Initial Effects of the Ankle Dorsiflexion Mobilization with Movement on Ankle Range of Motion and Limb Coordination in Young Healthy Subjects

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Background and purpose: Clinically, ankle dorsiflexion mobilization with movements (MWM) is a manual therapy technique widely used to increase joint range of motion, reduce pain, and improve functions. It has been reported in a single case study to have initial effects of improved functional outcomes and pain relief on acute ankle sprains. However, no study has examined the immediate effects of this technique on gait patterns in the ankle joint of healthy individuals. **Methods:** A total of 60 healthy collegiate students (40 females and 20 males, age 21 ± 1.8 years; BMI 21.02 ± 2.4) participated in three consecutive days. Spatial and temporal parameters of gait during level walking using a pressure sensor walkway and weight-bearing ankle dorsiflexion range using ankle lunge test were analyzed before and immediately after a single session of ankle dorsiflexion MWM intervention. Tests were repeated at day two and three after the intervention. **Results:** Significant improvements of ankle dorsiflexion range of motion on the dominant side were found between pre- and post-intervention ($p<0.0001$), at day two ($p<0.0001$) and at day three ($p<0.0001$). Significant changes in spatial (step length, stride length, and base of support) during slow walking and in temporal (gait cycle time and step time) variables on both sides were also observed during self-paced walking at day two ($p<0.004$) and day three ($p<0.004$) compared with pre-intervention. **Conclusion:** The results suggest that immediate and sustained spatio-temporal effects occur following ankle MWM. Changes during level walking indicate possible effects of alterations in motor strategies during functional tasks following ankle MWM. (FJPT 2006;31(3):173-181)

Key Words: Mobilization with movements, Spatio-temporal parameters, Ankle joint, Ambulation, Ankle dorsiflexion lunge test

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Mobilization with movement (MWM) is a manual therapy technique first developed by a New Zealand physiotherapist and is commonly used for the management of musculoskeletal problems.[1-5] Clinically, positive and immediate treatment outcomes such as pain relief, restoration of joint movement and improved function have been achieved following this technique.

Ankle dorsiflexion MWM involves a sustained passive mobilization (posterior-anterior glide of the tibia and fibula on talus) while performing active dorsiflexion movements to end-range.[1-5] A single-case study has demonstrated positive outcomes of ankle dorsiflexion MWM on acute ankle sprain.[6] In addition, a recent study on sub-acute ankle sprains[7] demonstrated immediate positive effects on functional outcomes and increase in ankle dorsiflexion range of movement. Crosbie et al (1999) have demonstrated that maximal available ankle dorsiflexion was influential in determining the contralateral step length.[8] Green et al (2001) demonstrated greater stride speed after a passive talocrural mobilization on the ankle joint with rest, icing, rest, and elevation (RICE) conventional treatments in acute sprained ankles.[9] Nevertheless, it remains unknown as to whether this technique could provide a significant change in the spatio-temporal parameters of gait in asymptomatic subjects.

To our knowledge, no previous study has investigated whether the initial effects of ankle dorsiflexion MWM can be transferred to dynamic functional tasks (for example, level walking or downstair ambulation) when applied to the ankle joint of healthy subjects. Therefore, the aims of this study were to: (1) examine the initial effect of ankle MWM on dorsiflexion range and how long would the effect last (2) determine there were any initial spatio-temporal effects from this technique during level walking.

METHODS

Research Design

One group repeated measures design.

Subjects

A total of 60 healthy collegiate students (male 20, female 40; age 21 ± 1.8 SD, range 18 - 26 years; BMI 21.02 ± 2.40 SD, range 16.52 - 27.02), mainly from the campus, voluntarily participated in this study after informed consent. This study has been approved by the local medical ethics committee at the Tzu-Chi University and hospital, Taiwan. Participants were physically examined to meet the inclusion and exclusion criteria. Inclusion criteria included physically active, able to walk at any one time without distress and no current or previous ankle injuries. Exclusion criteria included any presence or history of orthopedic or arthritic conditions of the lower limbs; any systematic or neurological problems; fractures or previous surgery of the lower limbs.

