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Comparing the Effect of 8 Weeks of Total Body Resistance Exercise and Core Stability Training on Selected Common Abnormalities and Postural Control in Deaf Adolescents

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ABSTRACT

Background: Deafness is the most common sensory-neurological defect in human beings. This study aimed to compare the effect of 8 weeks of Total Body Resistance (TRX) and core stability training on balance and some common abnormalities among deaf adolescents.

Methods: This study was conducted with a two-group pretest-posttest quasi-experimental study design. The participants included in this study were 20 hearing-impaired students with a degree of deafness between 71-90 dB in Bandar Abbas city who were purposefully selected and then randomly assigned into two groups, as TRX (N=10) and core stability training (N=10). In this study, static balance, dynamic balance, kyphosis and lumbar lordosis, and forward head were measured before and after eight weeks in both groups using one-leg stance test, Y balance test, flexible ruler, and goniometer, respectively. The core stability training consisted of 10 different exercises in the core in terms of the progressing and the TRX protocols. Moreover, these exercises were performed 3 sessions per week for an 8-week period (1 day in between), and each session lasted for 40 minutes. The dependent and independent t-tests were also used to perform the intra-group and inter-group comparisons, respectively. The statistical significance level was set at $P \leq 0.05$.

Results: The research results show that the abnormalities in the two methods of static balance with open and closed eyes as well as dynamic balance were equally evaluated based on the independent t-test and there was no significant difference between these two methods ($P \geq 0.05$). Also, in the forward head, kyphosis, and lordosis variables, the performances of these two methods to reduce the abnormalities were equally evaluated. In this regard, no significant difference was observed between the performances of these two methods ($P \geq 0.05$). However, there was a significant difference between the effects of TRX exercises and core stability training on dynamic balance ($P \leq 0.05$).

Conclusion: Therefore, to reduce abnormalities and improve balance in deaf children, both methods can be considered as effective with no difference.

Introduction

Deafness can be caused due to a problem in the small bones in the middle ear transmitting sound, or a problem in the branches of the vestibulocochlear nerve, known as the eighth cranial nerve, which transmits sound to the brain [1]. Moreover, hearing loss is a multifaceted condition with various medical and social aspects. In addition to experiencing communication barriers, deaf and hard-hearing children often are more subjected to

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physical, emotional, and sexual abuses compared to hearing children [2, 3].

Balance or postural stability is defined either as the ability of maintaining the Center of Gravity (COG) of the body within the Base of Support (BOS) or as the ability of maintaining a position to perform a movement or in response to an external disturbance applied [4]. Moreover, some factors affecting posture and balance in an individual's life can also change his/her living environment. Since the vestibular system is one of the three effective systems on maintaining posture and mobility, the evaluation of this system's contribution to control the posture and balance seems essential. According to numerous sources, the information provided by the vestibular system can play a decisive role in the maintenance of posture and balance, which can also be applied to the same extent that used the Visual-Somatosensory (VS) information [5, 6]. Balance, as one of the most controversial concepts in the sensory-motor system, examines the complex interaction between sensory input and motor responses required either for the maintenance or for change in the posture. Balance is considered as one of the key, inseparable components of the Activities of Daily Living (ADL) [7]. When there is a weak balance, some problems arise in performing those functional tasks associated with the activities of daily living. Furthermore, various studies have reported the negative effects of postural instability on the changes occurring in spinal curvature such as forward head deviation, thoracic hyperkyphosis, and lumbar lordosis. Also, any changes in one of the spinal curvatures can trigger the compensatory mechanisms in the spine, and consequently bring about changes in other spinal curvatures as well. Correspondingly, some studies have shown that by changing the forward head position, the effect of gravitational forces on the head increases, which induces degenerative changes in the cervical spinal joints in the long run as well as leading to intervertebral disc damage [8]. Furthermore, in the long run, it can also increase kyphosis [9].

