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The Dynamics of Maximal Aerobic Efficiency in Children and Adolescents with Hearing and Visual Impairment

by
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An experimental group of 86 deaf and 102 blind children and adolescents, and a matched group of hearing controls participated in a progressive exercise test to evaluate maximal oxygen uptake ($VO_{2\ max}$) in order to determine their physical efficiency.
The objective of the study was to investigate whether a sensory impairment has an effect on a decrease of physical efficiency of deaf and blind children in relation to their non-handicapped counterparts. A significant influence of sensory impairment on maximal oxygen uptake ($VO_{2\ max}$) was observed in boys ($F=4.3$, $P<0.05$). As compared to healthy subjects, deaf and blind adolescents had a lower level of $VO_{2\ max}$.
Key words: *sensory impairment, physical exercise, aerobic performance*

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Introduction

Motor abilities and sport performance of children increase with age primarily because of the development of the neuromuscular system (3, 4). An increase in pulmonary function and cardiovascular variables can also be associated with an increase of aerobic performance (13, 19). These findings may depend on regular participation in endurance training and biochemical and cellular adaptations within the skeletal muscle, which contribute to significant increases in maximal oxygen consumption (9, 13). The power output under predominantly aerobic conditions increases with age during growth. This increase is also the consequence of several determinants including gender, genetic factors and type of lifestyle (3, 14). Previous studies have suggested that the lack of sensory input affects the process of sensory-motor development of deaf and blind children (5, 8, 12). The level of physical abilities of children with hearing loss is significantly lower then that of their hearing counterparts (18, 20). Impaired hearing influences the development of balance as a consequence of damaged vestibular apparatus and disturbed connections with higher nervous structures (1, 7). Decreased muscle strength of respiratory system and chest mobility may also modify lung function and result in poorer spirometric variables in deaf children and adolescents (15, 20). Low motor development, worse movement coordination, and hypotonicity have also been observed (18). Few reports have demonstrated that the absence of sensory input also affects motor development of blind children and may cause decreased muscle strength and physical performance compared to the healthy children (11, 12, 15). Delay in the development of postural reactions and in the achievement of various activities that require the ability to maintain good balance was seen in blind children (8, 12). Skeletal muscle hypotonicity has also been indicated in up to 30 % of blind children with no neuromuscular abnormalities (11).

The objective of the study was to investigate whether a sensory impairment (hearing or visual loss) has an effect on a decrease of aerobic physical efficiency of deaf and blind children in relation to their non-handicapped counterparts.

Material and methods

A group of 86 deaf (D) and 102 blind (B) children and adolescents, and a matched group of healthy subjects (control group) (C) participated in this study. All subjects were divided into 3 age groups: children (up to 12 years), junior adolescents (up to 15 years), and senior adolescents (up to 18 years). All of them were pupils of schools for deaf and blind children. The medical history and other information about deafness and blindness etiology were analyzed using questionnaires prior to these investigations. All deaf subjects were characterized by loss of hearing above 80 dB. The group included 46% of acquired hearing loss (e.g. from meningitis before the age of 2 years), 22% of inherited hearing loss, 16% of congenital (for example idiopathic) and 16% of unknown etiology.

Subjects with visual loss were blind from birth or became blind during the first 6 months after birth. The causes of blindness were retinopathy of prematurity and retinal abnormalities (80 %), and optic nerve anomalies (20 %). Age, height and body mass of the subjects are presented in table 1 and 2. All parents granted their written consent, and 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.

Table 1

Characteristics of investigated girls (mean ± SD)

Variable	**Group I**			**Group II**			**Group III**		
	Control n=16	Deaf n=16	Blind n=18	Control n=12	Deaf n=12	Blind n=14	Control n=16	Deaf n=14	Blind n=20
Body height [cm]	143±8	141±10	146±10	155±6	157±7	159±7	166±5	161±5	161±5
Body weight [kg]	33±7	42±13	38±9	48±7	50±11	51±7	60±10	56±7	54±7
BMI [kg/m²]	17±3	20±2	21±2	20±3	20±4	22±3	22±4	21±3	22±3

Table 2

Characteristics of investigated boys (mean ± SD)

Variable	**Group I**			**Group II**			**Group III**		
	Control n=16	Deaf n=16	Blind n=18	Control n=12	Deaf n=12	Blind n=14	Control n=16	Deaf n=14	Blind n=20
Body height [cm]	146±7	146±9	146±3	164±8	169±9	168±13	180±6	173±7	173±5
Body weight [kg]	39±8	39±9	37±6	54±13	57±16	55±14	68±10	63±13	61±12
BMI [kg/m²]	18±3	18±3	17±2	20±3	20±6	19±4	21±6	21±5	20±4

The experimental procedures were performed in the schools. The Astrand Ryhming (2) test was performed for determination of physical efficiency. The cycle ergometer test (Monark 826, Sweden), consisted of a submaximal exercise with continuous heart rate (HR) monitoring what allowed to calculate the maximal oxygen uptake ($VO_{2\,max}$).

