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Effects of auditory rehabilitation program on physical functioning in deaf adolescents with and without cochlear implants

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INTRODUCTION

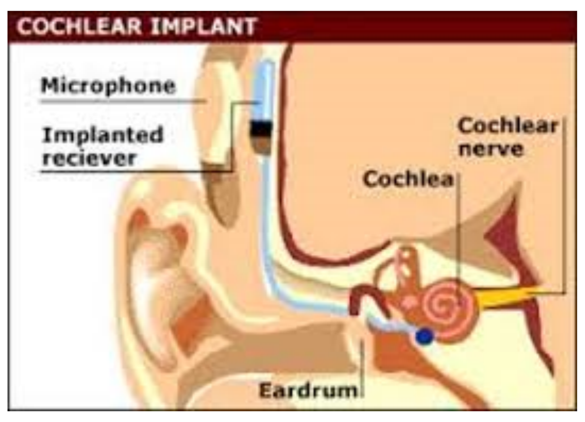
Deafness, apart from the consequences related to conceptual and emotional development, may result in motor, coordination, balance, and sensory-motor synchronization impairment. The physical fitness of children and adolescents with deafness may be lower compared to their hearing peers and may depend on the educational process who noted that school type, curricular emphasis and parenting styles. The potential physiological mechanism of lower physical fitness may include damage to inner ear structures but also may depend on their educational system.

The lack of auditory feedback results in functional voice disorder that may adversely affect the child's educational achievements. The regulation of breathing during articulation as well as respiratory system efficiency might be important neural mechanism responsible for language skills of deaf children.

Participation in voice and speech rehabilitation:

- increases the strength of the laryngeal muscles
- facilitates efficient vocal fold vibration
- improve respiratory fitness
- increases cognitive function.

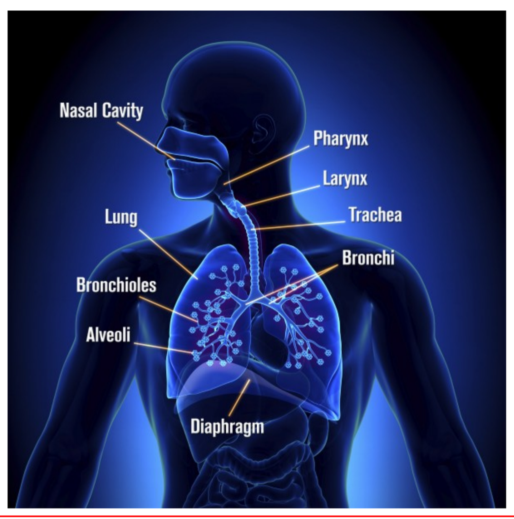
Children with early-onset deafness who had received a cochlear implant (CI) had higher speech intelligibility compared to deaf children without CI. Implantation may have a beneficial effects on the the process of speech learning by deaf children and respiratory system by improving respiratory muscle function.

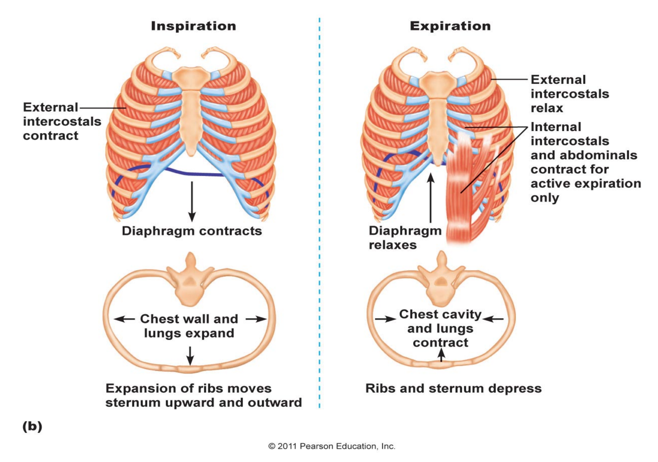


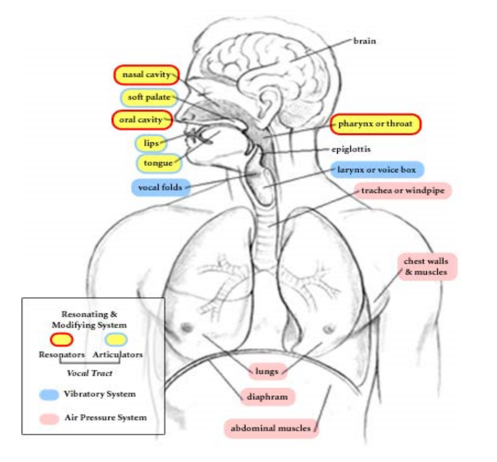
The objective of the study was to investigate the effects of auditory rehabilitation program on lung function of deaf adolescents with and without cochlear implants.

