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Original Article

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Effect of Elastic Aids (Bands) on Functional Reach Test in Patients with Spinal Cord Injury: Pilot Study

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Purpose: This study aimed: to confirm the balance ability of patients with spinal cord injury in the sitting state through a functional reach test using an elastic aid; and to propose a balance improvement plan.
Methods: The study evaluated seven patients with spinal cord injury who could maintain a sitting posture through minimum assistance. A functional reach test was performed before and after wearing an elastic aid while sitting on a chair, and the effects before and after use of the elastic aid were compared and analyzed through a motion analyzer.
Results: In the functional reach test, the forward movement distance of the hand was 97.45 mm before wearing the elastic aid, but significantly increased to 131 mm after wearing the aid ($p < 0.05$). Corresponding forward movement distances for the shoulder were 81.26 mm and 113 mm ($p < 0.05$ for the increase). There was no statistically significant change in lateral functional arm extension.
Conclusion: It was confirmed, through a functional reach test, that trunk stability in patients with spinal cord injury increased with use of an elastic aid. In future, more efficient rehabilitation treatment programs will be possible if trunk stability in patients with spinal cord injury is improved by using elastic aids, and if various exercise treatments are also included in the rehabilitation programs.

Keywords: Balance, Elastic aid, Functional reach test, Spinal cord injury

INTRODUCTION

It is important for patients with spinal cord injury to sit stably in chairs or wheelchairs,[1] because upper extremity activities can only be performed smoothly when sitting in a stable state, without shaking. However, it is not easy for patients with spinal cord injury to maintain a stable posture. Depending on the level of spinal cord injury, the ability to stably fix the trunk changes, and the higher the level of spinal cord injury and the wider the range of damage, the harder it is to maintain a stable posture.[2]

On a daily basis, patients with spinal cord injury perform various activities in chairs and wheelchairs.[3,4] However, if a patient with spinal cord injury performs upper extremity activities with an unstable posture, accuracy decreases and energy consumption increases, which can easily lead to fatigue, resulting in decreased functional ability or a fall.[5,6] The fall risk further limits the participation of spinal cord injury patients in activities. Therefore, improving maintenance of a stable posture is an important goal in patients with spinal cord injury, and we are trying to achieve this goal by studying various interventions.

Among the interventions available, exercise therapy is frequently performed. Exercise therapy, which is designed to train (as much as possible) the residual muscle strength of patients with spinal cord injury, allowing them to actively maintain posture, is becoming the most important intervention in patients with spinal cord injury.[7] However, there are limitations to functional improvement, depending on the level of spinal cord damage, and research on how to overcome these limitations is continuing: the most widely attempted intervention in this respect is the use of trunk aids, which fix the pelvis and trunk and allow stable movement and increased activity.[8] However, although trunk aids may be useful for patients with poor trunk stability, they may not be a good intervention for patients with some stability. This is because trunk aids can increase passive dependence and reduce patients' active performance abilities. Therefore, careful attention is needed before using trunk aids. In addition, it is not easy for most

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patients with spinal cord injury to wear and take off trunk aids and, in most cases, the use of trunk aids is high during the initial rehabilitation period and gradually decreases towards the end of the rehabilitation training period. Therefore, encouraging free use of the upper limbs, while reducing dependence on trunk aids, is an important factor in overcoming the restricted participation of patients with spinal cord injury in daily activities.

We regularly receive feedback from patients with spinal cord injury to provide passive stability to the front and side of the trunk aid, and to provide assistive tools that can stably perform movement and permit upper extremity activity. To determine the effectiveness of the trunk aid we designed, a functional reach test was conducted. The functional reach test examines the stability limit of patients with spinal cord injury and determines the balance ability and functional performance range of the upper limbs by measuring the distance that patients can extend the arms horizontally forwards and sideways while maintaining a standing or sitting position.[9,10] Therefore, this study intended to propose a plan to improve the balance of patients with spinal cord injury after performing a functional reach test when the patients were wearing an elastic trunk aids.

