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Effect of Eight Weeks of Combined Turning Exercises on the Motor Skills in Female Students with Down Syndrome: Quasi-Experimental Study

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Original Article

Abstract

Introduction: Down syndrome is one of the most common genetic diseases in people with intellectual disabilities, which leads to delays in motor skill. Therefore, this study was performed to determine the effect of eight weeks of turning exercises on the motor skills in femaile students with Down syndrome.

Materials and Methods: In this semi-experimental research, 26 female students with Down syndrome were selected in an accessible and purposeful manner and then divided into experimental group (with an average age of 12.15 ± 1.62, height 139.23 ± 8.94, weight 42.62 ± 13.44 and IQ 63.02 ± 5.54) and control group (with mean age 12.23 ± 1.53, height 141.15 ± 10.31, weight 45.46 ± 15.94 and IQ 63.05 ± 5.49) were randomly paired. Before and after the training period, gross and fine motor skills was evaluated using Short form of Bruininks-Oseretsky test. The subjects of the experimental group underwent 24 sessions (each session lasting 45-60 minutes). Analysis of variance for duplicate data was used to analyze the data at a significance level of 0.05.

Results: The findings revealed a significant interaction in gross motor skills ($P < 0.001$, $F = 113.60$), fine motor skills ($P = 0.040$, $F = 4.40$) and composite score ($P < 0.001$, $F = 68.56$) in the experimental group compared to the control group. These results indicate that the implementation of combined turning exercises had a significant impact on enhancing the motor skills of students with Down syndrome.

Conclusion: According to the results of this study, these exercises can be used as an effective method to improve the gross motor skills of students with Down syndrome.

Keywords: Down syndrome; Turning exercises; Motor skills; Rehabilitation

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Introduction

Down syndrome is one of the most prevalent genetic disorders among individuals with intellectual disabilities, occurring in approximately 1 in every 800 live births. People with Down syndrome exhibit distinct clinical symptoms. In the United States (US), about 5000 live births per year are affected by Down syndrome, and the disorder impacts the lives of over 200000 individuals (1). The primary cause of Down syndrome is trisomy 21, a condition characterized by an extra copy of chromosome 21. This additional genetic material leads to various medical and health complications, including mental, cardiac, and respiratory issues in individuals with Down syndrome (2).

According to the World Health Organization (WHO), approximately 200 million children have intellectual disabilities (3). Research findings indicate that Down syndrome accounts for 10% to 20% of cases among individuals with intellectual disabilities (4). The intelligence quotient (IQ) range for individuals with Down syndrome is typically reported to be between 50% and 75% (5). People with Down syndrome possess distinct anatomical and physiological characteristics that set them apart from individuals without the condition (2).

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One of the notable characteristics of individuals with Down syndrome is reduced physical activity levels (6). Compared to typically developing children of the same age, children with Down syndrome often exhibit weaknesses in areas such as balance, speed, strength, visual control, and fine and gross motor skills (7). Research has indicated that these difficulties in movement skills among children with Down syndrome can be attributed to hypermobility (loose joint ligaments) and muscle tone issues (8). Jabling suggests specific movement disorders are observed in children with intellectual disabilities, including Down syndrome. Still, with appropriate intervention,
age-related progress, and treatment, their recovery can be improved (9). Furthermore, it has been observed that challenging the brain with diverse environments can increase an individual's IQ by up to twenty points (10). The cerebral cortex thickens as the environment becomes more enriched, and dendritic branches create more connections (11).

Participating in sports activities is a crucial strategy for preventing health issues associated with inactivity and a sedentary lifestyle (12), which has been observed in individuals with Down syndrome (13, 14). Given that maintaining an independent lifestyle is significant for individuals with intellectual disabilities, implementing a suitable physical activity program allows them to undergo physical training and lead an active and healthy life as they transition into adulthood. This highlights the importance of physical activity and training for individuals with Down syndrome (14). Trampoline (16), strength and balance (17, 18), spark exercises (19), vestibular stimulation exercises (20), and perceptual-motor exercises (21) have affected the movement skills of people with Down syndrome.

