The Mulligan ankle taping does not affect balance performance in healthy subjects: a prospective, randomized blinded trial

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Abstract. [Purpose] The aim of this study was to evaluate the immediate effects of Mulligan fibular taping on static and dynamic postural balance in healthy subjects using computerized dynamic posturography (CDP). [Subjects and Methods] Forty-four volunteers (26 males and 18 females) aged 21 ± 2 years participated in the study. The Mulligan tape was applied by a specialist in this technique. The placebo group received a treatment with a similar tape but with several cuts to avoid the fibular repositioning effect produced by Mulligan tape. Main outcome measures: The Sensory Organization Test (SOT) and the Motor Control Test (MCT) were performed by each subject at baseline and after the interventions. Outcome measures included equilibrium and strategy scores from each trial and condition of the SOT, and speed of reaction (latency period) from the MCT. [Results] Mulligan ankle taping did not have an impact on postural control during static and dynamic balance in subjects with healthy ankles when compared with placebo taping. [Conclusion] There was no difference in equilibrium and strategy (SOT) and speed of reaction (MCT) in any of the subjects in this study. Therefore, this study suggests that Mulligan ankle taping does not have an impact on balance in healthy subjects.

Key words: Ankle, Balance, Dynamic posturography

INTRODUCTION

Ankle sprains are one of the most common musculoskeletal injuries, accounting for 15% of all sport injuries. Although the prognosis of ankle injuries is good, almost 80% of all athletes suffer from recurrent ankle sprains\textsuperscript{1}, and up to 40% may develop ankle instability\textsuperscript{2}.

Many theories have been postulated to explain the pathophysiology of an ankle sprain: muscular weakness\textsuperscript{3}, increased postural sway\textsuperscript{4}, and proprioceptive and positional deficits\textsuperscript{5,6}. In order to correct these fibular misalignments, Mulligan developed a fibular taping technique in the nineties\textsuperscript{7}. Other ankle taping techniques are used to treat patients with ankle sprains in order to improve mechanical stability and proprioceptive activity\textsuperscript{8}.

Moiler et al.\textsuperscript{9} demonstrated that fibular taping decreases the number of ankle injuries in basketball players. More recently, Delahunt et al.\textsuperscript{10} did not find any postural balance improvement with the Star Excursion Balance Test (SEBT) when using fibular taping compared with another type of taping.

In a recent study, Hopper et al.\textsuperscript{11} showed that Mulligan tape did not improve static and dynamic balance in patients with unilateral chronic ankle instability when compared with the same taping in healthy subjects. A drawback of their study is that balance was not evaluated with computerized dynamic posturography, which is considered the gold standard method. Computerized dynamic posturography (CDP) is a quantitative method of assessing and treating balance disorders\textsuperscript{12–14}.

The Sensory Organization Test (SOT) is included in the CDP. With a sensitivity of 95%, a specificity of 92%, and a 5% false positive rate, it is considered the gold standard for postural control\textsuperscript{15–17}. During this test, visual and somatosensory inputs are modified (by moving the visual panel and/or the force platform), and the subject’s reactions are recorded and analyzed. Also, the visual panel, force platform, or both may be “sway-referenced”, so they move to follow the subject’s sway, giving inaccurate information to the eyes or feet. The information is collected from six different “conditions” that combine the movement of the panel and the force platform, and the results express the subject’s degree of functional impairment and the ability to maintain equilibrium using different systems involved in balance.
control (visual, vestibular, and proprioceptive). When the somatosensory information is inaccurate (sway-referencing
of the platform) the subject must rely on the visual and/or vestibular references to maintain balance. Sway-referencing
the visual surround enables evaluation of the subject’s ability to disregard inaccurate visual information and rely on
vestibular and somatosensory inputs18–20.

Although the Mulligan taping method has been widely studied, little is known about its underlying physiological
mechanisms and balance effects. Consequently, the purpose of the present study was to evaluate the immediate effects of
Mulligan taping on static and dynamic postural balance in healthy subjects using CDP.

**SUBJECTS AND METHODS**

We conducted a prospective, randomized, blinded trial. Informed consent was obtained from all participants and
procedures were conducted according to the Declaration of Helsinki. Prior to participation in the study, all patients
signed an informed consent form (ICF). The protocol (No. URJC_20_2012) was approved by the Ethics Committee of
Rey Juan Carlos University, Spain.

Forty-four subjects volunteered to participate in the study. Recruitment was performed by public advertisement
at Rey Juan Carlos University. The inclusion criteria were good health and age between 20 and 30 years. The exclusion
criteria were any history of pain, lower limb injury in the past 12 months, ankle surgery, vertigo, dizziness, and/or
any balance-related disorder. All participants reported a medium level of physical activity. Characteristics of subjects are
presented in Table 1.