METHODS

1. Study participants

Ten patients were identified: who visited the exercise center for the disabled and regularly performed exercise; or who had been discharged after a diagnosis of spinal cord injury and who had stopped hospital rehabilitation. Target inclusion criteria were patients; with a score of >24 points on the Korea Mini-Mental State Examination; who could have a daily conversation; who could not stand up independently; who could sit in a seated position independently or with minimal assistance; without skin damage, such as bedsores; and who could flex their shoulders 90° by themselves. The study participants were informed of, and understood, the purpose, procedures, and methods of the study, and that personal information would remain confidential, and then agreed to voluntary participation. Study participants could withdraw, independently and at any time, their consent to participate. Three patients withdrew their consent to participate due to their high fear of falling, and seven patients successfully completed the study (Table 1).

2. Study measurements

A functional reach test was conducted using a motion analyzer (BTS Smart-DX, BTS Bioengineering, Italy) to find out how the elastic trunk aid functionally affected patients with spinal cord injury. The test performed in a sitting position in patients with spinal cord injury has proved reliable.[9,10] In this study, a motion analyzer was used to collect data and objectively measure the horizontal movement distance in the sagittal and coronal planes.

Table 1. General characteristics of subjects

Subject	Gender	Age	NLI	ASIA scale
A	Male	43	C5	A
B	Male	35	T3	C
C	Male	31	L1	C
D	Male	38	T6	A
E	Female	29	C4	C
F	Female	37	C5	C
G	Female	41	T1	A

NLI: neurological level of injury, ASIA scale: American Spinal Cord Injury Association Impairment Scale.

The motion analyzer used was BTS Smart-DX, and six infrared cameras were installed within 5 m of the chair where the patient sat, adjusting the height and angle to include the patient's movement, and perform calibration. Infrared markers with a diameter of 15 mm were attached (as below) to track trunk movement and the maximum activity range of the upper limb during each patient's functional reach test. Infrared markers were photographed at 120 Hz with five attached to the acromions, the test side ulnar styloid, and both greater trochanters, and four attached to the back of the chair's backrest. To calculate the infrared marker position in the 3D space, the marker model was set with a Smart Tracker (Smart Tracker, BTS Bioengineering, Italy) and analyzed with BTS SMART Analyzer software (BTS SMART Analyzer, BTS Bioengineering, Italy). The chair used for the measurement had no armrest and cushion. The height of the chair was set so that the patient's hip and knee joints were flexed at 90°. Patients were instructed to extend an arm as much as possible by tilting the trunk forwards and sideways by 90° using the upper extremity of the dominant hand, and the maximum movement distance to the end was measured based on the first prepared posture based on the ulnar styloid and acromion.[11] The functional reach test was performed three times before, and after, wearing the elastic aid to record average values.

3. Elastic trunk aid

The elastic trunk aid used a polychloroprene material with strong durability and sufficient flexibility (shore A hardness 40–90; tensile strength 60–250 kg/cm^2; elongation 100–500%), and that is not damaged by external

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Figure 1. Application of the elastic aid.

impacts. The trunk aid was manufactured to be 120 cm wide and 13 cm high, so that it had a wide contact area and could sufficiently wrap the trunk. Polychloroprene material is a material used to manufacture flexible aids that support the joints of the trunk, arms, and legs due to its high elasticity and strong durability. The elastic trunk aid was fixed with a velcro fastening after winding around the back of the chair and the body of the patient. The fixing position was between the iliac crest and xiphoid process, and the trunk aid was tightened as much as possible, while avoiding abdominal discomfort (Figure 1). Then, the functional reach test was performed according to the researcher's instructions, and the researcher continuously observed the patient to prevent falls.

4. Statistical analyses

Data were analyzed using the SPSS 22.0 program (IBM Corp., Armonk, NY, USA) and described as mean ± standard deviation (SD). The Wilcoxon signed-rank test was performed to compare the functional reach test results before and after fixing the elastic trunk aid. The statistical significance level was set as $p < 0.05$.

