Lumbar lordotic angle and pelvic tilt angle in the simple modified Thomas test position are easier to assess than those in the Thomas test position: A radiographic study

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Abstract The purpose of this study was to compare the lumbar lordotic angle (LL) and pelvic tilt angle (PT) in the simple modified Thomas test (SMTT) position with LL and PT in the Thomas test (TT) position. Participants (n = 20) were between the ages of 23 and 39 and had no history of trauma. LL and PT were measured by X-ray radiographs under three conditions: the SMTT position, TT position, and supine position. At the same time, the distance between the examination table and the popliteal fossa was measured with a ruler. These measurements were compared by one-way analysis of variance. LL (14.6 ± 6.7 degrees [°]) in the SMTT position was significantly lower than in the TT position (18.6 ± 6.6 °) (p < 0.01). PT (33.5 ± 7.6 °) in the SMTT position was significantly higher than in the TT position (31.3 ± 6.9 °) (p < 0.05). The distance between the examination table and the popliteal fossa in the SMTT position (100 ± 37.7 mm) was significantly higher than in the TT position (73.5 ± 27.4 mm) (p < 0.01). These results suggest that LL and PT in the SMTT position are easier to assess than those in the TT position.

Keywords : lumbar lordotic angle, pelvic tilt angle, Thomas test, simple modified Thomas test, radiographic study

Introduction

In clinical orthopedics, the Thomas test (TT) and modified Thomas test (MTT) are commonly used by clinicians to assess iliopsoas muscle flexibility in a sports setting. The importance of these assessment techniques is confirmed by their inclusion in many prominent sports medicine textbooks¹,², and their use as measurement tools in research examining iliopsoas muscle flexibility and range of motion (ROM) of the hip joint.

In the TT, participants were positioned in the supine position on the examination table, and the examiner passively flexed the untested hip joint, bringing the knee up to the chest in order to decrease the lumbar lordotic angle (LL) and increase rotation of the pelvic tilt angle (PT) (Fig. 1a)⁰. This test was scored as a fail if the tested hip joint flexed and the knee lifted off the examination table. In another study, the TT was used to measure the distance between the examination table and the popliteal fossa with a ruler⁴. This method was used for checking the flexibility of youth soccer players. While this test is a convenient method in a sports setting, there is a possibility that less LL and greater PT are insufficient.

MTT has been used to assess the flexibility of hip flexor muscle⁴,⁵. In MTT, participants sit at the end of an examination table, roll back onto the examination table, and hold both knees to the chest⁴. While holding the untested hip in maximal flexion with their arms, participants lower their tested limb towards the floor (Fig. 1b). Consequently, it is possible that the MTT result in less LL and greater PT compared to the TT⁶. This test was used to evaluate the range of motion about a hip joint. MTT requires the end of an examination table and a goniometer. The athlete has the flexibility to perform the prevented injuries and often checks the flexibility of muscle in a sports setting. However, MTT is not convenient for sports settings.

Therefore, we developed a simple modified Thomas test (SMTT) that is not required at the end of an examination; thus, the SMTT only requires a ruler (Fig. 1c). Although SMTT is a convenient method and may show less LL and greater PT compared to those obtained using TT, results are still unclear. The purpose of this study was to compare the LL and PT in the SMTT position with those in the TT position.

Materials and methods

Participants. Twenty healthy men with no history of
Trauma participated in this experiment (mean age: 30.8 years; age range: 23-39 years). The main criterion for inclusion was an absence of musculoskeletal limitations that would limit their performance in these tests. We obtained informed consent from all participants before beginning this investigation. Study protocols were approved by the ethics committee of Asahi Hospital (A-32).

**Procedures.** We assessed LL and PT under three conditions (supine position, TT position, and SMTT position). In these positions, the distance between the examination table and the popliteal fossa for each participant was measured by ruler. First, all participants underwent a radiography to examine LL and PT in the supine position. Next, we performed TT or SMTT. The order of procedures, after the supine position, was randomized using a random number table. The participants were allowed to rest for 5 minutes between the different tests.

