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Comparison of the effect of TRX and core stabilization training on trunk endurance, quality of life and walking speed in patients with paraplegic spinal cord injury

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Abstract

Background: Spinal cord injury leads to loss of movement and sensation below the level of the injured area.
Aim: The purpose of this study was to compare the effects of six weeks of TRX (Total Body Resistance Exercise) and core stabilization training on trunk endurance, quality of life, and walking speed in patients with paraplegic spinal cord injury.
Materials and Methods: Fourteen young men with paraplegic spinal cord injury voluntarily participated in this study. They were randomly assigned to either the TRX group or the core stabilization group. Participants completed quality of life questionnaires before training, and their trunk endurance (assessed by the sit-up test) and walking speed (10 m sprint at maximum speed) were also measured. Both groups then performed six weeks of training (three sessions per week).
Results: Both TRX and core stabilization training significantly improved trunk endurance ($P = 0.001$), walking speed ($P = 0.001$), and most dimensions of quality of life—except for the environmental health domain, which showed no significant change. When comparing the two interventions, participants in the TRX group demonstrated greater overall improvements ($P < 0.05$), particularly in walking speed and quality of life. However, the core stabilization group showed significantly greater improvement in trunk endurance ($P = 0.006$).
Conclusion: Strength training programs such as TRX and core stabilization exercises can significantly enhance walking speed, trunk endurance, and quality of life in individuals with paraplegic spinal cord injury.
Keywords: TRX, Spinal Cord Injury, Trunk endurance, Quality of Life, Paraplegia

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1. Introduction

Spinal cord injury (SCI) is a life-altering condition, with a global incidence estimated at 13–53 cases per million people each year(1). Among individuals affected by SCI, paraplegia—defined as the impairment or loss of motor and/or sensory function in the lower extremities—represents a significant subset. These individuals often face a range of physical, psychological, and social challenges. Key complications include impaired trunk control, chronic pain, limited mobility, muscle atrophy, and reduced quality of life (2). A major goal in the rehabilitation of individuals with paraplegia is to restore functional independence, particularly in areas such as walking ability, postural control, and daily living activities (3). Since paraplegia typically affects the lower body, compensatory mechanisms rely heavily on upper body strength and trunk stability. However, reduced core strength and trunk endurance often limit movement efficiency and increase the risk of falls and secondary complications.

Core stabilization training has become a widely recommended approach in SCI rehabilitation. These exercises target deep trunk muscles to improve postural alignment, balance, and force transmission, which are crucial for both static and dynamic movements in paraplegic individuals (4). Studies have demonstrated that core training not only promotes musculoskeletal health but also facilitates improvements in pain management, functional mobility, and psychosocial well-being (5, 6).

In recent years, Total Resistance Exercise (TRX) has emerged as an innovative method of core training, with promising applications in both athletic and rehabilitative settings. TRX employs a suspension system that enables body-weight exercises in a partially supported position, allowing variability in intensity and range of motion. This adaptability makes TRX particularly suitable for individuals with paraplegia who require safe and controlled environments for physical activity. Evidence suggests that TRX training activates core muscles effectively and improves balance, coordination, and neuromuscular control (7, 8).

Moreover, TRX's capacity to support body weight and deliver customizable resistance through strap adjustments has demonstrated potential for improving rehabilitation outcomes in patients with limited lower-body mobility(9). When integrated into rehabilitation programs, TRX may serve as a dynamic and functional alternative to traditional core stabilization exercises.

Despite these potential benefits, direct comparisons between TRX and conventional core stabilization programs in individuals with paraplegia remain limited. It is still unclear which approach is more effective in improving key rehabilitation outcomes such as trunk endurance, walking speed, and quality of life.Therefore, the present study aims to compare the effects of a six-week TRX training program and traditional core stabilization exercises on trunk endurance, walking speed, and quality of life in patients with paraplegia.

It is hypothesized that while both interventions will lead to improvements, TRX training may result in greater gains due to its dynamic and integrative approach to core engagement and movement control.

2. Methods and Materials

2.1. Participation

The present semi-experimental study was approved by the Human Subjects Ethics Sub-Committee of the Sport Sciences Research Institute (IR/ssri.rec.2023.13699.1912). The study was conducted on 14 male patients with paraplegic spinal cord injury, affiliated with the Spinal Cord Injury Association in Isfahan, Iran, who were randomly assigned to two groups (seven participants in each group). Subjects were selected through availability by convenience sampling and were then matched in two experimental groups based on the level of injury (definitive diagnosis was made of spinal cord injury to vertebra below T1 by neurologists based on MRI). Inclusion criteria consisted of having no medical prohibition for training and at least 1 year of injury. Unwillingness to cooperate, failure to complete research tests, and any event preventing subjects, such as poor physical condition for exercises, were exclusion criteria. The sitting height and weight as well as core area endurance, walking speed and quality of life of the participants were measured after filling the consent form. The training lasted for six weeks, three sessions per week, and each session averaged 45 minutes, after which the participants' trunk endurance, walking speed and quality of life were measured.