RESULTS

Before wearing the elastic trunk aid, the forward movement distance of the ulnar styloid was 97.56 mm, but this significantly increased to 131.00 mm after wearing the trunk aid ($p < 0.05$). The forward movement distance of the acromion also increased significantly from 81.26 mm to 113.00 mm ($p < 0.05$)(Table 2).

The lateral movement distance also increased after, compared to before, wearing the elastic trunk aid, but the change was not statistically significant ($p > 0.05$)(Table 3).

Table 2. Results of forward motion of a patient with spinal cord injury through functional reach test (n=7)

	Normal	Elastic trunk aids	p
Forward FRT			
Ulnar styloid	97.45±77.96 mm	131±42.58 mm	0.046*
Acromion	81.26±76.19 mm	113±31.10 mm	0.028*

Mean±standard deviation. FRT: functional reach test. *$p < 0.05$.

Table 3. Results of lateral motion of a patient with spinal cord injury through functional reach test (n=7)

	Normal	Elastic trunk aids	p
lateral FRT			
Ulnar styloid	38.56±19.17 mm	46.66±17.46 mm	0.173
Acromion	53.12±25.17 mm	84.25±65.84 mm	0.176

Mean±standard deviation. FRT: functional reach test. *$p < 0.05$.

DISCUSSION

This study investigated how much the functional reach test result changed in patients with spinal cord injury when an elastic trunk aid was used. The functional reach test revealed significantly increased forward movement when the elastic trunk aid was used, but there was no significant change in lateral movement, potentially because the original lateral movement was small. Abou et al.[12] reported that when the functional reach test was performed in patients with spinal cord injury, forward movement was 100.8 mm and lateral movement was 60.3 mm, based on the styloid process of the radius. These results were confirmed in patients with stroke-induced hemiplegia, in whom forward movement was 211.9 mm and lateral movement was 140.6 mm, based on the third finger when fists were clenched.[13] In Milosevic et al.[14] study, it was found that the lateral movement of the SCI patient's sitting posture was more unstable than the forward movement. In the forward movement, the range of support is wide due to the structure of the trunk and lower extremity, but in the case of the lateral movement in the sitting position is unstable because this support range is narrow. According to the results of this study and previous studies, it is considered that there was no significant change in lateral movement because the distance that can be moved is shorter than the forward and the stability is lower in the movement structure of the body. However, although there was no significant change, the elastic trunk aid provided stability against lateral movement, as the movement distance increased.

In this study, the forward movement distance increased by 35% due to wearing an elastic trunk aid, which is similar to the distance increase pro-

duced by an exercise program in a previous study: Sliwinski et al.[15] conducted an 8 week, complex exercise program in patients with spinal cord injury; with exercise progression and composition being 8 weeks, once a week, and 4 hours, consisting of resistance and aerobic exercise, body stability, and health education. Forward movement distance in the functional reach test increased by 18%, from 271 mm before exercise to 321 mm after exercise.

Considering the results of previous studies and our study, wearing elastic trunk aids can improve balance in patients with spinal cord injury, but applying an additional exercise program while wearing assisting devices is expected to have a better effect. In patients with spinal cord injury, the ability to control the trunk has an important association with sitting stability. Paralysis of trunk muscles reduces arm reaching and mobility.[14,16,17] Therefore, it is important to improve the ability to control trunk muscles in patients with spinal cord injury. Increased arm-reaching capabilities can potentially help reduce energy expenditure and allow increased participation in various exercises.[15]

Our study has several limitations. First, it was difficult to recruit the same level of spinal cord damage when recruiting patients with spinal cord injury. Since the functional reach test varies greatly depending on the level of spinal cord injury,[10] the SD of the study results was large. In addition, it was difficult to recruit patients because the study was designed to recruit patients with spinal cord injury who lived at home and visited an exercise center for the disabled. The large effect size observed in our study should be interpreted with caution because of the small number of patients. Future studies should divide patient groups according to levels of spinal cord injury and should recruit large numbers of patients.

