

Gluteal taping improves hip extension during stance phase of walking following stroke

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The aim of this study was to determine whether gluteal taping on the affected side improved hip extension during stance phase of walking for persons following stroke. Fifteen subjects who had suffered a stroke months to years previously resulting in mild to moderate gait impairments participated in the study. Their gait was measured under control, sham, and gluteal taping conditions, in random order. For each condition, subjects walked at a self-selected and a fast speed. Hip angle relative to that obtained during quiet standing, step length, stride length and walking velocity were measured. Hip extension increased significantly with gluteal taping ($p < 0.05$) for both walking speeds at late stance phase of walk compared to sham taping and control. The mean absolute difference between gluteal and control conditions for self-selected velocity was 14.2 degrees (95% CI 8.6 to 19.8) whereas the difference between sham and control conditions was 2.0 degrees (95% CI -2.0 to 6.0). Also, for both speeds, step length on the unaffected side increased significantly with gluteal taping compared with either the control or placebo conditions. The absolute difference between gluteal taping and control conditions at self-selected velocity was 3.3 cm (95% CI 2.2 to 4.3) and between sham and control conditions was 0.6 cm (95% CI -0.8 to 1.9). Affected step length and walking velocity, however, remained unchanged. Lastly, there was no significant difference between the control and sham taping condition for any of the measured variables. Gluteal taping may be a useful adjunct to current rehabilitation gait training strategies. [Kilbreath SL, Perkins S, Crosbie J and McConnell J (2006): Gluteal taping improves hip extension during stance phase of walking following stroke. *Australian Journal of Physiotherapy* 52 1: 53-56]

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Introduction

Decreased hip extension of the affected leg is a common impairment after stroke (Huitema et al 2004, Olney and Richards 1996) with significant consequences for gait. For example, Lehmann et al (1987) reported that peak hip extension could be reduced by 14 degrees during late stance, attributable to insufficient active extensor muscle moments (Kim and Eng 2003). Restricted hip extension on the affected side leads to a reduction in contralateral step length, temporospatial asymmetry, and reduced walking speed (Hsu et al 2003).

Taping over the gluteus maximus has been described by McConnell (McConnell 2002) as a strategy to improve hip and pelvis mechanics in chronic low back pain. The taping may reduce the effective length of the muscle, placing it at a more mechanically advantageous length. The taping may also mechanically restrict flexion or improve proprioception at the hip joint.

The aim of this study was to determine whether gluteal taping improved hip extension in chronic stroke subjects during late stance, and, if so, whether it changed temporospatial gait parameters.

Method

Fifteen volunteers with a history of stroke participated in the study which assessed walking under three conditions: 1) control, in which no taping was used; 2) gluteal taping; and 3) sham taping. Subjects were included if their gait was affected by their stroke but they could

walk without use of an aid. Subjects were excluded from participating if they had a hip flexor or ankle plantarflexor contracture (as evidenced by Thomas' test and Lidcombe template test respectively), if they had a known allergy to adhesive sports tape, or if they could not comprehend and follow simple verbal instructions. Ethical approval for the study was obtained from the University of Sydney Human Ethics Committee. Subjects (10 male, 5 female; 6 right side, 9 left side affected) were of mean age 62 years (SD 7.2). The mean time since stroke was 5.2 years (SD 2.8).

Taping Taping was applied to the affected side with the subject standing.

Gluteal taping Hypoallergenic tape was first applied without tension to protect the skin. Sport tape was then applied with tension over the protective tape. Three pieces of tape were applied while the buttock was supported by the researcher (Figure 1): 1) from the medial aspect of the gluteal fold, pulled laterally and superiorly towards the greater trochanter; 2) from the medial aspect of the gluteal fold to the top of the buttock above the gluteus maximus muscle belly, lifting the buttock; and 3) from the superior end of the second piece of tape to the greater trochanter. The tape was applied only to the buttock and not to the posterior thigh.

Sham taping As with the gluteal taping, the skin was first protected and sport tape was placed horizontally over the middle of the gluteus maximus muscle belly without tension.

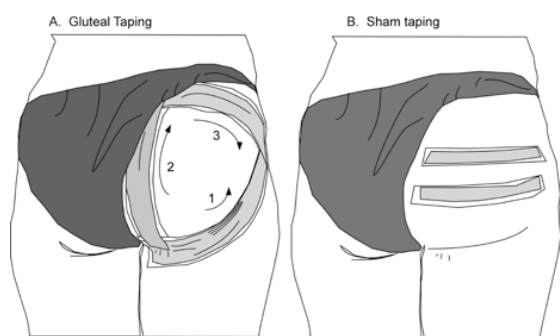


Figure 1. Schematic drawing of A) Gluteal taping and B) Sham taping.