2.2. Measures

In order to evaluate the trunk endurance, the subjects performed a modified sit-up test for 1 minute and the number of movements per minute was recorded and accounted as their record (10). Gait was evaluated using a 10-meter maximum walking speed test. To account for acceleration and deceleration, an additional 1 meter before the start line and 1 meter beyond the finish line were included. The test was performed twice, with a three-minute rest between trials, and the best performance (m/s) was used for data analysis (11). In this study, quality of life was assessed using the WHO Quality of Life-BREF (WHOQOL-BREF) questionnaire, which has reported validity ranging from 0.77 to 0.90. (11).

2.3. Procedure

Before training protocols, the warm-up was performed, which lasted 10 minutes, and mostly comprised the lower trunk and upper trunk stretching because the exercises protocol of intervention focused on these areas. finally, the cool down was performed for 5 minutes, using simple movements with the aid of the trainer.

The TRX training program was conducted as an individual activity and lasted 50–60 minutes. For instance, a modified sit-up test can be adapted to assess core strength in individuals with paraplegia. This adaptation could include the use of other methods of trunk stabilization, such as having the subject sit in a supine position with the lower body supported by the test taker. It should be noted that regarding the specific conditions of the subjects, a suitable rest time was given for the next training, depending on the conditions of everyone (12).

Modified TRX protocol for paraplegia (adapted from Dawes 2017)

Week	Frequency	Session Duration	Exercise	Set	Rep/Duration	Rest Interval
1	3 Sessions/ week	40-45 min	TRX Chest press (seated)	3	10-12 reps or 30 sec	30-45 sec rest
1	3 Sessions/ week	40-45 min	TRX low row (seated)	3	10-12 reps or 30 sec	30-45 sec rest
1	3 Sessions/ week	40-45 min	TRX biceps curl (seated)	3	10-12 reps	30 sec
3	3 Sessions/ week	40-45 min	TRX seated row (seated)	3	15-20 reps or 30 sec	45 sec
3	3 Sessions/ week	40-45 min	TRX triceps press (seated)	3	15-20 reps	45 sec
3	3 Sessions/ week	50-60 min	TRX plunk (modify of knee)	3	20-30 reps	45 sec
5	3 Sessions/ week	50-60 min	TRX seated chest	4	12-15 reps	45-60 sec

			(Lower angle)			
5	3 Sessions/ week	50-60 min	TRX Lat pulldown (seated)	4	12-15 reps	45-60 sec
5	3 Sessions/ week	50-60 min	TRX Hip press (using strap for leg)	3	15 reps	45 sec

The core stabilization training protocol consisted of six exercises performed over six weeks, with six sessions per week. Each session lasted 45 minutes, including warm-up and cool-down similar to the TRX training group. Considering the specific conditions of the participants, appropriate rest intervals were provided as needed. During the first two weeks, each exercise was performed in three sets of 10 seconds. In the following two weeks, the duration increased to three sets of 15 seconds, with repetitive movements performed at 10 repetitions per set. In the final two weeks, each exercise was carried out in four sets of 10 seconds and four sets of 15 seconds (15).

2.4. Statistical Analysis

Data analysis was conducted using SPSS version 22. To compare mean scores of the research variables before and after the training protocol, a paired t-test was applied. To evaluate the effect of pre-test and training on the variables within the training group, ANCOVA was used. Homogeneity of variance and normality of data were examined using Levene's test and the Shapiro–Wilk test, respectively. All hypotheses were tested at a 95% confidence level with $\alpha \leq 0.05$.

3. Results

The mean and standard deviation of the subjects' anthropometric characteristics are given in Table 1.

