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The Effect of Systematic Corrective Exercises on the Ankle Proprioception in People with Functional Pronation Distortion Syndrome: A Randomized Controlled Clinical Trial Study

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Original Article

Abstract

Introduction: Pronation distortion syndrome is one of the most common abnormalities in the lower extremity that causes distortions in the structures of the skeletal parts of the foot. The purpose of this study was to determine the effect of systematic corrective exercises on the ankle proprioception in people with functional pronation distortion syndrome.

Materials and Methods: In this randomized controlled clinical trial study, 30 volunteers who had pronation distortion syndrome were selected and randomly divided into control and experimental groups. The experimental group performed corrective exercises for 12 weeks (3 sessions per week for one hour), while control group performed the routine exercises. Ankle proprioception (using electrogoniometer) was evaluated before and after the interventions. Data were analysed using independent and paired t tests.

Results: Following 12 weeks of corrective exercises, the experimental group showed significant improvement in ankle proprioception ($P = 0.001$); however, there was no significant change in control group ($P > 0.050$). In addition, there was a significant improvement in ankle proprioception in the experimental group compared to control group ($P < 0.001$).

Conclusion: It can be concluded that systematic corrective exercises improve ankle proprioception in patients with pronation distortion syndrome, and it may be recommended for these people.

Keywords: Pronation, Exercises, Proprioception, Posture

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Introduction

Lower limb pronation distortion syndrome, which also affects the anterior part of the foot, is one of the most common anomalies that may cause pain in the foot area and distortions in the structures of the skeletal part of the ankle (Tarsal) and distal and proximal parts of the lower limb (1). In addition to flat foot, individuals with pronation distortion syndrome may experience internal tibial rotation, internal rotation of thighs, genu valgum, and, in the hyperpronation type, increased lumbar lordosis (1). The peroneal muscles, gastrocnemius, soleus, iliotibial band, short head of the biceps femoris, adductors, and psoas experience functional shortness and muscles of the tibialis posterior and tibialis anterior, gluteus medius, gluteus maximus, vastus medialis, and external hip rotators experience functional extension (2).

In this syndrome, the talus and navicular head are placed inwards and downwards, and the direction of the center of gravity is inclined inwards, and finally, the foot sole is flattened. Moreover, this disorder may cause hallux valgus and increased pressure on the proximal parts of the metatarsophalangeal (MTP) joints. Subtalar joints, the first MTP joint, talocrural, the sacroiliac, and the joints between the articular processes will be subject to dysfunction (1,2). These subjects may experience injuries such as Achilles tendon injury (3), plantar fasciitis (4), Medial tibial stress syndrome (MTSS) (5), ankle sprains and instability (6), patellar tendinopathy, patellofemoral pain syndrome (PFPS)

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(7), posterior tibialis muscle tendonitis, anterior cruciate ligament (ACL) injuries, and back pain (1,2). Furthermore, people with this syndrome are at higher risk of plantar fasciitis, knee pain, plantar injuries, fracture stress, poor athletic performance, and impaired balance and ankle proprioception (8). Movement disorders include restriction of dorsiflexion movement in the talocrural joint, weakness of the foot and ankle supinators, intrinsic muscles, and hip external rotator that are manifested by the restriction created in these individuals (9).

Proprioception is an important part of the information inputs of the sensory-motor system, generally referred to as the conscious perception of the position of the limbs in space (10). Mechanical receptors and specialized proprioceptive neurons (muscular spindle, Golgi organ, and articular receptors) are present in the soft tissues around the joints. An increase in pronation, which is associated with some degree of ligamentum laxity, due to the recurrent pressure on the soft tissues following this disorder, may result in impaired ankle proprioception (11). Therefore, patients with pronation distortion syndrome experience a decrease in the ankle proprioception.

The results of previous studies have shown that some corrective exercises to improve the postural stability of people with flat feet and pronation syndrome are superior to other methods (12-14). Another study considered exercise on the muscle group above or below the deformity site or a specific exercise method and emphasized this method for foot pronation correction and improvement of the complications of the pronation distortion syndrome (15).

Efforts to correct foot pronation and reduce its complications including ankle proprioception using old interventions that have a direct effect on feet, such as increasing the strength of the hip joint (16), various types of foot orthoses (17), taping. 18), strengthening the muscles of the ankle area (19), massage (20), and balance and combined exercises (21) have been studied before. There is disagreement about the effectiveness of corrective exercises on foot pronation. However, there are studies that do not confirm such a relationship and indicate that the corrective exercise program does not have a significant effect on improving flat foot complication and its related complications, including ankle proprioception (22-27).

