

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

B. Vicenzino\*, I. Prangley & D. Martin

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## Introduction

Dorsiflexion is a key movement of the ankle joint. Adequate ranges of ankle dorsiflexion of the order of 10 – 20° is required for normal gait and the prevention of both acute and overuse injuries of the lower limb–[1-3]. In addition to being a risk factor to ankle injuries [1] ankle dorsiflexion appears clinically to be limited following plantarflexion/inversion sprains of the ankle being in part responsible for functional difficulties in walking on flat surfaces, down slopes and down stairs [4-6].

Manipulative therapy (MT) is an integral part of best clinical practice management of restricted joint motion. There are several MT treatment techniques for limited dorsiflexion; most involve passive anteroposterior glide mobilisation of the talus in the crus [4], although a high velocity low amplitude thrust in a caudad direction has been described [7]. Green et al (2001) reported improvements in ankle dorsiflexion motion following treatment with a passive anteroposterior glide of the talocrural joint following acute ankle sprains whereas Nield et al (1993) showed that there was no change in dorsiflexion in asymptomatic subjects following a high velocity caudad thrust of the talocrural joint. Apart from these two studies, there is very little evidence of the effects and benefits of MT treatment techniques of the ankle. There is a clear need for further study of MT [8].

Recently, a new form of MT called mobilisation with movement (MWM) has been advocated for the treatment of joint pain, stiffness and dysfunction. For the treatment of limited ankle dorsiflexion the MWM treatment technique combines an anteroposterior glide with an active dorsiflexion of the ankle, either in a weight bearing (MWM\_WB) or non-weight bearing (MWM\_NW) position [9]. The rapid ameliorative effect in pain and dysfunction following MWM treatments have been documented in several single case studies [10, 11], case series studies [12] and controlled trials [13, 14], but these have not evaluated MWM\_WB or MWM\_NW. This paper describes a study of these treatment techniques in asymptomatic ankles with limited dorsiflexion.

The outcome of any evaluation of treatment effects is only as reliable and valid as the employed outcome measures. Recently, two methods of measuring dorsiflexion have been advocated, the weight bearing lunge (Figure 1) [1, 15] and the Lidcombe template for non-weight bearing dorsiflexion (Figure 2) [4, 16]. See Methods section. To date, there is no comparison of their ability to detect treatment-induced changes.

[Print](#)

[Index](#)

[Table of Contents](#)

[Quit](#)

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## Statement of the Problem

Clinicians frequently use MT treatments to improve range of motion and alleviate pain. For example, anteroposterior mobilisation of the talus in the crus is believed to improve ankle dorsiflexion. The problem is that there is limited research-based evidence to support this clinical approach. The aim of this study was to evaluate the initial effect of two types of Mulligan MWM treatment techniques on the range of ankle dorsiflexion. A secondary aim of the study was to evaluate the utility of both weight bearing and non-weight bearing measures of dorsiflexion.

## Methods

Subjects: Twenty-seven individuals, 10 male and 17 female with an age range from 18 to 27 years of age (mean  $\pm$  SD = 19.8  $\pm$  2.3) participated in the study. The primary inclusion criteria was that there was a greater than 10mm asymmetry on the weight bearing lunge for distance measurement of dorsiflexion (Figure 1). Main exclusion criteria were previous injury or surgery to the back, hip, knee or major injury to the ankle in previous 2 years. Participants with previous experience of MT (eg, physiotherapy students and clients) were also excluded in order to facilitate blinding. The Institutional Review Board of the University of Queensland approved the study. All participants provided informed consent.

Outcome Measures (Dependent Variables): Dorsiflexion measured in weight bearing (WB\_DF) and non-weight bearing (NWB\_DF) served as outcome measures.

WB\_DF was performed in standing with the foot and lower limb in a standardised position such that the great toe, centre of the heel and knee were kept in a plane perpendicular to a wall and the heel firmly in contact with the ground (Figure 1) [1, 15]. While in this position the participant lunged forward until the anterior knee contacted the wall and maximum dorsiflexion was obtained. Two indices of dorsiflexion were used for this test: (i) the distance from the great toe to the wall was measured by a vernier calliper (DIST), and (ii) the ankle dorsiflexion angle (WB\_DF) measured by an inclinometer over the anterior tibia.