Core stability is known as the motor control and muscular endurance in the core, which has a duty of maintaining the stability of this core in various postures and external forces applied to it. In this regard, core instability occurs when the disorder development does not resolve [4]. Also, the roles of core stability in improving athletic performance as well as injury prevention have been demonstrated in the literature. Clark et al. stated that core stability prevents the occurrence of incorrect movement patterns, so it improves athletic performance by maintaining postural alignment and a proper posture during performing functional activities [10]. The core stability of the body is also considered as one of the factors associated with an upper extremity injury. In addition, it has been reported that when long-term core stability training is performed as a supplement for training programs, the duration of maintaining a specific posture will be significantly improved and increased [11]. Moreover, these exercises by focusing on the abdominal and lower back muscles reduce the pain in the lower back as well as reducing lumbar injuries by maintaining a proper spinal alignment [12]. Studies have also shown that after performing these exercises, significant changes can be observed in speed and strength [13]. Accordingly, this increase in strength leads to an increase in the subjects' balance over time, which occurs as a result of performing core stability exercises [14]. In this regard, a variety of tools and equipment are used to perform resistance exercises. Among the tools recently applied to perform such exercises, Total Body Resistance (TRX) exercises are included, which are often used to improve muscle strength and athletic performance, rehabilitate orthopedic diseases, and prevent the loss of muscle strength in the elderly [15]. Since this training method has been recently applied in research topics, the researcher found no article directly associated with this subject. However, according to numerous sources, the effectiveness of this training method on the improvement of flexibility and strength, which are considered to be fundamental to correct abnormalities, has been confirmed [16].

Thus, the proprioception, balance, and possibly common abnormalities of movements appear to be affected by the TRX exercises. Moreover, it was shown that, both core stability training and TRX increase strength. Therefore, due to the low level of balance, which is an important factor in the maintenance of posture and also plays a role in performing the activities of daily living and health of deaf people. Also, on the other hand, due to the lack of research on the effect of TRX exercises on the problems faced by deaf people as well as comparing this treatment method with core stability training, as a treatment for the abnormalities and injuries among deaf people, in the present study, the researcher intended to compare the effect of 8 weeks TRX and core stability training on balance and some common abnormalities in deaf adolescents.

Methods

This study was conducted with a pretest-posttest quasi-experimental design. Concerning the limited size of the population, among all hearing-impaired students in Bandar Abbas city, 20 congenital hearing-impaired students were finally selected, whose degrees of deafness were between 70-91 decibels (dB). The inclusion criteria were as follows: male gender, the age range of 12-14 years old, no pathological history, absence of other diseases, no fracture, and not having a sport background, which were considered in the selection of samples. Moreover, the exclusion criteria were the followings: not doing exercises and leaving training sessions. In order to collect information before conducting the research, the Sports-Medicine Information Questionnaire and the consent form were completed by the subjects and their parents. In this regard, in a briefing session, the participants were acquainted with the details of the training program as well as how to perform the exercises and the test correctly. Notably, the subjects were approximately at the same level in terms of age and level of physical activity. After providing the information regarding the research objectives and methods to the subjects, the written consent to participate in the research was obtained from them. After selecting the subjects, they were randomly assigned into two experimental groups, as core stability training and TRX. This study was passed in Ethical Committee of Biomedical School of Islamic Azad University, Isfahan branch (Khorasgan).

Measuring Variables

Static Balance

In the One-Leg Stance Test (OLST), the subject stood on a flat surface without shoes, put his hands on his hips, and then put his non-dominant leg near his dominant leg knee. Afterward, he lifted his hills off the ground to balance on his toes. Once the subject lifted his hills off the ground, the stopwatch was started. The test was repeated three times and the best record was set. The stopwatch was stopped under the following conditions: 1) when the hands were taken off the hips, 2) when the dominant leg swung in any direction, 3) when the non-dominant leg lost contact with the knee, and 4) when the dominant leg heel touched the ground [1].

