

A novel objective evaluation method for trunk function

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Abstract. [Purpose] To investigate whether an objective evaluation method for trunk function, namely the “trunk righting test”, is reproducible and reliable by testing on different observers (from experienced to beginners) and by confirming the test-retest reliability. [Subjects] Five healthy subjects were evaluated in this correlation study. [Methods] A handheld dynamometer was used in the assessments. The motor task was a trunk righting motion by moving the part with the sensor pad 10 cm outward from the original position. During measurement, the posture was held at maximum effort for 5 s. Measurement was repeated three times. Interexaminer reproducibility was examined in two physical therapists with 1 year experience and one physical therapist with 7 years of experience. The measured values were evaluated for reliability by using intraclass correlation coefficients (ICC 1.1) and interclass correlation coefficients (ICC 2.1). [Results] The test-retest reliability ICC 1.1 and ICC 2.1 were all high. The ICC 1.1 was >0.90. The ICC 2.1 was 0.93. [Conclusion] We developed the trunk righting test as a novel objective evaluation method for trunk function. As the study included inexperienced therapists, the results suggest that the trunk righting test could be used in the clinic, independent of the experience of the therapists.

Key words: Trunk function, Reliability, Handheld dynamometer

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INTRODUCTION

The trunk consists of many different muscles that stabilize the spine, pelvis, and shoulder, and provides a foundation for the movement of the extremities. The muscles of the trunk help control movements, transfer energy, shift body weight, and distribute the stresses of weight bearing^{1–3)}. Many different muscles comprise the trunk. These muscles are classified into local and global muscles depending on their anatomical orientation and function⁴⁾. Local muscles, which have more direct or indirect attachments to the lumbar vertebrae, are associated with the segmental stability of the lumbar spine⁴⁾. Global muscles, those that attach to the hips and pelvis, are related to torque production and to the transfer of load between the thoracic cage and the pelvis⁴⁾. The interdependency of the osseoligamentous structures, trunk muscles, and neural control of the muscles is needed for optimal trunk stability⁵⁾. Particularly, coordination and co-contraction of

these local and global muscles are important⁶⁾. Thus, “trunk stability” is considered the ability to control the position and motion of the trunk during dynamic loading and movement conditions⁷⁾.

Trunk stability is integral to performing the activities of daily living⁸⁾. For example, lower levels of trunk muscle attenuation have been associated with reduced functional capacity in healthy older adults⁹⁾. Furthermore, cross-sectional studies reported small-to-medium correlations between trunk muscle strength and balance, functional performance, and falls in older adults¹⁰⁾.

Therefore, trunk function training has been the focus of research in recent years^{11–13)}. Mori et al. reported that ball exercise was effective in comprehensively improving muscle strength, endurance, and flexibility, as well as strengthening body reflexes, sense of balance, and proprioception in subjects with low back pain¹⁴⁾. Stanton et al.¹⁵⁾ also reported that the Swiss ball exercise is an effective stability exercise for trunk core muscles. However, few papers thus far have reported on objective evaluation methods for trunk function¹⁶⁾. For example, in a previous study, subjects were instructed to hold the postures indicated in “The FIFA 11+”, and the endurance time was recorded to evaluate the trunk function¹⁶⁾. If the objective and reproduction of simple methods for trunk function are established, it is possible to evaluate the core function more easily as important factors

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of physical performance.

Recently, we have started to use a novel test to evaluate the trunk function in patients with musculoskeletal disease in the lower extremities. The test involved a body righting movement while sitting on the bed, thus named the “trunk righting test” (TRT). The aim of this study is to investigate whether TRT is a reproducible and reliable test for the observers, independent of their experience.

SUBJECTS AND METHODS

Five healthy volunteer subjects (three men and two women; age, 33.2 ± 9.7 years; height, 164.6 ± 13.3 cm; weight, 56.6 ± 13.2 kg) were evaluated in this study (Table 1). The purpose of the study was explained, and informed consent was obtained from all subjects. The TRT was performed by using a handheld dynamometer (μ Tas F-1; ANIMA Co., Tokyo, Japan). The measurement range of this dynamometer is 0.1–999.9 N, with a recording interval of 0.1 N. The handheld dynamometer can be used to quantify maximal strength and may offer several advantages, including ease of transport, time efficiency, and low cost¹⁷⁾. The subjects were seated on a box with their feet above the ground. Both lower extremities were fixed with a band at the level of the thighs to suppress the compensation operation. The observer confirmed that the line connecting the bilateral acromion is parallel to the floor. Moreover, the sensor pad was fixed on the inner part of the acromioclavicular joint by adjusting the length of the belt restraint strap to be perpendicular to the bearing surface (Fig. 1). Then, the subjects were asked to move their shoulder with the sensor, 10 cm outward from the original position (Fig. 2). At that time, the subjects were confirmed to maintain the mirror position, keeping the line connecting the bilateral acromion parallel, and the fixing belt perpendicular to the floor. Furthermore, the observers placed