NWB\_DF was performed in supine with the Lidcombe Template [4, 16]. This device ensures a standard and reproducible torque (24 Nm in this study) is applied through the ankle joint at each testing session (Figure 2). The leg was secured to the treatment table with the knee in slight flexion. The tibio-foot angle, which was defined by surface markings on the fibular head, lateral malleolus and head of fifth metatarsal, was measured from digital recordings taken by a digital camera and (Powershot A50, Canon, Japan) calculated through a custom LabView vi program (National Instruments, Texas, USA). Both outcome measures were measured three times.

[Print](#)

[Index](#)

[Table of Contents](#)

[Quit](#)

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

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The University of Queensland, Australia



Figure 1: WB\_DF: The weight bearing lunge test for dorsiflexion being measured with vernier calliper (DIST).



Figure 2: NWB\_DF: The Lidcombe Template for non-weight bearing dorsiflexion measurement, including markers used to calculate tibial-foot angle. Independent Variable (Treatment Conditions): Treatment conditions had three levels, MWM\_WB, MWM\_NW and CONTROL.

1. The MWM\_WB shown in Figure 3 was applied in standing with the therapist manually stabilising the foot on the treatment bench. A non-elastic belt, which passed around both the distal leg of the participant and the waist of the therapist, was used to apply a sustained posteroanterior glide of the tibia. To perform the technique the participant started in an easy stand position while the therapist applied a sustained posteroanterior glide through the belt by using a backward lean of his body. Then the participant performed a slow dorsiflexion movement until the first onset of pain or end of range. Once this end point was reached the position was sustained for 10 seconds. The patient then returned to the easy standing position followed by release of the anteroposterior glide. This process was repeated 4 times in succession followed by a 20 second rest period, constituting one set of the treatment technique. Four sets of the treatment technique were applied.

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

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The University of Queensland, Australia

2. The MWM\_NW shown in Figure 4 was applied in supine with the tibia resting on the treatment bench and the ankle and foot unsupported off the edge of the table. The leg was stabilised to the bed by the non-elastic belt while the therapist applied a sustained anteroposterior glide to the ankle. While the therapist maintained this glide the participant performed an active dorsiflexion movement to the same endpoint as the weight bearing MWM technique (ie, pain threshold or end of range whichever came first). At this point in the range, when there was no pain, the therapist superimposed an overpressure into dorsiflexion. This position was sustained for 10 seconds and repeated as for the weight bearing MWM. In addition, to the application of these treatment techniques, two placebo control procedures were also applied prior to the treatments. For the weight bearing MWM treatment technique, the therapist performed a mock non-weight bearing MWM in which he gently rocked the ankle into mid range dorsiflexion-plantarflexion without any anteroposterior talar glide. For the non-weight bearing MWM treatment technique the therapist placed his hands over the distal tibia and fibular and leant back on the seat belt while preventing any glide or dorsiflexion from occurring. From a participant's perspective the placebo techniques involved similar hand contact to the treatment techniques.
3. A CONTROL condition was also included. This involved no manual contact or movement and during which the participant stood for the same time period it took to perform the treatments.

Experimental Procedure: A randomised, repeated measures, double blind, cross-over placebo design study was conducted to evaluate the effects of the MWM\_WB, MWM\_NW and CONTROL conditions on DIST, WB\_DF and NWB\_DF. Participants were randomly assigned to an order of treatments such that they experienced the MWM\_WB, MWM\_NW and CONTROL conditions on 3 separate days at a similar time of day with at least 24 hours between sessions. On each day a similar experimental procedure was followed. This involved the measurement of dorsiflexion followed by the application of the treatment condition assigned for that day, which was then followed up by a post-treatment measurement of dorsiflexion. The therapist and the investigator responsible for taking the dorsiflexion measurements remained blind to each other's activities throughout the data collection period. The participant was informed that the study was evaluating the influence of manual handling and positioning on a series of repeated measures.

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

B. Vicenzino\*, I. Prangley & D. Martin

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Figure 3: Mobilisation with Movement treatment in weight bearing (MWM\_WB).



Figure 4: Non-weight bearing Mobilisation with Movement technique (MWM\_NW).

