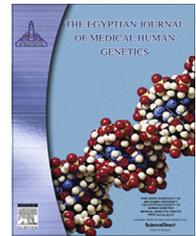




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ORIGINAL ARTICLE

Strength training versus chest physical therapy on pulmonary functions in children with Down syndrome



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KEYWORDS

Down syndrome;
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Abstract *Background:* Children with Down syndrome clinically show a diminished activity limit at all ages due to muscle weakness and respiratory problems.

Purpose: To compare the effect of strength exercises to lower limb muscles and effect of chest physical therapy treatment program on pulmonary functions in Down syndrome children.

Methods: Thirty Down syndrome children of both sexes (24 boys and 6 girls) were selected from outpatient clinic of the National Research Center for motor disabilities in children at Cairo, Egypt. Children were selected to be ranged in age from 10 to 14 years and to be free from any innate heart deformities. They were randomly divided into two groups of equal numbers (group A and group B). Group (A) received chest physiotherapy, and group (B) received strength training program for hip, knee and ankle muscles by utilizing universal exercise unit 3 times/week for 12 weeks. Ergospirometry system was utilized to evaluate the pulmonary functions (forced vital capacity, forced expiratory volume in 1 s, maximum voluntary ventilation, and peak expiratory flow) that were measured before and after the proposed treatment period.

Results: Post treatment results of FVC and PEFV showed a statistically significant difference in each group while no significant difference was recorded between both groups. Post treatment results of FEV1 and MVV showed significant distinction between both groups in favor to group (A).

Conclusion: Strength exercises to lower limb muscles are not effective as chest physical therapy on improving pulmonary functions in children with Down syndrome.

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1. Introduction

Down syndrome (DS) is trisomy of chromosome 21 which is the most common trisomy among live births. DS is caused by the presence of an additional chromosome 21 in all cells of the body [1]. Overall growth of children with Down syndrome is relatively slow when they are compared to their peers,

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as those children are floppy and poorly coordinated because of diminished muscle tone during childbirth (i.e., hypotonic) however it improves with age [2].

Down syndrome includes a combination of birth defects, mental retardation, characteristic facial features, heart imperfections, expanded infection, pulmonary problems, in addition to visual and auditory problems. Thus the severity of these problems varies greatly among those children [3]. Children with DS are at the risk of restrictive pulmonary disease with weak cough, concomitantly to a decrease in lung volume because of generalized trunk and extremity weakness [4]. Respiratory problems are a primary cause of morbidity and/or hospital admission particularly in young children with DS. There is an increased prevalence of sleep-related upper airway obstruction and lower airway disease [5]. A deficiency of the pulmonary system to oxygenate the mixed venous blood or remove the carbon dioxide from this blood may contribute to a high incidence of respiratory infections, reduced effectiveness of cough and diminished lung volume (i.e., vital capacity and total lung capacity) [4].

Pulmonary efficiency has been measured to be useful in assessing the presence and severity of both heart and lung diseases [6]. Spirometer is utilized to set up a baseline of lung functions, evaluate dyspnea, detect pulmonary disease, monitor the effects of therapies used to treat respiratory disease, evaluate respiratory impairment, evaluate operative risk, and perform surveillance for occupational related lung disease. It measures the mechanical function of the lung, chest wall, and respiratory muscles by surveying the aggregate volume of air exhaled from a full lung (total lung capacity) to an empty lung (residual volume) [7].

Children with DS usually suffer from overall muscle weakness, slow postural reactions, and response time, in addition to hyper flexible joints [8]. Adolescent with DS do not demonstrate the physiological increase in muscle strength as that typically occurs at 14 years of age [9], thus the preservation of muscle strength in DS child at a satisfactory level is necessary for the activities of daily life. The presence of hypotonicity, joint laxity, and decreased muscle strength will cause excessive wear and tear on the joints over time. Adults with DS develop early musculoskeletal changes, including patellofemoral instability, genu valgus, pes planus, and hip instability [10].

