were a result of early intervention and pre-school programs that might have eliminated the delays in development (Dummer 1996, 400; Libermman 2000, 20; Martens 1996, 106).The results of Liberman et al. (2000) are consistent with presented in our study and reveal a significant effect of the educational environment on the improvement of physical performance. Our comparative analysis of the values determining the motor profile revealed that motor adjustment, kinesthetic differentiation, and reaction time were statistically different in terms of the educational environment in favor of the children who lived in their family homes (Tab. 4). The data on maintenance of balance reveal a lack of any significant relationship with the environment. It can be hypothesized, however, that the environmental factor, i.e., the lack of auditory stimuli, might have a suppressive effect on the sense of balance (Martens 1996, 106; Arunowiċ 1996, 29; Selz 1996, 70; Rine 2000,1101; Effgen 1981, 873; Callier 1998, 7). The experimental studies that attempted to solve the problem of deteriorated balance in deaf children revealed a considerable effect of additional exercises on the development of overall balance (Fotiadou 2002, 301; Pelc 2005, 283; Ayres 1998). The results seem to confirm the hypothesis that suggests a suppressive effect of an external factor, i.e., the educational environment on endogenous factors (neurological determinants of deafness). The presented profile values of children and adolescents with deafness who live in dormitories were lower for all coordination abilities compared to their peers living with parents. Accounting for the phenomenon might be difficult; it might be an effect of abnormal function of several neural structures in the process of sensory integration. Children's brains function properly if they receive some input from three fundamental sources, i.e., vestibular, proprioceptive, and tactile combined with auditory, visual, and olfactory stimuli.

The relationships between children and other close relatives are based mainly on touch and evolve from tactile contact, visual contact, and conversations becomes established in the child's mind (Marschark 2000, 275). It might be postulated that long-term stay in the dormitory and limited contact with parents hampered the development of coordination skills in our deaf subjects from DHG. It is also likely that family homes, which promote children's sense of security, contribute to faster maturation of the central nervous system and optimization of sensory and motor functions (Ayres 1998). These conclusions seem to be supported with the studies carried out by Qinttner et al. (Qinttner 1994, 347) in the field of development of visual attention, in which the authors emphasized the importance of the educational environment, with particular focus on the positive effect of families. Attention and visual perception in deaf people, who experience richer experiences in communication from the very first years of their lives (sign language and verbal communication with hearing

parents who accept their 'different child'), might provide a better foundation for psychomotor development compared to children with 'poor' verbal communication and frequently incomplete acceptance in families. Our studies support the results of Qinttner et al. (1994) concerning the existence of compensatory properties, which develop under specific conditions of visual and kinesthetic perception. However, the results of studies by Schlunberger et al. (2004) are inconsistent with the data obtained in the present study who emphasizes the significance of auditory input and claims that an early cochlear implant helps develop spatial integration, motor control, and attention (Schlumberger 2004, 599).
A noticeable finding was a positive effect of the educational environment on vital capacity in children living in family homes. However, comparative analysis of the physical anaerobic and aerobic performance respect to the upbringing environment (family home: DHG, dormitory DDG) did not show any significant effects.

It should be emphasized that environmental factors are not easily measurable, which frequently puts research results in question. Additionally, human development is a combined effect of a number of different variables, which are sometimes very difficult to separate, define, and evaluate. It seems that empirical relationships between several parameters and the educational environment confirmed in our study deserve further research

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