

# The effect of different exercise intensities on knee and ankle joints' torque and functional mobility in children with Down Syndrome

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## ABSTRACT

The aim of this study was to compare the effect of mild and moderate exercise intensity on selected knee and ankle isokinetic parameters and functional mobility in children with Down Syndrome (DS), in order to find the appropriate exercise intensity that is beneficial for them. A clinical controlled trial was conducted on thirty-four male children with DS, aged between eight and twelve years, which were randomly divided into two groups (Group 1 and Group 2). The first group (Group 1) received mild-intensity treadmill aerobic exercises [T-AE] and the second group (Group 2) received moderate-intensity T-AE, three sessions weekly for three months. The timed up and go (TUG) test was utilized to evaluate the functional mobility while the peak eccentric torque of knee extensors and ankle plantar flexors of the dominant leg was evaluated by isokinetic dynamometry. IBM SPSS Program (version 20) was utilized to conduct the statistical analysis. There was a statistically significant improvement in the three variables after intervention with the moderate-intensity program ( $p < 0.05$ ), while the improvement was not statistically significant after intervention with the mild-intensity program ( $p > 0.05$ ). A moderate-intensity exercise program is an appropriate and beneficial intervention and should be considered as a part of rehabilitation programs for DS children.

## KEYWORDS

Exercise Intensity; Isokinetic; TUG; Down Syndrome

## 1. INTRODUCTION

Down syndrome (DS) is a common genetic deficiency, with an incidence of 1 in 700 to 800 living children. The prevalence of DS in Saudi Arabia is about 1.8 per 1,000 live births. It has certain dysmorphic features such as small ears, broad hands, short fingers, a flat face and nose, and small eyes (Roizen & Patterson, 2003). Additionally, they suffer from musculoskeletal complications such as hypotonia, muscle weakness, and ligamentous laxity (Krinsky-McHale et al., 2012; Weijerman & de Winter, 2010).

Patients with DS have a reduced exercise capacity which negatively affects their capability to achieve their functional duties. So, it is important to know the reasons for such low exercise capacity levels, as eventually, this will decrease the impact of these problems on DS subjects' health-related physical fitness. The reduced work performance of DS subjects during simple tasks such as treadmill exercises happens due to a number of reasons. The decreased muscle strength, low physical fitness, lower VO<sub>2</sub> max, impaired dynamic balance, and obesity are principal factors that reduce the physical activities in DS individuals compared to age-matched controls resulting in a decreased community incorporation, and impaired quality of life (Mendonca et al., 2010). Balic et al. (2000) mentioned that there is a positive link between muscular strength, social integration, and DS individuals' productivity in the community. This increases the focus of the latest research to evaluate their muscular strength.

Alsakhawi & Elshafey (2019) stated that the treadmill should be included in training programs designed for DS individuals to enhance their muscle strength and balance. They added that the treadmill improved the hamstring's and quadriceps' power and peak torque in addition to neuromuscular coordination in patients with DS. Also, they mentioned that treadmill training improves the kinetic, kinematic, and time parameters of gait by improving the lower limbs muscles' strength and boosting the functional capabilities. They concluded that the treadmill training is as effective as core stability training for DS children regarding balance and muscle strength.

Moreover, Mendonca et al. (2010) stated that the DS patients have different responses regarding energy expenditure to different exercise intensities. Ahmadi et al. (2020) also found different responses to different exercise intensities regarding the isokinetic parameters in adults with DS. They reported that the treadmill training using progressive resistance improved the isokinetic parameters of the lower extremities. They used treadmill training in addition to resistance bands that were attached to the patient's feet and to a par that was placed one meter behind the end of the treadmill. The bands had different colors that indicated different intensities. They didn't mention

specific intensity for their training as they gradually increased the resistance according to the individual ability.