Table 1. Anthropometric characteristics

Index	Group	SD ± Mean
Age (Year)	TRX	32.1 ± 2.96
	Core Stabilization	33.4 ± 2.50
Sitting Height (m)	TRX	84.4 ± 3.75
	Core Stabilization	86.8 ± 4.45

Weight (Kg)	TRX	77.8 ± 1.51
	Core Stabilization	73.7 ± 2.29
Injury History	TRX	3.28 ± 1.13
	Core Stabilization	4.28 ± 1.11

According to Table 2, the results of the analysis of covariance indicated a significant difference between the two training groups in the tests ($P < 0.05$). The results of the mean scores indicated that participants in the TRX group demonstrated superior performance in quality of life and walking speed compared to those in the core stabilization group, whereas the latter showed higher performance in trunk endurance. To compare endurance, walking speed, and quality of life scores within groups between pre-test and post-test, paired t-tests were applied. The findings are summarized in Table 3. Both TRX and core stabilization training produced significant improvements in endurance, walking speed, and quality of life dimensions, except for the environmental health dimension ($P \leq 0.05$).

Table 2. ANCOVA Results: TRX vs. Core Stabilization

Variable			F	Sig
Walking		Pretest	5.62	0.03*
		Groups	11.3	0.006*
Trunk endurance		Pretest	21.4	0.001*
		Groups	9.55	0.01*
Quality of life	Physical health	Pretest	2.9	0.11
		Groups	30.1	0.001*
	Mental health	Pretest	2.54	0.13
		Groups	41.24	0.001*
	Social relations	Pretest	0.79	0.39
		Groups	6.51	0.02*
	Environmental health	Pretest	0.58	0.46
		Groups	0.92	0.35
	Total score	Pretest	1.19	0.29
		Groups	64.6	0.001*

In this table: Pretest is covariate factor and group is significant different between groups, $P \leq 0.05$*

Table 3. Mean differences of variables in the subjects before and after the training protocol

Group	TRX training					Core stabilization training				
	Test	M ± SD	T	P	Cohen Effect sizes	Test	M ± SD	T	P	Cohen Effect sizes
Walking speed (cm/s)	Pretest	174.7 ± 21.9	6.01	0.001*	1.86	Pretest	202.5± 21.9	10.01	0.001*	1.40
	posttest	226.8 ± 33.0				posttest	236.0 ± 25.7			
Endurance (number/min)	Pretest	25.8 ± 3.33	-7.89	0.001*	2.83	Pretest	26.8 ± 2.85	-7.29	0.001*	1.81
	posttest	35.4 ± 2.07				posttest	32.0 ± 2.88			
Physical health	Pretest	39.2 ±9.22	-7.89	0.001*	3.23	Pretest	37.2 ± 7.94	-7.89	0.07	1.40
	posttest	69.3 ±9.41				posttest	47.0 ± 5.83			
Mental health	Pretest	36.3 ± 10.6	-8.73	0.001*	4.12	Pretest	36.3 ± 7.49	-8.73	0.001*	1.54
	posttest	75.0 ± 7.98				posttest	48.8 ± 8.23			
Social relations	Pretest	38.1 ± 10.6	-5.61	0.001*	3.68	Pretest	42.8 ± 11.2	-5.61	0.002*	1.38
	posttest	72.6 ± 7.92				posttest	59.1 ± 12.2			
Environmental health	Pretest	48.2 ± 6.71	-0.31	0.76	0.12	Pretest	47.7 ± 8.59	-0.31	0.54	0.32
	posttest	49.1 ± 7.37				posttest	45.1 ± 7.62			
Total score	Pretest	28.57 ± 9.44	-11.4	0.001*	7.44	Pretest	30.0 ± 10.4	11.45	0.01*	2.49
	posttest	91.07 ± 7.41				posttest	52.5 ± 7.41			

$P \leq 0.05$*

4. Discussion

The purpose of this study was to compare the effects of six weeks of TRX training and core stabilization on trunk endurance, walking speed, and quality of life in patients with paraplegic spinal cord injury. The findings revealed that both training protocols had significant effects on improving trunk endurance, walking speed, and quality of life, except for the environmental health dimension. When comparing the two training methods, participants in the TRX group showed greater overall improvements, especially in walking speed and quality of life. However, participants in the core stabilization group achieved more pronounced gains in core muscle endurance. Suspension training, on the other hand, can enhance walking speed even without direct lower-body engagement by improving neuromuscular coordination, core stability, and balance to a greater extent than conventional core stabilization. These adaptations contribute to more efficient gait mechanics (13). Regarding the impact of TRX training, it can be stated that by effectively engaging the muscles, this method provides strategies to enhance balance equally on both sides of the body. Moreover, it serves as a suitable approach to promote harmony by developing balanced strength throughout the human body. (14). Exercises that engage the central region of the body (such as core stabilization and TRX training in the present study) enhance the physical capacity to maintain a neutral spinal position during daily activities. This is achieved by increasing endurance and improving the coordination of spinal stabilizing muscles (14).