Dynamic Balance Test

To measure the Y Balance Test (YBT), the Y Balance Test Kit was used. In this study, concerning the measurement of the reliability of the YBT for the lower extremity, the intraclass correlation coefficient (ICC) and the ICC were reported to be 0.91-0.85 and 1.0-00.99, respectively. In the present study, a device similar to the YBT kit was made by the researchers, which its reproducible results are presented in the results section. In this regard, to measure CCI, 9 female subjects repeated the test for five times. To prevent the fatigue and learning effects, the time interval between each measurement was considered as 20 minutes [1]. Accordingly, this device consists of a fixed plate to which three bars with an angle of 120 degrees relative to each other are connected. There is a moving marker on every calibrated bar that can be pushed to determine the maximum access distance. Also, the access directions in the YBT are anterior, posteromedial, and posterolateral. To measure the non-dominant direction balance, firstly, the subject put his non-dominant leg on the fixed plate to get support and then moved his dominant leg in the posterolateral direction to determine the maximum access distance. Afterward, he returned to the initial state of the test. In addition, to measure the dominant direction balance, the subject put his dominant leg on the fixed plate and performed the access action with his non-dominant leg. Accordingly, the maximum access distance was read and then recorded through the calibrated bar at the edge of the marker. This test was repeated three times for each extremity, and the highest access score obtained from every direction was used for analysis. Also, to prevent fatigue, two minutes were taken between each effort. Meanwhile, before starting the test, the subjects' dominant leg was identified by hitting the ball regarding their willingness. It is noteworthy that, the subjects' access distance is affected by the length of their lower extremity; therefore, the raw balance scores were normalized based on the length of the subjects' extremities. To record the length of the lower extremity, the distance between the anterior superior iliac spines (ASIS) to the medial malleolus in the ankle was measured. The YBT errors, due to which the test was repeated, were as follows: 1) The subject could not maintain his stability on the fixed plate, 2) The free leg was detached from the marker on the bars, while the marker was still moving (throwing the marker), 3) Using the marker to maintain the stable position (the subject's fingers were on the marker), and 4) After performing the access action, the subject could not return the free leg to the starting position. If an error occurred, the test would be stopped and then performed again. Moreover, if the subject was not able to perform the test in 6 attempts in terms of the above-mentioned instructions, he would fail in that direction and no score would be recorded [17-19]. The YBT for the lower extremity is shown in Figure 1.

Measurement of Lordosis, Kyphosis, and Forward Head Abnormalities

The volunteer participants of this study were asked to take off their upper body clothes, so that the researcher could identify the three C7, T12, and S2 vertebrae through observing and touching their spine with his fingers. In this regard, to find the C7 vertebra, while the subject's upper body was completely naked, he was asked to tilt his head forward while in standing position, and thus his most prominent vertebra, as C7, was found and then marked. Subsequently, to find the T12 vertebra, at first, the L4 spinous process was found by touching the Iliac crest on both sides, and then T12 was identified by

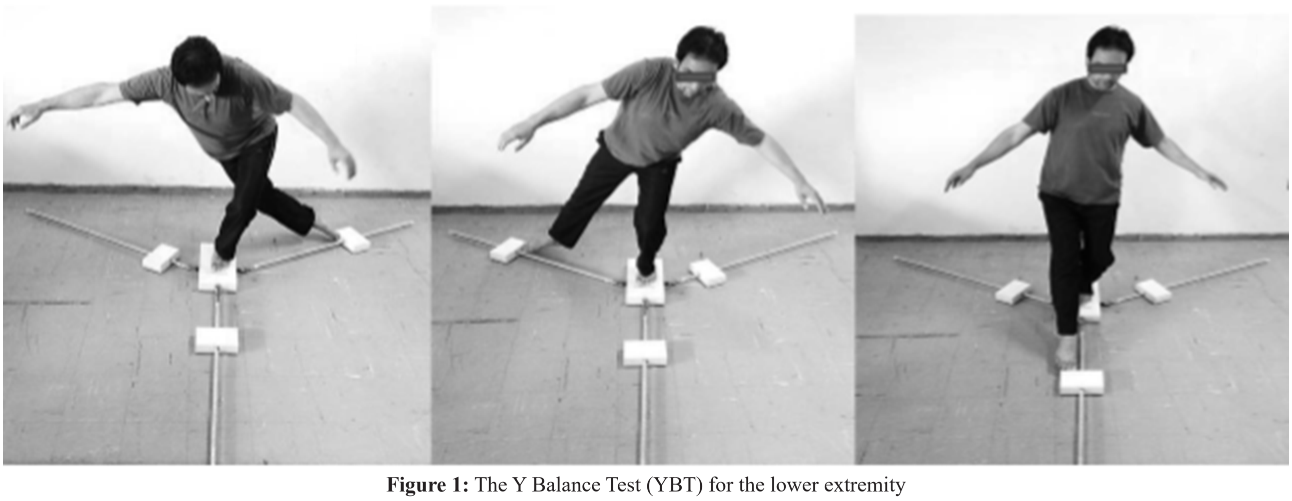
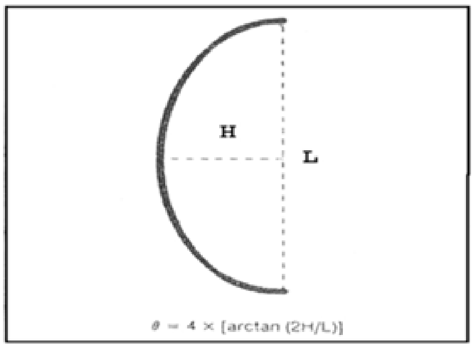


Figure 1: The Y Balance Test (YBT) for the lower extremity

counting the vertebrae upwards. Notably, another way to identify the T12 vertebra is to find the subject's last ribs on both sides by touching them and following the path of the ribs to reach the T12 vertebra.

