

# Effect of Aerobic Training on Physical Fitness in Children with Down Syndrome

Marwa M. Ibrahim<sup>1\*</sup>, Ghada A. Abdullah<sup>2</sup>

<sup>1</sup>Department of Physical Therapy For Growth and Development Disorders in Children and Its Surgery  
Faculty of Physical Therapy, Cairo University, Cairo, Egypt

<sup>2</sup>Department of Basic sciences, Faculty of Physical Therapy  
Cairo University, Cairo, Egypt

\*Corresponding author's email: [assprofpnu \[AT\] gmail.com](mailto:assprofpnu@gmail.com)

---

## ABSTRACT—

**Aim:** The aim of this study was to evaluate the effect of an aerobic training program on physical fitness in children with Down syndrome (DS). Thirty DS children (8–12 years) were randomized to two equal groups, study group (A) and control group (B).

**Procedure:** Measurements of maximum oxygen consumption ( $VO_2$  max), minute ventilation (VE), respiratory exchange ratio (RER), exhaustion time, forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) by using an Ergo spirometer device were performed before and after 16 weeks of the treatment program. Group (A) received aerobic training exercise and group (B) didn't receive any training during this period.

**Results:** after 16 weeks training, extreme significant improvements in cardiovascular parameters were seen for the study group for  $VO_2$  max, VE, RER, FVC and FEV1 and only significant improvement in exhaustion time, while no significant change in peak physiologic parameters was seen in the control group ( $p < 0.05$ ).

**Conclusion:** It is concluded that children with DS could improve their cardiovascular fitness when performing a well-designed aerobic training program.

**Key words** — Down syndrome, physical fitness, aerobic exercises, aerobic capacity and maximum oxygen consumption.

---

## 1. INTRODUCTION

Down syndrome is a chromosomal condition caused by the presence of all or part of an extra chromosomal 21<sup>st</sup>, and affects around 1/1,000 live births. The effects of an extra chromosome have direct consequences for their health and well-being (e.g. heart defects, muscle hypotonicity, joint hypermobility). Moreover, DS has been commonly related to obesity and low levels of physical fitness [1].

Physical fitness is defined as the ability to perform daily activities without fatigue. It incorporates the characteristics of body composition, flexibility, muscular strength, endurance, and cardiovascular fitness [2]. These five characteristics have long been the major area of research interest, and are used to identify level of physical fitness in people with intellectual disability (ID), including children with DS [3].

Aerobic training is a process whereby the heart and lungs are trained to pump blood more efficiently, allowing more oxygen to be delivered to muscles and organs. It is a determining factor in performance in events with a duration greater than 2 min which is usually achieved through aerobic exercises such as running, swimming, aerobics, etc. [4].

Children with Down syndrome have been reported with upper and lower airway abnormalities including a small upper airway, decreased numbers of alveoli and reduced surface area [5]. Also, generalized weakness, especially abdominal muscle, is prominent in people with DS. These two major problems can lead to decreased lung volumes. Cardiovascular and respiratory systems work dependently on each other to ensure sufficient amount of oxygen carried to organs. If lung volume or amount of oxygen consumption is reduced and removal of carbon dioxide is deficient, there will be limited available energy for activities [6].

At submaximal workloads, individuals with DS have higher heart rates (HRs), oxygen consumption (VO<sub>2</sub>), and minute ventilation (VE) than peers with mental retardation but without DS [7]. However, at maximal effort, individuals with DS have lower mean peak HRs and lower VO<sub>2</sub>, suggesting a lower level of aerobic conditioning [8].

Physiological changes due to aerobic conditioning include both cardiovascular and pulmonary benefits as lowering resting, submaximal heart rates (HR), and respiratory rates, while higher VO<sub>2</sub> at maximal workloads [9].

The aim of this study was to study the effect of an aerobic training program on physical fitness in children with DS.

## 2. SUBJECTS AND METHODS

### 2.1. Subjects

Thirty DS children of both sexes were recruited from the National Institute of Neuromuscular System and from the genetic disorders clinic of Abou El Reesh Hospital. Their ages ranged from 8 to 12 years (10 ±1.1 years) and their heights ranged from 117 and 132 cm (125 ±0.5 cm). The children IQ level ranged from 50-60 % as they had sufficient cognition and were able to understand commands given to them . Children with any medical condition that would severely limit their participation in the study as vision or hearing loss, cardiac anomalies and diseases or musculoskeletal disorder were excluded. The children were equally randomized to either study group (A) who received aerobic training or control group (B) who conducted only their usual daily activities and no other specific exercises. This work was carried out in the out-patient clinic of The Faculty of Physical Therapy, Cairo University and in accordance with the code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Parents of the children signed a consent form prior to participation as well as acceptance of the Ethics Committee of the University.

