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Effects of Eight Weeks of Dynamic Neuromuscular Stabilization Exercises on Respiratory and Functional Tests and Quality of Life of Educable Intellectually Disabled Students: Quasi-experimental Study

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Original Article

Abstract

Introduction: Sedentary lifestyles and neurological disorders among individuals with intellectual disability have caused them to suffer from weaknesses in physical fitness and social adjustment factors. Breathing exercises along with the reconstruction of movement patterns from the first year of life in Dynamic Neuromuscular Stabilization (DNS) exercises, in addition to treatment, can be effective in preventing many disorders in these individuals. Therefore, the present study investigated the effect of 8 weeks of DNS training on respiratory function, functional tests, and quality of life (QOL) of educable intellectually disabled students.

Materials and Methods: In this semi-experimental research, 26 educable, intellectually disabled, female students with a mean age of 17.19 ± 1.50 years and mean intelligence quotient (IQ) score of 61.15 ± 6.07 were selected purposefully and were randomly divided into an experimental (n = 13) and control group (n = 13). Before and after the training intervention, respiratory function, functional test, and QOL variables were assessed using the Rockport Walking Test, the Functional Movement Screen (FMS) test, and the Comprehensive Quality of Life Scale (ComQOL), respectively. Repeated measures ANOVA at a significance level of 0.05 was used to analyze the data.

Results: According to the results of this study, after performing 8 weeks of DNS training, a significant difference was observed in respiratory function (P = 0.001; F = 82.93), right FMS (P = 0.011; F = 51.00), left FMS (P = 0.001; F = 46.09), and QOL (P = 0.001; F = 34.25) in the experimental group compared to before training and compared to the control group (P < 0.05). Therefore, DNS exercises showed a significant effect on respiratory performance, functional tests, and QOL of students with intellectual disabilities.

Conclusion: Based on the current results, it appears that DNS exercises can be used as an effective method for improving the breathing performance, functional tests, and QOL of mentally disabled female students.

Keywords: Mentally retardation; Exercises; Respiration; Quality of life

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Introduction

Intellectual disability is defined as a lack of development in cognitive functions and social adaptability (1), and it occurs at different stages depending on various conditions (2). Approximately 10% of the world's population consists of individuals with disabilities, and 120 to 200 million of them worldwide have intellectual disabilities (3). Children with intellectual disabilities, who have an intelligence quotient (IQ) of 50-69, possess the ability to learn and make progress in education and employment (4). The development of motor skills is of great importance for individuals with intellectual disabilities so that they may achieve appropriate functionality in daily activities (5). However, various studies have indicated weaknesses in different factors related to physical

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readiness among individuals with intellectual disabilities (7, 6). There are significant differences between individuals with intellectual disabilities and healthy individuals in terms of cardiovascular, respiratory, and vascular capacities (3). Factors such as sedentary lifestyle, respiratory infections, scoliosis, and genetic diseases contribute to respiratory disorders, thus increasing the risk of coughing and mortality in these individuals. Neurological disorders and muscle coordination play an important role in respiratory impairments in individuals with intellectual disabilities (8).

Due to the motor skill impairments of these individuals, the designing of a specialized program focusing on fundamental movements should be emphasized (5). Functional performance tests provide the possibility of identifying at-risk individuals. One of these tests is the Functional Movement Screen (FMS), which is used for both athletes and non-athletes (9). FMS primarily indicates success in performing more complex movements that individuals engage in on a daily basis (5). Individuals with intellectual disabilities often lack active participation in social programs. To enable their active participation in society, it is necessary to enhance their self-confidence (10). Both physical and mental health play important roles in the concept of quality of life (QOL), and individuals with intellectual disabilities experience impairments and disorders in these aspects (8). The psychological pressure imposed on families of individuals with intellectual disabilities disrupts peace within their families (11), and research results indicate lower QOL in individuals with intellectual disabilities and their families (11, 10, 8).