their palm above the trapezius muscle of the subjects to prevent the elevation of the shoulder girdle. The subjects applied maximum power to the belt for 5 s, and the highest values were used in this study. The measurements were repeated three times per day with at least >30 s interval to negate the influence of fatigue. The measurements were repeated after >2 days interval; thus, a total of six measurements were performed. The evaluation was performed by one of the authors who was blind to the examination. To examine the interexaminer reproducibility, a total of three observers participated in this study. Two of the three observers are resident physical therapists with 1 year experience (examiners A and B); the other observer is a senior therapist (examiner C). Physical measurements were evaluated by using intraclass correlation coefficients (ICC 1.1) and interclass correlation coefficients (ICC 2.1). The ICC 1.1 and ICC 2.1 reliability was examined for each variable. Reliability was calculated separately for the right and left measured values. ICC calculations were performed by using SPSS (version 21). The range of ICC values was described by using the classification of Fleiss, and ICC > 0.75 was considered excellent¹⁸⁾. This study reported the contents of the research in Kobe Kaisei hospital ethical committee. And we had the consent of that to carry out research under the guidance of the ethical committee. All of the subjects understood the purpose of this study and provided written informed consent before participation according to the ethical standards of the Declaration of Helsinki.

RESULTS

The test-retest reliability ICC 1.1 and ICC 2.1 were all high (Table 2). The ICC 1.1 values were as follows: examiner A, 0.93; examiner B, 0.96; and examiner C, 0.90. The

Table 1. Data of subject specific factors

	Value (mean \pm SD)
Males / females	3 / 2
Age (yrs)	33.2 \pm 9.7
Height (cm)	164.6 \pm 13.3
Weight (kg)	56.6 \pm 13.2

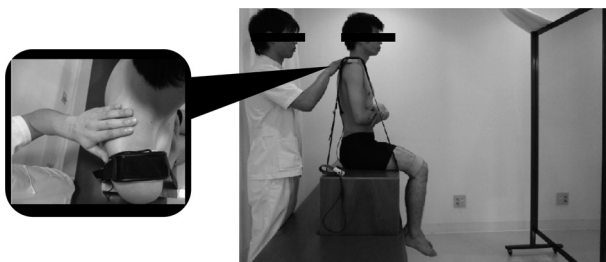


Fig. 1. Start position of the trunk righting test
The examiner palpates the line in the upper portion of the trapezius muscle. The examiner prevents the compensation. The subject confirms the position of the plate while looking at the mirror.

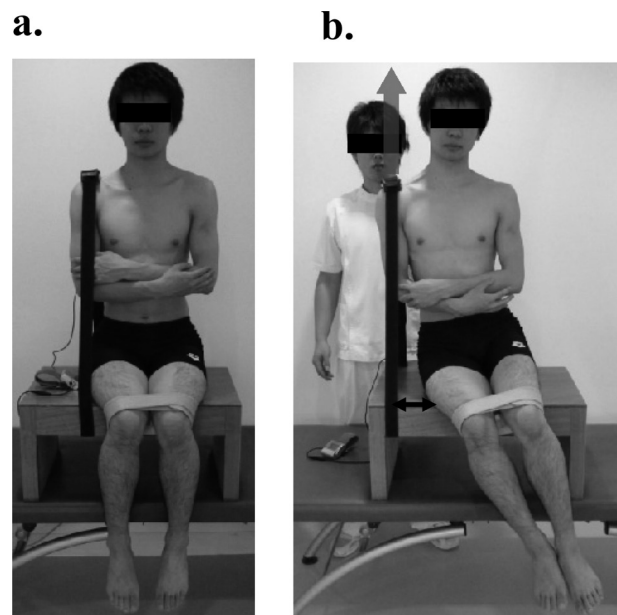


Fig. 2. The length of the belt is decided according to the start position. The sensor of the handheld dynamometer is placed on the inner part of the acromioclavicular joint (a). The position of the belt is moved by 10 cm toward the side (b).

ICC 2.1 was 0.93. I represents the results of the five subjects (Table 3). This is the average of the three subjects.

DISCUSSION

The most important aim of this study is to develop the TRT as a novel objective evaluation method for trunk function. The intraexaminer intraclass correlation coefficient showed that the reproducibility was higher than the standard of 0.90, confirming that the test could be performed with excellent reproducibility within the same examiners. Furthermore, the interclass correlation coefficient was also as high at 0.93, revealing that the interobserver reproducibility is also high. There was no statistically significant difference between the therapists with different levels of experience. The results suggest that the test is simple and reproducible even for inexperienced therapists, and that the TRT could be used in the clinic, independent of the experience of the therapists.