### 2.2. Materials

**2.2.1. For evaluation:** both groups of children were evaluated by the following devices:

**2.2.1.1. Ergo spirometer:** an electronic treadmill with Zan 100 flow handy II medical device apc-connected open spirometry system, made in Germany. The software running under windows 95 up to win NT. It was used for assessment of the physical fitness through VO<sub>2</sub> max, VE, RER, exhaustion time, FVC, and FEV1.

**2.2.1.2. Standard weight and height scale:**

A valid and reliable weight (0 to 120 kilograms) and height scale (0 to 200 centimeters), was used to measure the weight and the height. The obtained data were basic for Ergo spirometer data entry.

### 2.3. Methods

**2.3.1. For evaluation:**

**2.2.1.1. Physical fitness testing :**

Ergo spirometry was performed according to the American Thoracic Society/European Respiratory Society guidelines 2005 [10]. Participants ate only a light meal at their last meal before testing. All tests were conducted at an ambient temperature of 19 degrees Celsius and humidity of 23%.

Aerobic performance was assessed during a submaximal treadmill stress test according to the protocol of Bruce [11]. The subjects had one practice session on the treadmill one week before testing to familiarize them with walking on a treadmill. The protocol is as following:

**a- Warm up:** the treadmill was adjusted automatically at speed of 1.7 Km/h and 0 % grade of slope for five minutes.

**b- The testing phase:** during which the child worked up to complete exhaustion. They performed three-minute stages starting at 2.7 Km/h and inclination of 10 % grade, then the speed and slope were increased every 3 minutes intervals automatically. They were encouraged to complete each stage and progress to the next stage. The test was ended when they showed that they did not want to go to a higher stage or could no longer be able to walk at the current stage. After testing, they went through a cool down period in which the treadmill was adjusted at speed of 1.7 Km/h and inclination of 0% for five minutes.

**2.3.2. For treatment:**

The study group (A) received aerobic exercises which consisted of treadmill, walking through an obstacle course, rowing machine without resistance, bicycle ergometer without resistance, and stair climbing. The aerobic program was performed 45 to 60 minutes, 3 times/week.

**Exercise Intensity:** Maximal HR of individuals with DS is less than that of peers without the disorder [12]. Using the ACSM guidelines of maximal training HR (220- age= maximal HR) [13] would overestimate the HR of individuals with

DS. According to Fernhall et al.<sup>(12)</sup> maximal HR of young adolescents with DS was found to be approximately 170 to 180 beats per minute, so the Initial aerobic training intensity was 60% of 180 and finalized with 80%.

### 3. STATISTICAL ANALYSIS

The mean values of VO<sub>2</sub> max , VE, RER, exhaustion time, FVC, and FEV1 measured before and after 16 weeks for both groups were compared by using the Statistical Package for the Social Sciences (SPSS) version (16) using paired “t” test”, and an independent “t-test” was used for comparison between two groups. The results were expressed as mean ± SD, and P values less than 0.05 were considered significant.

### 4. RESULTS

The baseline characteristics of groups (a) and (B) are presented in table (1) as mean± SD of age, weight, height, and BMI of both groups. There were no significant differences between them.

The program adherence was not less than 75% as calculated by the number of recommended sessions and the actual number of sessions were reported. Measurements were applied for both groups before and after 16 weeks.

**Table (1) Baseline characteristics of children with DS in groups(A) and (B)**

Characteristics	Group (A) mean± SD	Group (B) mean± SD	P- value
Age (years)	10.00± 1.0	10.5± 0.6	0.11
Weight (kg)	37.30± 5.33	38.30± 2.83	0.53
Height (cm)	128.4 ± 1.30	127.9± 1.9	0.41
BMI (kg/m <sup>2</sup> )	23.2± 2.56	23.6± 1.77	0.20

The results of this study indicated that there were a greater significant improvement in exhaustion time, while extremely significant improvement in VO<sub>2</sub> max , VE, RER, FVC and FEV1 in group (A) than in group (B) (P<0.05) (table 2).