Respiratory system and speech

- Respiratory performance is one of the most important aspects of the process of speech learning by deaf children.
- In the process of voice production, the lung air pressure for speech results from functions of the respiratory system during a prolonged phase of expiration after a short inhalation.
- Air vibration for voiced sounds is initiated by the vocal folds in the larynx and controlled by a set of laryngeal muscles and airflow from the lungs.







Dysfunction of the respiratory system in people with hearing impairment

Most people with hearing impairment exhibit speech breathing changes including:

- irregular breathing rhythm
- longer non-inspiratory pauses
- changes in airway pressure and decrease the function of the lungs
- ventilation-perfusion abnormalities

Speech and language therapy

- communication skills that may include receptive language (what child understands)
- expressive language (what child signs or says)
- speech skills (how child pronounces words)
- interaction skills (how child uses language in conversations, for example, by asking questions).

METHODS

A group of 72 deaf adolescents with cochlear implants (CI; the Nucleus 22-electrode CI) and without cochlear implants (non-CI), and a 48 normal hearing adolescents (CG) took part in a study. The assessment of linguistic competence was performed in all subjects according to the examination standards. All deaf adolescents participated in a rehabilitation program including vocal function exercises and respiratory muscle training. Spirometric tests were performerd before and after 6 weeks training, including 2 training sessions per week.

Spirometric measurements were performed in all subjects using PonyGraphic 3.7, Cosmed, Italy and included vital capacity (VC), forced vital capacity (FVC), peak expiratory flow (PEF), forced expiratory flows (FEF) and maximal voluntary ventilation (MVV).

TABLE 1. Somatic characteristic of the subjects with cochlear implant (CI), without cochlear implant (non-CI), and a control group (CG).

Variables	Girls			Boys		
	CI n=12	non-CI n=25	CG n=25	CI n=12	non-CI n=23	CG n=23
Age [yr]	16.9 (1.8)	16.3 (1.2)	16.0 (2.0)	16.1 (2.4)	15.6 (0.9)	15.9 (2.5)
Height [m]	163.0 (7.8)	160.0 (6.8)	160.8 (7.4)	172.5 (6.3)	171.0 (7.9)	173.9 (8.3)
Weight [kg]	57.1 (10.2)	55.7 (8.8)	52.3 (9.0)	65.0 (20)	60.2 (16.8)	63.3 (11.6)
BMI [kg/m^2]	21.5 (3.9)	21.2 (3.3)	20.2 (1.9)	21.7 (6.5)	20.7 (6.2)	20.9 (2.8)
PBF [%]	25.5 (6.6)	19.5 (6.3) [a]	23.2 (6.4) [b]	18.3 (6.5)	10.0 (8.2) [a]	10.6 (4.2) [c]

TABLE 2. Lung function indices in girls.

Variables	GIRLS			Statistical significance		
	CI n=12	Non CI n=25	CG n=25	CI vs non CI	CI vs CG	Non CI vs CG
FVC [L]	2.9 (0.6)	2.7 (0.7)	3.8 (0.4)	ns	p<0.05	p<0.05
FVC [%pred]	80.5 (0.5)	76.3 (19.2)	100.0 (10.3)	ns	p<0.05	p<0.05
VC [L]	2.9 (0.5)	3.0 (0.8)	3.9 (0.4)	ns	p<0.05	p<0.05
FEV1 [L/s]	2.6 (0.6)	2.6 (0.5)	3.5 (0.3)	ns	p<0.05	p<0.05
FEV_1 [%pred]	85.1 (16.3)	83.6 (11.5)	102.4 (13.3)	ns	p<0.05	p<0.05
PEF [L/s]	4.3 (1.3)	3.7 (1.2)	5.0 (1.6)	p<0.05	ns	p<0.05
ERV[L]	0.8 (0.3)	0.9 (0.3)	1.0 (0.4)	ns	ns	ns
FEF_{25-75}) [L/s]	3.3 (0.9)	2.9 (0.7)	4.2 (1.0)	ns	ns	p<0.05
FEV_1/FVC [%]	93.3 (5.2)	90.4 (9.7)	92.7 (8.3)	ns	ns	ns
$\dot{V}_E$ [l/min]	13.1 (4.7)	11.6 (2.9)	12.2 (4.6)	ns	ns	ns
MVV [L/min.]	77.8 (27.8)	72.0 (16.7)	100.5 (15.1)	ns	p<0.05	p<0.01

TABLE 3. Lung function indices in boys.