Then, while the subject was standing in a relaxed position, his body weight was equally distributed between both legs and he faced forward. The examiner placed the fixed arm of the goniometer alongside the seventh cervical vertebra, parallel to the ground surface (aligned with it), the moving arm was placed alongside the external auditory canal (EAC), and the number read by the goniometer was considered as the forward head angle (FHA) for each subject [20]. All the participants in this study were tested three times and their mean was regarded as the FHA. Then, to find the T12 vertebra, the subject was asked to place his hands on the edge of the table and to transfer his weight to his hands while standing in half forward bend position, the examiner touched the twelfth rib of the subject on both sides with his thumb, and simultaneously followed the path of the ribs upwards and inwards to the point where they disappeared into the soft tissue of the body. At this point, the tips of two thumbs were connected by the researcher by drawing a straight line, and consequently, the location of the L4 spinous process was determined. It was found that, the last point of the intended mark was S2, whose spinous process is at the same level as the posterior superior iliac spine (PSIS). In this regard, the specified points were then marked with an easy-to-clean and anti-allergic oil pen. All these measurements were performed in a relaxed standing position and the subjects were asked to face forward and stand in a position where their weight was distributed between both legs during the measurement. After specifying the desired points, they were transferred to the ruler placed on the spine. At the end, the ruler was carefully removed from the spine and then placed onto the desired paper, the curve was drawn on the paper using a pencil, and the desired points were specified on the curve drawn. Also, the distance between the two L and H (curve depth (width)) points was measured by a ruler, and the obtained numbers were entered the following formula to calculate the kyphosis and lordosis angles [21]:

$$\emptyset = 4Arctan2H/L$$



Training Protocol

After selecting the subjects, they were randomly assigned into two experimental groups. Accordingly, the subjects in the TRX group performed an 8-week TRX program under the supervision of an instructor who was experienced in core stability training and TRX exercises. After explaining the research procedure to the subjects, static balance, dynamic balance for the lower extremity, forward head, kyphosis, and lordosis were measured in both groups. In this study, the intended exercises were performed 3 sessions per week, each one lasted for 40 minutes over an 8-week period in both groups. The training groups participated in a core strength training program that was continuously implemented. Core stability exercises consisted of 10 different core exercises, which were performed in terms of the training protocol program presented in Table 1 [16].

The duration of each training session was about 40 minutes. Also, the intensity of the exercises has been increased after the end of each week. The protocol exercises included bridge with leg lift, static contraction of the abdominal muscles, lower trunk rotation, abdominal bridge, right-side bridge, left-side bridge, bicycle crunch, bridge with march, Sit-Up with hands outstretched, and bilateral leg lowering, which each one of them was

Table 1: Core stability training protocol

Week	Bridge with leg lift	Static contraction of the abdominal muscles	Lower trunk rotation	Bridge (abdominal, left-side, and right-side)	Bicycle crunch	Fully vertical Sit-Up	Bridge with march	Sit-Up with hands outstretched	Dumbbell trunk rotation	Bilateral leg lowering
First	10 reps[1]	20 reps	5 reps	3 reps 10s	15 reps	10 reps	10 reps	10 reps	10 reps	5 reps 10s
Second	15 reps	30s	5 reps	3 reps 15s	20 reps	15 reps	15 reps	15 reps	10 reps	5 reps 15s
Third	15 reps	2 sets of 20s	10 reps	3 reps 30s	25 reps	20 reps	15 reps	20 reps	15 reps	5 reps 15s
Fourth	2 sets of 10	2 sets 30s	10 reps	3 reps 30s	2 sets of 20	25 reps	2 sets of 10	25 reps	2 sets of 10	5 reps 20s
Fifth	2 sets of 15	2 sets of 45s	15 reps	3 reps 45s	2 sets of 20	2 sets of 15	2 sets of 15	2 sets of 15	2 sets of 15	5 reps 20s
Sixth	2 sets of 15	2 sets of 45s	15 reps	3 reps 45s	2 sets of 25	2 sets of 20	2 sets of 15	2 sets of 20	2 sets of 15	5 reps 25s
Seventh	2 sets of 20	3 sets of 50s	20 reps	3 reps 60s	2 sets of 25	2 sets of 30	2 sets of 20	2 sets of 20	2 sets of 20	5 reps 25s
Eighth	2 sets of 20	3 sets of 50s	20 reps	3 reps 60s	2 sets of 25	2 sets of 35	2 sets of 20	2 sets of 25	2 sets of 20	5 reps 25s

[1]Repetitions

performed in one training session in three sets.