Data Management and Analysis: The triplicate repeated measures at each measurement point were assessed for intra-rater reliability, using indicators such as the intra-class coefficients (ICC), absolute error between trials and standard error of the measurement (SEM). Prior to further analysis the triplicate measures were averaged. A 3 X 2 within-subject multivariate analysis of covariance (MANCOVA, SPSS) was performed on the 3 dependent variables (DIST, WB\_DF, NWB\_DF) with adjustments made for the difference between ankles in range of motion at entry into the study (covariate). The independent variable was treatment condition (3 levels: MWM\_WB, MWM\_NW, CONTROL) and time (2 levels: pre and post). Significant main effects and interactions were followed up with tests of simple effects with the level of type I error rate being adjusted in line with the number of repeated tests.

Reliability of outcome measures: The intra-rater reliability of the dorsiflexion measures was good. For DIST there was total agreement in 20% of observations and 82% were below 5.7 mm of absolute error (ICC = 0.99, SEM = 0.355), for WB\_DF there was total agreement in 37% of observations with 83% below an absolute error of 1° (ICC = 0.98, SEM = 0.147), and for NWB\_DF there was total agreement in 34% of cases with 80% of observations disagreeing by less than 1.35°s (ICC = 0.99, SEM = 0.139). This data indicates that the dorsiflexion measurements were reliable.

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

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The University of Queensland, Australia

## Results and Discussion

The omnibus MANCOVA over the three dependent variables revealed that the main effect of time was the only significant effect (Wilk's Lambda = 0.519,  $F_{(3,23)} = 7.111$ ,  $p=0.002$ , Eta squared = 0.481). There was no main effect for treatment condition, no effect of the covariate, and no interaction effect ( $F_{(6,20)} = 1.222$ ,  $p=0.336$ ,  $F_{(3,23)} = 1.727$ ,  $p=0.189$ , and  $F_{(6,20)} = 0.656$ ,  $p=0.685$ , respectively). That is, the overbearing feature of the data was that change occurred after the application of the treatment conditions. Table 1 has a summary of the relevant significant findings.

Univariate analyses of variance concurred with the MANCOVA results (ie, no main effect for treatment condition and no interaction effect), but only for the weight bearing measures (DIST, WB\_DF), indicating a differential ability of the outcome measures to detect change in ankle dorsiflexion. The effect sizes as indicated by Eta squared were 0.373 and 0.394 for DIST and WB\_DF measures, respectively, as opposed to 0.03 for the NWB\_DF measure. The lack of a treatment effect in the non-weight bearing measure contrasts to the findings of Green et al (2001) who reported significant improvements in ankle dorsiflexion as measured by a non-weight bearing measurement. The measurement device used in both studies was similar, however the study by Green et al (2001) evaluated treatment effects in patients with acute ankle sprains who had an approximate 40% deficit in ankle dorsiflexion as opposed to the asymptomatic ankles used in the current study with a deficit of the order of 15% (DIST mean deficit  $\pm$  SD =  $18.7 \pm 5.6$ mm).

Follow up tests of simple effects revealed that the predominate source of the main effect for time in the omnibus MANCOVA came from the MWM treatment induced differences rather than the CONTROL condition (Table 1). The MWM\_WB and MWM\_NW produced small increases in weight bearing dorsiflexion in the order of 6% (6.3-6.8 mm) and 3% (1.2-1.3°) of pre-treatment dorsiflexion, respectively. These increases were both statistically significant and in excess of the error of the measurement (SEM = 0.36mm and 0.15°). The effect sizes for the treatment effects were small ( $d = 0.247-0.272$ ) [17]. This small effect size may be due to the small deficit in ankle dorsiflexion that was present in the group before treatment, although the MANCOVA did not indicate that the pre-existing level of ankle dorsiflexion deficit influenced the independent variables. A limitation of this interpretation of the MANCOVA is that there was a small range of ankle dorsiflexion deficits in the study sample (ie, 10-31mm). Interestingly, there appeared to be little difference in the two MWM techniques, suggesting weight bearing is not necessary for maximising effects on range of motion. The improvements noted on the CONTROL condition although significant were within the error of the measure and probably resulted from the repeated dorsiflexion testing that was performed in the experiment.