Procedures and Equipments

Subjects were initially asked to perform three tasks to define the dominant side of the lower limb – kicking a ball three times in a standing position, stamping on an object in a sitting position, and stamping on an imaged object in a standing position. An experienced physical therapist familiar with MWM applied this technique on all subjects, treatment consisted of ten repetitions of posterior-anterior (PA) glide with active dorsiflexion movements on ankle joints in the dominated leg (Figure 1.). Subjects completed a series of tests including active ankle lunge test and level walking measures prior to and immediate after the intervention, at day two, and at day three after intervention.

Participants were tested during a series of level walking tasks at three different speeds (slow 80 steps/min, self-selected pace cadence, and fast 140 steps/min) in a randomized order using an electronic metronome with an active electronic walkway (GAITRite® system, SMS Technologies, PA 19083). All gait measurements were performed with this portable system which consisted of an active area of 3.66 × 0.61m walkway and

Figure 1. A photo to show a weight-bearing ankle dorsiflexion moblization with movement on the dominant leg.

13,824 sensors (each 1cm in diameter) arranged in a 48 × 288 grid pattern. The system continually scanned the sensors and provided information about the geometry of the footprints in 2-D space as well as dynamic pressure mapping during walking by recording the location of activated sensors and the time of sensor activation/deactivation. Spatial and temporal gait variables calculated were based on the geometric centers of the heel for each of the three consecutive footprints. Despite the limitation of the length of walkway mat for data collection, we extended a two-meter length on each side to allow the participant to walk on a 10-meter walkway. At least one complete stride of each side was required to complete the computation. Recent literature has indicated high validity[10-13] and reliability[14,15] in measuring spatio-temporal gait parameters using this system. Weight-bearing ankle lunge test (Figure 2.) was used to measure the change in ankle dorsiflexion range of motion. This measure is useful to measure the range of ankle dorsiflexion based on the knee-to-wall principle. The participant stood in front of a wall, with the test foot's second toe and midline of the heel and knee maintained in a plane perpendicular to the wall. The participant slowly lunged forward into talocrural dorsiflexion until the knee contacted the wall, and progressively moved the foot back to the point where the knee could just touch the wall with the heel sustained on the ground.[7] The represented end of range dorsiflexion and distance between the wall and the second toe was measured in centimeters

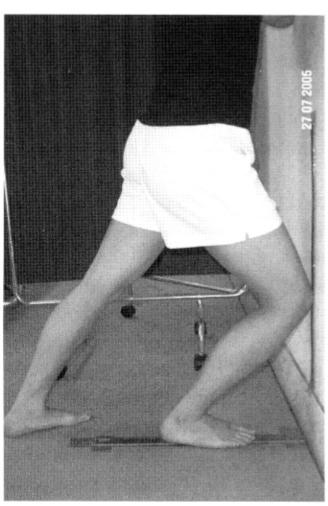


Figure 2. A photo to demonstrate a weight-bearing ankle lunge test to examine the range of ankle dorsiflexion in the dominant leg

(cm) using a tape measure placed on the ground. The examiner ensured maintenance of heel contact via verbal instructions and manual contact with the calcaneum. Previous work have reported high inter- and intra- rater reproducibility (ICC > 0.95, SEM = 0.6 cm) using this measure to assess ankle range of motion in weight-bearing.[16-18] Vicenzino (2001) also found this measure was more sensitive in detecting treatment effects than an angular weight-bearing measure and a non-weight-bearing measure.[19]

The following twelve spatial and temporal variables in gait measurements were evaluated: step length (cm), stride length (cm), base of support (cm), toe in / toe out (deg), step time (sec), cycle time (sec), stride time (sec), swing time (sec), stance time (sec), double support time (sec), walking velocity (cm/s) and mean normalized velocity (/s). The definitions of these variables were indicated in Table 1.