Various forms and methods of turning exercises are employed, including pivot, twisting, swinging, and change of direction training. These exercises target different body parts, such as the shoulder joints, thighs, core region, or the total body. They are performed with diverse objectives, such as enhancing balance, coordination, speed, agility, range of motion (ROM), strength, and core stability. These exercises can be conducted individually or in combination. Given that turning exercises involve movement around different axes and necessitate coordination among various systems and structures of the body, they can lead to significant improvements within a relatively short period. By incorporating turning components into exercises and performing movements in multiple planes, turning exercises introduce a higher level of challenge than traditional exercises. This approach yields positive and additional effects, and these exercises, resembling everyday movement patterns, appear to enhance transferability (22).

Consequently, turning exercises allow individuals with Down syndrome to enhance their movement skills within an active and stimulating environment. The statistics of Down syndrome in boys are more than in girls (9), and fewer studies have been done on girls. Therefore, without studies investigating the effects of combined turning exercises on individuals with Down syndrome, the present study aims to examine the impact of 8 weeks of combined turning exercises on the motor skills of female students with Down syndrome.

Materials and Methods

This study employed a semi-experimental research design with pre-test and post-test measurements conducted on two groups: a control group and an experimental group. The objective was to evaluate the effect of eight weeks of combined turning exercises on muscle strength among female students with Down syndrome aged 9-14 years in Isfahan City, Iran. A total of 26 students were selected through purposeful sampling and matched based on IQ. They were then assigned to either the control group or the experimental group. The sample size was determined based on a sampling method considering an alpha level of 0.05 and a beta coefficient of 0.2, estimated to be 18 (20, 23). However, considering the possibility of sample attrition and to avoid compromising the statistical power, a sample size of 26 individuals was ultimately chosen.

Initially, written consent forms were obtained from the parents of the participants. The subjects' demographic characteristics, including age, height, weight, and IQ, as well as their cardiovascular and pulmonary health and any other existing medical conditions, were evaluated based on the available medical records from the educational institution. All subjects were found to be physically healthy, and their IQ ranged between 50 and 70. The inclusion criteria for the study encompassed individuals with educable mental retardation and Down syndrome, diagnosed by a medical professional, with an IQ ranging from 50 to 70. Other criteria included the absence of additional disabilities or specific medical conditions, no prior regular participation in sports activities, and obtaining consent from parents and the subjects to participate in the study. The exclusion criteria for the study were as follows: subjects from the experimental group who were absent for more than 30% of the training sessions, voluntary withdrawal from participation in the study, the occurrence of unforeseen issues that rendered the subjects unable to attend the sessions, inability to complete the research tests, and the presence of other significant disabilities or diseases (23). However, it is worth mentioning that all 26 participants completed the study plan.

The Bruininks-Oseretsky test was used to measure motor skills, a set of standard reference tests that measure the motor performance of children aged 4.5 to 14.5 years. The complete set of this test includes eight subtests that evaluate gross and fine motor skills. Four subtests evaluate gross motor skills, three subtests evaluate fine motor skills, and one subtest evaluates both motor skills (24). The internal validity of this test has been estimated to be between 0.90 and 0.98 (24). Besides, Wuang et al. (25) and Wuang and Su (26) evaluated the test-retest validity and its internal consistency as excellent (0.95 and 0.98, respectively) for children with intellectual disabilities. The short form of the test is used when the overall assessment of children's movement abilities is desired. The short form measures children's motor skills, and the total score indicates children's general skills, including gross and refined skills. This research used the short form of the test (Figure 1).

After taking the pre-test, the training group (13 people) performed combined turning exercises (27) for eight weeks, during 24 sessions (45 to 60 minutes each session). Exercises were performed under the supervision of a specialist in corrective exercise and sports injuries. In the design of exercises, the principles of overload, progress, and individual differences were considered. An overview of the exercises is given in table 1. After completing eight weeks of exercises, the subjects were given a post-test.