Before the start of the training program, the participants contributed in an introductory session on exercises, training safety principles, and the principled use of the TRX rope. The training and the combined groups performed TRX exercises 3 times a week for an 8-week period. This 8-week TRX training included large upper extremity, lower extremity, and core muscle groups. Each training session consisted of 10 minutes of warm-up followed by 45 minutes of TRX training, which was ended with a 10-minute cool-down, respectively. The training programs of the training group and the combined group are presented in Table 2. During the 8-week training program, the control group's subjects performed their normal daily activities.

Descriptive statistics and inferential statistics were used to describe the variables analyze data, respectively. The Shapiro-Wilk test was used to test the normality of data, and the Levene's test was then used to assess the assumption of the equality of variance. Therefore, to compare the two variables between these two groups, the independent and dependent t-tests were used through SPSS software. The significant level was set at $P \leq 0.05$

Results

Based on the results of the Shapiro-Wilk test, the distribution of data was normal in all variables in both training groups ($P>0.05$). Also, the results of the Levine's test showed that the variances of the two groups were equal in all variables ($P>0.05$).

The results presented in Table 3 show that there was no significant difference in the mean pre-test scores obtained from the subjects' characteristics such as height, weight, age, and body mass index (BMI) between these two groups. Moreover, the two groups were homogeneous in terms of these characteristics.

The results given in Table 4 show that the static balance with open eyes was significant in the intra-group comparison ($P \leq 0.05$); however, no significant difference was observed in the inter-group comparison between the core stability and TRX groups ($P \geq 0.05$). Moreover, the static balance with closed eyes was also significant in the intra-group comparison ($P \leq 0.05$); however, there was no significant difference in the inter-group comparison between the core stability and TRX groups ($P \geq 0.05$).

The anterolateral and posterior directions were

Table 2: TRX training program

Warm-up for 10 minutes		
Sequence of movements	**Exercise**	**Repetition**
1	Shoulder	15-20
2	Squat with biceps	15-20
3	Triceps	15-20
4	Aerobic exercises	120 seconds
5	Cross fly	15-20
6	Single-leg squat	15-20
7	Swimming	15-20
8	Aerobic exercises	120 seconds
1	Shoulder	15-20
2	Squat with biceps	15-20
3	Triceps	15-20
4	Aerobic exercises	120 seconds
5	Cross fly	15-20
6	Single-leg squat	15-20

Cool-down for 10 minutes by performing TRX-specific strengthening exercises

Table 3: Summary of descriptive information on the distribution of demographic characteristics of the sample

Variable	TRX	Core stability training	t-value	Significance level
	Mean±SD			
Age (years old)	14.91±1.24	14.66±1.23	0.49	0.62
Weight (kg)	42.32±5.51	43.56±5.25	0.56	0.57
Height (cm)	148.39±2.58	147.50±2.31	0.89	0.38
BMI (kg/m)	19.17±2.09	19.97±1.92	0.97	0.34
Degree of deafness	76±3.2	79±2.6	0.78	0.42

Table 4: Evaluation of static balance with open and closed eyes as well as dynamic balance in deaf adolescents using two methods

	Study group	Pre-test	Post-test	t-dependent test		t-independent test (pre- and post-test differential effect)	
		Mean±SD (seconds)		Test value	Significance level	Test value	Significance level
Static balance with open eyes	TRX	31.5±1.83	34.3±1.98	3.78	0.003	1.64	0.10
	Core stability training	28.8±1.86	34.6±1.50	2.79	0.006		
Static balance with closed eyes	TRX	13.2±1.25	19.6±1.34	3.68	0.004	0.75	0.46
	Core stability training	14.3±0.92	18.3±1.11	2.80	0.017		

Table 5: Evaluation of dynamic balance among deaf adolescents using two methods

Study group		Pre-test	Post-test	t-dependent test		t-independent test (pre- and post-test differential effect)	
		Mean±SD (cm)		Test value	Significance level	Test value	Significance level
Anterior	TRX	82.25±1.54	85.66±1.30	17.70	0.000	6.84	0.000
	Core stability training	89.41±2.71	93.75±2.22	10.74	0.000		
Posteromedial	TRX	90.16±4.36	95.08±2.99	2.98	0.01	1.06	0.29
	Core stability training	87.58±2.93	94.66±6.26	5.98	0.000		
Posterolateral	TRX	93.41±2.93	93.91±3.94	0.33	0.74	0.000	1.00
	Core stability training	92.33±2.38	92.83±1.99	0.48	0.64		