Radiographs were taken between the lower thoracic vertebra and hip joint. A radiology technologist evaluated LL and PT. The technologist was blinded to the details of this study, and whether the radiograph was taken in the TT position or SMTT position. These parameters were evaluated two times with an interval of 1 week. The averages of the two measured values were used for this study.

**Measurements**

*Distance between the examination table and popliteal fossa in the TT position and SMTT position*

The TT was carried out according to the procedures described in the Orthopedic Physical Assessment textbook. The participants were positioned in the supine position on an examination table, and the examiner passively flexed one hip, bringing the knee up to the chest in order to decrease lumbar lordosis and increase pelvic posterior tilt (Fig. 1a). In this study, we used a ruler to measure the distance between the examination table and popliteal fossa in the TT position for assessing iliopsoas muscle flexibility.

We developed the SMTT based on Harvey’s MTT. Participants reclined on the examination table, and the examiner actively flexed both hip joints, with both knees brought up to the chest to decrease lumbar lordosis and increase pelvic posterior tilt. While participants held...
The simple modified Thomas test is more effective than the Thomas test, as the untested hip in maximal flexion with their arms, the tested limb was lowered toward the floor (Fig. 1c). The measurement obtained in the SMTT position was obtained in the same way as for the TT position. During the TT and SMTT, it was important to prevent the pelvis and lumbar spine from shifting to a neutral position in coronal alignment.

We performed a pilot test to determine the reliability of the TT and SMTT assessments. Eight healthy men (mean age 28.6 ± 5.7, age range 23-38 years) with no history of trauma participated in this experiment. Two experienced physical therapists were recruited as examiners. Participants underwent independent assessment by both examiners, randomly. Examiners performed two testing sessions at an interval of 1 week. Intra-class correlation coefficients (ICC) were used to evaluate the relative reliability of the values. Intra-rater reliability (ICC [1, 1]) of the TT ranged from 0.82 to 0.90 and that of SMTT ranged from 0.88 to 0.90. Inter-rater reliability (ICC [2, 1]) of the TT was 0.92 and that of SMTT was 0.94.

**LL and PT in TT position and SMTT position**

LL and PT were determined using standing sagittal radiographs (Fig. 2). These parameters were also reported for the supine position (Fig. 3). LL was measured from the superior end plate of the first lumbar vertebra to the superior endplate of the first sacral vertebra. PT was defined as the angle between a vertical axis and the line through the midpoint of the sacral plate to the femoral head axis. We compared LL and PT among the supine position, TT position, and SMTT position.

**Statistical analysis**

We calculated the distance in the SMTT position minus the supine position change. This value was taken as the SMTT change value. Likewise, we calculated the distance in the TT change value. Moreover, we also calculated LL and PT in the SMTT change and TT change.

Outcomes were analyzed using repeated measures one-way analysis of variance (ANOVA) with post-hoc Bonferroni correction. A paired t-test was used to assess differences between TT change and SMTT change. Statistical
analyses were performed with EZR (Saitama Medical Center, Jichi Medical University), a graphical user interface for R (The R Foundation for Statistical Computing, version 2.13.0). More precisely, it is a modified version of the R Commander (version 1.6-3) that includes statistical functions frequently used in biostatistics. P-values less than 0.05 were considered statistically significant.

Results

Characteristics of the participants. Descriptive statistics for study participants are presented in Table 1. The mean age of participants was 30.8 years (30.8 ± 5.1 years), and all participants were adult men.

Measured LL, PT and distance between the examination table and popliteal fossa in the TT position and SMTT position. LL, PT and the distances between the examination table and popliteal fossa on several tests are presented in Table 2. These parameters were significantly different (p < 0.01). The LL in the SMTT position showed the lowest values (p < 0.05). PT in the SMTT position showed the highest values (p < 0.05). The distance in the SMTT position was the highest among other tests (p < 0.01).