Data Management and Analysis

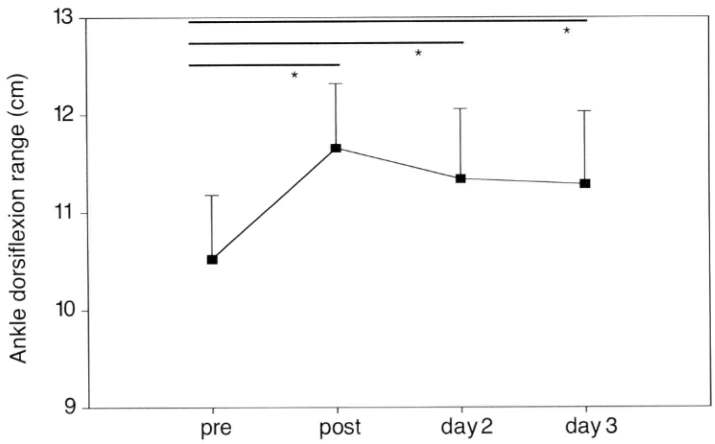
Footsteps which did not fall entirely on the GAITRite® mat were deleted. Mean values for each gait parameter were calculated using the first six complete steps derived from five trials at each speed: slow (80 steps/min), self-selected pace and fast (140 steps/min) cadence.

SPSS 10.0 (SPSS Inc., Chicago, IL 60606) was used for statistical analysis. Spatial and temporal gait variables in three different cadences and weight-bearing ankle dorsiflexion range of motion over three continuous days (pre, post, day two and day three) were examined using repeated-measures ANOVA and paired-t tests to compare the difference of these parameters over different test sessions. In order to avoid the possibility of Type I error, a Bonferroni adjustment was used to set the level of significance at 0.004 (0.05 divided by 13 from one ROM and twelve spatio-temporal variables).

RESULTS

Weight-bearing Ankle Dorsiflexion Range of Motion

A significant increase in range of motion of the ankle joint was found after MWMs ($p<0.0001$). Statistically significant changes in ankle dorsiflexion were shown immediately after MWMs and maintained at day two and day three when compared with pre measurement ($p<0.0001$; Figure 3.).



*$p<0.004$

pre vs. post	t = -9.647; $p< 0.0001$
pre vs. day 2	t = -5.119; $p< 0.0001$
pre vs. day 3	t = -4.078; $p= 0.00014$
post vs. day 2	t = 2.386; $p= 0.020$
post vs. day 3	t = 2.364; $p= 0.021$
day 2 vs. day 3	t = 0.509; $p= 0.613$

Figure 3. Mean range of ankle dorsiflexion (95% confidence intervals) at pre-, post-MWM intervention and at day two and day three.

Table 1. Definitions of spatial and temporal variables used in this study[15, 26]

Variable	Definition
SPATIAL	
Step length (cm)	is measured along the horizontal axis, from the geometric heel center of the current foot fall to the geometric heel center of the previous footfall on the opposite foot.
Stride length (cm)	is measured on the line of progression between the heel points of two consecutive footfalls of the same foot (left to left, right to right).
Base of support (cm)	is the perpendicular distance from heel point of one footfall to the line of progression of the opposite foot, which is named H-H base of support or base width.
Toe in/Toe out (deg)	is the angle between line of progression and the line connecting the heel point to the forward point of the footfall. The angle is reported positive for toe out and negative for toe in.
TEMPORAL	
Step time (sec)	is the time elapsed from the first contact of one foot to the first contact of the opposite foot.
Cycle time (sec)	is the time elapsed between the first contacts of two consecutive footfalls of the same foot.
Stride time (sec)	is the time elapsed between the first contacts of the first and the last footfalls.
Stance phase (%)	is expressed the percentage of stance time divided by the time of gait cycle. Stance time is the time elapsed between first contact of the current footfall and the last contact of the previous foot footfall, added to the time elapsed between the last contact of the current footfall and the first contact of the next footfall.
Swing phase (%)	is expressed the percentage of swing time divided by the time of gait cycle. Swing time is elapsed between the last contact of the current footfall to the first contact of the next footfall on the same foot.
Double support (%)	is expressed the percentage of double support time divided by the time of gait cycle. Double support is the time elapsed between the first contact of the current footfall and the last contact of the previous footfall, added to the time elapsed between the last contact of the current footfall and the first contact of the next footfall.
Walking velocity (cm/s)	is obtained after dividing the distance by the stride time.
Mean normalized velocity (/s)	is obtained after dividing the walking velocity by the average leg length and is expressed in leg length per second. The average leg length is computed (left leg length + right leg length)/2.

