DEVELOPMENT, INSTRUMENTATION AND STANDARDIZATION OF THE EQUIPMENT FOR MODIFIED THOMAS TEST

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Abstract. *Flexibility tests have been widely used in physical assessment (straight leg raising - SLR; ober-test; original Thomas test; modified Thomas test). However, limitations of standardization have been shown in the literature. The modified Thomas test is one of the main tests available to evaluate the flexibility of the hip flexors muscles. Studies have used the Thomas test to assess the flexibility of mono and biarticulate hip flexors muscles. The interpretation of Thomas test's results should be done carefully, since there are no control over compensatory movements such as, flexion of the opposite hip, tibial rotation, hip abduction and rotation or pelvic rotation and obliquity. The lack of standardization also makes difficult to assure the body position for reevaluation. Through the instrumentation the variability of the tested subject position could be significantly minimized. The present paper aims to develop mechanical equipment for standardization of the modified Thomas test.*

Keywords: *Modified Thomas test, Mechanical Equipment of flexibility, Flexibility, Hip flexors*

1. Introduction

Stretching exercises are widely used among athletes and sports practitioners from different modalities. Health professionals usually recommend stretching exercises for relaxation of stress and tension, improvement of posture, development and maintenance of the flexibility and to reduce the flexibility loss through life (Alter, 1996). Physical activity programs, high performance athletes and rehabilitation have stretching as an important component of the program. Carneiro and Andrade (2002) define stretch as the group of techniques used to maintain or increase the flexibility in one or more joints, with safety and efficiency.

Flexibility can be defined as the range of motion (ROM) in a joint or group of joints (Bloomfield, Ackland and Elliott, 1994) or the ability of a person to move a part or parts of the body in a wide range of purposeful movement (Alter, 1996). Flexibility can be assessed with a specific test for each joint movement (Bloomfield, Ackland and Elliott, 1994; Harvey, 1998). The assessment of this physical capacity should be done with valid and reliable tests. For Corbin and Noble (1980) the flexibility is specific for each joint, so if an athlete is flexible in one joint it doesn't mean that he'll have a similar ROM in others. Weineck (1999) stated that flexibility tests are responsible for transforming joint ROM in quantifiable measure as centimeter or degrees, what is necessary for training feedback (Achour, 1996).

Many flexibility tests used by health professionals are available in the literature, such as Straight Leg Raising (Bohannon, 1982), Ober-test (Melchione and Sullivan, 1993), Knee Extension test (TEJ) (Gajdosik and Lusin, 1983), original Thomas test (Thomas, 1876) and modified Thomas test (Kendall, Mccreary and Provance, 1995). However, these tests have been criticized for their absence of standardization during the execution (Gajdosik et al., 1985;

Bohannon, 1982). The Thomas test is proposed to measure the flexibility of hip flexion muscles, but as mentioned, it has a reduced standardization.

There are several hip flexion muscles, but the main ones are psoas major, iliacus, sartorius, rectus femoris and tensor fasciae latae. Kapanji (1980) stated that hip flexor muscles are located anteriorly to the frontal plan which passes through the hip joints. All these muscles have their course anteriorly to the flexion-extension hip axis XX' of the Fig. 1. However, hip flexor muscles have secondary actions such as adduction, abduction or internal-external hip rotation.

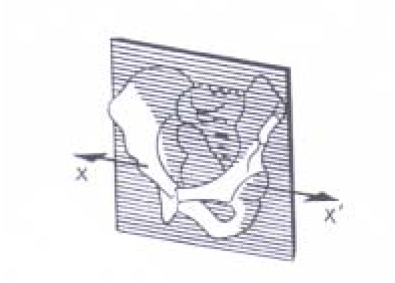

Figure 1. Flexor-extension of the hip joint axis

Muscle stretch tests are used to verify the length of the muscle, and allow us to classify it's length as normal, tight or loose. These tests consist of a body movements which increase the distance between origin and insertion of the muscle, thus the movements are contrary to muscle actions. Normally these tests stabilize the bone where muscle origin is located while the bone where muscle is inserted moves away from origin (Kendall, Mccreary and Provance, 1995).

The original Thomas test (Thomas, 1876) and modified Thomas test (Kendall, Mccreary and Provance, 1995) are the most used tests to assess hip flexion muscle flexibility. The former one has been used by many authors to evaluate the range of motion of hip joint muscles (Krivickas, 2001; Magee, 2002), while the latter has been used to evaluate the muscles that cross both hip and knee joint (Kendall, Mccreary and Provance, 1995). Meanwhile, other movements as tibial rotation, hip adduction or pelvic obliquity were left out of count. These variables could affect significantly the results and lead to a misinterpretation of results (Kendall, Mccreary and Provance, 1995).