The dynamics of maximal oxygen uptake were regularly monitored at yearly intervals from 2004 through 2006 and were compared with reference ranges and control group values.

Data are presented as means ± SD. The data from 3 groups of subjects were analyzed by two-way ANOVA with the use of Statistica 7.1 (StatSoft) software. Statistical significance was set at $P<0.05$.

Results

An age-dependent increase in $VO_{2\,max}$ expressed in liters per minute [l/min] was found in 3 age groups: I- children (up to 12 years), II-junior adolescents (up to 15 years), and III-senior adolescents (up to 18 years). Significant differences were observed in deaf and blind 12- and 15-year old girls vs. control at $p<0.05$ (Fig.1) and 18-year old boys ($p<0.01$) (Fig.2).

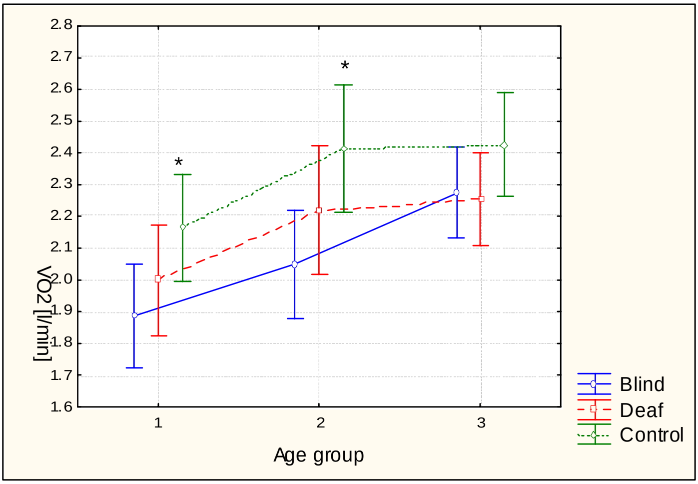

Fig. 1

Mean maximal oxygen uptake ($VO_{2\,max}$ [l/min]) in 3 age groups: I-girls (up to 12 years), II-junior adolescents (up to 15 years), and III-senior adolescents (up to 18 years)

** Significant differences deaf and blind vs. control atp p<0.05*

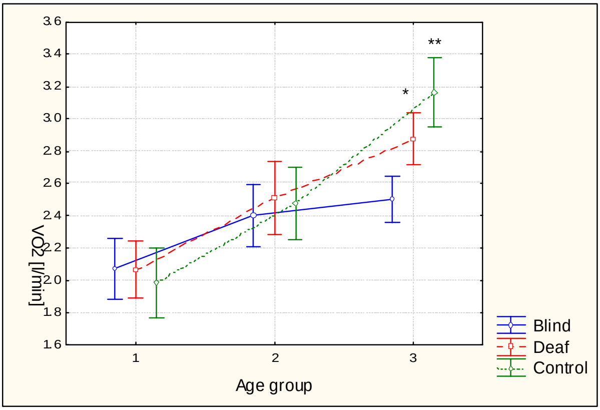

Fig. 2

Mean maximal oxygen uptake ($VO_{2\,max}$ [l/min]) in 3 age groups: I-boys (up to 12 years), II-junior adolescents (up to 15 years), and III-senior adolescents (up to 18 years).

** Significant differences in deaf and blind vs. control at P<0.05*

*** Significant differences in deaf and blind vs. control at P<0.01*

ANOVA revealed a significant influence of sensory impairment on maximal oxygen uptake ($VO_{2\,max}$) in boys ($F=4.3$, $p<0.05$). The mean $VO_{2\,max}$ [ml/kg/min] was significantly lower in deaf and blind junior adolescent boys as compared to non-handicapped subjects (Fig.4). A similar tendency was found in deaf and blind girls but did not reach the level of statistical significance (Fig.3).

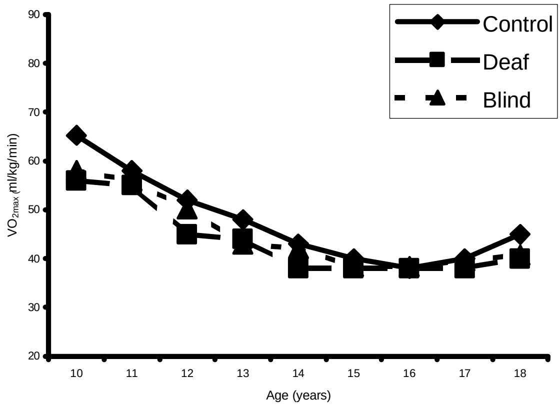

Fig. 3

The dynamics of mean maximal oxygen uptake ($VO_{2\,max}$ [ml/kg/min]) in deaf and blind girls in comparison to the physically efficient control.