Spatio-temporal Parameters of Gait before and after ankle MWMs

A 1 × 4 repeated measures design was analyzed using planned trend analysis on spatio-temporal variables for 60 participants. Factors were pre, post, day two and day three after the intervention. The mean, standard deviation and 95% confidence interval of spatial and temporal variables were shown in Tables 2. and 3.

Significant increases of step length (dominant F=5.97, p=0.001; non-dominant F=5.95, p=0.001), stride length (dominant F=4.76, p=0.003; non-dominant F=5.74, p=0.001) in bilateral legs and base of support (F=6.66, p=0.0002) were found after MWMs during slow walking at post, day two and day three (Table 2.).

Significant increases in step time of bilateral legs were found after MWMs during self-paced (dominant F=22.7, p<0.0001; non-dominant F=16.28, p<0.0001) walking at day two and day three (Table 3.). In addition, significant increases in cycle time of bilateral legs were found after MWMs during self-paced (dominant F=22.7, p<0.0001; non-dominant F=16.28, p<0.0001) walking at day two and day three (Table 3.). However, we did not find a significant change immediate after the intervention (p>0.05). Interestingly, significant increases of velocity (F=8.63, p=0.00013) and mean normalized velocity (F=7.62, p=0.0005) were found immediately after MWMs during self-paced walking, but decreases of these were at day two and three (Table 3.).

DISCUSSION

This is the first study to demonstrate a significant increase in ankle dorsiflexion range of motion after one session of ankle dorsiflexion MWM, which maintained the effect for two days. Importantly, changes in motor control of lower limb after intervention during level walking at a self-selected pace were observed at day 2 and day 3. This is consistent with previous

Table 2. Mean (SD) and 95% Confidence Interval (lower & upper limit) of spatial variables during level walking in three different cadences (slow 80 steps/min, self-pace and fast 140 steps/min)