Table 6: Evaluation of forward head, kyphosis, and lordosis in deaf adolescents using two methods

	Study group	Pre-test	Post-test	t-dependent test		t-independent test (pre- and post-test differential effect)	
		Mean±SD (angle)		Test value	Significance level	Test value	Significance level
Forward head (angle)	TRX	36.33±7.63	32.16±7.03	2.02	0.04	1.57	0.13
	Core stability training	36.25±5.80	36.08±5.59	0.41	0.68		
Kyphosis (degree)	TRX	36.41±7.10	35.67±5.74	1.35	0.20	1.48	0.13
	Core stability training	38.25±5.36	38.75±5.69	1.61	0.10		
Lordosis (degree)	TRX	40.2±8.86	39.2±5.83	0.89	0.38	0.000	0.99
	Core stability training	41.2±8.72	38.9±08.39	1.39	0.19		

significant in the intra-group comparison; however, they were not significant in the inter-group comparison.

In addition, the mean values of the forward head, lordosis, and kyphosis abnormalities for deaf adolescents by the two methods of TRX and core stability training are presented in Table 5.

The results presented in Table 6 show that there was no significant difference between the performance of these two methods on reducing kyphosis, lordosis, and forward head based on the t-test.

Discussion

The results show that there was a significant increase in the mean static balance with open and closed eyes in the core stability training and TRX groups in the post-test compared to the pre-test. It was also found that there was no significant difference between the two training groups. Also, there was a significant increase in the mean dynamic balance in hands and legs in core stability training and TRX groups in the post-test compared to the pre-test. Moreover, there was no significant difference between the training groups in this regard. In a study by Patel et al. on comparing balance performance in children with and without hearing loss (HL), it has been shown that children with HL had significantly weaker balance compared to normal and healthy children [22]. Since the vestibular system and the cochlea in the ear are anatomically very close to each other, if one part is damaged, the other part may also be damaged as well. In this case, it can be considered as a reasonable assumption that, besides having sensorineural hearing loss (SNHL), hearing-impaired people develop vestibular disorders as well [1].

There have been several studies on the effect of core stability training on the balance performance of deaf children. For instance, Hesari et al. in their study investigated the effect of an 8-week core stability training program on the balance of hearing-impaired students [23], and 27 deaf boys were examined in this study. Accordingly, the results revealed that there were significant increases in the static and dynamic balance following an 8-week training in the experimental group, which is consistent with the results of the present study. Therefore, according to the results obtained from the present study, training under different sensory conditions with open and closed eyes, and by manipulating various environmental components and tasks seems to improve sensory integration leading to the adaptation to different environmental conditions as well. Furthermore, it can lead to make a better use of other senses involved in balance (visual and somatosensory) in children with hearing loss followed by the improvement of balance performance under static and dynamic conditions [23]. Regarding the effectiveness of core stability training on how long an individual can stand on one leg, Kimberly and Stederly in their study stated that, in a core stability training program, training movements, instead of muscles so that different types of muscles work together, is of importance. Accordingly, this improves the activity of the neuromuscular system for postural control [24]. Moreover, anatomically, the core is the area where the center of gravity (CG) is located and where the movements come from. Therefore, strengthening the muscles of this area resulted by the core stability training program seems to improve the neuromuscular system as well as reducing the displacement of the center of gravity outside the base of support (BOS) and its fluctuations. Accordingly, this increases the duration of standing at certain support. Moreover, the balance must be controlled at the nonintentional level, instead of the level of consciousness. As shown in the present study, the increase in the duration of standing on one leg indicates an improvement in the ability to balance, which is likely due to the improved levels of consciousness rather than unconsciousness. Notably, to be capable of stabilizing and orienting, the postural control requires communication and interaction of the neuroskeletal system. The factors affecting posture consist of sensory processes including visual, vestibular, and somatosensory systems; motor processes including synergistic neuromuscular responses; and higher-level integration processes by having cognitive effects on the postural control [25].