Based on the principles governing corrective exercises and taking into account the fact that individuals with pronation distortion syndrome suffer from an ankle proprioception (11), the use of corrective exercises with a systematic approach may be a good intervention for patients with this syndrome. Besides, there has been no study to show the effectiveness of corrective exercises with a systematic approach including muscle massaging on the foam roller (release exercises in which the muscles are released by the person using the foam roller), stretching exercises (using which the right length is created for the muscles and the muscles become flexible), activation exercises (including distinct isometric posture and strengthening exercises that strengthen the individual's weak muscles), and integrated dynamic exercises (including dynamic combination exercises that increase neuromuscular coordination and strengthen motor units) on improving the ankle proprioception disorders in patients with pronation distortion syndrome, and other treatment methods are very contradictory. Some studies have reported the exercise effectiveness (12-14) and some have reported its ineffectiveness (23-25,28-35). Additionally, these exercises may reduce treatment costs and prevent the side effects associated with this type of syndrome in the future. It is worth noting that the functional pronation distortion syndrome is more common in students in the elementary school and the first and secondary high school (10-16 years old). Moreover, since students at this age are at the peak of physical growth, they may better respond to the corrective exercises, so the present study was of great importance. Therefore, the aim in this study is to determine the effect of corrective exercises with a systematic approach on the ankle proprioception in students with functional pronation distortion syndrome.

Materials and Methods

This study was a single-blind randomized controlled clinical trial carried out to examine the effect of corrective exercises on the ankle proprioception of students with functional pronation distortion syndrome.

The statistical population of the study consisted of male students aged 10 to 16 years. In the present study, the alpha level, beta level, and the effect size of the intervention programs were considered to be 0.05, 0.2, and 0.8, respectively (35). For this purpose, 30 students of 10 to 16-year-old boys with functional pronation distortion syndrome were selected through the New York Screening Test (2) based on the targeted sampling method after matching in terms of age, height, weight, body mass index (BMI), functional flat foot on both feet without pain symptoms, and anthropometric characteristics, using the cluster-randomized method from schools in districts 1, 2, and 3 of Kermanshah Province, Iran. Then, the subjects selected were placed in the two experimental and control groups each with 15 individuals by simple randomized method (coin tossing). The subjects and their parents were provided with information on the lower extremity functional pronation distortion syndrome, the objective of the study and its implementation, and the conditions for improvement and systematic corrective exercises. If they were willing to participate in the study, they will be given a consent form to complete and sign. After signing the form, the person entered the groups and the systematic corrective exercise process as a subject, taking into account the desired criteria.

The study inclusion criteria included ages 10 to 16 and the presence of the functional pronation distortion syndrome according to the diagnosis of an orthopedic doctor and a corrective movement specialist, both of whom were present for evaluation at the same time.

Having the functional pronation syndrome was determined based on all the specifications, including functional flat feet without symptoms of pain, based on the heel rise test, in which the person was placed on the edge of the steps on his toes moving his heel upwards. If a dimple appeared on the sole of the foot, the subject suffered from the functional flat feet (9). Navicular bone drop greater than 10 mm was confirmed using the Brody method (8), second degree flat feet based on the Denis A footprint test by seeing the soles on the mirror box and talcum powder, the sign of which was the identical size of the central part and the front of the foot (23), the genu valgum by measuring the distance between the two inner ankles (at least 4 cm) (24), the lumbar lordosis more than 35 degree (26) using a flexible ruler (Kidoz) by Youdas method (25), and having a natural or corrected vision with glasses or lenses.

Having other acute or chronic debilitating diseases contradictory to exercise or the prohibition by a specialist physician for exercise, history of injury or lower limb surgery, the inner ear and atrial fibrillation diseases, and problems affecting balance in the nervous system, abnormal range of motion (ROM) of the lower extremity joints, and serious orthopedic problems such as having a hard (structural) flat foot, not knowingly completing the consent form and personal health questionnaire, presence or creation of pain during the study, lack of completing the pre-test and post-test tests, and not continuously attending the exercises (absence in the two consecutive sessions or absence in three sessions during the period) were considered as the exclusion criteria.