		Pre		Post		Day 2		Day 3	
	Cadence	Mean (SD)	95% CI Lower - upper	Mean (SD)	95% CI Lower - upper	Mean (SD)	95% CI Lower - upper	Mean (SD)	95% CI Lower - upper
Step length (cm)									
Dominant	Slow	57.6* (7.85)	56.41-58.74	58.3* (7.19)	57.28-59.42	57.2* (9.19)	55.81-58.54	59.2* (9.41)	57.80-60.60
	Self-paced	65.2 (11.01)	63.56-66.82	65.8 (7.78)	64.60-66.91	65.2 (7.80)	64.05-66.36	65.8 (8.22)	64.54-66.97
	Fast	68.9 (9.88)	67.43-70.36	68.4 (12.12)	66.55-70.15	68.1 (9.93)	66.61-69.56	69.3 (9.33)	67.90-70.67
Non-dominant	Slow	56.8* (7.54)	55.71-57.94	57.7* (6.52)	56.76-58.69	57.0* (7.34)	55.95-58.13	58.5* (7.43)	57.36-59.57
	Self-paced	64.8 (10.71)	63.26-66.43	65.2 (7.60)	64.05-66.30	64.9 (7.35)	63.77-65.95	65.3 (7.96)	64.16-66.52
	Fast	68.2 (9.14)	66.84-69.55	68.7 (10.37)	67.14-70.21	67.5 (9.56)	66.08-68.92	68.8 (9.40)	67.37-70.16
Stride length (cm)									
Dominant	Slow	114.4* (16.50)	111.93-116.82	116.4* (13.56)	114.35-118.37	114.2* (17.03)	111.64-116.69	117.4* (14.72)	115.20-119.57
	Self-paced	128.6 (17.16)	126.09-131.18	131.2 (15.36)	128.97-133.52	128.8 (20.59)	125.77-131.87	131.6 (15.93)	129.23-133.96
	Fast	137.4 (18.47)	134.61-140.09	137.1 (22.55)	133.75-140.44	136.0 (19.45)	133.11-138.88	138.5 (18.71)	135.72-141.27
Non-dominant	Slow	114.5* (15.66)	112.13-116.78	116.3* (13.54)	114.29-118.30	115.0* (15.54)	112.73-117.34	117.3* (14.64)	115.08-119.43
	Self-paced	127.7 (18.70)	124.95-130.50	130.9 (17.84)	128.28-133.58	130.6 (14.76)	128.39-132.77	131.1 (18.26)	128.43-133.85
	Fast	137.3 (18.44)	134.55-140.02	138.0 (20.59)	134.91-141.02	135.6 (19.84)	132.66-138.54	138.5 (18.53)	135.72-141.22
Base of support (cm)									
	Slow	9.8* (4.67)	9.15-10.54	10.0* (4.65)	9.33-10.71	10.6* (4.23)	9.99-11.25	10.7* (4.53)	10.07-11.42
	Self-paced	8.9 (3.80)	8.34-9.46	9.1 (3.93)	8.49-9.66	9.6 (3.94)	9.00-10.17	9.1 (5.52)	10.07-13.33
	Fast	9.5 (3.65)	8.96-10.04	9.5 (4.10)	8.94-10.15	9.9 (4.38)	9.23-10.53	10.1 (3.76)	9.52-10.64
Toe in/Toe out (deg)									
Dominant	Slow	4.1 (6.74)	3.07-5.12	3.9 (6.42)	2.91-4.84	4.4 (6.46)	3.48-5.41	4.6 (6.21)	3.64-5.53
	Self-paced	3.9 (6.07)	2.99-4.81	3.6 (6.03)	2.74-4.54	4.4 (5.81)	3.50-5.24	4.6 (6.01)	3.36-5.16
	Fast	3.5 (5.71)	2.65-4.36	3.7 (5.90)	2.79-4.55	4.2 (6.36)	3.20-5.14	4.1 (5.98)	3.19-4.99
Non-dominant	Slow	1.5 (6.27)	0.53-2.45	1.7 (6.15)	0.79-2.65	1.8 (6.37)	0.81-2.73	2.4 (6.05)	1.48-3.32
	Self-paced	1.7 (6.45)	0.68-2.64	1.7 (6.08)	0.83-2.65	2.4 (6.19)	1.51-3.37	2.3 (6.74)	1.26-3.27
	Fast	1.0 (5.93)	0.16-1.92	1.3 (5.89)	0.42-2.19	1.6 (5.79)	0.77-2.51	1.6 (5.91)	0.71-2.47

* indicates p<0.004

Table 3. Mean (SD) and 95% confidence interval (lower & upper limit) of temporal variables during level walking in three different cadences (slow 80 steps/min, self-pace and fast 140 steps/min)