The body of knowledge concerning the knee and ankle isokinetic parameters in children with DS and the efficacy of different exercise intensities on these parameters is limited. So, the DS children may benefit from the application of specialized training program to increase their performance, fitness, and consequently, and their quality of life. So, the main objective of the current study was to compare the effect of mild and moderate exercise intensity on selected knee and ankle isokinetic parameters and functional mobility in children with DS in order to find the appropriate exercise intensity that is beneficial for them.

## **2. METHODS**

### **2.1. Study Design**

A clinical controlled trial was conducted to evaluate the study variables and compare the effect of mild and moderate-exercise intensity on the selected parameters. At first, a specialized investigator who was blinded by the group classification did the clinical evaluation for all children. The study was conducted in the laboratories of the University of Taif.

### **2.2. Participants**

A total of thirty-eight male DS subjects were selected at the beginning of the enrollment procedures from different hospitals in the western area of Saudi Arabia. Only thirty-four children aged from eight to twelve years completed the study because two children did not meet the required criteria (one had epileptic fits and one had visual impairments) and the parents of two children rejected to join the study. They were randomly divided into two groups (Group 1, n=17) and (Group 2, n=17). Group 1 engaged in the mild intensity T-AE and group 2 engaged in the moderate-intensity T-AE.

The participants were included if they had the ability to move freely without assistance, their intelligence quotient (IQ) level lied between 45 and 70, were right foot dominant (according to what the parents told us), their body mass index percentile lied between the 50th and 75th percentile according to the American Academy of Pediatrics. They were excluded when if they had any disease or any congenital abnormality that may influence walking, for example, cardiac problems, respiratory complications, auditory, and visual deficits., if they engaged in strength training or involved in competitive sports emphasizing muscular strength or power or had a preceding injury, deformity, or

surgery in the lower extremity which needed medical care. At the beginning, the children obtained permission to participate in the study from their physician.

Parents of all children signed a written consent form before being enrolled in the intervention. The study was approved by the ethical committee at Taif directorate of health affairs, KSA, [No 291]. Additionally, the clinical trials registration number is (NCT05271201).

### **2.3. Randomization**

The supervisor brought 34 envelopes and put a card inside each one branded either Group 1 or Group 2 and each participant was asked to select and open one envelop and detect if he belonged to either group.

### **2.4. Measurements**

#### 2.4.1. Body mass index (BMI)

The child was weighed by a Seca digital scale while he is standing barefoot and wearing light clothing. Height was measured with a measuring rod while the child was standing upright. BMI is then determined by this formula:  $BMI = \frac{kg}{m^2}$  where kg is a child's weight in kilograms and m<sup>2</sup> is his height in meters squared. The BMI percentile then was computed to categorize each participant.

#### 2.4.2. Intelligence quotients (IQ) level

The Binet Kamat test was utilized to detect the IQ level. It is an Indian version of the Stanford–Binet Scale that is utilized for DS (Parikh & Goyel, 1990). The IQ ranged from 45 to 70.

#### 2.4.3. Physical Activity

The participants' level of physical activity was detected by the Physical Activity Questionnaire (Baecke et al., 1982). This questionnaire provides scores for both sports and leisure time. The summation of both values represents the total score. The participants' levels lay between four to seven.

#### 2.4.4. Measurements of Isokinetic Parameters

The isokinetic parameters were measured through Cybex-6000 isokinetic system. The peak normalized torque of knee extensors and ankle plantar flexors of the dominant leg were assessed during eccentric contraction. The torque was normalized to the child's body weight [NM/Kg]. At the beginning of the assessment, all children performed 5 minutes warming up on a cyclic ergometer [60-70 revolutions/minute]. Sixty degrees per second angular velocity was used to assess the desired

muscles. The subjects were given guidelines on the aim of the examination and provided time to be familiarized with the device by performing 5 repetitions of the test movement at the selected speed. Subjects were stabilized in a sitting position with straps set around their waistlines, thighs, and around their shoulders. Three trials were done at the required angular velocity. Each trial involved 5 repetitions. The children got a one-minute rest between trials. Verbal reinforcement was given throughout the trials and the maximum peak torque value was obtained (Wiggin et al., 2006).