Systematic Corrective Exercise Program: The subjects in the experimental group performed a regular corrective exercise program for three months, and the control group continued the normal function. The corrective exercise program consisted of two sections of training and practice; in the training section, the correct way to perform the functional activities of daily living was clearly explained in a two-hour theoretical class session. The training section included a total of 21 exercises as listed below.

Muscle Massage on the Foam Roller: Included the muscles of peroneal, gastrocnemius, soleus, psoas, hip adductor, and short head of the biceps femoris, and iliotibial band for 30 seconds

Static Stretching Exercises: were performed on the gastrocnemius and soleus muscles on an inclined surface, the tensor fasciae latae muscle, the short head of the biceps femoris, and the psoas muscle.

Resistance Exercises: To strengthen the sole eccentric muscles, including ankle dorsiflexion and inversion, adduction, extension, and external rotation of the thigh with green and blue Thera band resistance band (Sporting, China) and short leg exercises to strengthen the sole intrinsic muscles.

Dynamic Exercises: Included the Star Excursion Balance Test (SEBT) on all planes, climbing stairs, and launching exercises.

In all exercises, the principles of practice were observed (9). The corrective exercises were collected from different scientific references (2,9,13) (Table 1). The subjects in the experimental group entered the training program one day after the pre-test (3 training sessions per week for three months). The corrective exercises used for the experimental group included 36 sessions of 60 minutes (10 minutes of initial warm-up, 10 minutes of inhibitory exercises, 35 minutes of stretching, strength, and integrated exercises, and 5 minutes of cooling) (2,9). At the same time, the control group continued its normal activities. The screening process and the corrective exercises were implemented in the Corrective Exercise Center of Hazrat Mahdi (as) in Kermanshah Province in the school year of 2017-1028. The individuals cooperated during the exercises and attended the center, and none of them withdrew from the study.

Evaluation of Variables: Before and after 12 weeks of corrective exercises, the desired variables were evaluated in both groups.

Table 1. Corrective exercise program

Parameters Exercises	Purpose or type of exercise	Period	Frequency	Rest	Time(s)	Intensity	Description
Rubbing the muscle on the foam roller	Rubbing the gastrocnemius/soleus muscle on the foam roller	1	1	20	30		Internal part
	Rubbing Biceps femoris muscle on the foam roller	1	1	20	30		Short head
	Rubbing the iliotibial band/ tensor fasciae latae muscle on the foam roller	1	1	20	30		
	Rubbing the peroneal muscle on the foam roller	1	1	20	30		
Stretching exercises	Stretching the gastrocnemius muscles	1	1	10	30		Internal rotation of the back of the foot
	Stretching soleus muscles	1	1	10	30		
	Stretching the Biceps femoris muscle in the open arch mode	1	1	10	30		
	Stretching iliotibial band/ tensor fasciae latae muscle in standing position	1	1	10	30		External rotation of the back of the foot
Resistance exercises	Ankle dorsiflexion (Theraband)	1-2	10-15	20		2/2/4	Tibialis anterior
	Plantar flexion and inversion (Theraband)	1-2	10-15	20		2/2/4	Posterior tibia
	Lifting one calf (on the edge of the step)	1-2	10-15	20		2/2/4	Medial gastrocnemius
	Bending the knee with internal rotation (Traband)	1-2	10-15	20		2/2/4	Medial hamstring
	Collecting the towel under the feet, shortening the feet	1-2	10-15	20		2/2/4	Intrinsic muscles of the soles and toe flexors
	Abduction and external rotation movement against Pilates and bodybuilding elastic bands resistance	1-2	10-15	20		2/2/4	Hip adductor and external rotator
	90-degree bending of the knee against hand resistance in the supine position	1	4	20		25, 50, 75 and 100 percent	Medial hamstring
	Plantar flexion and inversion of the foot in the open arch position with the knee straight against the resistance of the hand	1	4	20		25, 50, 75 and 100 percent	Posterior tibia
	Dorsiflexion of the foot in the open arch position with the knee straight against the resistance of the hand	1	4	20		25, 50, 75 and 100 percent	Anterior tibia
Dynamic exercises	To achieve balance on one leg in several directions (Star Excursion Balance Test (SEBT) in all directions using a chair and without it)	1-2	10-15	30	30		Maintaining a proper arch of the foot, straight knee in the direction against the second and third toes
	Climbing steps and maintaining balance (plyometric exercises using a step)	1-2	10-15	30	30		Maintaining a proper arch of the foot, straight knee in the direction against the second and third toes