Maintaining spinal stability during movements is crucial. Simultaneous contraction of the diaphragm, pelvic floor, and abdominal muscles increases intra-abdominal pressure, leading to trunk stability (12). Exercises performed by individuals with intellectual disabilities should mainly involve local and core muscles, while incorporating correct engagement of the respiratory and nervous systems based on everyday movement patterns. This approach can have significant effects on the performance of these individuals (13). One of the exercises used is Dynamic Neuromuscular Stabilization (DNS). The basis of this exercise protocol is the correction of established neural pathways. The movement patterns of an infant in the first year of life reflect the stages of nervous system development. These exercises, by reconstructing movement patterns and influencing the central nervous system (CNS), actually prevent and treat skeletal, muscular, and respiratory abnormalities and disorders controlled by sensory-motor information and function (14). DNS exercises promote trunk stability through coordinated muscle contractions, which is crucial for the prevention of injuries and respiratory disorders. Diaphragmatic breathing exercises incorporated into the movement patterns of DNS exercises enhance neuromuscular coordination and spinal stability, and result in suitable functioning of the respiratory and musculoskeletal systems (15). Various studies have evaluated the positive impact of DNS exercises on respiration and functional performance tests (17, 16). On the other hand, different studies have indicated weaknesses in physical readiness factors and QOL among individuals with intellectual disabilities (11, 7). Considering the importance of having an efficient respiratory system and improving various physical readiness factors to prevent different injuries and achieve independent living and performance of daily activities, thereby enhancing the QOL of individuals with intellectual disabilities, the present study was conducted to investigate the effects of an 8-week DNS exercise program on respiration, functional performance tests, and QOL in trainable intellectually disabled students.

Materials and Methods

This study employed a semi-experimental research design with both a control group and an experimental group. Pretest and posttest measurements were conducted to examine the effects of an 8-week DNS exercise program on respiration, functional performance tests, and QOL of intellectually disabled female students of 15 to 20 years of age in Fooladshahr, Iran. For the feasibility of implementing this exercise protocol on intellectually disabled students, 2 girls were initially selected to participate in a pilot study. Based on the results obtained from the pilot study and ensuring the safety of the exercise protocol, a total of 28 students were purposively and conveniently selected and assigned to either the control or experimental group based on their IQ scores. Considering a significance level of 0.05 and a power of 0.80, and based on the effect size, a sample size of 18 participants would have been sufficient. However, to account for potential dropouts and to ensure an adequate statistical power, a sample size of 28 participants was considered (18). Initially, the participants were assessed based on their IQ scores and demographic characteristics. Using the Wechsler Adult Intelligence Scale (WAIS), which has a validity of 0.74 and reliability of 0.73, the participants were found to have IQ scores of 50 to 70 (19). In addition, all of the participants were physically healthy (cardiorespiratory health, absence of epilepsy, seizures, and musculoskeletal health), which was confirmed through the medical records available at the Department of Education. The inclusion criteria for this research were intellectual disability, female gender, 15-20 years of age, confirmation of physical health, absence of other disabilities, and written consent of parents. The exclusion criteria included irregular attendance of training sessions (absence from 3 consecutive sessions or 5 alternate sessions), voluntary withdrawal from participation in the research by parents, occurrence of any sudden issue that would prevent the participant's presence, and inability to complete the research tests (20). The recruitment and selection of participants were conducted based on these criteria. Written consent was obtained from parents. By the end of the study, 1 participant from the experimental group had been excluded due to irregular attendance, and 1 participant from the control group had withdrew from the study at the request of their parents, resulting in a final total of 26 students who completed the program.

To assess the respiratory system, the Rockport 1-Mile Walking Test was used to determine the maximum oxygen consumption. During this test, intellectually disabled girls walked 1 mile (1600 meters) at their maximum speed, and elapsed time and the participants' heart rate after completion were measured. Based on the obtained results and using the following formula, the maximum oxygen consumption (VO_{2max}) was calculated, which indicates the efficiency of the cardiorespiratory system (21).

$$VO_{2max}\ (\text{ml/kg/min}) = 132.853 - (0.0769 \times \text{body weight}) - (0.3877 \times \text{age}) + (\text{gender} \times 6.315) - (\text{elapsed time} \times 3.2649) - (\text{final heart rate} \times 0.156)$$