- Ankle Isokinetic Parameters

The child was standing in a semi-reclined position with the knee in 90-degree flexion. The lateral malleolus was aligned with the device's axis of rotation, and straps were located around the dorsum of the foot. Subjects were tested in a concentric-eccentric mode throughout the range of motion from dorsiflexion of 10° to plantar flexion of 30° (Wang et al., 2000).

- Knee Isokinetic Parameters

The tested knee joint was flexed at 90° and the axis of the dynamometer was lined up with the distal point of the lateral condyle of the femur. The dynamometer cuff was fastened just above the malleoli. Subjects were tested in a concentric-eccentric mode throughout the range from 90-degree knee flexion to full extension (Törpel et al., 2017).

#### 2.4.5. Exercise Intensity

To calculate the exercise heart rate, Martti Karvonen formula was utilized. At first, the resting heart rate (rest-HR) for every individual was obtained through a heart rate monitor during lying in the prone position for 10 minutes in a quiet area to prevent any interruptions. Then maximum heart rate (max-HR) was calculated by using the following formula:  $\text{max-HR} = 220 - \text{age}$ . After that, the heart rate reserve (HRR) was expressed as:  $\text{HRR} = \text{max-HR} - \text{rest-HR}$ . The required exercise intensity (target-HR) was detected by using the formula:  $\text{target-HR} = \text{HRR} \times \text{intensity\%} + \text{rest-HR}$ . The exercise intensity was mild when the activity practices 40%-50% of the HRR added to the rest-RH while the moderate-intensity exercise utilizing 50% to 70% of HRR added to the rest-RH (Ignaszewski et al., 2017).

#### 2.4.6. Functional Mobility

The participant's functional mobility was assessed by using the timed up and go (TUG) test. The validity and reliability of the test were obtained previously. A square was drawn first on a wall at a three meters' distance. A chair with a backrest was brought. The chair didn't have an armrest and

was adjusted to allow 90 degrees of flexion of the knee and hip and plantigrade feet. The child was asked to sit down on the chair then stand up and walk with his/her free walking speed, and touch the square, then return and sit down on the chair. The stopwatch was used to calculate the time elapsed from leaving the seat to returning and sitting down. The test was done thrice, and the mean time was taken (Williams et al., 2005).

## 2.5. Interventions

The children were presented to the outpatient clinic at the identical period of the day. The T-AE was applied for both groups, 3 sessions weekly, for 3 months according to Tsimaras and Fotiadou, (2004). The exercises were done by using a motorized treadmill. At first, the participant performed 5 minutes of exercises on a bicycle ergometer as warming up. Gentle stretching for the lower limb muscles was done for 5 minutes as cooling down at the end of each session. The training program for GI and GII was done following the sequence illustrated in (Table 1). The treadmill was inclined 5° up. The walking speed on the treadmill was at first 4 Km/hour then every 5 minutes, it was increased by 0.8 Km/h up until the child reached the required exercise intensity. One supervisor and one assistant organized the exercise sessions. Absence at any session was documented to calculate regularity with the training program.

**Table 1.** The treadmill parameters for the study groups

Week	Group 1	Group 2	Duration [min]
	Mild intensity	Moderate intensity	
1 <sup>st</sup> ,2 <sup>nd</sup>	30%	53%	18
3 <sup>rd</sup> ,4 <sup>th</sup>	35%	58%	23
5 <sup>th</sup> ,6 <sup>th</sup>	40%	63%	28
7 <sup>th</sup> ,8 <sup>th</sup>	45%	70%	33
9 <sup>th</sup> ,10 <sup>th</sup>	50%	70%	38
11 <sup>th</sup> ,12 <sup>th</sup>	50%	70%	43

## 2.6. Statistical Analysis

IBM SPSS program version 20 was utilized to conduct the statistical analysis. The study sample size was determined by the power analysis using the G\*power program with a power of 0.80;  $\alpha = 0.05$ ; effect sizes =0.5, and Pillai V=0.2. According to the Shapiro Wilk test, skewness, and kurtosis, the data was nearly normally distributed. Both Levene's test and Box's tests had non-significant results. The study's variables were analyzed by using the repeated measure MANOVA.