Table 1. Corrective exercise program (Continue)

Parameters Exercises	Purpose or type of exercise	Period	Frequency	Rest	Time(s)	Intensity	Description
	Squat on one leg	1-2	10-15	30	30		Maintaining a proper arch of the foot, straight knee in the direction against the second and third toes
	Launching movements and maintaining balance	1-2	10-15	30	30		Maintaining a proper arch of the foot, straight knee in the direction against the second and third toes

Evaluation of Proprioception: An electrogoniometer (SG110A, Biometrics Ltd, UK) was used in order to measure the absolute error of repositioning of the ankle joint angle in four movements. This device has a good validity (r $\geq$ 0.93-0.95) and high reproducibility [intraclass correlation coefficient (ICC) $\geq$ 0.97-0.98] in measuring the ankle joint angle (36). To operate the device, one must first attach it, which has two arms, to the limb at the ankle joint so that the joint is positioned exactly below the junction of the two arms. In order to connect the electrogoniometer to the ankle to assess plantar flexion and dorsiflexion in the sitting position, the protrusions of the tibia head and external ankle of the dominant foot were marked. One of the heads of the electrogoniometer was positioned above the external ankle on the axis connecting the tibia head to the external ankle, and the other head was located along this axis below the external ankle. In order to assess the inversion and eversion movements in the sitting position, one of the heads of the electrogoniometer was placed on the foot along the second toe and the other head was placed in the lower third of the tibia (37,38). In the next step, the radio receiver of the device was connected to the computer and the software program was run. The zero button was pressed to set the current angle to zero. To measure the absolute error of the ankle joint repositioning angle, the subject sat on the bed, with the ankle protruding from the bed and the thigh and knee making a 90-degree angle. The subject's foot was then fixed to the bed using a bandage. To evaluate the angle in the dorsiflexion, plantar flexion, inversion, and eversion movements, the electrgoniometer heads were placed at the desired sites (37,38).

To calibrate the electrgoniometer, the starting point for the inversion and eversion was considered where the ankle was relaxed on the frontal plane, and for the plantar flexion and dorsiflexion, it was a 90-degree angle formed by the longitudinal axis of the sole and the calf. This method made the starting angle for the subjects the same. The subject was asked to repeat one of the angles set three times, and when that angle was reached, the subject was told to learn or memorize the position of that angle. This was performed three times with an interval of 15 minutes to reduce the effect of learning. In order to familiarize the students with the movements, the tester once moved their feet for inactive training and asked the subject to perform these movements for measurements. In order to reconstruct the 10-degree dorsiflexion angle, the subjects were first asked to move their ankles to the target angle three times with their eyes open, hold them in the same position for 5 seconds, and memorize the target angle. Then, in order to eliminate the visual intervenor, the subject's eyes were blindfolded, and after 7 seconds of pause, he/she actively repoaition the target angle, and when he/she reached the target angle, informed the tester by saying the word “here”. The difference between the angle created in the repositioning of the ankle joint angle and the target angle was considered as the error angle regardless of whether its direction was positive or negative as an absolute error.

This move was repeated three times, and finally, the mean of the three error angles obtained was considered as a record. After a 1-minute rest, the 20-degree plantar flexion angle, the 20-degree inversion angle, and the 10-degree eversion angle were reconstructed in this manner. In order to prevent learning that could occur after each movement, the subjects were not given any feedback on their performance (36,39).

The tests were conducted in one session and did not cause any problems or discomfort for the students. The students' moods were considered during the tests, and enough time was given to rest between tests so that the individuals would not get too tired or injured.

Descriptive statistics tests such as mean and standard distortion (SD) were employed to describe the data. In the inferential statistics section, first the Levene test was used to check the normal distribution of the data, and then the independent t-test and paired t-test were utilized to compare the mean values between the groups and the effect of the independent variable on the dependent variables. The data were analyzed in SPSS software (version 22, IBM Corporation, Armonk, NY, USA).

Results

Given the results of the Levene test, the data of the two groups had a normal distribution. There was no sample drop in the present study. The demographic characteristics of the subjects are presented in table 2. Based on the findings, there was no significant difference between the groups in the pretest stage.