The test used to assess the participants' motor performance was the FMS. This test consists of a set of positions and challenges that assess the level of weakness and muscle imbalance in the participants. The FMS includes 7 movement patterns that can be used to evaluate movement and stability patterns in various positions (22). These patterns include:

Deep Squat Test, which assesses the symmetrical movement of the upper and lower limbs while maintaining trunk stability (Figure 1; Image 1);

Hurdle Step Pattern, which evaluates stepping over an obstacle (Figure 1; Image 2);

Inline Lunge Test, which assesses forward stepping (Figure 1; Image 3);

Shoulder Mobility Test (right and left), which measures shoulder mobility (Figure 1; Image 4);

Active Straight Leg Raise Test (right and left), which evaluates leg raise while lying down with knees fully extended (Figure 1; Image 5);

Trunk Stability Push-Up Test, which assesses trunk stability through performing a Swedish exercise (Figure 1; Image 6);

Rotary Stability Test, which measures neuromuscular coordination (Figure 1; Image 7).

In the execution of all the mentioned movement patterns, a score of 3 is given if the movement is performed without compensatory actions, a score of 2 is given if compensatory actions are present, a score of 1 is given if the movement cannot be performed without compensatory actions, and a score of 0 is given if pain is experienced during the movement (22).

For the assessment of QOL, the Comprehensive Quality of Life Scale (ComQOL) was utilized. The ComQOL consists of several subscales, and the section relevant to intellectually disabled adolescents was used in this study. This questionnaire examines both the subjective and objective aspects of life in these individuals and can also be completed by parents. The total score of this questionnaire ranges from 21 to 105, with higher scores indicating a higher QOL.

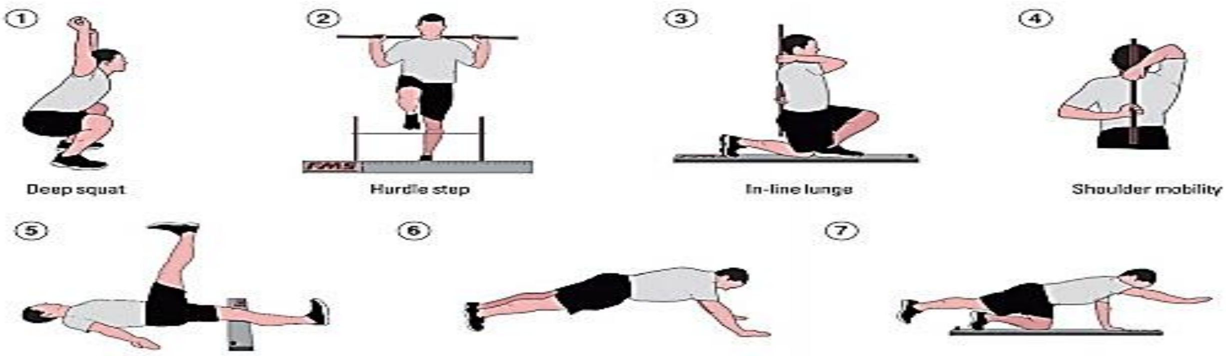

Figure 1. Screening Movements of the Functional Movement Screen: 1) Deep Squat, 2) Hurdle Step, 3) Inline Lunge, 4) Shoulder Mobility Test, 5) Active Straight Leg Raise, 6) Trunk Stability Push-Up, 7) Rotary Stability Test

The reliability coefficient of the ComQOL has been reported as 0.86. For the Persian version, a Cronbach's alpha of 0.89 has been reported. This 7-dimensional scale for individuals with intellectual disabilities evaluates safety, intimacy, material well-being, social inclusion, health, emotional well-being, and productivity (23).

After the pretest, the experimental group underwent 24 sessions of DNS exercises, with each session lasting approximately 40 minutes. The exercise protocol was determined based on previous studies conducted in this area and the participant’s level of ability (15, 14). The exercise protocol was individually tailored to each participant's characteristics and was closely supervised by the examiner. The first session focused on correct diaphragmatic breathing, followed by diaphragmatic breathing exercises combined with DNS movement patterns. As the participants progressed, more challenging DNS movement patterns were incorporated into the breathing exercises. Considering the specific characteristics of the participants, during the implementation of the exercise protocol, individual differences, fatigue, and the level of anxiety and stress of the participants were controlled. Finally, posttests were conducted on the participants. Data collection was carried out by the researcher, who is a master's degree holder in sports pathology and corrective exercises.