Subjects were randomly distributed into 2 groups with a statistics program (GraphPad Software, Inc., La Jolla, CA, USA). Group 1 was treated with Mulligan tape; group 2 was treated with placebo tape. Subjects were evaluated at baseline without any intervention and with the tape (to rule out learning effects). Both participants and the examiner were blind to the type of intervention (double-blind randomized controlled trial study). The present document was prepared according to the editorial form of medical publishing and CONSORT publishing rules21.

Experimental setup. Balance was assessed using a SMART Equi Test® system (International Inc., Clackamas, OR, USA)3. Experimental protocol. Participants were asked to wear comfortable clothes and socks during the evaluation. Height (cm) and body mass (kg) were measured without shoes. Subjects stood upright on the force platform facing the visual panel with their feet positioned to align each medial malleolus with specific marks according to the SMART Equi Test® system operator’s manual. For safety while standing, each participant wore a safety harness to prevent falls, and
the operator was within touching distance of the participant. Participants stood as steady as possible and were asked to
maintain their balance during the SOT and Motor Control Test (MCT) protocols.

All participants completed 3 trials, each lasting 20 seconds, of the 6 balance testing conditions in the SOT protocol (Fig. 1)14. The force platform remained fixed for the first 3 conditions of the SOT. SOT1 was conducted with the eyes open, SOT2 was conducted with the eyes closed, and SOT3 was conducted with the visual panel sway-referenced to the participant’s postural oscillations. SOT4, SOT5, and SOT6 repeated the visual pattern of the first 3 conditions with a platform sway-referenced to the anteroposterior oscillation of the subject (cancellation of ankle proprioceptive inputs).

The MCT assesses the ability of the automatic motor system to quickly recover following an unexpected external
disturbance18. Horizontal translations of the platform result in displacement of the center of gravity (COG) in the op-

| Table 1. Baseline demographics for both groups |
|-----------------------------------------------|
|                                               |
| Number of subjects (n) | Tape group | Placebo group |
|------------------------|------------|---------------|
| Age (yrs)              | 21.7 (2.5) | 21.7 (3.0)    |
| Gender (M/F)           | 9/14       | 9/12          |
| Height (cm)            | 168.2 (8.9)| 171.0 (8.2)   |
| SOT1 (%)               | 93.8 (2.4) | 93.6 (2.1)    |
| SOT2 (%)               | 90.7 (4.9) | 90.8 (6.2)    |
| SOT3 (%)               | 86.1 (9.9) | 89.8 (2.1)    |
| SOT4 (%)               | 63.3 (10.4)| 64.9 (10.5)   |
| SOT5 (%)               | 58.2 (20.5)| 66.8 (14.3)   |
| CES (%)                | 77.3 (7.4) | 80.2 (4.3)    |
| SR (%)                 | 0.9 (0.0)  | 0.9 (0.0)     |
| TSS (%)                | 90.7 (4.2) | 91.0 (2.0)    |
| MCTLF (ms)             | 119.6 (28.0)| 129.0 (9.9)  |
| MCTMF (ms)             | 123.9 (9.4)| 127.1 (10.0) |
| MCTLB (ms)             | 104.3 (43.1)| 104.8 (45.3) |
| MCTMB (ms)             | 115.6 (37.9)| 111.4 (45.3) |

Values are expressed as the mean (standard deviation). SOT1–6: sensory organization test for conditions 1 to 6; CES: composite equilibrium score; SR: somatosensory ratio (SOT2/SOT1); TSS: total strategy score; MCTLF: motor control test large forward; MCTMF: motor control test medium forward; MCTLB: motor control test medium backward; MCTMB: motor control test large backward

*p<0.05

Fig. 1. SOT conditions. Courtesy of NeuroCom®
positional direction. To restore balance, a quick movement of the COG is required. Sequences of small, medium, or large platform translations (according to the person’s height) are applied in the forward and backward\(^3\) directions to elicit automatic postural responses\(^{14}\).

To minimize the effect that external stimuli could have on the results of the test, the evaluations were performed at the same time of the day and same room temperature. Keyboard buttons were pressed carefully to avoid acoustic clues indicating the beginning of the test.