Table 2. Demographic characteristics of the subjects

Variable	Groups	n	Mean ± SD	P value
Age (year)	Experimental	15	12.6 ± 1.7	0.676
	Control	15	12.6 ± 1.8	
Height (cm)	Experimental	15	165.3 ± 6.5	0.145
	Control	15	166.4 ± 9.5	
Weight (kg)	Experimental	15	67.1 ± 5.7	0.06
	Control	15	68.9 ± 9.9	
BMI (kg/m2)	Experimental	15	24.5 ± 1.6	0.182
	Control	15	24.7 ± 2.2	

BMI: Body mass index; SD: Standard deviation

Ankle Proprioception: Information on the students' ankle proprioception is displayed in table 3. Following 12 weeks of systematic corrective exercises in the experimental group students, the ankle proprioception improved significantly in the four movements mentioned (P = 0.001), but no significant difference was observed in the control group (P > 0.050). Overall, there was a significant difference in the ankle proprioception of the students of the experimental and control groups, so that the ankle proprioception of the experimental group was better than that of the control group.

Discussion

This study was accomplished with the aim to determine the effect of 12 weeks of systematic corrective exercises on the ankle proprioception of students with functional pronation distortion syndrome. The findings suggested that the proprioception of the participants in the experimental group was better compared to the control group after the end of the corrective exercise program. They had a lower angle repositioning error (greater proprioception) in the dominant foot than the control group. This finding indicates the higher effectiveness of the regular corrective exercises method compared to the usual activity; this is consistent with the results of studies by Chung et al. (12) and Najafi et al. (14). They reported that the postural stability, physical condition, and proprioception of the subjects in the experimental and control groups before the corrective exercises were not different, but this trend was reversed after performing the corrective exercises, and the experimental group subjects had a better postural stability and proprioception compared to the pretest stage and the control group (12,14). The reason for this alignment may be the use of the corrective exercises in these studies (12,14) similar to the exercises applied in the present study. Najafi et al. used combined exercises in their study (14), but the systematic exercises were used in the present study.

Table 3. Absolute error of the ankle joint repositioning angle (ankle proprioception)

Variable	Groups	Pre-test (mean ± SD)	Post-test (mean ± SD)	t	P value (Paired t)	P value (Independent t)
Dorsiflexion (10 degrees)	Experimental	2.52 ± 0.72	1.10 ± 0.19	8.43	< 0.001*	0.001**
	Control	2.66 ± 0.68	2.63 ± 0.70	1.63	0.125	
Plantar flexion (20 degrees)	Experimental	3.69 ± 0.58	1.29 ± 0.34	23.09	0.001*	0.001**
	Control	3.78 ± 0.55	3.75 ± 0.54	1.93	0.070	
Inversion (20 degrees)	Experimental	2.22 ± 0.35	1.12 ± 0.25	18.08	0.001*	0.001**
	Control	2.20 ± 0.41	2.18 ± 0.40	1.65	0.121	
Eversion (10 degrees)	Experimental	1.58 ± 0.27	0.71 ± 0.15	14.59	0.001*	0.001**
	Control	1.63 ± 0.24	1.61 ± 0.24	1.85	0.085	

*P < 0.050 Experimental group compared to control group (Paired t test), **P < 0.050 experimental group compared to control group (Independent t test)

Morrison and Kaminski conducted a review study and concluded that when the ankle proprioception is reduced due to anomalies, it causes muscle imbalance and increased instability, and ultimately, damage to the joint (40). This finding did not match the findings of the studies carried out by Cote et al. (8) and Nobakht et al. (28). The reason for the discrepancy with the present study may be due to the type of study, because the systematic corrective exercises were used in the present study, but the study by Nobakht et al. (28) was of the comparative type. In general, the inconsistency in the findings of the studies is due to the compensation of the neuromuscular defect to reduce the high load on the internal longitudinal arc in these subjects. However, in the present study, systematic corrective exercises were performed to improve posture and increase the ankle proprioception. Furthermore, the use of different training protocols with different approaches, the characteristics of the study participants (age, gender, and different populations), and different tools or assessment methods can be the causes for the inconsistency of these studies.