Figure 1. Some sub-tests of Bruininks-Oseretsky test

Table 1. Overview of the exercise program in the experimental group

Training program		
Warm up	Low intensity aerobic exercises and ROM exercises	10 minutes
Turning resistance exercises	Upper limb: shoulder girdle, pectoral, humerus Core: curl up, bridge, plank, superman Lower limb: hip abduction, adduction and flexion, knee flexion and extension, squat, stand plantar flexion	20 minutes
Standing turning exercise	Double leg standing, anterior crossed standing, posterior crossed standing, heel to heel standing, double leg standing and head rotation, double leg standing and trunk rotation, double leg standing and waist rotation, double leg standing and turning weight transfer, standing and upper body rotation with open arms, standing on one leg, standing on one leg turned outward, standing on one leg and rotating the head, standing on one leg and rotating the trunk, standing on one leg and waist rotation, standing on one leg and transferring turning weight, standing and rotating the lateral pair on the heel, standing and rotating the lateral pair of feet on the paw, standing and rotating the parallel legs on the paw, standing and rotating one leg around the other leg, 180° rotation, 270° rotation, clockwise rotation, 90° double-leg and single-leg rotation jump	25 minutes
Walking turning exercise	Exercises in turning paths: walk, side walk, narrow walk, march walk, half brisk walk, toe walk, brisk walk, brisk toe walk, tightrope walk, trot, slide, hiccups, li li, lateral walk on heel and toe, cross walk, braiding walk, dynamic walk, walking in a circular path and ball rotation around the waist, walking to back side in a circular path, walking in a circular path and carrying an object in hand, grapevine walk	
Cool down	Low intensity aerobic exercises and ROM exercises	5 minutes

ROM: Range of motion

It should be noted that to comply with ethical considerations, after the end of the project in the experimental group, the exercise program was carried out in the control group by researcher, who was the sports teacher of the sampling school.

To assess the normal distribution of the data, the Shapiro-Wilk test was used. Descriptive statistics, such as standard deviation (SD) and mean, were utilized to summarize the data. A repeated measures analysis of variance (ANOVA) was conducted for the inferential analysis, with a significance level set at 0.05.

Results

Table 2 shows the demographic characteristics of the subjects, including height, weight, age, and IQ. The statistical analysis revealed that there were no significant differences ($P < 0.05$) between the two groups in any of the measured factors, indicating homogeneity between the groups in terms of demographic characteristics, particularly mental performance.

Table 3 presents both the descriptive information and the results of the ANOVA. The findings indicate a significant interaction ($P < 0.05$) in gross motor skills. As shown in table 3, there was an interaction observed in all parameters, except for upper limb coordination, response speed, visual-motor control, and speed. Notably, there was a significant difference ($P < 0.05$) in upper limb agility, which represents fine motor skills. This implies that the training group exhibited significantly greater improvements compared to the control group, highlighting their greater progress as a result of the training program.

Table 2. Demographic characteristics of the subjects (n = 26)

Criteria	Group	Mean ± SD	t	P value
Age (year)	E	12.15 ± 1.62	0.90	0.60
	C	12.23 ± 1.53		
Height (cm)	E	139.23 ± 8.94	1.10	0.10
	C	141.15 ± 10.31		
Weight (kg)	E	42.62 ± 13.44	1.70	0.08
	C	45.46 ± 15.94		
IQ (score)	E	63.02 ± 5.54	0.85	0.70
	C	63.05 ± 5.49		

IQ: Intelligence quotient; SD: Standard deviation; E: Experimental; C: Control

Discussion

The present study aimed to investigate the effect of eight weeks of combined turning exercises on the motor skills of students with Down syndrome.

Table 3. Results of repeated measures analysis of variance (ANOVA)