Variables from the SOT included the following: Equilibrium scores for each of the 6 conditions (SOT1–6), composite equilibrium scores (CES), somatosensory analysis ratio (SR), total strategy score (TSS), and strategy scores for each of the 6 conditions (EST1–6). The equilibrium scores for SOT1–6 quantify the COG sway, showing how participants make use of each sensory input. The CES is calculated by independently averaging the scores for SOT1 and SOT2, adding them to the scores for SOT3–6, and dividing the sum by 14\(^{20}\). The equilibrium scores for SOT1–6 and the CES range from 0 (participants swaying close to the limits of stability) to 100 (participants did not sway at all, an indication of good balance). The SR (SOT2/SOT1) assesses the ability to use somatosensory inputs to control balance. The TSS quantifies the relative amount of movement about the ankles (ankle strategy) and hips (hip strategy) the patient used to maintain balance during each trial. Sway movements about the ankle produce a small and low frequency COG acceleration and shear, while hip movements produce larger shear forces that are also higher in frequency. Healthy individuals use ankle strategies when the surface is fixed and shift to hip movements as balance becomes difficult to maintain. The scores for EST1–6, expressed as a percentage, are calculated by dividing the difference between the maximum and minimum shear forces of the participants into a standard shear force\(^{22}\). Scores close to 100 indicate the use of ankle strategy, while scores close to 0 show a predominant hip strategy\(^{23–25}\). Latency time (ms) is the variable obtained from the MCT. It represents the time in milliseconds between the onset of the force platform translation and initiation of the active force response of the participant. The data collected for this study included those from medium and large backward and forward translations.

A 20-cm length of rigid Leukotape\(^{p}\) was used for Mulligan taping. It was obliquely applied over the fibular malleolus while a painless posterolateral pressure was applied. The tape circled the leg beginning on the posterior side and ending on the its anterior face proximal to the malleolus. A similar length of tape which was cut in several places to rule out the therapeutic effects of the original unbroken tape, was applied to the placebo group. Both the Mulligan and placebo tapes were applied to the nondominant leg by a physiotherapist who was specialized in the Mulligan technique. Before applying the bandage, the subject’s skin was cleaned with alcohol. The SOT and MCT were performed for each subject at baseline and while the tape was applied (on average, 6 days after application).

Data were analyzed using SPSS version 20.0 (IBM, Armonk, NY, USA). The sample calculation was based on detecting significantly clinically significant differences of 20% on dependent variables between groups with an alpha level of 0.05, a desired power of 80%, and an estimated individual coefficient of variation of 20%. This generated a sample size of at least 15 subjects per group. Repeated-measures analysis of variance was used to test the effects of taping on parameters of dynamic posturography (SOT and MCT). Descriptive statistics were generated for the demographic, SOT, and MCT measures. Pretreatment groups differences were analyzed with one-way ANOVA. Analysis of time, group, and time × groups interactions was performed using the repeated-measures ANOVA test for all variables. The statistical analysis was conducted at a 95% confidence level, and a p<0.05 was considered statistically significant.

**RESULTS**

Forty-four asymptomatic subjects (26 males and 18 females), the age and height of which were 21 ±2 years (mean ± standard deviation) and 169.57 ±8.6 cm (mean ± standard deviation), were included in this study and assigned to two groups. Age ranged from 20 to 30 years, and height ranged from 156 to 186 cm. Figure 2 shows the flow diagram of subject progress through the study and the examined criteria, and Table 1 details the demographic and clinical data of each group.

A normal distribution was confirmed with the Kolmogorov-Smirnov test (p>0.05). No statistical differences in demographic and physical data were found between the groups after comparison with the t-test (p>0.05).

There were no dropouts during the different phases of the study. None of the subjects started drug therapy during the study. Descriptive statistics for results are presented in Table 2.

The outcome for SOT1, SOT2, and SR demonstrated no significant time factor or group-by-time interactions (p>0.05). However, ANOVA showed significant differences
for time factor for all SOT tests (SOT3 F=7.25, p=0.01; SOT5 F=43.36, p=0.0001; SOT6 F=13.58, p=0.0011; CES F=42.83, p=0.0001; and TSS F=12.95, p=0.001) except for SOT4 (F=3.15, p=0.083) but no group-by-time interaction for SOT3, SOT4, SOT5, CES, and TSS.

For MCT variables, the ANOVA revealed no significant effect of time or group-by-time interactions (p>0.05).

**DISCUSSION**

Mulligan proposed a form of ankle taping for treatment and prevention ankle sprains based on fibula repositioning. CDP has become the gold standard method for the evaluation of balance in clinical settings. A key CDP test performed with the SMART Equi Test system is the SOT, which provides information about the integration of multiple components of balance and the general performance of subjects.