Children with DS are commonly more sedentary and less physically active, they are at increased danger of secondary health conditions, including type II diabetes, cardiovascular disease, and osteoporosis [11]. So strength especially to lower-extremity muscles in children with DS and individuals with mental retardation, has a central significance to their general health and daily activity performance ability [12]. Cardiovascular exercise programs and community programs to keep children physically active have been shown to improve peak oxygen consumption and maximum workload [13]. Intervention to improve strength and coordination and to decrease wear and tear on the weight-bearing joint structures should be implemented as preventive practice. Training includes endurance training which involves large group of muscles working at moderate intensity for a more extended period, and strength training which involves small group of muscles working for short period with three sets for eight repetitions. Strength training was shown to be equally as effective as endurance training on exercise capacity and health quality [14].

This study had been conducted to compare between the strength training to lower limb muscles and chest physical therapy on pulmonary functions in children with Down syndrome.

2. Subjects

A group of 30 children with Down syndrome from both sexes (24 boys and 6 girls) with a mean age 12.80 ± 1.32 years selected from National Institute for Research of motor disability in children, Cairo University hospitals, participated in the current study. They were selected by taking after consideration criteria: they could walk independently, no history of congenital cardiopulmonary defects. The IQs level was more than 70 to be able to understand and follow instructions. The IQ level was determined by a psychologist on the Stanford-Binet Intelligence Scale [13]. That study had been carried out at Mataria teaching hospital after parents or care givers of each child signed a consent form that was approved by the Ethical Research Committee of the Faculty of Physical Therapy, Cairo University, Egypt. Selected children were randomly divided by sealed envelopes into group A and group B. Group A received chest physical therapy program. Group B received strength training to lower limb muscles (hips, knees, and ankles) using universal exercise unit.

3. Instruments and procedures

3.1. Zan-680 "Ergospirometry system"

Ergospirometry system was used to detect the pulmonary functions including forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1), maximum voluntary ventilation (MVV), and peak expiratory flow (PEF) [15]. Ergospirometry system was calibrated before operating procedure. Data including the child's name, sex, age (year), height (cm) and weight (kg) were entered into the unit. The child was instructed to put the mouth piece of spirometry in his/her mouth, and breathe normally and inhale fully then exhale slowly as much as possible for vital capacity, inhale slowly and fully and exhale fully as much force as possible blasting out the air in the lungs for PEF and FEV1 maneuver, inhale slowly and fully and exhale fully as much force fully as possible for 15 s for MVV. After each maneuver, the child was allowed to relax for five minutes.

3.2. Universal exercise unit (UEU)

It was utilized to increase muscle strength, by expanding dynamic and inactive scope of movement [16]. Before the strength training session, all children were requested to perform 10 min of low intensity aerobic exercise and stretching of hip, knee and ankle joint muscles.

The muscles of lower limbs that were fortified, included (1) hip flexors, extensors, abductors, and adductors, (2) knee flexors and extensors, and (3) ankle dorsi and planter flexors. The strength training exercise was done following the program of UEU illustrated in Table 1. Weight was increased by 0.5 kg once the child successfully completed 3 sets of 30 repetitions of isolated movement, with a 30-s rest between each exercise

Table 1 Universal exercise unit exercises; strength training program.

<i>Hip and knee flexion:</i> Supine position cuffs around ankle at opposite side of child head at the same level of the leg
<i>Hip extension:</i> Supine position with knee extension and cuffs around knee and ankle attached to upper part of UEU
<i>Hip adduction and abduction:</i> Supine position with knee extension cuffs around ankle and knees attached to sides of UEU (Rt or Lt side of child)
<i>Knee extension:</i> Prone position and cuffs around ankle attached to side of UEU (side of child head)
<i>Ankle dorsiflexion and planter flexion:</i> Supine position cuff around the forefeet attached to side of UEU (side of child foot)

set without difficulties [17,18]. The strength training was applied for 50 to 60 min three times weekly, for 12 successive weeks [19].