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Table 1: Summary table including the mean (standard error) values of data for PRE- and POST-application of the treatment conditions (MWM\_WB, MWM\_NW and CONTROL) for the 3 Dependent Variables (DV: DIST, WB\_DF & NWB\_DF). Included are summaries of significant findings on the multivariate and univariate output of the 3 X 2 MANCOVA. Also presented are the main effect of Time<sup>#</sup>, effect sizes presented as Etta Squared, Effect Size (d), % Change of post- from pre-application data, and the results of the tests of simple effects (t-tests\*).

DV	PRE	POST	$F_{(1,25)}$ & (p)-values <sup>#</sup>	Etta <sup>2</sup>	Effect size % Change (d)	Mean Difference	t-value <sub>(26)</sub> *	
<i>DIST (mm)</i>			<i>14.88 (0.001)</i>	<i>0.37</i>				
MWM_WB	111.59 (4.84)	118.39 (5.07)			0.27	6.18	-6.80	-8.80*
MWM_NW	110.55 (5.12)	116.84 (5.04)			0.25	6.40	-6.29	-9.19*
CONTROL	111.68 (5.31)	114.47 (5.41)			0.10	2.52	-2.79	-4.88*
<i>WB_DF (°)</i>			<i>16.27 (0.000)</i>	<i>0.39</i>				
MWM_WB	44.44 (0.99)	45.78 (0.97)			0.27	3.07	-1.33	-7.65*
MWM_NW	44.14 (0.97)	45.35 (0.94)			0.25	2.83	-1.21	-7.64*
CONTROL	44.64 (1.03)	45.15 (1.02)			0.10	1.19	-0.51	-3.60*
<i>NWB_DF (°)</i>			<i>0.78 (0.386)</i>	<i>0.03</i>				
MWM_WB	95.55 (1.49)	94.29 (1.49)			0.16	-1.30	1.27	2.56
MWM_NW	94.85 (1.21)	94.43 (1.43)			0.06	-0.52	0.43	1.13
CONTROL	95.09 (1.27)	94.68 (1.31)			0.06	-0.46	0.41	1.14

# The multivariate analysis of covariance returned a Wilk's Lambda of 0.52,  $F(3,23) = 7.11$ ,  $p=0.002$ , Etta squared = 0.48. The values in the column are from the univariate breakdown of the DVs. and are the main effect of Time as there was no main effect of Condition, no interaction effect, and no effect of the covariate (side to side limitation in dorsiflexion).

\* Significant differences from pre- to post-treatment condition to an alpha of 0.006, corrected for 9 repeated t-tests.

[Print](#)

[Index](#)

[Table of Contents](#)

[Quit](#)

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

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The University of Queensland, Australia

## Conclusion

This study provides initial evidence of the effects of Mulligan's MWM treatment techniques on ankle dorsiflexion in an asymptomatic population with minimally to moderately limited ankle dorsiflexion. The findings also indicate that a weight bearing measure of dorsiflexion is more likely to detect treatment effects than a non-weight bearing measure of dorsiflexion.

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[Print](#)

[Index](#)

[Table of Contents](#)

[Quit](#)

# The initial effect of two Mulligan mobilisation with movement treatment techniques on ankle dorsiflexion

B. Vicenzino\*, I. Prangley & D. Martin

The University of Queensland, Australia

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[Print](#)

[Index](#)

[Table of Contents](#)

[Quit](#)

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Manipulative therapy (MT) is an integral part of best clinical practice management of restricted joint motion. There are several MT treatment techniques for limited dorsiflexion; most involve passive anteroposterior glide mobilisation of the talus in the crus [4], although a high velocity low amplitude thrust in a caudad direction has been described [7]. Green et al (2001) reported improvements in ankle dorsiflexion motion following treatment with a passive anteroposterior glide of the talocrural joint following acute ankle sprains whereas Nield et al (1993) showed that there was no change in dorsiflexion in asymptomatic subjects following a high velocity caudad thrust of the talocrural joint. Apart from these two studies, there is very little evidence of the effects and benefits of MT treatment techniques of the ankle. There is a clear need for further study of MT [8].

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The outcome of any evaluation of treatment effects is only as reliable and valid as the employed outcome measures. Recently, two methods of measuring dorsiflexion have been advocated, the weight bearing lunge (Figure 1) [1, 15] and the Lidcombe template for non-weight bearing dorsiflexion (Figure 2) [4, 16]. See Methods section. To date, there is no comparison of their ability to detect treatment-induced changes.