To assess the normal distribution of the data, the Shapiro-Wilk test was conducted. Data were summarized using descriptive statistics such as standard deviation and mean. The collected data were analyzed and examined for potential differences between the groups during the pretest and posttest stages using repeated measures analysis of variance (ANOVA) in SPSS software (version 21; IBM Corp., Armonk, NY, USA). A significance level of 0.05 was considered.

This research has obtained ethical approval from the Ethics Committee of Isfahan University of Medical Sciences with the code IR.UI.REC.1399.088. Prior to the implementation of the exercise protocol, written informed consent was obtained from the parents of the participants.

Results

Table 1 displays the demographic characteristics of the participants, including height, weight, age, and IQ score. Based on the t-values, which are not statistically significant for any of the measured variables (P > 0.05), indicating no significant differences between the control and experimental groups, it can be stated that the study groups are homogeneous in terms of demographic characteristics, particularly cognitive performance.

Descriptive statistics and ANOVA results are presented in table 2. In the repeated measures ANOVA, the focus is on the interaction, which indicates the changes between the control and experimental groups relative to each other, and comparing the slopes of the two lines indicates the trend of change. According to the results, it can be inferred that the variables of respiratory function, FMS right, FMS left, and QOL show a significant interaction at a significance level of p < 0.05. This means that the changes in the experimental group were significantly greater than the control group, indicating greater improvement in the experimental group.

Discussion

The present study examined the effect of an 8-week DNS exercise program on respiratory function, FMS, and QOL in intellectually disabled students. The significant interaction observed in all 3 variables (P < 0.05) indicates the effectiveness of this exercise protocol in improving respiratory function, FMS, and QOL in intellectually disabled students.

The results indicate a significant 44.21% improvement in respiratory performance in the experimental group, and considering the lack of progress in the control group, it demonstrates the positive impact of DNS exercises on the respiratory function of intellectually disabled students. In the study by Moon and Renzaglia (24), among the factors contributing to respiratory disorders in intellectually disabled individuals, neurological impairment was identified as a disruptive factor in the pattern of respiratory muscle recruitment. According to this research, exercising the respiratory muscles in intellectually disabled individuals can lead to improvements in respiratory factors. The study by Kunal et al. (25) demonstrated that daily combined exercises of pranayama and meditation improve baseline respiratory rhythm in intellectually disabled individuals.

Table 1. Demographic characteristics of the participants (n = 26)

Variable	Practice (n = 13) (mean ± SD)	Control (n = 13) (mean ± SD)	T	P
Age (years)	17.23 ± 1.300	17.15 ± 2.11	0.69	0.42
Weight (kg)	59.65 ± 9.06	58.15 ± 16.81	0.63	0.52
Height (cm)	158.38 ± 5.66	157.46 ± 8.08	0.78	0.31
IQ	61.23 ± 6.52	61.08 ± 5.66	0.72	0.35

P < 0.05; SD: Standard deviation; IQ: Intelligence quotient

Table 2. Overall results of repeated measures analysis of variance for respiratory function, functional performance test, and quality of life

Factor	Group	Pretest (mean ± SD)	Posttest (mean ± SD)	Changes within the group	Interaction
Rockport test (ml/kg/min)	Experimental	42.24 ± 10.16	51.30 ± 7.39	F = 35.34,	F = 93.82,
	Control	43.91 ± 9.36	42.1 ± 9.14	P = 0.001	P = 0.001*
FMS (right)	Experimental	11.07 ± 3.01	13.53 ± 2.81	F = 39.70,	F = 51.00,
	Control	11.07 ± 1.89	10.92 ± 2.21	P = 0.001	P = 0.001*
FMS (left)	Experimental	12.07 ± 3.40	14.53 ± 2.90	F = 18.93,	F = 46.09,
	Control	11.76 ± 1.69	11.23 ± 2.04	P = 0.001	P = 0.010*
ComQOL	Experimental	75.23 ± 9.74	82.54 ± 9.27	F = 24.44,	F = 34.25,
	Control	69.23 ± 8.79	62.68 ± 8.82	P = 0.001	P = 0.001*