3.3. Chest physical therapy

Participants in group A received a chest physical therapy program that includes positioning, breathing exercises, and incentive spirometer training for 60 min for three times weekly, for 12 successive weeks.

4. Statistical analysis

Results were expressed as mean \pm standard deviation (SD). Comparison between pre- and post-assessments within the groups and between groups was performed using paired *t* test and unpaired *t* test, respectively. Statistical Package for Social Sciences (SPSS) computer program (version 19 windows) was used for data analysis. The *p* value ≤ 0.05 was considered significant while the *p* value < 0.01 was considered very high.

5. Results

Each group included 15 children with Down syndrome. The mean age \pm SD of both groups is shown in Table 2. It was clear that there was no statistically significant difference between the mean value of age of both groups with *p* value = 0.311. Sex distribution within both groups was statistically comparable with *p* value = 0.766. Weight and height within both groups were practically identical with *p* values 0.727 and 0.628, respectively. Comparisons between pretreatment and post treatment revealed no statistically significant distinction between group A and group B regarding pulmonary functions (Table 3).

In the control group, when the pretreatment mean values were compared to post treatment mean values they revealed

a significant improvement (*p* value ≤ 0.05) in forced vital capacity (FVC), forced expiratory volume after 1 s (FEV1); peak expiratory flow rate (PEFR); and Maximum voluntary ventilation (MVV), while in the study group; there was an insignificant difference of mean value between pre and post mean values of FEV1 and MVV (*p* value ≥ 0.05) and a significant improvement in FVC and PEFR (*p* value ≤ 0.05) Table 3.

6. Discussion

The strength of lower-limb muscles is a prerequisite of gait, balance, and physical activities. Children with DS suffer from pulmonary dysfunctions, and impaired physical activities so they have decreased physical capacities. This study seeks if the strength of lower limbs with simple application protocol has the same effect on pulmonary functions as well as chest physical therapy. The reports of previous studies done on subjects with chronic obstructive pulmonary disease, informed that the lower limb muscle dysfunction is a prominent extra-pulmonary feature and is related to exercise tolerance [20].

Improvement of post treatment results of pulmonary functions in group A might be attributed to the chest physical therapy program, that was used to improve the efficiency of ventilation, and it may also help the children in improving their pneumonic capacity and circulation, and preventing lung infection by improving alveolar ventilation, venous return, lymph waste and decreasing dead space ventilation [21]. Using incentive spirometer for children in group A might improve the efficiency of ventilation by increasing strength and endurance of respiratory muscles, maintaining positive pressure in the air ways, and increasing perfused alveoli [22]. Several studies found out that the incentive spirometer is viable on improving pulmonary functions (VC, FEV1, PEFR, and MVV), as it reduces the resistance to air flow by increasing lung volume, improving deep diaphragmatic breathing and expansion of collapsed areas and it also gives visual feedback for diaphragmatic training [4,23].

In group B, there were improvements in post treatment mean values of FVC and PEFR while no improvements were detected in FEV1 and MVV, so the comparison between both groups revealed a significant difference in post treatment mean values of FEV1 and MVV and irrelevant distinction in FVC and PEFR (Table 3). Improvement in the ventilatory functions in group (B) might be due to an increased strength in muscles of lower limbs. The results of the current study is supported by the report of Wilmore and Graham [19,23] who mentioned that the sedentary lifestyle of people with DS is believed to be among the main factors contributing to muscle weakness and hypotonia, which are higher prevalence of circulatory abnormalities, poor function of the pulmonary system, and decreased levels of physical fitness.

Table 2 Demographic data.