**STATEMENT OF THE PROBLEM:** Clinicians frequently use MT treatments to improve range of motion and alleviate pain. For example, anteroposterior mobilisation of the talus in the crus is believed to improve ankle dorsiflexion. The problem is that there is limited research-based evidence to support this clinical approach. The aim of this study was to evaluate the initial effect of two types of Mulligan MWM treatment techniques on the range of ankle dorsiflexion. A secondary aim of the study was to evaluate the utility of both weight bearing and non-weight bearing measures of dorsiflexion.

**METHODS:** Subjects: Twenty-seven individuals, 10 male and 17 female with an age range from 18 to 27 years of age (mean  $\pm$  SD = 19.8  $\pm$  2.3) participated in the study. The primary inclusion criteria was that there was a greater than 10mm asymmetry on the weight bearing lunge for distance measurement of dorsiflexion (Figure 1). Main exclusion criteria were previous injury or surgery to the back, hip, knee or major injury to the ankle in previous 2 years. Participants with previous experience of MT (eg, physiotherapy students and clients) were also excluded in order to facilitate blinding. The Institutional Review Board of the University of Queensland approved the study. All participants provided informed consent.

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NWB\_DF was performed in supine with the Lidcombe Template [4, 16]. This device ensures a standard and reproducible torque (24 Nm in this study) is applied through the ankle joint at each testing session (Figure 2). The leg was secured to the treatment table with the knee in slight flexion. The tibio-foot angle, which was defined by surface markings on the fibular head, lateral malleolus and head of fifth metatarsal, was measured from digital recordings taken by a digital camera and (Powershot A50, Canon, Japan) calculated through a custom LabView vi program (National Instruments, Texas, USA). Both outcome measures were measured three times.



Figure 1: WB\_DF: The weight bearing lunge test for dorsiflexion being measured with vernier calliper (DIST).

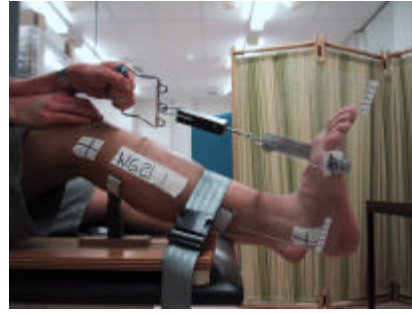


Figure 2: NWB\_DF: The Lidcombe Template for non-weight bearing dorsiflexion measurement, including markers used to calculate tibial-foot angle.

Independent Variable (Treatment Conditions): Treatment conditions had three levels, MWM\_WB, MWM\_NW and CONTROL.

1. The MWM\_WB shown in Figure 3 was applied in standing with the therapist manually stabilising the foot on the treatment bench. A non-elastic belt, which passed around both the distal leg of the participant and the waist of the therapist, was used to apply a sustained posteroanterior glide of the tibia. To perform the technique the participant started in an easy stand position while the therapist applied a sustained posteroanterior glide through the belt by using a backward lean of his body. Then the participant performed a slow dorsiflexion movement until the first onset of pain or end of range. Once this end point was reached the position was sustained for 10 seconds. The patient then returned to the easy standing position followed by release of the anteroposterior glide. This process was repeated 4 times in succession followed by a 20 second rest period, constituting one set of the treatment technique. Four sets of the treatment technique were applied.

2. The MWM\_NW shown in Figure 4 was applied in supine with the tibia resting on the treatment bench and the ankle and foot unsupported off the edge of the table. The leg was stabilised to the bed by the non-elastic belt while the therapist applied a sustained anteroposterior glide to the ankle. While the therapist maintained this glide the participant performed an active dorsiflexion movement to the same endpoint as the weight bearing MWM technique (ie, pain threshold or end of range whichever came first). At this point in the range, when there was no pain, the therapist superimposed an overpressure into dorsiflexion. This position was sustained for 10 seconds and repeated as for the weight bearing MWM. In addition, to the application of these treatment techniques, two placebo control procedures were also applied prior to the treatments. For the weight bearing MWM treatment technique, the therapist performed a mock non-weight bearing MWM in which he gently rocked the ankle into mid range dorsiflexion-plantarflexion without any anteroposterior talar glide. For the non-weight bearing MWM treatment technique the therapist placed his hands over the distal tibia and fibular and leant back on the seat belt while preventing any glide or dorsiflexion from occurring. From a participant's perspective the placebo techniques involved similar hand contact to the treatment techniques.

