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Balance highly influences flexibility measured by the toe-touch test

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ABSTRACT

Flexibility evaluation is a standard assessment in clinical and in sports settings. The Toe-touch test (TTT) is a common assessment tool to evaluate posterior muscular chain flexibility, but the test procedure implies a balance demand. The objective of the study was to verify the hypothesis that the balance demand during the TTT may affect the flexibility measured by the test. Twenty healthy, active young adults participated in the present study. Toe-touch test outcome (the linear finger to toe distance), Center of Pressure (CP) and sagittal plane joint angles were compared under two balance conditions: (1) standard TTT (ST) and (2) minimised postural demand (MPD) during TTT (using a device that restrained the participant against a forward fall). Then, ST was re-tested to verify a possible effect of motor learning on TTT outcome. Compared to ST, MPD showed an improvement of 73% in test outcome, greater flexion of the ankle, greater total body flexion, and a forward displacement of the CP. Re-test of ST showed indications of motor learning with a different balance strategy compared to the first trial in the same condition. The test outcome showed significant negative correlations with CP position in ST (weak correlation), in the re-test (strong correlation) and when the conditions were combined (moderate correlation). In conclusion, TTT outcome was highly affected by balance performance. Maximum range of motion during ST was a fraction of the range obtained when balance demand was minimized.

1. Introduction

Poor muscular flexibility has been understood as a factor related to a variety of conditions such as patellofemoral disorders (Witvrouw, Bellemans, Lysens, Danneels, & Cambier, 2001; Witvrouw, Lysens, Bellemans, Cambier, & Vanderstraeten, 2000), plantar fasciitis (Bolívar, Munuera, & Padillo, 2013), muscle soreness after exercise (LaRoche & Connolly, 2006) and muscle injuries (Witvrouw, Danneels, Asselman, D'Have, & Cambier, 2003). Therefore, the evaluation of posterior muscular chain flexibility is a standard assessment included in the screening for risk factors (Ayala, Sainz de Baranda, De Ste Croix, & Santonja, 2012a), in the assessment of the physical fitness status of the general population (Tveter, Dagfinrud, Moseng, & Holm, 2014), and in the measurement of the effectiveness of rehabilitation programs (Bonetti et al., 2010; Gagnon, Lensel-Corbeil, Duquesnoy, & Renodos, 2009).

The toe-touch test (TTT), also known as fingertip-to-floor test, is one of the most common tests chosen by clinicians, researchers, and athletic trainers to assess posterior muscular chain flexibility; it is a reliable and reproducible test, easily performed, requiring only a measurement tape. The TTT starts with the participant in an upright stance. He/she is then asked to flex the trunk trying to touch the toes while keeping the knees extended. The outcome of the test is the linear distance between the third finger and the hallux. It is thought to represent the maximum length of the posterior muscular chain. Large finger to toe distances, as well as increased ankle or hip angles, would suggest shortened muscles (Ayala et al., 2012a; Ayala, Sainz de Baranda, De Ste Croix, &

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Santonja, 2012b; Ekedahl, Jönsson, & Frobell, 2012; Kippers & Parker, 1987; Perret et al., 2001; Robinson & Mengshoel, 2014; Sainz de Baranda, Rodríguez-Iniesta, Ayala, Santonja, & Cejudo, 2014).

During the execution of the TTT, however, the trunk flexion required to reach the toes displaces forward and downward an equivalent of 60% to 70% of the total body mass (head, trunk and arms) (Winter, 2009). The displacement of such a mass represents a challenge to body balance and requires a balance strategy to counter the forward fall (Horak, 2006; Pollock, Durward, Rowe, & Paul, 2000). Given the body equilibrium requirement of maintaining a close relationship between center of pressure (CP) and center of mass (CM), one balance strategy that can be used during the execution of the TTT involves moving the CP forward proportionally to the CM displacement while eccentrically controlling the stretching muscles. Another possible strategy is focused on the primary control of the CM by increasing the ankle angle; this moves the hips backward to counteract the forward trunk movement (Hall, Brauer, Horak, & Hodges, 2010; Horak & Nashner, 1986; Van Ooteghem, Frank, & Horak, 2009). Probably, the strategy centered on the forward displacement of the CP might produce a better test outcome as it is more in line with the forward-downward reaching of the task test.