	Groups		<i>p</i> value
	B (<i>n</i> = 15)	A (<i>n</i> = 15)	
Age (years) Mean value \pm SD	12.20 \pm 1.82	12.80 \pm 1.32	0.311
sex (F/M)	(2/13) (13.33%/86.67%)	(4/11) (26.67%/73.33%)	0.361
Weight (kg) Mean value \pm SD	45.33 \pm 10.63	46.67 \pm 10.10	0.727
Height (cm) Mean value \pm SD	144 \pm 10.62	145.80 \pm 7.83	0.628

Table 3 Comparison between pre and post treatment mean values within and between groups (A & B).

Pulmonary functions	Pre treatment Mean value \pm SD	Pre/post (Mean value \pm SD)		Post treatment Mean value \pm SD
		Group A	Group B	
FVC (liter)	Group A	2.22 \pm 0.32	2.01 \pm 0.52/2.22 \pm 0.52	Group A
	Group B	2.01 \pm 0.49	0.01*	2.51 \pm 0.35
	<i>p</i> value	0.17		Group B
FEV1 (liter)	Group A	1.39 \pm 0.31	1.22 \pm 0.31/1.39 \pm 0.35	2.22 \pm 0.52
	Group B	1.22 \pm 0.31	0.415	<i>p</i> value
	<i>p</i> value	0.126		0.076
MVV (liter)	Group A	8.81 \pm 10.94	48.81 \pm 10.94/56.75 \pm 11.67	Group A
	Group B	2.55 \pm 10.82	\pm 12.24	6.75 \pm 11.67
	<i>p</i> value	0.126	0.412	Group B
PEFR (liter/minute)	Group A	2.56 \pm 0.28	2.53 \pm 0.31/2.98 \pm 0.27	8.71 \pm 12.24
	Group B	2.53 \pm 0.31	0.01*	<i>p</i> value
	<i>p</i> value	0.463		0.02*

FVC, forced vital capacity; FEV1, forced expiratory volume after one second; PEFR, peak expiratory flow rate; MVV, maximum voluntary ventilation.

* Significant difference.

The muscular exercises increase the rate and depth of respiration that may improve FVC, and increase the consumption of O₂ and the rate of diffusion. It was documented that during endurance and strength training the body demands more oxygen, so the lungs must deliver more oxygen to the working muscles through the blood. As the depth of breathing increases, exchange of oxygen and carbon dioxide between the lungs and the blood occurs more rapidly and efficiently. So the regular exercise increases the lung capacity to deliver oxygen [24].

The improvement in PEFR in children of group (B) may be due to the increased force of expiration by strengthening training. This is in agreement with the result of Hoff and Farid et al. [25,26] who mentioned that aerobic exercises and strength training increase oxygen consumption and carbon dioxide production by working muscles, and the pulmonary response is precisely calibrated to maintain homeostasis of these gases in arterial blood. Lactic acid formed in working muscles begins to appear in the circulation. It causes metabolic acidosis which is called the lactate threshold. During exercise, the lungs respond to lactic acidosis by further increasing ventilation, lowering the arterial PCO₂ and maintaining arterial blood pH at normal levels. Strength training in children with DS according to the current data, could be efficient in improving physical capacity during physical activities such as walking. That is supported by the positive relationship between muscle strength and exercise tolerance through multiple regression analysis. Exercise training is now considered an essential component of pulmonary rehabilitation in patients with chronic obstructive pulmonary disease (COPD), although it does not change pulmonary functions, it improves exercise capacity [20].

The study is limited by the small sample size due to the difficulties in the process of the study, that is why the site of treatment application was not the same of evaluation.

7. Conclusion

It was concluded that the strength training of lower limb muscles including hip, knee and ankle in children with DS is safe and effective on some pulmonary functions as forced vital capacity and peak expiratory flow rate, but it is less effective on other pulmonary functions than chest physical therapy on pulmonary functions.

Funding resources

None.

Conflict of interest

The authors declare that there is no conflict of interest. There is no financial and personal relationship with other people or organizations that can inappropriately influence this work.

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