Two dimensional adhesive markers of diameter 1.5 cm were placed over the mid-axillary line of the iliac crest, the greater trochanter, and the lateral femoral condyle of the affected side and each subject was filmed, both in a relaxed standing posture, to provide a neutral reference, and as they walked over the mid-section of a fourteen metre track. A static digital video camera^a was placed such that its field of view was the two metre central zone of the walkway. Video images were collected at 200 Hz with a spatial resolution of 2 mm. Body markers remained *in situ* for all tests.

Marker pens were attached to the subject's heels prior to testing. These left marks on paper covering the walkway (Cerny 1983) permitting calculation of spatial gait parameters. All steps which fell within the 10 metres were included in determination of step length. The time required to walk the middle 10 metres was measured with a stopwatch.

For each condition, subjects walked over the track five times at their self-selected speed and five times at their fastest speed. Data from the last three trials at each speed were processed, the first two being discarded to avoid learning effects (Fransen et al 1997). The five trials for each speed were completed in a block and the order in which subjects completed the two blocks was randomised, as was the order of the tape conditions. Subjects rested between conditions for approximately 10 minutes.

The video frame in which the unaffected heel struck the ground was selected and digitised^b by a person blinded to the condition. Vertical and horizontal reference points, visible within the image, were used to derive the X and Y axes and marker co-ordinates from the body segments were used to determine hip, thigh and pelvic angles. The thigh angle was defined as the angle of the line of the femur (greater trochanter–lateral condyle) to the vertical, and the pelvic angle was defined as the angle between the line from the iliac crest to the greater trochanter and the vertical. The hip angle was defined as the angle subtended by the lines defining the pelvis and thigh. Once the angles were calculated, the absolute difference between each angle obtained during the relaxed erect posture and late stance was determined.

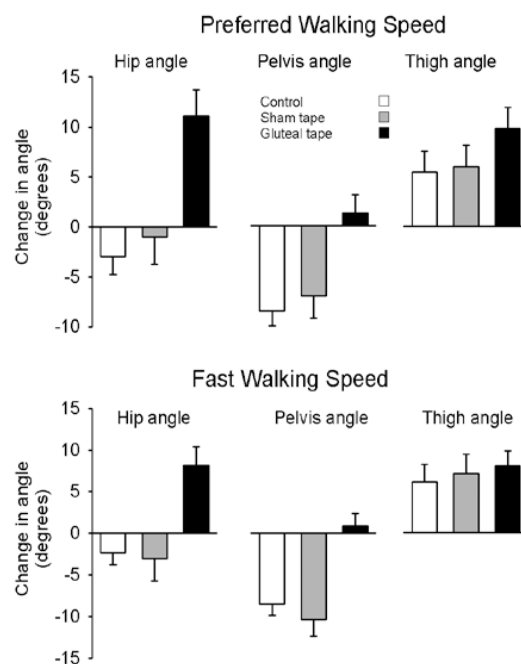


Figure 2. Change in hip, thigh and pelvis extension from standing alignment in self-selected and fast speed trials. Mean and SE values illustrated for the control, sham and taped conditions. Positive values indicate extension beyond the reference posture.

A positive hip angle reflected extension relative to quiet standing, whereas a negative value indicated flexion.

Repeated measures analyses of variance (RMANOVA) were used to determine whether gluteal taping changed dependent kinematic and temporospatial variables. The two factors, both repeated measures, were taping condition and speed of walking. When significant differences were identified, post hoc planned contrasts were used to determine which conditions differed significantly. Means and 95% confidence intervals are reported. Statistical significance was set at $p < 0.05$.

Results

Hip, pelvis and thigh angle Relative hip extension was greater with gluteal taping than with either the sham taping or no taping (RMANOVA [condition] $p < 0.001$) and this effect was greater during self-selected walking velocity compared to fast walking velocity ([condition × speed] $p = 0.001$) (Figure 2). The hip joint did not reach the reference value for extension in the control or sham conditions at either speed, while the taped condition elicited hip extension beyond the reference posture. There was no significant difference between the control and sham conditions at either speed. The mean absolute differences between gluteal and control conditions for self-select and fast velocities were 14.2 degrees (95% CI 8.6 to 19.8) and 10.5 degrees (95% CI 5.3 to 15.7) whereas the differences between sham and control conditions were 2.0 degrees (95% CI -2.0 to 6.0) and -0.7 degrees (95% CI -5.0 to 3.7).

Table 1. Kinematic and temporospatial parameters under three test conditions and two velocities. Mean (SD) are shown.