This study has some limitations. First, the study was performed in healthy subjects. It may be difficult to use for subjects with clumsy or impervious to the explanation. Second, quantitative evaluation of trunk function was not performed in this study. However, no objective method to quantify the trunk function has been established, and it might be impossible to correctly evaluate the TRT. Third, the consistency between different subjects is unknown to this study. Thus, further investigation is needed to determine whether the TRT will be a useful evaluation method for comparing trunk function in different subjects. Finally, this paper does not include clinical information that supports the importance of this test, although the TRT has already started to be used clinically at

our institution. Further studies are needed to confirm the importance of this test in clinical use, including a comparison within the same subjects at different time points.

In the TRT, the power toward the floor from the pelvis

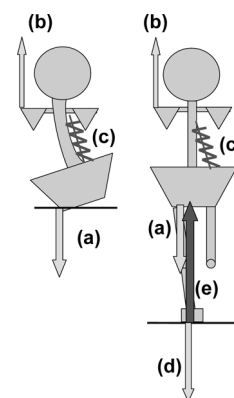


Fig. 3. In the TRT, the power toward the floor from the pelvis was transmitted to the belt and measured at the upper shoulder girdle of the same side. Simultaneously, asymmetric trunk muscle activity was required to fix the trunk; thus, the power measured in this test was considered to come from trunk. With the subjects in the standing position, the supporting force from trunk muscle was transmitted to the lower extremities and combined with the force from the lower extremities. The combined force would be the power against the floor force, and would be the mechanical base for body movements and posture stability against gravity.

(a) In the trunk righting test, the floor is pressed with the support of the pelvic region.

(b) The power is reflected in the pushing force to the upper shoulder girdle of the same side. The trunk righting test is performed to measure the trunk force.

(c) To fix the trunk, right and left asymmetry in muscle activity is required.

(d) With the subject in the standing position, the supporting force is transmitted to the lower limbs from the trunk.

(e) The floor reaction force from pushing the floor becomes the power source for antigravity activities; it will be mechanical foundation of body movements and posture stability against gravity.

Table 2. Test-retest reliability data for the trunk righting test in the three examiners

Test-retest reliability ICC(1.1) A	0.93
B	0.96
C	0.90
Test-retest reliability ICC(2.1)	0.93

Table 3. Measurement data for the trunk righting test in the five subjects

	Trial 1			Trial 2		
	First time	Second time	Third time	First time	Second time	Third time
Subject A R	146.3±54.5	120.0±22.7	131.3±9.5	128.0±11.4	120.0±28.0	127.3±11.1
L	77.7±19.6	82.3±7.6	78.3±7.2	67.3±5.0	67.3±10.7	71.0±14.1
Subject B R	156.7±9.8	151.3±8.3	148.3±13.6	136.0±34.8	125.3±27.6	143.7±9.1
L	168.7±17.6	176.0±19.0	168.3±7.5	172.7±14.0	195.3±5.1	176.3±2.9
Subject C R	214.0±7.9	222.7±9.7	213.0±5.0	223.7±2.5	212.0±4.0	211.0±2.6
L	213.3±11.0	218.0±16.7	227.0±20.0	232.7±1.2	234.0±8.0	229.3±6.1
Subject D R	95.3±7.2	94.0±3.5	96.7±15.0	106.0±9.6	91.3±2.5	96.3±4.0
L	91.0±8.2	86.0±10.6	86.0±10.6	84.3±12.1	86.7±7.5	87.0±9.6
Subject E R	150.7±16.3	149.0±9.5	150.0±11.3	145.7±19.7	144.3±16.2	140.7±10.7
L	108.7±9.0	108.7±5.7	109.0±4.4	110.7±17.0	109.0±8.7	103.0±17.7

Mean ± SD

was transmitted to the belt and measured at the upper shoulder girdle of the same side. Simultaneously, asymmetric trunk muscle activity was required to fix the trunk; thus, the power measured in this test was considered to come from trunk. With the subjects in the standing position, the supporting force from trunk muscle was transmitted to the lower extremities and combined with the force from the lower extremities. The combined force would be the power against the floor force, and would be the mechanical base for body movements and posture stability against gravity (Fig. 3). Thus, the force from the trunk, transmitted to the lower extremities, is considered to be essential for such movements and for stability. TRT is considered to measure this trunk force; thus, it is believed that the assessment of trunk function by using TRT is important.

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