Based on the results of our study, when the elastic trunk aids was used, the movement distance increased significantly in the case of the forward movement during the functional reach test. However, in the case of the lateral, it was confirmed that the movement distance increased, but there was no significant change. In addition, it is believed that effective rehabilitation treatment will be possible if sitting posture balance training is performed using elastic trunk aids when treating spinal cord injury patients.

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REFERENCES

1. Rath M. Trunk Control and Postural Stability in Individuals with Spinal Cord Injury: Noninvasive Enabling Strategies and Modeling. University of California. Dissertation of Master's Degree. 2016.
2. Yoo JH. Evaluation and prognosis of spinal cord injury. J Korean Med Assoc. 2020;63(10):596-602.
3. Ekiz T, Özbudak Demir S, Özgirgin N. Wheelchair appropriateness in patients with spinal cord injury: a Turkish experience. Spinal Cord 2014;52(12):901-4.
4. Singh H, Scovil CY, Bostick G et al. Perspectives of wheelchair users with spinal cord injury on fall circumstances and fall prevention: a mixed methods approach using photovoice. PloS One 2020;15(8):e0238116.
5. Craig A, Tran Y, Wijesuriya N et al. Fatigue and tiredness in people with spinal cord injury. J Psychosom Res. 2012;73(3):205-10.
6. Gollie JM. Fatigability during volitional walking in incomplete spinal cord injury: cardiorespiratory and motor performance considerations. Neural Regen Res. 2018;13(5):786-90.
7. Sandrow-Feinberg HR, Izzi J, Shumsky JS et al. Forced exercise as a rehabilitation strategy after unilateral cervical spinal cord contusion injury. J Neurotrauma. 2009;26(5):721-31.
8. Sison-Williamson M, Bagley A, Hongo A et al. Effect of thoracolumbosacral orthoses on reachable workspace volumes in children with spinal cord injury. J Spinal Cord Med. 2007;30(sup1):S184-91.
9. Lynch SM, Leahy P, Barker SP. Reliability of measurements obtained with a modified functional reach test in subjects with spinal cord injury. Physical Therapy 1998;78(2):128-33.
10. Kim YR, Min WK. The inter- and intra-rater reliability of the functional reach test in subjects with spinal cord injury. Phys Ther Korea 1999;6(3):51-8.
11. Parkinson MB, Reed MP, Chaffin DB. Balance maintenance during seated reaches of people with spinal cord injury. SAE transactions. 2004:82-6.
12. Abou L, Sung J, Sosnoff JJ et al. Reliability and validity of the function in sitting test among non-ambulatory individuals with spinal cord injury. J Spinal Cord Med. 2020;43(6):846-53.
13. Lee MK, Kang JW, Han SH. Evaluation of standing balance in hemiplegic patients using the functional reach test. J Korean Acad Rehabil Med. 2002;26(6):647-51.
14. Milosevic M, Masani K, Kuipers MJ et al. Trunk control impairment is responsible for postural instability during quiet sitting in individuals with cervical spinal cord injury. Clin Biomech. 2015;30(5):507-12.
15. Sliwinski MM, Akselrad G, Alla V et al. Community exercise programming and its potential influence on quality of life and functional reach for individuals with spinal cord injury. J Spinal Cord Med. 2020;43(3):358-63.
16. Desroches G, Gagnon D, Nadeau S et al. Magnitude of forward trunk flexion influences upper limb muscular efforts and dynamic postural stability requirements during sitting pivot transfers in individuals with spinal cord injury. J Electromyogr Kinesiol. 2013;23(6):1325-33.
17. C Gauthier, D Gagnon, M Grangeon et al. Comparison of multidirectional seated postural stability between individuals with spinal cord injury and ablebodied individuals. J Rehabil Med 2013;45(1):47-54.

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