*The accepted significance level is P < 0.05

FMS: Functional Movement Screen; SD: Standard deviation; MS: Multiple sclerosis; ComQOL: Comprehensive Quality of Life

These exercises have a positive impact on brain function, which in turn enhances overall body function to the extent that heart rate and respiration improve in intellectually disabled individuals (25). A systematic review conducted by Bahiraei et al. (26) revealed that individuals with special needs experience weaknesses in physical fitness factors, including cardiorespiratory capacities, compared to healthy individuals. Physical activity can play a role in improving the respiratory system, thus contributing to overall health and enabling independent living in intellectually disabled individuals.

DNS exercises have been mentioned as exercise interventions that can have positive effects on the respiratory performance of individuals with intellectual disabilities. Respiratory function is influenced by various factors, including the strength of respiratory muscles and the nervous system. DNS exercises are defined based on developmental kinesiology principles and emphasize the stability of the spinal column and the desired alignment of the chest. During this exercise protocol, diaphragmatic breathing exercises are performed in different positions (14). DNS exercises primarily emphasize the process of CNS control. During the execution of these exercises, the diaphragm, back muscles, and abdominal muscles are automatically controlled and activated (16). Essentially, by enhancing neuromuscular coordination, optimizing activity, and improving the strength of the diaphragm and other muscles involved in respiratory control, DNS exercises create a foundation for the improvement of respiratory performance. Increasing stability in the spinal column and achieving suitable alignment allows the respiratory muscles to become more efficient and promotes desirable mobility in the chest (27). Park et al. have also demonstrated the positive impact of core stability exercises and optimal stimulation of the chest on pulmonary function (28).

The results indicate a 2.22% improvement in the right FMS score and a 3.20% improvement in the left FMS score in the experimental group, demonstrating the positive impact of DNS exercises on the FMS scores of students with intellectual disabilities. Mahdieh et al. (17) examined the effects of DNS exercises on functional performance tests and demonstrated that this protocol can improve central stability and neuromuscular control, thus enhancing the results of FMS tests in female athletes. Another study demonstrated that (6), if the sports game used is of good quality and suitable for the age and abilities of individuals with intellectual disabilities, it can bring about changes in their motor skills. This indicates that the correct application of fundamental movement patterns in skills can effectively contribute to preventing future injuries (6). Play activities, by burning extra energy, optimizing the development of different body parts, improving learning control, and increasing enjoyment in learning, can improve fundamental skills in individuals with intellectual disabilities. Kesumawati and Rahayu presented a model of a game called "My Mother, My Hero", which was effective in improving basic movement skills in individuals with intellectual disabilities (29). Individuals with intellectual disabilities have low levels of physical fitness and struggle with coordination, particularly in performing complex movements (7). Consequently, they demonstrate poor results in the FMS test, indicating that they are susceptible to various musculoskeletal disorders. DNS exercises involve fundamental functional movements that not only improve core stability, but also enhance flexibility and muscle strength. Motor development begins with head and neck control and progresses to rolling, crawling, kneeling, standing, and walking. The absence of any of these stages of motor development can lead to movement disorders in the future. Reconstructing these movement patterns in DNS exercises provides a basis for improving motor skills and preventing musculoskeletal injuries. These patterns are genetically hardwired and any barrier, such as an underdeveloped nervous system, hinders the initial neural pathway and impairs motor skills. DNS exercises correct movement patterns by improving sensory-motor pathways (17). Respiratory exercises integrated into DNS movement patterns optimize muscle utilization by eliminating excessive contractions and promoting coordinated contractions of the abdominal and diaphragm muscles with the help of pelvic floor muscles, thus enhancing central body stability (30, 5).