Criteria	Group	Pre-test	Post-test	Within changes	Interaction	Between changes	η^2	Power
		mean ± SD						
Running speed and agility (score)	Experimental	3.46 ± 1.89	7.00 ± 1.91	F = 95.08	F = 47.08	F = 2.38	0.662	1
	Control	3.77 ± 2.08	4.38 ± 2.02	P < 0.01	P < 0.01	P = 0.13		
Balance (score)	Experimental	1.15 ± 1.72	6.92 ± 1.97	F = 110.81	F = 72.20	F = 12.16	0.751	1
	Control	1.46 ± 1.98	2.08 ± 1.60	P < 0.01	P < 0.01	P < 0.01		
Bilateral coordination	Experimental	2.62 ± 1.32	4.38 ± 0.96	F = 25.07	F = 5.87	F = 10.79	0.197	0.642
	Control	1.62 ± 1.60	2.23 ± 1.48	P < 0.01	P = 0.02	P < 0.01		
Strength (score)	Experimental	7.54 ± 2.66	15.62 ± 2.84	F = 88.33	F = 58	F = 28.37	0.707	1
	Control	7.23 ± 1.42	8.08 ± 1.65	P < 0.01	P < 0.01	P < 0.01		
Upper limb coordination (score)	Experimental	2.00 ± 1.35	6.46 ± 9.86	F = 3.99	F = 1.85	F = 2.46	0.072	0.257
	Control	1.54 ± 0.77	2.38 ± 0.76	P = 0.05	P = 0.18	P = 0.13		
Reaction time (score)	Experimental	0.00 ± 0.00	3.96 ± 5.34	F = 9.21	F = 3.56	F = 3.56	0.129	0.441
	Control	0.00 ± 0.00	0.92 ± 2.25	P < 0.01	P = 0.07	P = 0.07		
Visual-motor control (score)	Experimental	4.62 ± 1.32	5.62 ± 1.55	F = 23.14	F = 0.03	F = 0.72	0.002	0.054
	Control	5.08 ± 1.44	6.00 ± 1.08	P < 0.01	P = 0.84	P = 0.40		
Upper limb speed and agility (score)	Experimental	2.69 ± 0.75	3.85 ± 1.46	F = 17.75	F = 3.26	F = 0.10	0.120	0.411
	Control	2.92 ± 0.76	3.38 ± 1.04	P < 0.01	P = 0.08	P = 0.75		
By skill								
Gross motor composite	Experimental	14.32 ± 5.94	33.69 ± 4.67	F = 198.35	F = 113.64	F = 31.18	0.826	1
	Control	14.08 ± 3.45	16.77 ± 2.77	P < 0.01	P < 0.01	P < 0.01		
Fine motor composite	Experimental	7.31 ± 1.65	13.42 ± 5.99	F = 21.75	F = 4.44	F = 1.55	0.156	0.525
	Control	8.00 ± 1.52	10.30 ± 2.17	P < 0.01	P = 0.04	P = 0.22		
Total motor composite	Experimental	23.77 ± 6.53	51.03 ± 10.95	F = 165.70	F = 68.53	F = 20.24	0.741	1
	Control	23.46 ± 4.35	29.38 ± 4.05	P < 0.01	P < 0.01	P < 0.01		

SD: Standard deviation

The results revealed a significant interaction effect on gross motor skills ($P < 0.05$), indicating that turning combined exercises had a positive influence on improving the motor skills of students with Down syndrome. Previous research has demonstrated the beneficial effects of various exercises and physical activities, such as swimming (15), trampoline (16), strength and balance exercises (17, 18), spark exercises (19), vestibular stimulation exercises (20), and cognitive-movement exercises (21), on the motor skills of individuals with Down syndrome.

Motor skills can be classified into two main categories: gross motor skills and fine motor skills. Gross motor skills involve movements that are primarily controlled by large muscle groups or multiple muscles, such as walking and running. Fine motor skills, on the other hand, involve movements that are primarily controlled by small muscle groups or individual muscles, such as drawing or manipulating objects with precision. Both gross and fine motor skills play a crucial role in a child's overall development and should be fostered and enhanced. Children with intellectual disabilities often experience delays in the development of motor skills and typically demonstrate lower proficiency levels in both gross and fine motor skills when compared to their typically developing peers (28). The acquisition and progression of movement skills are influenced by a combination of environmental factors and genetic predispositions although the relative effects of these influences may vary. It is important to provide appropriate support and interventions to help children with intellectual disabilities improve their motor skills and reach their full potential in both gross and fine motor abilities. An essential environmental factor in the development of motor and perceptual abilities is the provision of active environments and opportunities for learning. It is particularly crucial during sensitive developmental periods, especially in childhood and adolescence (29).

The more important and novel aspect of the study lies in the results of turning exercises. Rotation is a fundamental element of mobility (30) and is involved in various daily life activities (31). Compared to straight walking, turning movements present a more demanding maneuver (32-35). Turning exercises encompass exercises that involve at least one rotation or revolution around one or more axes (vertical or horizontal) within one or multiple joints, or the rotation of the entire body around an internal or external axis. These exercises can be applied to various body parts, including the upper, trunk, and lower regions, as well as different joints. In turning exercises, the incorporation of rotation into movements and the execution of multi-plane movements intensify the challenge posed by typical exercises, leading to additional positive effects (22). By adding the turning component, these exercises enhance the difficulty level and contribute to further benefits beyond conventional exercises.