Therefore, as the TTT represents a high postural demand and different strategies can be used to deal with it, it was raised the hypothesis that the balance strategy used during the test would affect the outcome of the TTT. Then, manipulating the test conditions to minimise the balance demand might improve the test outcome.

Hence, the objective of this study was to verify if the TTT outcome (finger to toe distance) is changed by controlling the balance demand of the test. A second objective was to verify the correlation between the TTT outcome and the CP position during the test.

2. Methods

2.1. Experimental approach to the problem

This is a transversal observational study with continuous quantitative variables. To assess the influence of balance on the TTT, the balance demand of the test was manipulated. The variables were pairwise compared between the tests in the different balance conditions.

2.2. Subjects

In total, 20 healthy active young adults, 6 men and 14 women (24.9 ± 5.3 years old; 65.3 ± 12.6 kg of body mass; 170 ± 10 cm height; and 22.5 ± 2.9 BMI), agreed to participate in the study; they signed the Consent Form (1.956.241) approved by the Ethics Committee of the Hospital das Clinicas Faculdade de Medicina, Universidade de Sao Paulo (HCFMUSP). They were all able-bodied, capable of performing the TTT and classified as active by matching one of the following criteria: a) vigorous physical activity ≥ 3 days/week, ≥20 min/training session; b) moderate activity ≥ 5 days/week, ≥30 min/training session; or c) aggregation of any activity ≥ 5 days/week and ≥150 min/week.

Non-inclusion criteria included conditions that could interfere with balance or with the execution of the TTT, such as sensorial-motor dysfunctions, cognitive disorders, joint deformities, or any pain or discomfort that might prevent the performance of the test. Additionally, people engaged in competitive sports and/or flexibility training were also not included.

2.3. Procedures

All tests were performed by the same trained researcher at the Laboratory of Medical Investigation 23 (LIM 23), at a comfortable temperature, during afternoons. The participants were barefoot and wearing comfortable sports clothes which allowed them to move freely.

With the participant in upright stance, seven spherical markers were attached to the trunk and right lower limb as follows: (1) head of the fifth metatarsal (5MT); (2) lateral malleolus (LM); (3) head of the fibula (HF); (4) great trochanter (GT); (5) anterior superior iliac spine (ASIS); (6) posterior superior iliac spine (PSIS); (7) second lumbar vertebrae (L2); and (8) seventh cervical vertebrae (C7). Two digital cameras (Canon Powershot SX500) were placed at the right side of the participant. One camera captured the lower limb, while the other captured trunk images. The calibration was performed by two marks 50 cm apart in the vertical and two in the horizontal.

Participants were positioned as comfortably as possible on the force platform (Pro Balance Master - Neurocom software 8.4.0, Neurocom®), with feet positioned using the platform landmarks, i.e., the medial malleolus matched with the X axis of the platform and each foot was placed equally apart from the Y axis.

A 30-second trial was performed with the participant in a quiet upright stance to normalise the CP position. Then, the participants were asked to perform one repetition of the TTT in two balance conditions in the following sequence: (1) standard test (ST); (2) minimised postural demand (MPD); and (3) re-test of the ST.

ST and re-test were performed as usual, with the participant in an upright stance, he/she was asked to flex the trunk trying to touch the toes while keeping the knees extended and neck relaxed. The MPD was performed with a device that restrained participants from falling forward. A 10-cm wide Velcro strap was crossed in front of the participant at the hip level and was firmly attached to the lateral bars of the platform support. These bars are normally used to attach the security harness of the platform, and the Velcro strap was sufficient to support the participant's weight without risk of falling forward. The participants were asked to bring the hip forward so that they could feel the body weight lying against the strap (see Fig. 7). Then, the participants were asked to perform the TTT