Variables	BOYS			Statistical significance		
	CI n=12	Non CI n=25	CG n=25	CI vs non CI	CI vs CG	Non CI vs CG
FVC [L]	3.4 (0.7)	3.0 (0.9)	4.5 (0.9)	p<0.05	p<0.05	p<0.01
FVC [%pred]	73.8 (12.0)	60.0 (21.5)	98.9 (8.3)	ns	p<0.01	p<0.01
VC [L]	3.6 (0.8)	3.6 (0.7)	4.4 (0.7)	ns	p<0.05	p<0.05
FEV1 [L/s]	3.3 (0.5)	2.9 (0.5)	3.8 (0.7)	ns	p<0.05	p<0.05
FEV_1 [%pred]	83.1 (8.4)	78.9 (8.8)	88.0 (10.0)	ns	ns	p<0.05
PEF [L/s]	5.6 (0.9)	4.4 (1.5)	6.5 (1.2)	p<0.05	p<0.05	p<0.01
ERV[L]	0.9 (0.4)	1.3 (0.7)	1.0 (0.4)	ns	ns	ns
FEF_{25-75}) [L/s]	4.2 (0.8)	3.6 (1.3)	4.5 (1.4)	ns	ns	p<0.05
FEV_1/FVC [%]	93.3 (5.0)	82.4 (6.8)	96.2 (10.3)	ns	ns	p<0.05
$\dot{V}_E$ [l/min]	14.4 (5.3)	13.2 (3.7)	12.4 (2.6)	ns	ns	ns
MVV [L/min.]	105.0 (37.3)	101.5 (24.8)	132.0 (29.1)	ns	p<0.05	p<0.01

CONCLUSION

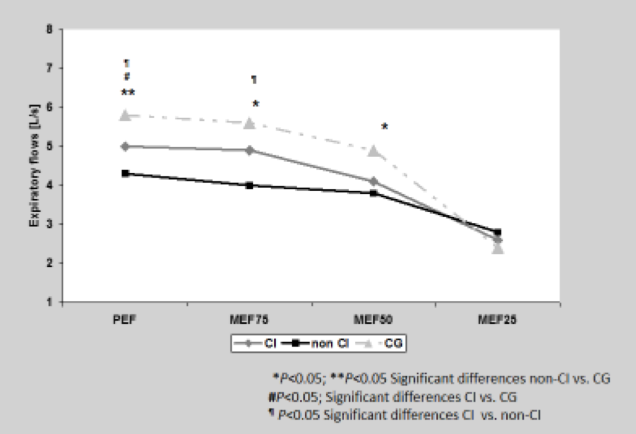
The majority of deaf adolescents with CI used oral communication (83.3 %), and a significant minority used mixed communication (16.7 %) ($p < 0.001$). Among children fit with hearing aids, 37.5 % communicated using spoken language, 33.5 % used mixed communication, and 29.2 % used sign language only.

The results of the gymnasium examination test (FGET) did not differ significantly between CI and non-CI students (37.9 ± 15.1 and 38.6 ± 16.3 %; $p = 0.8$). Hearing participants achieved better results (54.0 ± 9.8 %) compared to both CI ($p < 0.001$) and non-CI group ($p < 0.01$). Deaf girls without CI had significantly higher scores compared to non-CI boys (45.7 ± 16.8 vs. 30.8 ± 13.4 %; $p < 0.004$) and girls with CI (37.2 ± 11.2 %; $p < 0.05$).

The mean values of FVC and VC were below normal range in 36.5 % of all deaf adolescents and were significantly lower in deaf participants compared to their hearing counterparts. Significantly lower aerobic performance (VO_2max) were also observed in deaf subjects compared to CG. No effect of training on VC and VO_2max was seen in CI adolescents compared to non-CI. A significant correlation was found between years of device-use and the type of communication mode. The use of oral communication was associated with higher FVC ($r = 0.41$; $p < 0.01$).

The sensory deprivation of prelingually deaf adolescents affects the function of the respiratory system and exercise tolerance. The rehabilitation therapy seem to have beneficial effect in the reduction of airflow resistance and positively affected functional capacities of the respiratory system and the child's educational achievements.

Fig.1. Peak expiratory flow (PEF), midexpiratory flow of forced vital capacity (MEF_{75-25}) in examined subjects



*P<0.05; **P<0.05 Significant differences non-CI vs. CG
#P<0.05; Significant differences CI vs. CG
¶ P<0.05 Significant differences CI vs. non-CI