The results of study showed that Mulligan ankle taping did not have an impact on postural control during static and dynamic balance in subjects with healthy ankles when compared with placebo taping. Therefore, this study could not confirm the Mulligan hypothesis, which states that repositioning of the fibula produces positive effects on balance.(10)

The results of previous studies of taping and balance and postural control are in agreement with our results. A recent study by Delahunt et al. (10) reported no effects of Mulligan repositioning fibular tape on dynamic postural control evaluated using a Star Excursion Balance test. An earlier publication by Hopper et al. (11) evaluated the effects of the Mulligan taping on static and dynamic postural stability using a stable force platform, and they did not report an improvement of static and dynamic balance in patients...

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**Table 2.** Within-group pre- and post-intervention values for each outcome measure

| Outcome | Placebo group | Ankle Tape group |
|---------|---------------|------------------|
|         | Pre-intervention | Post-intervention | Pre-post difference | Pre-intervention | Post-intervention | Pre-post difference |
| SOT1 (%) | 95.1±1.4 (94.6/95.7) | 95.2±1.5 (94.6/95.8) | −0.1 (−0.8/0.6) | 95.3±1.5 (94.7/95.9) | 95.3±1.3 (94.6/95.9) | 0.1 (−0.6/0.7) |
| SOT2 (%) | 93.6±2.1 (92.6/94.6) | 93.4±1.9 (92.4/94.4) | 0.2 (−0.5/0.8) | 93.8±2.3 (92.8/94.7) | 93.2±2.4 (92.3/94.2) | 0.5 (−0.1/1.2) |
| SOT3 (%) | 90.8±6.2 (88.3/93.3) | 93.8±2.7 (92.6/95.0) | −3.0 (−5.4/−0.5) | 90.7±4.9 (88.3/93.0) | 92.3±2.8 (91.9/93.5) | −1.6 (−3.9/0.8) |
| SOT4 (%) | 89.7±2.1 (86.5/93.0) | 90.3±2.8 (88.5/92.2) | −0.6 (−3.7/2.4) | 86.1±9.9 (83/89.1) | 89.2±5.0* (87.5/91.0) | −3.2 (−6.1/−0.2) |
| SOT5 (%) | 64.8±10.4 (60.2/69.4) | 74.8±5.2** (71.6/78.0) | −10.0 (−14.1/−5.8) | 63.2±10.3 (58.9/67.6) | 72.1±8.7** (69.0/75.2) | −8.8 (−12.8/−4.8) |
| SOT6 (%) | 66.8±14.2 (58.9/74.6) | 74.0±10.5 (68.7/79.3) | −7.2 (−15.5/1.1) | 58.1±20.5 (50.6/65.6) | 72.0±13.3** (66.9/77.1) | −13.8 (−21.8/−5.8) |
| CES (%) | 80.1±4.3 (77.4/82.8) | 84.8±2.9** (83.2/86.4) | −4.7 (−7.0/−2.2) | 77.2±7.3 (74.6/79.8) | 83.2±4.3** (81.6/84.8) | −6.0 (−8.2/−3.7) |
| SR (%) | 0.98±0.02 (1.0/1.0) | 0.98±0.02 (1.0/1.0) | 0.002 (−0.01/0.01) | 1.0±0.01 (0.97/0.98) | 1.0±0.01 (0.97/0.98) | 0.01 (−0.01/0.01) |
| EST 1 (%) | 97.7±1.1 (97.2/98.3) | 97.8±0.7 (97.4/98.2) | −0.1 (−0.5/0.4) | 97.9±1.2 (97.4/98.4) | 98.0±1.1 (97.6/98.4) | −0.05 (−0.5/0.3) |
| EST 2 (%) | 97.7±1.1 (97.0/98.5) | 97.2±1.3 (96.6/97.8) | 0.5 (−0.003/1.1) | 97.8±2.0 (97.1/98.5) | 97.6±1.3 (97.0/97.2) | 0.2 (−0.3/0.7) |
| EST 3 (%) | 95.1±8.0 (92.3/98.0) | 97.1±1.5 (96.3/98.1) | −2.1 (−4.9/0.7) | 95.9±4.7 (93.2/98.7) | 96.8±2.3 (96.0/97.7) | −0.9 (−3.6/1.7) |
| EST 4 (%) | 91.5±2.1 (90.6/92.4) | 91.4±2.5 (90.3/92.4) | 0.1 (−0.8/1.1) | 91.2±2.0 (90.3/92.0) | 91.9±2.0 (90.9/92.9) | −0.7 (−1.6/0.1) |
| EST 5 (%) | 79.2±5.7 (75.5/82.9) | 82.3±5.6 (79.6/85.0) | −3.1 (−6.6/0.4) | 80.4±10.3 (76.9/84.0) | 84.5±6.5* (81.9/87.1) | −4.1 (−7.4/−0.7) |
| EST 6 (%) | 82.5±4.8 (79.0/86.1) | 86.0±3.6 (83.6/88.4) | −3.5 (−7.2/0.2) | 81.8±10.1 (78.4/85.2) | 85.4±6.7 (83.1/87.8) | −3.6 (−7.2/−0.1) |
| TSS (%) | 91.0±2.0 (89.5/92.4) | 92.4±1.7 (91.4/93.4) | −1.4 (−2.6/−0.1) | 90.6±4.1 (89.2/92.0) | 92.4±2.5* (91.5/93.3) | −1.8 (−2.9/−0.5) |
| MCT (msec) | 114.8±39.2 (98.0/131.5) | 115±39.1 (98.6/133.1) | −0.2 (−19.5/19.1) | 114.7±36.8 (98.6/130.6) | 107.3±43.1 (89.9/124.6) | 7.3 (−11.1/25.8) |