3. A CONTROL condition was also included. This involved no manual contact or movement and during which the participant stood for the same time period it took to perform the treatments.

Experimental Procedure: A randomised, repeated measures, double blind, cross-over placebo design study was conducted to evaluate the effects of the MWM\_WB, MWM\_NW and CONTROL conditions on DIST, WB\_DF and NWB\_DF. Participants were randomly assigned to an order of treatments such that they experienced the MWM\_WB, MWM\_NW and CONTROL conditions on 3 separate days at a similar time of day with at least 24 hours between sessions. On each day a similar experimental procedure was followed. This involved the measurement of dorsiflexion followed by the application of the treatment condition assigned for that day, which was then followed up by a post-treatment measurement of dorsiflexion. The therapist and the investigator responsible for taking the dorsiflexion measurements remained blind to each other's activities throughout the data collection period. The participant was informed that the study was evaluating the influence of manual handling and positioning on a series of repeated measures.



Figure 3: Mobilisation with Movement treatment in weight bearing (MWM\_WB).

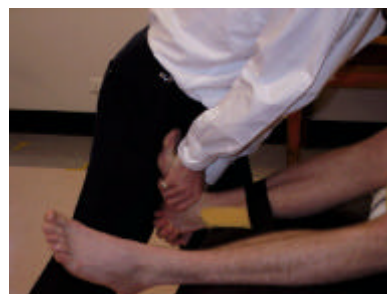


Figure 4: Non-weight bearing Mobilisation with Movement technique (MWM\_NW).

**Data Management and Analysis:** The triplicate repeated measures at each measurement point were assessed for intra-rater reliability, using indicators such as the intra-class coefficients (ICC), absolute error between trials and standard error of the measurement (SEM). Prior to further analysis the triplicate measures were averaged. A 3 X 2 within-subject multivariate analysis of covariance (MANCOVA, SPSS) was performed on the 3 dependent variables (DIST, WB\_DF, NWB\_DF) with adjustments made for the difference between ankles in range of motion at entry into the study (covariate). The independent variable was treatment condition (3 levels: MWM\_WB, MWM\_NW, CONTROL) and time (2 levels: pre and post). Significant main effects and interactions were followed up with tests of simple effects with the level of type I error rate being adjusted in line with the number of repeated tests.

**Reliability of outcome measures:** The intra-rater reliability of the dorsiflexion measures was good. For DIST there was total agreement in 20% of observations and 82% were below 5.7 mm of absolute error (ICC = 0.99, SEM = 0.355), for WB\_DF there was total agreement in 37% of observations with 83% below an absolute error of 1° (ICC = 0.98, SEM = 0.147), and for NWB\_DF there was total agreement in 34% of cases with 80% of observations disagreeing by less than 1.35°s (ICC = 0.99, SEM = 0.139). This data indicates that the dorsiflexion measurements were reliable.

**RESULTS AND DISCUSSION:** The omnibus MANCOVA over the three dependent variables revealed that the main effect of time was the only significant effect (Wilk's Lambda = 0.519,  $F_{(3,23)} = 7.111$ ,  $p=0.002$ , Eta squared = 0.481). There was no main effect for treatment condition, no effect of the covariate, and no interaction effect ( $F_{(6,20)} = 1.222$ ,  $p=0.336$ ,  $F_{(3,23)} = 1.727$ ,  $p=0.189$ , and  $F_{(6,20)} = 0.656$ ,  $p=0.685$ , respectively). That is, the overbearing feature of the data was that change occurred after the application of the treatment conditions. Table 1 has a summary of the relevant significant findings.

Univariate analyses of variance concurred with the MANCOVA results (ie, no main effect for treatment condition and no interaction effect), but only for the weight bearing measures (DIST, WB\_DF), indicating a differential ability of the outcome measures to detect change in ankle dorsiflexion. The effect sizes as indicated by Eta squared were 0.373 and 0.394 for DIST and WB\_DF measures, respectively, as opposed to 0.03 for the NWB\_DF measure. The lack of a treatment effect in the non-weight bearing measure contrasts to the findings of Green et al (2001) who reported significant improvements in ankle dorsiflexion as measured by a non-weight bearing measurement. The measurement device used in both studies was similar, however the study by Green et al (2001) evaluated treatment effects in patients with acute ankle sprains who had an approximate 40% deficit in ankle dorsiflexion as opposed to the asymptomatic ankles used in the current study with a deficit of the order of 15% (DIST mean deficit  $\pm$  SD = 18.7  $\pm$  5.6mm).