2. The original Thomas test

In the Original Thomas test, the person lies supine with both lower legs straightened. The examiner flexes one of the person's hip and knee, bringing the knee to the chest to flatten out the lumbar spine, and the patient holds the flexed hip against the chest. If there is flexion contracture, the hip being tested rises off the table (Fig. 2) and the angle of the contracture can be measured (Magee, 2002). This test, however, lacks in evaluating the influence of bi-articular muscles in the passive hip extension (Carneiro and Andrade, 2002).

Figure 2. Original Thomas test

2.1. The modified Thomas test

Kendall, McCreary and Provance (1995) suggested the Modified Thomas test as an improvement of the Original Thomas test. The Modified Thomas test should be able to assess the flexibility of mono or bi-articular muscles. To evaluate the length of bi-articular muscles the volunteer lies supine close to the edge of the examination table, so that both lower extremity are hung up. The use of the modified Thomas Test allows an accurate assessment of the hip flexor muscles, giving more information about the tight muscle. However, some cautions are needed while performing the test, thus only expert examiners are capable of elucidate accurately the results. Kendall, McCreary and Provance (1995) and

Magee (2002) emphasize that the examiner should be careful while performing the Modified Thomas test, since compensatory movements might happen leading to misinterpretation (Fig. 3).

Figure 3. Modified Thomas test

Dillen et al. (2000) studied the influence of knee flexion angle, hip abduction and adduction angle during the passive hip range of motion. They concluded that knee angle and hip abduction and adduction angle alter the hip extension ROM, what disturbs the test results (Fig. 4 and Fig.5).

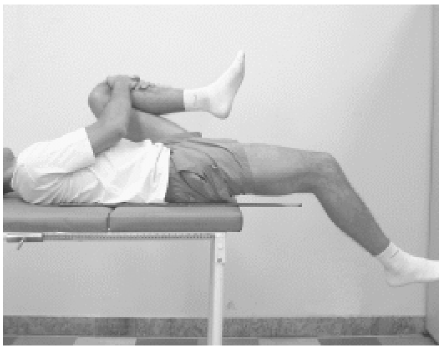

Figure 4. Knee extension.

Figure 5. Hip abduction.

Both Original and Modified Thomas test lack of standardization, so the subject posture and setup are not recorded. This procedure problem makes harder the reevaluate the person after a period of time. Based on the limitations of the Modified Thomas tests an instrument were developed to improve standardization and to obtain a high variable stability.

2.2. Development of the equipment for modified Thomas test with the instrumentation

This instrument was developed to reduce the compensatory movements and assess both mono and bi-articular muscle during the performance of the Modified Thomas Test. The Biomechanical laboratory (BIOLAB) from the Physical Education, Physical Therapy and Occupational Therapy school and the Department of Mechanical Engineering at UFMG worked together to develop the instrument. It’s basically a bench with holders for the shoulders. These holders are adjustable to fit people of different height. To assure that the holders could be adjusted in the same position over time, a metrical scale was horizontally attached to the examination table with 0,1cm precision (Fig. 6). Parallel to the bench an adjustable, 45 cm wide and 35 cm high, transparent plastic (acrylic) plate was used to forbid hip abduction in open kinetic chain. This plate is horizontally and vertically adjustable fitting different pelvic height and width (Fig. 7).

Figure 6. Bench with adjustable holders for shoulders.

Figure 7. Bench with acrylic plate for hip abduction limitation.

Two splints were made to minimize the compensatory movements. One was used to assure that the ankle joint would remain in neutral position of plantar flexion and in the sagittal plane. The purpose of this splint is to maintain the knee and ankle position while the Modified Thomas test is being performed, since a tight tensor fasciae latae cause external tibial rotation and a tight sartorius can rotate the tibia internally, leading to a misinterpretation of the results. The second splint keeps the knee flexed at 90^{o} degree angle (Fig. 8).

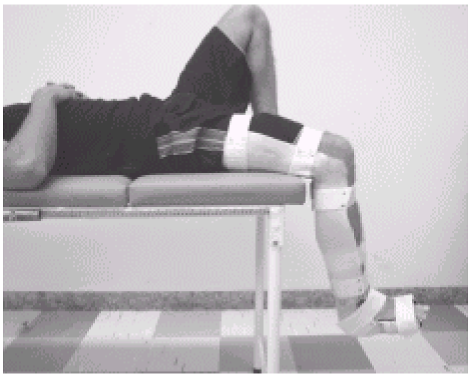

Figure 8. Splints for fixation of knee and ankle ROM.