	Control Self-selected speed	Sham Self selected speed	Tape Self-selected speed	Control Fast speed	Sham Fast speed	Tape Fast speed
Change in hip angle (°)	-3.0 (6.6)	-1.0 (10.6)	11.1 (9.9)	-2.4 (5.5)	-3.1 (10.3)	8.1 (8.6)
Change in pelvis angle (°)	-8.6 (5.7)	-7.0 (8.8)	1.3 (6.9)	-8.5 (5.2)	-10.4 (8.0)	0.1 (5.6)
Change in thigh angle (°)	5.4 (8.2)	6.0 (8.2)	9.8 (8.2)	6.1 (8.0)	7.1 (8.9)	8.0 (7.0)
Velocity (m/sec)	0.60 (0.26)	0.60 (0.26)	0.60 (0.26)	0.76 (0.33)	0.76 (0.34)	0.75 (0.35)
Unaffected step length (m)	0.384 (0.134)	0.390 (0.128)	0.417 (0.137)	0.439 (0.149)	0.438 (0.140)	0.470 (0.147)
Affected step length (m)	0.452 (0.113)	0.449 (0.092)	0.460 (0.108)	0.497 (0.112)	0.490 (0.102)	0.499 (0.123)

The angle of the thigh to the vertical was not significantly different in any of the three conditions for either speed, however the pelvic angle showed significant differences ($p < 0.001$). In the taped condition the pelvis remained neutral or rotated backwards slightly, while in the control and sham conditions the pelvis rotated forwards (Table 1).

Gait characteristics Gluteal taping produced a modest but significant increase in step length on the unaffected but not the affected side (Table 1; RMANOVA [side \times condition] $p < 0.001$). The mean absolute differences in unaffected step length between gluteal and control conditions for self-select and fast velocities were 3.3 (2.2 to 4.3) cm and 3.2 (1.7 to 4.6) cm whereas the differences between sham and control conditions were 0.6 (-0.8 to 1.9) cm and 0.5 (-1.4 to 1.5) cm. There was no significant difference in step length between the control or sham group at either speed. Walking velocity was not apparently influenced by gluteal taping at either self-selected or fast speed (Table 1; RMANOVA [condition] $p > 0.05$).

Discussion

Gluteal taping led to an immediate improvement in hip extension at the end of single support, with a concomitant small increase in step length on the unaffected side. Examination of trials that followed gluteal taping revealed that the improvement was lost as soon as the tape was removed. In contrast, sham taping did not lead to any improvement in hip extension compared with the control condition in which no tape was used.

There was no substantial change in temporospatial gait characteristics as a function of the small change in thigh/vertical angulation between the conditions. However, the fact that the trunk was more upright in the taped condition suggests that the subjects may have been better able to utilise inner range hip extensor muscle activity and that their pelvis was more stable over the thigh. This contrasted with the control and sham conditions, in which thigh/vertical extension was offset by forward pelvic rotation, suggesting a forward lean of the trunk.

The increase in hip extension was the result of an increase in 'true' (i.e. anatomical) hip extension. That is, the increased

hip extension was not simply due to greater anterior rotation of the pelvis producing an associated increase in thigh angle to the vertical without a change in the hip angle, as was the case with the control and sham conditions. It appears that therapeutic taping helped to maintain the pelvis in a relatively neutral position perhaps assisting the hip extensors to produce a greater force, thus moving the thigh into a more extended posture at the end of single support. This created a significant increase in true hip extension angle. In the sham and control conditions, apparent hip extension was produced entirely through anterior pelvic rotation with no 'true' hip extension.

We recognise and acknowledge the limitations of using a single camera to provide two dimensional angular data, however the consistency of the walks, as we observed from the spatial markers, suggested to us that little out of plane movement had occurred and that subjects were consistent in their general patterns of motion across trials. Nevertheless, a further study should utilise a three-dimensional analysis protocol. The method for derivation of temporal and spatial variables was labour-intensive and would lend itself to application of an automated walkway system, such as is now in place.

The mechanism underlying the gluteal taping is not known. McConnell (2002) has hypothesised that this particular taping technique may alter the orientation of the gluteus maximus muscle fibres. According to this hypothesis, the taping elevates and stretches the belly of the muscle, increasing the overlap between the actin and myosin filaments and therefore the potential cross-bridge interactions (Morrissey 2000). The length-tension curve is shifted to the left, with the gluteus maximus able to contract more forcefully, producing an increase in hip extension. Other explanations may be that taping improves muscle activation through cutaneous stimulation (Garnett and Stephens 1981) or improves proprioceptive acuity through the pull of the tape on the skin (Robbins et al 1995). These are unlikely, however, as there was no significant effect of the sham tape on any of the measured variables. A fourth possible explanation is that therapeutic taping may simply impose a physical limit on hip flexion.

This study provides evidence that gluteal taping is worthy of further investigation as a strategy for improving hip extension. The participants in this study had a history of stroke ranging from months to years with well-entrenched gait patterns. With the application of gluteal taping, participants increased their hip extension by 10 degrees which lead to a modest increase in step length of the unaffected side. Further investigation is required to determine how it could be used to improve and retain hip extension in persons with a history of stroke as well as the mechanism by which it evokes change.

Footnotes ^aGR-DVL9800, JVC, Victor Company of Japan Ltd ^bSigmaScan, Jandel Scientific, SPSS Inc.

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