The results of the change values of LL, PT and distance are shown in Table 3. LL mean change in the SMTT position was greater than that in the TT position (p < 0.01, Cohen d = 0.66). PT mean change in the SMTT position was greater than that in the TT position (p < 0.05, Cohen d = 0.49). Additionally, the distance mean change in the SMTT position was greater than in the TT position (p < 0.01, Cohen d = 0.86, Table 3).

Discussion

Athletes can reduce injuries by maintaining a higher level of muscle flexibility, and are able to check muscle flexibility in a sports setting. MTT has been used to assess the flexibility of the hip flexor muscle. However, MTT requires an examination table and goniometer. Thus, it is not a convenient method for checking flexibility. We

Table 1. Participants’ anthropometric data (mean, [SD]) in the present study

<table>
<thead>
<tr>
<th>Parameter</th>
<th>mean (SD)</th>
<th>min</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (years)</td>
<td>30.8 (5.1)</td>
<td>23</td>
<td>39</td>
</tr>
<tr>
<td>height (m)</td>
<td>1.7 (0.04)</td>
<td>1.6</td>
<td>1.8</td>
</tr>
<tr>
<td>weight (kg)</td>
<td>64.1 (5.6)</td>
<td>55</td>
<td>81</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.0 (2.1)</td>
<td>18.8</td>
<td>28</td>
</tr>
</tbody>
</table>

Table 2. Lumbar lordosis angle (LL), Pelvic tilt angle (PT) and the distance between the examination table and popliteal fossa on several tests

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Supine, mean (SD)</th>
<th>TT, mean (SD)</th>
<th>SMTT, mean (SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL (°)</td>
<td>42.9 (7.6)</td>
<td>18.6 (6.6)</td>
<td>14.6 (6.7)</td>
<td>a*, b*, c*</td>
</tr>
<tr>
<td>PT (°)</td>
<td>11.0 (5.9)</td>
<td>31.3 (6.9)</td>
<td>33.5 (7.6)</td>
<td>a*, b*, c**</td>
</tr>
<tr>
<td>Distance (mm)</td>
<td>19.5 (9.9)</td>
<td>73.5 (27.4)</td>
<td>100 (37.7)</td>
<td>a*, b*, c*</td>
</tr>
</tbody>
</table>

One-way ANOVA, a: Supine vs. TT, b: Supine vs. SMTT, c: TT vs. SMTT
* : < .01, **: < .05
developed the simple modified Thomas test (SMTT) that doesn’t require an examination table or other such equipment. In our data, an important clinical observation by radiographic analysis revealed that LL and PT in the SMTT position are easier to assess than in the TT position. To our knowledge, radiographic analysis in the TT or SMTT position has not been previously reported. In addition, the distance between the examination table and popliteal fossa means the change in the SMTT position was greater than that of the TT position. These results imply that SMTT is clinically useful to assess iliopsoas muscle flexibility in a sports setting.

It has been reported that the flexibility of the hip flexor muscles using MTT provides some objective data for this clinical test in a sports setting\(^1\)\(^{10-12}\). Its commonly used by clinicians to assess ROM about the hip joint\(^1\)\(^2\). Examination iliopsoas muscle flexibility using MTT uses the end of an examination table and a goniometer, so it was not convenient to use in a sports setting. While the TT is a method developed to evaluate flexion contracture in childhood hip joint disease\(^3\), it has been applied to evaluate hip flexion contracture in athletes\(^3\)\(^{14}\). Ohba measured iliopsoas muscle flexibility of a junior soccer player using the TT as a convenient method in a sports setting\(^3\). The TT only uses a ruler and can be done easily. However, in the TT, since the examiner passively flexes one hip bringing the knee up to the chest, there is concern that lumbar flattening and posterior rotation of the pelvis is insufficient. Therefore, we proposed that the SMTT is more convenient to use in a sports setting.