### 3. RESULTS

The demographic data of both groups were tested using MANOVA test. MANOVA revealed that there were no statistical differences between Group 1 and Group 2 before the intervention regarding age, physical activities, weight, height, IQ, BMI, and BMI percentile. Table 2 illustrates these findings.

**Table 2.** Comparison of baseline patient demographics

MANOVA				
Effect	Test	Value	F	p
Grouping	Wilks' Lambda	.794	.817	.58
Bonferroni pairwise comparisons				
Dependent Variable	Groups		Mean Difference	p
	Group 1 (n=17) M±SD	Group 2 (n=17) M±SD		
Age	10.31±.52	10.1±1.5	.067	.90
PA	4.9±0.83	5.53±1.12	-.67	.08
IQ	56.46±5.09	58.6±5.16	-2.13	.27
BMI	18.04±1.01	17.87±1.02	.170	.65
BMI percentile	70.26±6.55	67.13±6.02	3.13	.18
Height	129.02±2.64	128.4±2.46	.61	.52
Weight	30.15±2.68	29.43±2.36	.72	.44

Concerning the study variables, repeated measure MANOVA within and between subjects comparison was conducted. The test revealed that there were no statistical differences between Group 1 and Group 2 before the intervention regarding knee extensors and ankle plantar flexors peak eccentric torque and TUG ( $p > 0.05$ ) (Table 3).

After the intervention, the within-subjects comparison showed a statistically significant improvement in the three variables with a moderate-intensity program ( $p < 0.05$ ). On the other hand, the mild intensity program did not show any statistically significant improvement ( $p > 0.05$ ). Comparing the results of both groups after the intervention (between-subjects comparison), Group 2 showed a statistically significant improvement in the three variables in comparison with Group 1 (Table 3).

**Table 3.** Within and between-subjects comparison for the study variables

MANOVA				
Effect	Test	Value	F	Sig.
Pre-post		.57	13.52	.000
Grouping	Wilks' Lambda	.58	13.27	.000
pre-post * Grouping		.79	4.80	.005
Bonferroni pairwise comparisons				

Variables	Mild (n=17) [M±SD]	Moderate (n=17) [M±SD]	MD [mild-moderate]	Sig.
TUG pre	7.55±0.6	7.27±0.41	.27	.15
TUG post	7.36±0.7	6.53±0.42	.83	.0001
<b>MD [pre-post]</b>	.187	.740		
<b>Significance</b>	.32	.001		
PF pre [M±SD]	1.5±0.13	1.46±0.1	.03	.45
PF post [M±SD]	1.54±0.12	1.64±0.12	-.098	.02
<b>MD [pre-post]</b>	-.046	-.176		
<b>Significance</b>	.28	.002		
Knext pre [M±SD]	1.16±0.1	1.22[±0.13]	-.057	.11
Knext post [M±SD]	1.2±0.11	1.38±0.11	-.18	.0001
<b>MD [pre-post]</b>	-.039	-.159		
<b>Significance</b>	.27	.01		

#### 4. DISCUSSION

The purpose of the study was to compare the effect of mild-intensity with moderate-intensity exercises on knee extensors and ankle plantar-flexors eccentric peak torque and functional mobility in Down's syndrome children. There was a statistically significant improvement in the three variables (knee extensors, ankle plantar flexors peak eccentric torque and TUG) after intervention with a moderate-intensity program ( $p < 0.05$ ). On the other hand, the mild intensity program did not show any statistically significant improvement ( $p > 0.05$ ).