The knee angle was assured by an iron bar attached in the base of the splint, and the lower limbs postured in it and hold by straps. The aim of the second splint is to minimize knee movements during test performance, such as knee extension due to rectus femoris or tensor fasciae latae tightness, and knee flexion due to sartorius tightness. Changes in the knee angle could alter the hip flexion, leading to a misinterpretation of the results.

In order to help low back pressure standardization while holding the flexed hip against the chest and knee, an equipment call stabilizer (pressure Bio-Feedback) was used. The stabilizer works as sphygmomanometer, showing the compression force imposed to the low back while performing the test. While performing the rest the examiner can maintain the force, which helps to obtain stable measures.

The reliability of the Modified Thomas Test with the instrument previously described was studied at the Physical Education School at UFMG. Both intratester and intertester were calculated in this study. Fourteen male students of physical education volunteer to this study. The volunteers had no knee or hip joint problem. Volunteers had both lower limbs assessed by two examiners. One week latter volunteer were reevaluated at the time by both examiners. Results show a moderate intraclass correlation coefficient (ICC = 0,50 and 0,68) and a Pearson product-moment correlation of 0,82 to the first evaluation day 1 and 0,79 to the second day. The paired-sample *t*-test showed significant difference between the mean values of both evaluation days for examiner 1. Author mentioned that while performing the test compensatory movements not yet mentioned in the literature, such as pelvic obliquity and hip external rotation, were manually corrected.

Based on the results of this primary results of the modified Thomas test with standardization, the present study aims to introduce a new proposal to develop an instrument that allows a high stability and specificity of the measures obtained with the Modified Thomas Test.

In the second phase, the development of especially projected equipment was based on the previous cited limitations. The result can be seen in the figure below at the elaborated virtual mock-up (Fig. 9). The sizing was made considering a useful load of 2000 N and estimated weight of 1000 N for the mechanical equipment. Moreover, it was looked to use easy manufacture materials such as wood and aluminum plates and profiles, which basically demanded manual operations of cut, drilling and finishing.

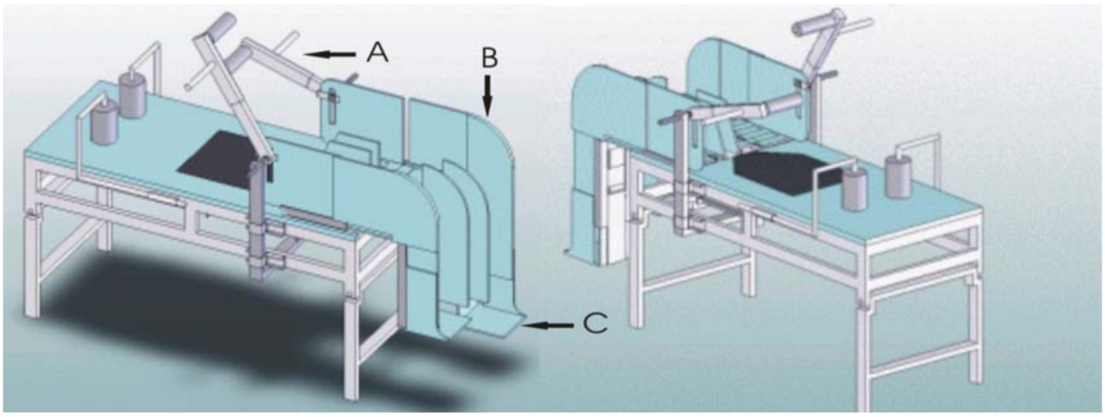

Figure 9. Virtual mock-up of the equipment of the modified Thomas test.
a- hip flexion control system, b- leg frame c- adjustable footplate

3. Preliminary results

The preliminary results presented in this study are associated with the mechanical solutions achieved by virtual mock-up. The poor reliability of the modified Thomas test is consequence of difficulty in standardizing the hip flexion ROM against the chest. To maintain a specific hip joint angle the hip flexion control system was developed (Fig. 9-a). This system moves the thigh against the chest until the end position, which the tester determines. This position can remain stable throughout the testing improving the reproducibility. Another cited limitation is compensatory movement, for example tibial rotation, knee extension, hip abduction and adduction. The movements also affect the test results and reliability. The leg frame (Fig. 9-b) was created to restrict tibial rotation, knee extension, hip abduction and adduction. The leg frame associated with the shoulder pads and adjustable footplate enable to adjust subjects with different heights to the equipment and to standardize the subject postures (Fig. 9-c).

4. Conclusions

The results of the first tentative of instrumentation and standardization of the modified Thomas test showed the limitations of the existent tests. Based on problems and limitations of modified Thomas Test and previous instruments this equipment was developed. The present mock-up seems to solve the cited problems with the use of easy to manufacture materials.

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6. Responsibility notice

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