One of the main reasons for the improvement in core endurance is the training protocols selected, which emphasize strengthening the trunk flexor and extensor muscles. This targeted approach enhances the strength of these muscle groups and contributes to greater endurance (15). In other words, the improvement in endurance is primarily attributed to neuromuscular adaptations. Neurological factors contributing to this include increased activation and synchronous recruitment of motor units, reduced neural inhibition, and a higher frequency of motor neuron discharge. Since the exercises in core stabilization training are fully controlled, they effectively improve multiple fitness factors, prevent motor weakness, and enhance muscle strength in individuals with paraplegic spinal cord injury. Moreover, performing exercises based on the principle of overload, and utilizing tools such as TRX as resistance under unstable conditions, leads to muscle cell hypertrophy and consequently increases muscle strength (16).

A recent study explored the relationship between walking speed and muscle strength in children with cerebral palsy (CP). The findings revealed a logarithmic association between muscle strength and walking capacity in children with spastic bilateral CP. Specifically, muscle strength was correlated with walking speed and energy expenditure, with the effect being more pronounced in weaker children. This suggests that muscle strength plays a critical role in walking capacity within this subgroup (17). One of the major challenges for patients with spinal cord injury is walking and achieving independent gait. Compared to healthy individuals, these patients experience reduced step length and frequency, slower walking speed, and shorter walking distance. The most critical consequence of such impairments is disruption of balance and gait, which increases the risk of falls (18). Exercise training reduces central nervous system–dependent limitations and improves walking speed and distance indices. (19). In our study, the greater improvement in walking speed observed in the TRX group may be attributed to the nature of TRX suspension training, which emphasizes dynamic stabilization and multi-planar muscle activation, particularly in the core and proximal lower limb muscles. TRX exercises demand active engagement of stabilizing muscles during movement, thereby promoting neuromuscular coordination, balance, and efficient force transmission across the kinetic chain. (7, 8). This is particularly beneficial for individuals with paraplegia, as enhancing trunk stability and intermuscular coordination can compensate for lower-extremity deficits and improve gait performance. (4).

Considering the improvements in indices such as endurance and quality of life observed in the present study, it can be expected that these enhancements will positively influence walking ability in patients following exercise training. This achievement is consistent with findings in Parkinson's disease, where Nordic Walking—combining active use of the trunk and upper limbs with traditional walking—has been shown to improve quality of life (20). *Overall, it should be emphasized that the fundamental principle of TRX training is the activation of trunk muscles, which is essential for controlling and stabilizing the spine. Restoring this activity as much as possible in patients with paraplegic spinal cord injury requires coordination among active, passive, and neural structures. Accordingly, exercise programs that target trunk muscles to control spinal movements (such as TRX and core stabilization training in the present study) appear reasonable and can enhance endurance, walking speed, and quality of life by increasing muscle strength and coordination, thereby correcting imbalances and restoring stability. Nevertheless, our study has certain limitations. All participants were male, and including female subjects in future research may help to account for differences in clinical presentation and potential variations in response to physical activity.* (21). The study lacks longitudinal follow-up, and therefore we cannot determine whether the training effects are maintained after completion, nor can we predict whether participants will continue their activity on a regular basis.

5. Conclusion

Decreased balance and endurance, and consequently reduced quality of life, are common complications of paraplegic injury that negatively affect daily functioning. The overall findings of this study demonstrated that TRX training, as well as core stabilization exercises combined with routine treatments, significantly improved balance, trunk muscle endurance, walking speed, and quality of life in individuals with paraplegia. Accordingly, it is recommended that therapists incorporate these training approaches into rehabilitation programs for individuals with paraplegia. Future studies are encouraged to: (1) include more diverse samples with both sexes to enhance generalizability, (2) implement longitudinal follow up assessments to evaluate the durability of training effects, and (3) Future studies should examine additional components of health related physical fitness—such as cardiovascular endurance, muscle strength, and body composition—to gain a more comprehensive understanding of the impact of these interventions on individuals with paraplegia.

Conflict of interest

The authors declared no conflicts of interest.

Authors' contributions

All authors equally contributed to the writing and revision of this paper.

Ethical considerations

This study was approved by the Human Subjects Ethics Sub-Committee of the Sport Sciences Research Institute (IR/ssri.rec.2023.13699.1912).

Data availability

The dataset generated and analyzed during the current study is available from the corresponding author on reasonable request.

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