**Table (2) Comparison between study and control groups before and after treatment:**

Parameters	Before treatment			After treatment		
	Group (A) mean± SD	Group (B) mean± SD	P value	Group (A) mean± SD	Group (B) mean± SD	P value
VO <sub>2</sub> max (ml/kg/min)	24.2 ± 1.2	24.5 ± 1.2	0.76	26.8 ± 2.2	24.4 ± 1.3	0.001
VE (liter/min)	62.1±2.3	60.9±3.1	0.24	69.1±3.4	59.4±3.2	0.0001
RER	1.07±0.4	1.01±0.6	0.06	1.8±0.2	1.02±0.4	0.0001
Exhaustion time (sec)	364± 96	372±116	0.17	472±122	375±126	0.041
FVC (liter)	3.07±0.38	2.96±0.34	0.40	3.35±0.44	2.91±0.37	0.006
FEV1 (liter)	2.41±0.33	2.40±0.35	0.94	2.92±0.36	2.41±0.34	0.0004

VO<sub>2</sub> max (maximum oxygen consumption), VE (Minute ventilation), RER (Respiratory exchange ratio), FVC (Forced vital capacity), FEV1( forced expiratory volume in one second), p value <0.05.

### 5. DISCUSSION

Low Physical fitness is considered to be a risk factor for cardiopulmonary disorder, and can result in a shortened lifespan for children and adolescents with DS. While the determinants of physical fitness as well as sedentary behavior have been investigated widely in children and adults without disabilities, there is limited and controversial published information about the benefits of aerobic exercise on people with ID including DS.

The exercise capacity is an important prerequisite for many activities of daily living and in maintaining independence [14]. As mentioned, individuals with DS have significantly lower VO<sub>2</sub> max, minute ventilation, forced vital capacity and faster time to exhaustion than those with and without other forms of ID at all stages of life. Also, Pastore et al. [15] demonstrated that 43% of individuals with DS, were classed as obese. All of these factors indicate poor cardiovascular health and functioning which reflects the reduced exercise capacity in this population [16].

The results of the present study revealed a significant increase in Exhaustion time and an extremely significant improvement in other parameters of the cardiovascular fitness including VO<sub>2</sub> max , VE, RER, FVC and FEV1 in group (A) after 16 weeks of aerobic training.

These results come in agreement with Tomporowski and Jameson [17] who paired adults with ID and nondisabled exercise partners over an 18-week walk/jog program. The training program was effective for promoting exercise behavior in that participants progressively increased their distance walked/jogged and their speed of walking/jogging over the course of the intervention. A similar approach was taken by Lavay and McKenzie [18] who reported that five men with ID actively participated in a supervised walk/jog program three days per week for 12 weeks. Aerobic fitness levels increased significantly as a result of participation. Again, Pitetti and Tan [19] examined participation and adherence to a 16-week stationary cycling program for adults with ID. Aerobic fitness levels increased as a 2000 results of participation.

The findings of this study differ from those reported by other two studies [20,21] in which the subjects were adolescents and young adults with DS who performed a 10-week program of walking/jogging and a 16-week rowing ergometer training, respectively. In both of these studies, subjects demonstrated no changes in cardiovascular variables. The duration, intensity, and frequency followed in these two research studies were those recommended by the American College of Sports Medicine [22] for subjects without impairment: 30 minutes per day, 55% to 70% intensity, three days per week. Differences in this study compared with previous research may result from differences in exercise training protocols. In this study, aerobic training intensity was higher, 60% to 80% maximal HR versus 55% to 70%, duration was longer (30 to 60 minutes vs 30 to 45 minutes).

The improvement in aerobic capacity is directly proportional to the improvement in both peripheral and central circulation with the improved ability to consume and utilize oxygen, which are primarily dependent on specific key physiological adaptations such as increased cardiac output, increased oxidative enzymes [23], increased slow twitch muscle fibers and increased red blood cell count [24].

## 6. CONCLUSION

The results indicated beneficial effects for improvement of physical fitness including an increase in maximum oxygen consumption, minute ventilation, and other pulmonary functions without any reports of withdrawals or negative effects in children with DS.

## 7. ACKNOWLEDGMENTS

This work was supported in part by the Faculty of Physical Therapy, Cairo University. The critical comment offered on the initial draft of this manuscript by our colleagues at the department of Physical Therapy for the Growth and Developmental Disorder in Children and its Surgery and department of Basic Sciences are very much appreciated.

### *Conflict of interest*

There are no conflicts of interest or financial disclosures of any author of this manuscript. None of the authors have any financial interest.

### *Source of fund*

All work of this study was conducted in the outpatient clinic at the Faculty of Physical Therapy, Cairo University, Egypt and was not funded, in whole or in part.