		Pre			Post			Day 2			Day 3		
	Cadence (steps/min)	Mean	(SD)	95% CI Lower - upper	Mean	(SD)	95% CI Lower - upper	Mean	(SD)	95% CI Lower - upper	Mean	(SD)	95% CI Lower - upper
Step time (s)													
Dominant	Slow	0.74	(.02)	0.74-0.75	0.75	(.03)	0.74-0.75	0.74	(.02)	0.74-0.75	0.75*	(.02)	0.74-0.75
	Self-paced	0.52*	(.05)	0.51-0.52	0.51*	(.05)	0.50-0.52	0.51*	(.05)	0.50-0.52	0.53*	(.06)	0.52-0.54
	Fast	0.43	(.01)	0.43-0.43	0.43	(.02)	0.43-0.43	0.43	(.01)	0.43-0.43	0.43	(.01)	0.43-0.43
Non-dominant	Slow	0.74	(.02)	0.74-0.74	0.74	(.02)	0.74-0.75	0.75	(.03)	0.74-0.75	0.75*	(.03)	0.74-0.75
	Self-paced	0.51*	(.05)	0.50-0.52	0.51*	(.04)	0.50-0.51	0.52*	(.05)	0.51-0.53	0.53*	(.05)	0.52-0.53
	Fast	0.43	(.01)	0.43-0.43	0.43	(.02)	0.43-0.43	0.43	(.02)	0.43-0.43	0.43	(.02)	0.43-0.43
Cycle time (s)													
Dominant	Slow	1.47	(.14)	1.45-1.49	1.49	(.04)	1.48-1.49	1.48	(.11)	1.46-1.50	1.47	(.17)	1.44-1.49
	Self-paced	1.02*	(.10)	1.00-1.03	1.01*	(.10)	1.00-1.03	1.04*	(.11)	1.03-1.06	1.04*	(.11)	1.02-1.06
	Fast	0.86	(.02)	0.86-0.86	0.86	(.03)	0.86-0.87	0.86	(.03)	0.85-0.86	0.86	(.02)	0.86-0.86
Non-dominant	Slow	1.48	(.04)	1.48-1.49	1.49	(.04)	1.48-1.50	1.49	(.04)	1.48-1.50	1.49	(.09)	1.47-1.50
	Self-paced	1.01*	(.12)	1.00-1.03	1.01*	(.09)	1.00-1.03	1.05*	(.12)	1.03-1.06	1.05*	(.11)	1.03-1.07
	Fast	0.86	(.02)	0.86-0.86	0.86	(.03)	0.86-0.87	0.86	(.03)	0.85-0.86	0.86	(.02)	0.85-0.86
Stride time (s)													
Dominant	Slow	4.0	(.73)	3.92-4.14	4.0	(.70)	3.86-4.07	4.1	(.80)	3.94-4.18	3.90	(.76)	3.78-4.00
	Self-paced	2.40	(.10)	2.32-2.47	2.30	(.45)	2.27-2.41	2.40	(.56)	2.31-2.48	2.40	(.57)	2.32-2.49
	Fast	1.90	(.37)	1.82-1.93	1.90	(.42)	1.85-1.97	1.90	(.43)	1.83-1.96	1.90	(.32)	1.82-1.91
Stance phase (%)													
Dominant	Slow	61.9	(4.19)	61.31-62.55	61.9	(4.65)	61.23-62.62	61.9	(6.59)	60.93-62.89	62.1	(2.89)	61.68-62.53
	Self-paced	60.3	(3.96)	59.75-60.92	60.3	(2.62)	59.88-60.66	60.1	(2.66)	60.08-60.87	60.8	(3.08)	60.30-61.21
	Fast	60.0	(3.51)	59.44-60.48	59.6	(1.83)	59.33-59.87	59.5	(2.10)	59.23-59.85	59.3	(1.81)	59.03-59.57
Non-dominant	Slow	62.1	(3.17)	61.61-62.55	62.1	(3.36)	61.65-62.65	62.2	(2.41)	61.80-62.51	62.1	(2.34)	61.76-62.45