The results of the present study indicate a 7.9% improvement in QOL in the experimental group, and considering the lack of progress in the control group, the results demonstrate the positive impact of DNS exercises on the QOL of individuals with intellectual disabilities. Ghosh and Datta (31) showed that regular physical activity, by controlling and improving motor skills, can have positive effects on the social development of individuals with intellectual disabilities, and consequently, improve their QOL. Bondar et al. (32) demonstrated that due to its role in building self-confidence, enjoyment of life, self and others' satisfaction, and enhancing self-efficacy, sports improves psychological factors in individuals with intellectual disabilities, which can lead to an improvement in their QOL. Hashemi at al. (11) stated that improving social structures through simple, affordable, and accessible sports activities provides the conditions for improving the QOL of individuals with intellectual disabilities by influencing their lives. The results of the current study are consistent with that of the mentioned studies due to the improvement in neuromuscular coordination and the functioning of the nervous system. In the study by Taghian et al. (33), 8 weeks of strength and balance exercises had no effect on aggression in individuals with intellectual disabilities. Therefore, the results obtained in this study may not correspond to this research due to the inadequacy of exercise intensity and duration, and the difference in the type of exercises performed. Individuals with intellectual disabilities often experience social challenges and may become socially withdrawn due to a lack of social adaptability. As a result, they may exhibit certain abnormal behaviors that hinder their interactions with others. Recent research has shown that physical activity can have positive effects on the social interactions of individuals with intellectual disabilities and, consequently, improve their QOL (11). Additionally, studies have indicated that individuals with intellectual disabilities have a strong interest in participating in sports programs (3). One such effective exercise program is DNS exercise, which activates muscles through CNS engagement, thereby facilitating improvements in the performance of individuals with intellectual disabilities. Increasing spinal stability through increased abdominal pressure leads to improved central core stability, coordination, and overall body function (34). As body efficiency and self-efficacy increase in individuals with intellectual disabilities, we can observe improvements in their QOL and social adaptability.

Limitations

Due to the specific characteristics and limitations of the participants, such as their restricted ability to perform diaphragmatic breathing during movements, it is not possible to implement the DNS exercise protocol in a group setting. This protocol should be individualized and conducted under the complete supervision of the examiner. Additionally, psychological conditions, lifestyle patterns, and the participants' dietary habits are among factors that can potentially influence the results, but their assessment and control may not have been feasible.

Recommendations

It is recommended that the effects of DNS exercises on male intellectually disabled individuals who are receptive to learning and different age groups be investigated in the future. Furthermore, comparisons with other exercise protocols can be made. This exercise protocol can be evaluated over longer periods of time.

Conclusion

The problem faced by individuals with intellectual disabilities is the underdevelopment of the CNS, which leads to impaired motor function, and consequently, a decrease in their QOL. Repeated DNS exercises have an impact on CNS function and can be extended to daily living activities. Diaphragmatic breathing exercises improve the activation patterns of respiratory muscles and can have positive effects on the respiratory function of individuals with intellectual disabilities. Respiratory function, functional movements, and QOL are among the variables that can be improved through the implementation of DNS exercises. Therefore, it appears that these exercises can be valuable in preventing various physical injuries and musculoskeletal disorders, as well as enhancing life satisfaction in individuals with intellectual disabilities.

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Authors' Contribution

Designing and conceptualizing the study: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Obtaining financial resources for the study: Gholamali Ghasemi
Supportive, executive, and scientific services for the study: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Providing study equipment and facilities: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Data collection: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Analysis and interpretation of results: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Specialized statistical services: Morteza Sadeghi
Manuscript preparation: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Expert evaluation of the manuscript in terms of scientific concepts: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Approval of the final manuscript for submission to the journal office: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi
Responsibility for maintaining the integrity of the study process from initiation to publication and responding to reviewers' comments: Gholamali Ghasemi, Ensie Dehghani, and Morteza Sadeghi

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Conflict of Interest

The authors do not have any conflicts of interest. Dr. Gholamali Ghasemi obtained funding for conducting the basic research related to this article from the University of Isfahan and is currently working as a professor of sports injury at this university. Dr. Morteza Sadeghi is also an assistant professor in the Department of Sports Injury of the School of Sports Sciences in this university. Ensieh Dehghani has been a master's student in sports injury and corrective exercises at the School of Sports Sciences, University of Isfahan, since 2019.

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