Performing core exercises improves strength, endurance, and nervous control in the core as well as the increased control of the internal portion of the spine, control of the intra-abdominal pressure (IAP), and muscular control of trunk movement. Besides, the ability of the body in maintaining balance in various dynamic movements is affected by core exercises. In a study by Makaski et al. in 2011 on the effects of core exercises on dynamic balance, it has been found that core training programs can exert a positive effect on dynamic balance. Moreover, core stability and strength, due to the placement of the center of gravity in the core, reduce the displacement of the center of gravity outside the base of support as well as reducing its fluctuations, which consequently reduces the number of falls [26].

Regarding the evaluation of dynamic balance in legs, many researchers have suggested that performing access action in some directions that are related to the Star Excursion Balance Test (SEBT) is the most difficult direction compared to some other easier lateral directions [18]. Interestingly, the obtained results suggest that, core stability exercises exert more effects and improve the dynamic balance in easy directions, as well; however, in difficult directions, they exert fewer effects. Concerning the effectiveness of core exercises on balance and postural control, it should be explained that, the contraction of core muscles before the limb movement, is a predictive postural response generated by the central nervous system (CNS), which prevents postural disorders and contributes to organizing the dynamic balance. Therefore, the core stability training program improves the activity prediction, and thus reduces the impaired displacement and oscillation of the center of gravity. Notably, human balance control depends on the integration of the afferent information received from the vestibular, visual, and somatosensory systems. The decreased activity of one of the systems involved in postural control or losing its information, in turn leads to a decrease in the performance of the other mechanisms of postural control [19]. Moreover, during performing the Y-balance access action in all directions, the contraction of hamstring and quadriceps muscles occurs. The quadriceps are mostly active in three directions as follows: anterior, anterolateral, and anteromedial. Accordingly, this is due to the fact that, in order to perform these anterior directions, the individual must lean back and the trunk must be in the extension position, so that he/she can maintain balance. In this position, the force of gravity acting on the upper trunk causes a high knee flexion torque, which must be controlled by the extension torque (eccentric contractions) produced by the quadriceps muscle. The external broad muscle is the most active one in the medial and posteromedial directions, which is likely due to the muscle stabilization occurring against the muscular forces that are active in these directions to perform the access action [27]. In addition, maintaining balance in a closed kinetic chain heavily depends on the coordinated movement and feedback strategies among the thighs, knees, and ankles, and the reduction in the afferent feedbacks or the mechanical strength and stability of any joint can also reduce balance. When there is an instability in the spine, movement incorrectly occurs, the motor pattern of the neuromuscular coordination decreases, and the risk of injury to the spine increases. Therefore, facilitating the simultaneous contraction of the muscles around the lumbar vertebrae such as the abdominal obliques, transverse abdominal, multi-headed, and erector spinae muscles, may increase the stability of the vertebrae. Thus, the goal of core stability training is creating a physical capacity to maintain a neutral position in the spine during the activities of daily living (ADLs), which is accomplished with the increase of the endurance and coordination of the muscles stabilizing the spine [25]. Chang et al. examined the effect of four weeks of core stability training on dynamic balance and motor function of stroke patients, and found that these exercises can improve dynamic balance and motor function in these patients [28]. Also, in Aswani and Hess's study , it was indicated that a nine-week core stability training program exerted no significant effect on the swimmers' balance that was measured by the Biodex stability system [29]. Accordingly, this result is not consistent with the findings of the present study. The nature of the core stability training program in the literature have been found to be identical; however, the reason for this discrepancy between the results of this study and those of the abovementioned research may be due to the differences in some variables such as methods, age, activity level, and type of subjects. In Aswani's study, which was conducted on the balance evolution, the effect of the core stability training was not significant, likely due to the fact that the swimmers have no balance problem. While people with hearing loss have a balance problem. Due to such contradictory results and in general, the positive effects of core stability training and TRX exercises on the dynamic balance of deaf and hearing-impaired individuals, it is recommended to use these exercises in their training and rehabilitation programs.

The study results show that there was no significant difference in the forward head abnormality between the two core stability training and TRX groups. The findings of the present study do not corroborate with the results of Rostami et al.'s study regarding the comparison of the effect of three corrective methods on the quality of life and forward head among those men with the upper crossed syndrome (UCS). Also, there was a difference between theese three methods in this study [30]. In a study performed by Haj Hosseini et al. (2015) on the effect of four weeks of core stability training on the forward head angle and spirometric indicators in female students, which can contribute to the increase of the maximum voluntary ventilation (MVV), it has been suggested that core stability exercises can improve forward head position [31]. Correspondingly, this program was designed to reduce the lower extensor muscles, deep-upper neck flexors, the adductor muscles of the shoulder, and the external rotators of the arm and at the same time to strengthen their ability in maintaining a proper posture as much as possible in all exercises performed. Due to the effectiveness of these exercises and the significant positive results of other studies, it is recommended to use these exercises to correct inappropriate posture and forward head abnormalities in deaf people. In addition, the research results reveal that there was no significant increase in the mean kyphosis abnormality in the core stability training and TRX groups by comparing the post-test and the pre-test. It was also found that there was no significant difference between the two training groups.