The participants' age ranged from 8 to 12 years, which was chosen because it is a serious period for the development of well-being performances and attitudes continuing later to the next life phases (Mercer & Lewis, 2001). The muscular torque has constant values through the selected age range according to (Cioni et al., 1994). The isokinetic dynamometer is one of the most important evaluative methods as it allows a quantifiable assessment of muscular activities, through certain variables such as power and torque (Serrao et al., 2012). It is a safe, reliable, and objective method for assessment through the full range of motion (Wiggin et al., 2006). The desired muscles were examined at a slow velocity (angular velocity 60°/s). Chapman et al. (2006) mentioned that the slow velocity eccentric contraction causes lesser muscle damage and lesser delayed onset muscle soreness than fast velocity contraction in the untrained subjects. Also, Ferri et al. (2003) stated that the ability of the muscle to produce torque is well at the lower velocities as 30°/s and 60°/s. Choosing the eccentric muscle contraction, the eccentric contraction is considered an important part of children's ADL. It ensures the protective mechanisms for children's immature joints and muscles (De Ste Croix, 2012).



The eccentric torque of the knee extensors and ankle plantar flexors in both groups at the endpoint was improved but only the improvement in the Group 2 was significant. Brightwell et al. (2019) agreed with these findings when they concluded that the quadriceps peak torque was significantly increased after the application of moderate-intensity TA-E. The improvement may be related to an increase in the synthesis of myofibrillar protein and improvement in muscle capillarization which may increase the supply of nutrients and removal of waste products.

Additionally, our study agrees with a study by Tuttle et al. (2012) which found that the functional mobility, dorsiflexor, and plantar-flexor peak torque were significantly enhanced after the application of three months of a moderate-intensity exercise program including a treadmill walking. They related the increase in muscle strength to alterations in the neural system instead of changes in the muscle structure. Furthermore, Carmeli et al. (2002) coincided with our findings when they applied 45 minutes of a submaximal treadmill training program for 24 weeks to children with DS. They found that the average power %BW, knee extensors and flexors isokinetic peak torque, and dynamic balance were significantly enhanced after treadmill walking. They related the improvement in dynamic balance and functional mobility to improvement in knee muscle performance.

Garnier et al. (2018) explained the effect of the application of treadmill training for forty-five minutes at 75% heart rate reserve on knee extensors' function of 10 healthy subjects in level, incline, and decline conditions. They reported that there was a decrease in the peak torque of the knee extensors after the application of the treatment procedures at the three inclination levels of the treadmill. The contradiction between their study and the current study may be related to certain factors. Firstly, is a limited sample size (only 10 subjects completed the study). Another factor was the high walking velocity ( $15.2 \pm 1.3$  km/h). They attributed the reduction in the muscular torque after using high-velocity training to the central and peripheral fatigue, muscle soreness as well as reduced enjoyment. Central fatigue decreased the central nervous system's capability to efficiently activate the muscles.

Moreover, Ulrich et al. (2008) added that the increase in the exercise intensity resulted in a significant increase in leg muscle strength in DS children. This may be attributed to these more intense exercises which increase the afferent feedback sense and accelerate the development of the neuromuscular system which may improve functional mobility and balance.

Furthermore, the functional mobility in the Group 2 was significantly improved when it was compared to Group 1 at the endpoint. The improvement in functional mobility and balance may occur because of the increase in knee muscle performance (Carmeli et al., 2002).

Additionally, Alsakhawi & Elshafey (2019) found that treadmill training is a recommended therapeutic intervention for DS children. They reported that treadmill training improved the balance. They concluded that both treadmill and core stability exercise led to similar significant improvement in balance. The improvement in functional mobility in the current study may be due to balance improvement after the treadmill intervention.

## 5. LIMITATIONS

The study included only male children because of customs, and traditions in KSA. We limit the isokinetic assessment to certain parameters of the knee and ankle joints in the dominant limb only. Further studies may be needed to assess more parameters in both lower limbs.

## 6. CONCLUSIONS

A moderate-intensity exercise program is an appropriate and beneficial intervention and should be considered as a part of rehabilitation programs for DS children.

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### **AUTHOR CONTRIBUTIONS**

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