	Self-paced	60.5	(3.79)	59.92-61.05	60.2	(2.67)	59.82-60.61	60.5	(1.69)	60.26-60.76	60.3	(2.03)	60.04-60.65
	Fast	59.8	(2.60)	59.40-60.18	59.4	(1.68)	59.11-59.60	59.2	(2.56)	58.81-59.57	59.3	(1.73)	59.07-59.59
Swing phase (%)													
Dominant	Slow	37.7	(2.04)	37.40-38.01	37.6	(3.05)	37.13-38.03	37.2	(3.44)	36.72-37.74	37.7	(2.34)	37.32-38.02
	Self-paced	39.2	(1.68)	38.93-39.43	39.5	(1.75)	39.25-39.76	39.4	(1.65)	39.12-39.61	39.5	(1.94)	39.20-39.78
	Fast	40.3	(1.68)	40.08-40.58	40.4	(1.75)	40.14-40.68	40.1	(1.65)	39.77-40.49	40.6	(1.94)	40.39-40.88
Non-dominant	Slow	37.6	(3.38)	37.07-38.07	37.6	(2.23)	37.27-37.93	37.8	(2.38)	37.48-38.19	38.0	(2.91)	37.58-38.44
	Self-paced	39.3	(1.74)	39.02-39.54	39.6	(1.77)	39.32-39.84	39.4	(1.94)	39.16-39.73	39.4	(3.35)	38.94-39.93
	Fast	40.3	(1.72)	40.09-40.60	40.6	(1.68)	40.39-40.89	40.5	(2.24)	40.15-40.81	40.7	(1.81)	40.43-40.97
Double support (%)													
Dominant	Slow	25.5	(3.44)	25.02-26.04	25.3	(3.74)	24.79-25.90	25.4	(4.85)	24.73-26.16	24.9	(3.93)	24.31-25.48
	Self-paced	22.2	(3.36)	21.68-22.68	21.6	(3.13)	21.17-22.10	21.6	(3.15)	21.12-22.05	21.5	(3.59)	21.00-22.07
	Fast	19.8	(2.70)	19.38-20.18	19.8	(3.52)	19.03-20.08	19.8	(3.10)	19.32-20.24	19.3	(3.43)	18.84-19.85
Non-dominant	Slow	25.3	(3.74)	24.73-25.84	25.2	(3.60)	24.67-25.74	25.4	(3.84)	24.82-25.95	24.8	(4.19)	24.22-25.47
	Self-paced	22.2	(3.42)	21.73-22.75	21.8	(3.53)	21.23-22.28	21.9	(4.26)	21.31-22.58	21.5	(3.28)	21.04-22.01
	Fast	19.9	(3.57)	19.38-20.44	19.5	(3.07)	19.04-19.95	19.6	(3.36)	19.09-20.08	19.1	(2.84)	18.70-19.55
Velocity (cm/s)													
	Slow	77.2*	(10.96)	75.55-78.80	77.7*	(10.87)	76.04-79.26	76.7*	(11.11)	75.01-78.31	78.4*	(10.33)	76.85-79.91
	Self-paced	127.4	(21.07)	124.12-130.52	130.8	(20.80)	127.70-133.87	126.1	(21.66)	122.86-129.28	125.6	(24.59)	121.95-129.25
	Fast	158.7*	(23.07)	155.30-162.14	159.5*	(24.41)	155.90-163.14	157.6*	(22.25)	154.27-160.87	160.8*	(21.11)	157.71-163.97
Mean Normalized Velocity(/s)													
	Slow	1.0	(.14)	0.98-1.02	1.0	(.13)	0.99-1.03	1.0	(.26)	0.98-1.06	1.0	(.26)	1.00-1.08
	Self-paced	1.7*	(.28)	1.61-1.69	1.7*	(.34)	1.66-1.76	1.6*	(.28)	1.59-1.68	1.6*	(.29)	1.59-1.68
	Fast	2.1	(.24)	2.02-2.10	2.1	(.27)	2.02-2.10	2.0	(.25)	2.00-2.07	2.1	(.25)	2.05-2.12