The abnormal increase in the arch in this area, kyphosis, is known as one of the most relevant common abnormalities and one of the important factors affecting the pathology of the upper quadrant of the body, which is ranged from shoulder pains to spinal fractures. During this complication, the anterior muscles of the trunk get stiff and short, and consequently, the rounded shoulder occurs. In contrast, the posterior muscles of the trunk get weak and loose due to the constant stretching. The increased curvature of the thoracic spine leads to the poor performance of the joints in the shoulder girdle and upper back area. The results of this study are inconsistent with the findings of the studies performed by Mashhadi et al. and Azizi et al. Moreover, Mashhadi et al. examined the effect of combined exercise on the kyphosis of adolescents [32, 33]. Accordingly, in this study, the results showed the effectiveness of the exercises applied to reduce the kyphosis angles significantly. Azizi et al. investigated the effect of 8 weeks of aquatic therapy exercises on the kyphosis angle of some male students. In this regard, the included participants were 15 men with kyphosis above 40 degrees. According to the results obtained from this study, there was a significant improvement in the angle after performing 8-week aquatic therapy exercises [34].

The research results show that there was no significant difference in the mean lordosis abnormality between the two groups of core stability training and TRX. The decreased lordosis occurs when an increase in the strength of the back extensor muscles is associated with a decrease in lordosis. Notably, in case of any change in the relative balance between the anterior and posterior pelvic muscles, the position of the pelvis will also change; therefore, the weakness in the large abdominal and gluteal muscles (hip extensor) and the shortness in the hamstring, back extensors, and hip flexors lead to the anterior pelvic tilt (APT). Most people have weak abdominal and gluteal muscles with short lumbar muscles, and the APT in them also leads to the hyperlordosis of the spine at the present or in future. Overall, deaf people have lots of muscle tonus when they keep performing movements because they require a lot of concentration, especially during performing unfamiliar movements. Regarding the lack of coordination and the need for a high thought concentration, there is a motor restlessness among deaf and hearing-impaired individuals, which in turn causes early fatigue during exercises [9]. As mentioned earlier, poor motor function in the deaf also is due to the concentration and high tonus of the muscles; therefore, it can be concluded that people with hearing loss have several problems with muscle weakness. The frequently repeated habits and postures (such as certain physical activities that are frequently performed) can lead to the frequent usage of some muscles and neglecting the antagonist muscles, which result in the balance of strength, flexibility, muscle length, and soft tissue. Accordingly, in the long run, they can correct some common abnormalities. These changes occur over many years, so it cannot be expected that performing an 8-week training program completely correct the abnormalities as well as the wrong habits. Therefore, it is required to achieve the desired outcomes. It should also be noted that both muscle weakness and muscle shortness cause abnormality, but their subsequent mechanisms differ. Muscle weakness paves the way for abnormalities, while muscle shortness itself causes abnormalities, so the proven abnormalities cannot be considered as the result of weakness alone unless the shortness occurs in a stronger agonist muscle [35]. To correct the abnormalities, firstly, the shortened muscle should be stretched and then returned to its normal length, and following that, the weakened muscle should be strengthened with the isometric muscle strength. However, in the present study, subjects had no lordosis abnormality, so no changes occurred due to performing exercises in this regard. One of the limitations of this research is the lack of access to more accurate tools for measuring variables.

Conclusion

This study with the purpose of comparing the effects of eight weeks of TRX and core stability training on balance and some common abnormalities in deaf adolescents, is among the rare studies that compared the two methods of core stability training and TRX on the performance and abnormalities in deaf people. According to the results obtained from the current study, taking part in the 8-week TRX and core stability training programs increased static and dynamic balance and also improved forward head, lordosis, and kyphosis abnormalities. Moreover, there was no difference in the inter-group comparison. Therefore, it is recommended to use this low-cost and convenient training program to improve the living condition and the quality of life in hearing-impaired adolescents.

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