Turning exercises in different forms and methods, including axial rotation exercises, twisting and rotating exercises, swing exercises, exercises to change the direction of movement, etc., and focusing on different parts of the body, including shoulder joints, thighs, central part, or It is performed independently and combined with various goals such as improving balance, coordination, speed, agility, ROM, strength, central stability, etc. Considering that turning exercises are performed in different axes and require coordination between different systems and structures of the body to perform, they will lead to proper improvement in the minimum time. Turning exercises, by adding the component of rotation to the movements and performing multi-plane movements, increase the level of challenge of the usual exercises and create positive and additional effects, and it seems that by being more similar to everyday movement patterns, it helps them to be more transferable (22).

The exercises performed in the turning exercises group have increased the usual challenge by adding the rotation component to the movements and performing multi-plane movements. It seems that these exercises are more similar to everyday movement patterns and help them to be more transferable. It has been stated that multi-planar exercises, compared to performing movement in a linear path or in a single-planar form, lead to more improvement in neuro-muscular integration, stability, and increase in functional transfer (36). Task rotation is a challenging and relatively new task, and participants may have been more attentive during this intervention. Therefore, such creative and challenging tasks can increase motivation, coordinate muscle activity, and stimulate the reorganization of the cerebral cortex, which results in improved performance (37). Hence, it provides the opportunity for these children to improve their movement skills in an active and challenging environment. It can be said that this program is designed in such a way that it provides the child's interest in the game and is in accordance with his abilities. Therefore, children are encouraged to do these exercises and develop their skills, without imposing failure or disappointment.

Since mentally retarded children have a kind of crude movement, group games and exercises lead to modeling and imitation of psycho-motor skills and give them the opportunity to practice these skills. Due to the fact that the training program of the research was more focused on gross motor skills (Table 1) and as the information in table 3 shows, the interaction in all parameters except for upper limb coordination, response speed, visual-motor control, and upper limb speed and agility was significant ($P < 0.05$).

Limitations

Among the limitations of the current research, we can point out the exclusiveness of the statistical sample to girls, the lack of follow-up tests after the post-test to evaluate the durability of the results, and the lack of research background on the effectiveness of rotation exercises in order to compare and generalize the results.

Recommendations

According to the results of the present research, it is suggested that more studies be conducted with the presence of both genders along with long-term follow-up tests. Besides, due to the effectiveness of turning combined exercises in this research, it is suggested that this training program be used in the sports program of other mentally disabled people.

Conclusion

The results of the present study showed that turning combined exercises were effective in improving the gross motor skills of students with Down syndrome. Therefore, these exercises can be used as an effective training method to improve the gross motor skills of students with Down syndrome.

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Authors' Contribution

Study design and idea: Negar Heidari
Getting financial resources for the study: Negar Heidari
Scientific and executive support of the study: Negar Heidari
Providing equipment and study samples: Negar Heidari, Gholamali Ghasemi
Data collection: Negar Heidari
Analysis and interpretation of the results: Negar Heidari
Specialized statistical services: Negar Heidari, Morteza Sadeghi
Manuscript preparation: Negar Heidari, Gholamali Ghasemi, Morteza Sadeghi
Specialized scientific evaluation of the manuscript: Negar Heidari, Gholamali Ghasemi, Morteza Sadeghi
Confirming the final manuscript to be submitted to the journal website: Negar Heidari, Gholamali Ghasemi, Morteza Sadeghi
Maintaining the integrity of the study process from the beginning to the publication, and responding to the referees' comments: Negar Heidari, Gholamali Ghasemi, Morteza Sadeghi

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Conflict of Interest

The authors did not have a conflict of interest. Negar Heidari is a master's student in Sport Injuries and Corrective Exercise at University of Isfahan. Dr. Gholamali Ghasemi is a professor of Sport Injuries and Corrective Exercise and Dr. Morteza Sadeghi is an assistant professor of Sport Injuries and Corrective Exercise in School of Sport Sciences, University of Isfahan.

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