* indicates $p<0.004$

literature that showed improvements of ROM and functional activity in patients with pathology.[7,19-22] The results of this study may lead to the potential for the effect of this intervention on motor control strategy in patient's populations.

Increase in ankle dorsiflexion range after MWM is seen clinically in injured[7] and asymptomatic[19] populations. The results in the present study are consistent with previous research work.[9,19] An immediate improvement in dorsiflexion was shown in our study to indicate possibly mechanical effects of MWM on local joints. Previous research findings suggest that the predominant mechanism of action for the dorsiflexion MWM is most likely mechanical, rather than other mechanisms such as motor control effect.[7] Furthermore, the effect was able to be retained at day two and day three. Due to the design of this study, we did not investigate the effect beyond three days. However, we suggest further investigations to determine the long term effects of MWM are warranted.

Interestingly, we found that statistically significant changes occurred in most of spatial (bilateral step length and stride length, and base of support) during slow walking at post-intervention and day three following ankle MWMs and two spatial parameters (i.e. step time and cycle time in dominant and non-dominant legs) bilaterally during self-paced walking at day two and day three following ankle MWMs. This is a new finding suggesting that the use of manipulative therapy techniques could possibly have effects on motor control strategies during functional activity such as level walking. Two possible mechanisms could contribute to the changes after intervention. First, increases in dorsiflexion ROM will enhance the time of stance phase, step length, and stride length in both legs. This is consistent with the finding of Crosbie et al.[8] Second, changes in motor control strategies will adapt in bilateral legs during level walking because of increased ankle dorsiflexion ROM. Bilateral changes of spatial and temporal parameters could come from an adaptation of motor control strategies during functional activity after the change of local joint range of motion. This may be one of many mechanisms that contribute to increases in spatial (step length, stride length and base of support) and temporal parameters (step time and cycle time), but other factors may have been evident. Although only one session of ankle dorsiflexion MWM was performed on the dominant leg in participants, limb coordination was affected bilaterally at day two and day three. Previous studies have shown that during pedaling tasks changes in contralateral movement and extensor force generation could alter muscle coordination such as flexors in lower limb.[23-25] Ankle dorsiflexion MWM consists of posterior-anterior gliding with active reversible dorsiflexion movements synchronically may have provided stimulation task-dependent inter-limb coupling mechanisms.[25] This could explain the findings that subjects have a longer cycle time in both legs after the intervention.

From a clinical perspective, a limitation of ankle dorsiflexion is very commonly seen in people following acute ankle sprains.[8,9,17] Ankle dorsiflexion MWM could not only increase the range of ankle dorsiflexion, but also stimulate a modulation of motor control strategy in bilateral lower limbs during level walking. A multimodal treatment strategy, including ankle MWM and gait re-training, could increase the possibility of a successful management and outcome for patients with pathological or injured joints in lower extremity.

The current study mainly focused on the mechanical effects of range dorsiflexion in the dominant side of young healthy subjects and motor control effects of functional activities. However, sensory-motor changes in these subjects may have also appeared following intervention and future investigations are needed to examine these. In addition, the present study provides a basis for further studies looking into the application of this technique in the individuals with ankle injures. The limitation of this study was no control group data for comparison (sham group) in the research design. Further research includes a control group is warrant.

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踝關節動態屈背操作治療對於健康年輕人關節活動度及平地走路時下肢協調性之效應

郭藍遠[1] 楊志鴻[2] 曹智鈞[3] 王靜怡[2] 梁忠詔[4]

目的：踝關節動態背屈關節鬆動術(Ankle Dorsiflexion Mobilization With Movements)，是一種臨床上常用徒手治療方法，用來增加關節活動度、減輕疼痛和改善功能等目的。過去研究顯示該治療方法，對急性踝關節扭傷者，具有初期改善功能和減輕疼痛的效果。然而，過去沒有文獻探討踝關節動態關節鬆動術，對於健康受測者步態的影響，提供此治療技術療效更深入成效的探討。**方法**：60位健康大學學生(男性20人、女性40人，平均年齡21歲，BMI值21.2)，連續三天參與本研究的資料收集。受測者第一天必須接受踝關節動態關節鬆動術治療介入，在介入前和後立即接受評估。評估方法是利用具有壓力感測單元的步道，收集受測者在平地步行時的時間和空間步態參數。此外，評估也包括使用踝關節劍步測試(ankle dorsiflexion lunge test)，測量受測者踝關節在載重下背屈的程度。踝關節動態關節鬆動術介入後第二天和第三天，受測者再次接受上述兩項評估。**結果**：踝關節背屈劍步測試結果顯示慣用側踝關節足背屈程度，在介入後立即、第二天和第三天都有改善，並具有統計上明顯差異($p<0.0001$)。慢速步頻步行時，兩側下肢的步長、步幅及步寬，於介入後立即、第二天及第三天和介入前比較，呈現統計上明顯差異($p<0.004$)。自選步頻步行時，兩側下肢的步態週期時間及步伐時間，於介入後第二天及第三天和介入前比較，也呈現統計上明顯差異($p<0.004$)。**結論**：本研究顯示踝關節動態關節鬆動術，對關節活動度及平地步行時的時間和空間表現，具有立即和持續的效應；顯示該治療技術方式，可能會影響到健康受測者在功能性活動時的動作策略。(物理治療 2006;31(3):173-181)

關鍵詞：動態關節鬆動術、時間和空間參數、踝關節、步行、踝關節背屈劍步測試

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