The findings in some investigations have indicated that a series of specific and corrective sports interventions and exercises lead to improved ankle proprioception and instability, which is one of the secondary complications associated with this type of syndrome (20,21,37,41). In the present study, the use of appropriate corrective exercises may increase the efficiency of muscles and joint receptors, muscle spindle, and Golgi muscles, and these muscles and their proprioceptive receptors before the exercises in the experimental group, did not have coordinated and appropriate activity to understand the ankle proprioception. Therefore, in order to improve and enhance the ankle proprioception and reduce the physical abnormality of the individuals with this type of syndrome, designing and organizing a regular corrective training course that was conducted in the present study and followed by the experimental group seem appropriate.

Biomechanical changes caused by ankle pronation may affect joint loads, mechanical muscle performance, proprioceptive feedback, and orientation, leading to changes in the neuromuscular control of the lower extremities (42). In individuals with flat feet and pronation syndrome, the direction of the ankle joint changes due to the rotation of the talus and calcaneovalgus, leaving the whole structure in a completely unstable position (43). Additionally, due to excessive stress applied on the proprioceptive receptors (muscular spindle, Golgi limb) and tendon-bone structures, the proprioception and kinesthesis of the muscles around the joint are reduced (43). Subjects with the sole structural deformity are more likely to engage the sensory-motor system to cope with the unbalanced state caused by confusion, thereby preventing the fall (44). Defects in the sole receptors cause increased postural oscillations (44). Afferent nerve fibers are important components for motor control, and the muscle spindles that are the muscle sensory receptors are greatly influenced by the information sent through the joint afferents (44); i.e., in response to the afferent messages, the joint-tendon-muscle relation in the form of an efferent command, control and dynamize the joint (44).

By strengthening the muscular structures through resistance training, which is part of the corrective exercises, proprioception can be increased by stimulating the muscular spindle and the Golgi organ (45). Muscle spindles receive static and dynamic stimuli from gamma-afferent neurons, and resistance training may increase the gamma-afferent activity, thereby increasing the proprioception (45). Regarding how regular corrective exercise can affect the ankle proprioception, it can be explained that stretching, contraction, and strengthening of the thigh, knee, leg, ankle, and sole muscles may improve the nervous-muscular system and their coordination and balance. It may also increase the efficiency and number of the proprioceptive receptors of muscles (muscle spindle and Golgi organ) and joint receptors, thereby reducing the mean absolute error of the repositioning angle and increasing the ankle proprioception (14). Corrective exercises with increased lower limb strength may provide better muscle stabilization (length-stress) and, as a result, increase accuracy during the test, and ultimately, subjects may achieve a better record (45). Therefore, the mean absolute error of the reposinioning angle is decreased, in other words, the ankle proprioception is increased.

Limitations

In the present study, there were limitations in the control of nutrition, mood, and mental state of the subjects, because the samples were monitored only within the center of corrective exercise and for accurate execution of the corrective exercises. Besides, the study was performed only on 10- to 16-year-old male students.

Recommendations

It is suggested that the present study be conducted on larger samples. Moreover, samples including male and female students in different age groups should be practiced and evaluated. It is better to perform the same study on individuals at different and longer times.

Conclusion

Given the finding in the present study, systematic corrective exercises are likely to improve the ankle proprioception in students with functional pronation distortion syndrome. Therefore, it is recommended for this group of students. Furthermore, it can be concluded that coherent and neuromuscular exercises should be part of corrective exercises to increase the ankle proprioception and improve the physical condition of patients with functional pronation distortion syndrome.

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Authors' Contribution

Ali Golchini: Study design and ideation, attracting financial resources for the study, supportive, executive, and scientific study services, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistics services, manuscript arrangement, specialized manuscript evaluation in terms of scientific concepts, confirmation of the final manuscript to submit to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments; Nader Rahnama: Study design and ideation, attracting financial resources for the study, supportive, executive, and scientific study services, providing study equipment and samples, data collection, analysis and interpretation of results, specialized statistics services, manuscript arrangement, specialized manuscript evaluation in terms of scientific concepts, confirmation of the final manuscript to submit to the journal office, responsibility for maintaining the integrity of the study process from beginning to publication, and responding to the referees' comments.

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Conflict of Interest

The authors declare no conflicts of interest. Dr. Nader Rahnama attracted funding from the University of Isfahan to conduct basic studies related to this study, and he has been working as an associate professor in the department of physical education in the field of sports pathology and corrective exercise at this university since 2005. Ali Golchini has been a PhD student in Sports Pathology and Corrective Exercise, School of Physical Education, University of Isfahan, since 2014.

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