Values are expressed as the mean ± standard deviation (95% confidence interval). SOT1–6: sensory organization test for conditions 1 to 6; CES: composite equilibrium score; SR: somatosensory ratio (SOT2/SOT1); EST: strategy score for conditions 1 to 6; TSS: total strategy score; MCT: motor control test

*p<0.05, **p<0.001
with chronic ankle instability. Additionally, Akbari et al. measured the effect of ankle taping in patients with ankle instability using the single-limb hopping test and the modified Star Excursion Balance test and the results did not show any benefits for balance.

Although our results are similar to those previously mentioned, we are the first using a gold standard tool to evaluate balance. Other studies used different methods of static and dynamic balance analysis that may not be sensitive and reliable for measurement of postural stability deficits of the ankle. Bauer et al. showed that CDP with eyes-closed conditions had very good reliability, with an intraclass correlation coefficient (ICC) above 0.90. Ford-Smith et al. determined the 1-week test-retest reliability of the SOT in noninstitutionalized older adults. They found that conditions SOT1 and SOT2 varied little across subjects and may be best used as a record of baseline performance; SOT1 and the composite equilibrium score had ICC of 0.66. Chien et al. compared the psychometric properties of CDP (test-retest reliability, responsiveness, and predictive validity) in patients with stroke and found that the composite equilibrium score had acceptable test-retest reliability, responsiveness, and predictive validity in patient with mild stroke. They concluded that the SOT is associated with clinical balance measures in people with balance dysfunction.

Ford-Smith et al. described a lower anxiety level in subjects during their second CDO session, which may account for higher mean SOT scores. In our study, we cannot rule out the possibility that the improvements seen in both groups resulted from a lower anxiety level, since no psychological data were collected in the study. Other possible mechanisms that could explain the balance improvement in both groups are a learning effect in the second evaluation and the cutaneous input effect of the ankle tape. It has been reported that repeated SOT exposures result in 10% improvement in composite balance. Dickin et al. recommended two baseline assessments for the SOT to establish the basal level of stability or to allow participants to practice the SOT prior to testing. Guskiewicz et al. specified that a minimum difference of 6.83 is needed for the composite balance score between baseline and posterior evaluations to consider the change to be not due to a learning effect.

It has been suggested that application of an extrinsic ankle support may alter postural control assessment results both positively and negatively. In this sense, prophylactic classic taping reduces ankle range of motion, which may decrease the efficacy of the ankle strategy in maintenance of balance. On the other hand, ankle support methods like taping may provide somatosensory feedback that could improve one’s ability to maintain balance. Our results showed that both Mulligan and placebo taping increase ankle strategies instead of reducing ankle range of motion. Despite increasing cutaneous afferents with the taping we could not appreciate a higher somatosensory ratio which has been described in the literature.

Future research must be performed in patients with acute ankle injury or chronic ankle instability to elucidate the underlying mechanism of the effect of Mulligan ankle taping on balance, postural, and motor control.

There are some limitations to this study. This experiment was confined to healthy pain-free subjects, so the results cannot be applied to patients with ankle instability or acute ankle sprain. Subjects were evaluated at baseline and when the Mulligan or placebo ankle tape was applied. Evaluation was not performed after several taping sessions, so the long-term effects of taping were not analyzed. Physical activity was recorded during anamnesis by asking the subjects about the level of physical activity they performed. This information should have been collected with a validated scale in order to evaluate the effect of physical activity on the results of CDP. The authors recommend taking these points into consideration when designing future studies.

This study showed that Mulligan ankle taping did not have a significant impact on postural and motor control in healthy subjects when evaluated by computerized dynamic posturography.

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