This study indicated that the SMTT position is associated with less LL and greater PT compared to the TT position. For the SMTT and MTT, the participant rolls onto the examination table, and holds both knees to the chest. Harvey argue that differences in results when comparing the TT position and MTT position could be related to lumbopelvic alignment\(^5\). In the TT position, the contralateral hip is not sufficiently held maximally flexed to the chest, so the pelvis may not be a sufficient posterior rotation position. Thus, there is less tension on the iliopsoas muscle in the TT position, so a lower LL and greater PT are difficult to achieve compared to the MTT position.

For validity, it is important that a participant hold both knees to the chest in the SMTT and MTT. Therefore, the SMTT position also resulted in less LL and greater PT compared to the TT position.

In our pilot study, the reliability of the TT and SMTT showed that the comparison was good between the ICC values (intra-rater ICC = 0.88 [tester A], 0.99 [tester B]; inter-rater ICC = 0.94) for the TT and the ICC values (intra-rater ICC = 0.82 [tester A], 0.90 [tester B]; inter-rater ICC = 0.92) for the SMTT. The reliability of the TT and MTT using a goniometer has been evaluated, showing ICC values for the TT (intra-rater ICC = 0.52, inter-rater ICC = 0.60)\(^6\) and for the MTT (intra-rater ICC = 0.67, inter-rater ICC = 0.50)\(^6\). Our method to measure the distance between the examination table and popliteal fossa might show better reliability compared to these previous studies using a goniometer.

In our study, the SMTT showed measures of at least 50 mm from the examination table to the popliteal fossa. This value means that the hip joint is in flexion. Similar to our study, Peeler reported that hip joint range of motion using the TT observed an average flexion of 7 ± 2°. In contrast, values from Harvey’s study showed measures of approximately −11° from horizontal for the femur in the MTT. This value means that the hip joint is in extension. Differences in results when comparing the MTT and SMTT might be related to use of the end of the examination table in the MTT position. When the tested limb was lowered towards the floor, in order to take the leg down from the end of the examination table, the tested hip joint was strongly extended. In the case of the SMTT, when the tested limb was lowered from the examination table, the tested hip joint was not strongly extended.

This study has several limitations. First, the TT and MTT are commonly used by clinicians to assess ROM of the hip joint. In the case of the SMTT, the distance between the examination table and the popliteal fossa is measured. Because the SMTT only uses a ruler, it is convenient, but is affected by the femoral length\(^5\). When a participant is taller, a correlation is reported between the femoral length and height, and the popliteal fossa to examination table distance may become larger. However, in

<table>
<thead>
<tr>
<th>parameter</th>
<th>TT change, mean (SD)</th>
<th>SMTT change, mean (SD)</th>
<th>effect size</th>
<th>relative size</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL (°)</td>
<td>24.3 (7.0)</td>
<td>28.3 (7.5)</td>
<td>0.66</td>
<td>medium</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>PT (°)</td>
<td>20.3 (6.4)</td>
<td>22.5 (7.6)</td>
<td>0.49</td>
<td>small</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Distance (mm)</td>
<td>54.0 (27.0)</td>
<td>80.4 (35.9)</td>
<td>0.86</td>
<td>large</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

A paired t-test, TT change vs. SMTT change
our study, the correlation between height and distance in the SMTT position was not significant (r = 0.26, p = 0.26). Therefore, we determined that the femoral length has little influence on the distance. Second, we could not directly assess the flexibility of the iliopsoas muscle, which can affect movement of the hip joint. The flexibility of the iliopsoas muscle can be evaluated quantitatively using ultrasonography16). The result of such a study would help to clarify the results of our study.

Conclusions

In this study, we examined the LL and PT with the SMTT and TT using radiographs. The results of this study indicate that the SMTT position resulted in less LL and greater PT compared to the TT position. Therefore, the SMTT may provide important information for practitioners in a clinical and sports setting.

Conflict of Interests

The authors declare no conflict of interests regarding the publication of this article.

References