## 8. REFERENCES

- [1] Roizen NJ, Patterson D. Down syndrome. Lancet 2003; 361: 1281-9.
- [2] Pollock ML, Gaesser GA, Butcher JD, Després J-P, Dishman RK, Franklin BA, et al. American College of Sports Medicine Position Stand: The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults. Med Sci Sports Exerc 1998;30:975-91.
- [3] Luke A, Roizen NJ, Sutton M, Schoeller DA. Energy expenditure in children with Down syndrome: Correcting metabolic rate for movement. J Pediatr 1994;125:829-38.
- [4] Am J Lifestyle Med. (2010). Aerobic Conditioning and Physical Activity. Sage Publications.
- [5] Uong E, McDonough J, Tayag-Kier C, Zhao H, Haselgrove J, Mahboubi S, et al. Magnetic resonance imaging of the upper airway in children with Down syndrome. Am J Respir Crit Care Med 2001;163:731-6.

- [6] McDowell K, Craven D. Pulmonary complications of Down syndrome during childhood. *J Pediatr* 2011;158:319-25.
- [7] Fernhall B, Miller AL, Tymeson GT, et al. Maximal exercise testing of mentally retarded adolescents and adults: reliability study. *Arch Phys Med Rehabil*. 1990;71:1065–1068
- [8] Pitetti KH, Climstein M, Campbell KD, et al. The cardiovascular capacities of adults with Down syndrome. *Med Sci Sport Exerc*. 1992;24:13–19.
- [9] Blair SN, Kohl HW, Barlow CE, et al. Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men. *JAMA*. 1995;273:1093–1098.
- [10] American Thoracic Society/European Respiratory Society ATS/ERS Statement: Standardisation of lung function testing: Standardisation of spirometry. *European Respiratory Journal*, 2005 26: 319–338.
- [11] BRUCE RA. "Exercise Testing and Training of apparently Health Individuals: A handbook for physicians. Mosby, New York, 1972; Pp:169-183.
- [12] Fernhall B, McCubbin JA, Pitetti KH, et al. Prediction of maximal heart rate in individuals with mental retardation. *Med Sci Sports Exerc*. 2001;33:1655–1660.
- [13] American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription, 6th ed. Baltimore: Lippincott Williams & Wilkins, 2000.
- [14] Baynard T, Pitetti KH, Guerra M, Unnithan VB, Fernhall B. Age-related changes in aerobic capacity in individuals with mental retardation: a 20-yr review. *Med Sci Sports Exerc*. 2008;40(11):1984–1989.[PubMed]
- [15] Pastore E, Marino B, Calzolari A, Digilio MC, Giannotti A, Turchetta A. Clinical and cardiorespiratory assessment in children with Down syndrome without congenital heart disease. *Archives of Pediatric and Adolescent Medicine*, 2000; 4:408-410
- [16] Carmeli E, Kessel S, Bar-Chad S, Merrick J. A comparison between older persons with Down syndrome and a control group: clinical characteristics, functional status and sensorimotor function. *Downs Syndr Res Pract*. 2004;9(1):17–24. [PubMed]
- [17] Tomporowski PD, Jameson LD. Effects of a physical fitness training program on the exercise behavior of institutionalized mentally retarded adults. *Adapt Phys Activ Q* 1985;2:197-205.
- [18] Lavay B, McKenzie TL. Development and evaluation of a systematic walk/run program for men with mental retardation. *Educ Train Ment Retard* 1991;September:333-341.
- [19] Pitetti KH, Tan DM. Effects of a minimally supervised exercise program for mentally retarded adults. *Med Sci Sports Exerc* 1991;23:594-601.
- [20] Miller AL, Fernhall B, Burkett LN. Effects of aerobic training in adolescents with Down syndrome. *Med Sci Sports Exerc*. 1993;25:270–274.
- [21] Pitetti KH, Climstein M, Campbell KD, et al. The cardiovascular capacities of adults with Down syndrome. *Med Sci Sport Exerc*. 1992; 24:13–19.
- [22] American College of Sports Medicine. ACSM's Guidelines for Exercise Testing and Prescription, 6th ed. Baltimore: Lippincott Williams & Wilkins; 2000.
- [23] Kubukeli ZN, Noakes TD, Dennis SC. Training techniques to improve endurance exercise performances. *Sports Medicine*, 2000; 32: 489-509
- [24] Jones AM, Carter H. The effects of endurance training on parameters of aerobic fitness. *Sports Medicine*. 2000;29: 373-386