Follow up tests of simple effects revealed that the predominate source of the main effect for time in the omnibus MANCOVA came from the MWM treatment induced differences rather than the CONTROL condition (Table 1). The MWM\_WB and MWM\_NW produced small increases in weight bearing dorsiflexion in the order of 6% (6.3-6.8 mm) and 3% (1.2-1.3°) of pre-treatment dorsiflexion, respectively. These increases were both statistically significant and in excess of the error of the measurement (SEM = 0.36mm and 0.15°). The effect sizes for the treatment effects were small ( $d = 0.247-0.272$ ) [17]. This small effect size may be due to the small deficit in ankle dorsiflexion that was present in the group before treatment, although the MANCOVA did not indicate that the pre-existing level of ankle dorsiflexion deficit influenced the independent variables. A limitation of this interpretation of the MANCOVA is that there was a small range of ankle dorsiflexion deficits in the study sample (ie, 10-31mm). Interestingly, there appeared to be little difference in the two MWM techniques, suggesting weight bearing is not necessary for maximising effects on range of motion. The improvements noted on the CONTROL condition although significant were within the error of the measure and probably resulted from the repeated dorsiflexion testing that was performed in the experiment.

Table 1: Summary table including the mean (standard error) values of data for PRE- and POST-application of the treatment conditions (MWM\_WB, MWM\_NW and CONTROL) for the 3 Dependent Variables (DV: DIST, WB\_DF & NWB\_DF). Included are summaries of significant findings on the multivariate and univariate output of the 3 X 2 MANCOVA. Also presented are the main effect of Time<sup>#</sup>, effect sizes presented as Eta Squared, Effect Size (d), % Change of post- from pre-application data, and the results of the tests of simple effects (t-tests\*).

DV	PRE	POST	$F_{(1,25)}$ & (p)-values <sup>#</sup>	Eta <sup>2</sup>	Effect size % Change (d)	Mean Difference	t-value <sub>(26)</sub> *	
<b>DIST (mm)</b>								
MWM_WB	111.59 (4.84)	118.39 (5.07)	14.88 (0.001)	0.37	0.27	6.18	-6.80	-8.80*
MWM_NW	110.55 (5.12)	116.84 (5.04)			0.25	6.40	-6.29	-9.19*
CONTROL	111.68 (5.31)	114.47 (5.41)			0.10	2.52	-2.79	-4.88*
<b>WB_DF (°)</b>								
MWM_WB	44.44 (0.99)	45.78 (0.97)	16.27 (0.000)	0.39	0.27	3.07	-1.33	-7.65*
MWM_NW	44.14 (0.97)	45.35 (0.94)			0.25	2.83	-1.21	-7.64*
CONTROL	44.64 (1.03)	45.15 (1.02)			0.10	1.19	-0.51	-3.60*

NWB_DF (°)		0.78 (0.386)	0.03				
MWM_WB	95.55 (1.49)	94.29 (1.49)		0.16	-1.30	1.27	2.56
MWM_NW	94.85 (1.21)	94.43 (1.43)		0.06	-0.52	0.43	1.13
CONTROL	95.09 (1.27)	94.68 (1.31)		0.06	-0.46	0.41	1.14

# The multivariate analysis of covariance returned a Wilk's Lambda of 0.52,  $F(3,23) = 7.11$ ,  $p=0.002$ , Eta squared = 0.48. The values in the column are from the univariate breakdown of the DVs. and are the main effect of Time as there was no main effect of Condition, no interaction effect, and no effect of the covariate (side to side limitation in dorsiflexion).

\* Significant differences from pre- to post-treatment condition to an alpha of 0.006, corrected for 9 repeated t-tests.

**CONCLUSION:** This study provides initial evidence of the effects of Mulligan's MWM treatment techniques on ankle dorsiflexion in an asymptomatic population with minimally to moderately limited ankle dorsiflexion. The findings also indicate that a weight bearing measure of dorsiflexion is more likely to detect treatment effects than a non-weight bearing measure of dorsiflexion.

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