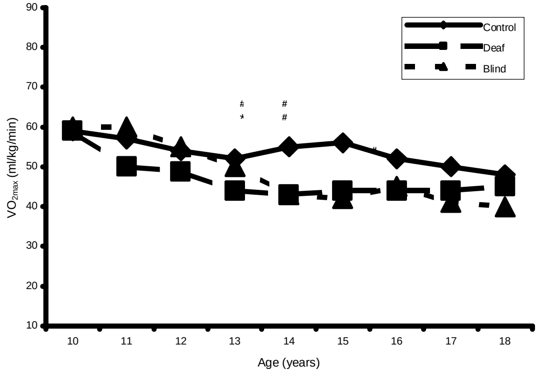

Fig. 4

The dynamics of mean maximal oxygen uptake ($VO_{2\,max}$ [ml/kg/min]) in deaf and blind boys in comparison to the physically efficient control.
** Significant differences in deaf vs. control at P<0.05*
Significant differences in blind vs. control at P<0.01

Significant positive correlations were observed in deaf and blind children between vital capacity and $VO_{2\,max}$ (r= 0.30; P<0.05 and r=0.72; P<0.001, respectively). There was also a positive correlation between forced expiratory flow and $VO_{2\,max}$ in deaf (r= 0.29; P<0.05) and blind subjects (r=0.52; P<0.001).

Discussion

The development of aerobic physical efficiency of children and adolescents with visual and hearing impairments was evaluated at annual intervals during longitudinal studies. Previous analyses of physical abilities of deaf and blind children were performed on the basis on the results of morphological and motor development tests (e.g. balance, movement coordination, running speed, explosive strength and physical work capacity) (1, 6, 17, 18). The aim of the present study was to examine maximal oxygen uptake and functional capabilities of deaf and blind children to determine whether their physical performance was actually lower than that of non-handicapped counterparts.

Subjects from special schools for deaf and blind children, aged 10 to 18 years were evaluated. There were no significant differences in morphological characteristics, intellectual development and socio-economics factors. Therefore, the results of this study most likely reflect a sensory impairment-induced effect on maximal aerobic efficiency. Several longitudinal studies reported that $VO_{2\,max}$ increases continuously until about 16 years of age in boys. In girls $VO_{2\,max}$ increases until about 13 years of age and then remains at a plateau throughout adolescence (3, 10). On the average, absolute values of VO_{2max} are greater in boys than in girls at all ages (13, 14, 19). The level of physical abilities of adolescents with visual and hearing loss is significantly lower then that of their physically efficient counterparts (2, 15, 20). Previous studies has revealed that deaf children had poorer spirometry results which might be explained by a lack of verbal language acquisition so that the positive effect on lung development through the use of the lungs for speech, singing, or screaming is missing (20). It is important to emphasize that impaired hearing, possibly a consequence of damage to the vestibular apparatus, might also affect the function of higher nervous structures (18). Vestibular nuclei in brain stem are connected with the cerebellum, oculomotors, spinal cord and brain cortex as well as vegetative centres. All these structures could influence physical abilities, synergic muscle regulation, and movement coordination (1). On the other hand, sedentary lifestyle might be implicated as a cause of weakened physical abilities of blind subjects. Additionally, overprotective parents feel that physical activity may be disadvantageous to blind or deaf children.

In the present study, deaf adolescents had a lower level of $VO_{2\ max}$ in comparison to healthy, physically fit control subjects. Impaired hearing influenced motor development, and was associated with lower aerobic efficiency. Results of his study seem to confirm previous observations made in deaf children with a lower $VO_{2\ max}$ level in comparison to physically efficient control (20). A significant positive correlation was found between chosen spirometric variables (vital capacity and maximal mid-expiratory flow, maximal voluntary volume) and $VO_{2\ max}$ of deaf and blind subjects.

Conclusions

Our results seem to suggest that the dynamics of aerobic efficiency was significantly decreased in adolescents with hearing and visual impairment in comparison to healthy, physically efficient control group. The physical efficiency of deaf boys was lower compared to hearing boys and the tendency for a lower level of maximal oxygen uptake was observed for deaf girls compared to hearing counterparts Considering the fact that differences between the obtained and reference variables tend to increase with age, it seems well-justified to emphasize the importance of systematic physical exercise and training not only in childhood but throughout adolescence.

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