ANKLE TAPING ALTERS SHANK-REARFOOT JOINT COUPLING DURING WALKING IN PATIENTS WITH CHRONIC ANKLE INSTABILITY AND HEALTHY CONTROLS

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The purpose of this study was to analyze the shank-rearfoot joint coupling with and without ankle taping in patients with and without chronic ankle instability (CAI) during walking gait. Twenty-three patients (CAI,n=12, healthy,n=11) participated. Three-dimensional kinematics were collected using a 12 camera motion capture. Fifteen strides were collected while subjects walked. A vector coding analysis was performed to assess the magnitude, direction (θ) and variability (VCV) in the coupling between the shank transverse plane and rearfoot frontal plane motion. Both groups had lower magnitude of coupled motion around initial contact while taped. VCV was significantly lower throughout the gait cycle in both groups while taped. Ankle taping appears to create a rigid coupling pattern in both healthy and CAI patients and may explain its role in prophylactically prevention of lateral ankle sprains.

KEY WORDS: Biomechanics, lateral ankle sprain, dynamical systems theory

INTRODUCTION: Lateral ankle sprains (LAS) are one of the most common injuries in athletic populations.(Fong et al., 2007) They result from a hypersupination mechanism and produce damage to the lateral ankle ligaments and alterations in neuromuscular function at the joint.(Hertel, 2002) A reported 30-70% go on to develop chronic ankle instability [CAI](Garrick & Requa, 1988). CAI is defined as subjective instability following a significant ankle sprain outside of 12 months and is associated with disability. CAI has been associated with changes in gait during walking and jogging compared to healthy controls.(Chinn et al., 2013) Alterations in the coupling of the shank and rearfoot during gait have also been identified in patients with CAI.(Drewes et al., 2009; Herbet al., 2013) Ankle taping has been shown to decrease total motion in all three planes at the ankle in healthy patients (Stoffel et al., 2010) and in patients with CAI (Chinn, 2013). Ankle taping has also shown to decrease the risk for lateral ankle sprain in high school athletes.(Mickel et al., 2006) The purpose of this study is to analyze the effects that ankle taping has on shank-rearfoot joint coupling during walking in patients with CAI and healthy patients.

METHODS: Twenty-three young adults, 11 healthy controls and 12 CAI, were recruited. CAI patients had a history of at least one LAS and continued instability outside of 12 months and also had Foot and Ankle Ability Measure-Sport scores of <80%. Healthy patients had no history of lower extremity surgery or injury within the past 3 months.
Lower extremity kinematics were captured using a 12 camera motion capture system (Vicon Motion Systems, Inc, Lake Forest, CA) and instrumented treadmill with an imbedded force plate (AMTI OR 6-7, Watertown, MA). Joint kinematics were collected at 250 Hz using Vicon PlugIn Gait model (Oxoford Metrics, London, UK). Following placement of 13 individual markers and 2 marker clusters on the lower extremity, all patients walked at 4.83km/hr. Marker location was recorded and foot markers were removed and a closed basket weave ankle taping procedure

was applied bilaterally by a certified athletic trainer. Markers were reapplied and patients returned to the treadmill to complete a second walking trial. Trials were filtered and normalized to 100 frames representing the gait cycle. Fifteen strides were extracted during both tape and no tape conditions. Strides were analyzed using a vector coding analysis to assess the shank internal/external rotation and rearfoot inversion/eversion kinematics throughout the entire gait cycle. Vector angle (θ), magnitude, and stride-to-stride variability (VCV) were assessed. The variable θ represents the relative proportion of motion between the two segments, magnitude represents the total relative motion between the two segments, and VCV represents the stride-to-stride consistency of magnitude and θ over the 15 strides. The calculations were based on previously reported methods.(Mullineaux & Uhl 2010; Herbet al., 2013) Group means and 90% confidence intervals were found for θ, magnitude, and VCV in both tape and no tape conditions. Any region where the confidence intervals did not overlap for more than 3 percentage points of gait were considered to be significantly different.

RESULTS: In healthy patients (Figure 1) coupling magnitude was lower with tape from 1-13% (tape:0.46±0.20, no tape: 0.79±0.27) and 87-100% (tape:0.38±0.17, no tape:0.65±0.25) of the gait cycle. VCV was lower while taped from 1-62% (tape:0.15±0.04, no tape:0.37±0.03) and from 68-100% (tape:0.20±0.08, no tape:0.50±0.11) of the gait cycle.

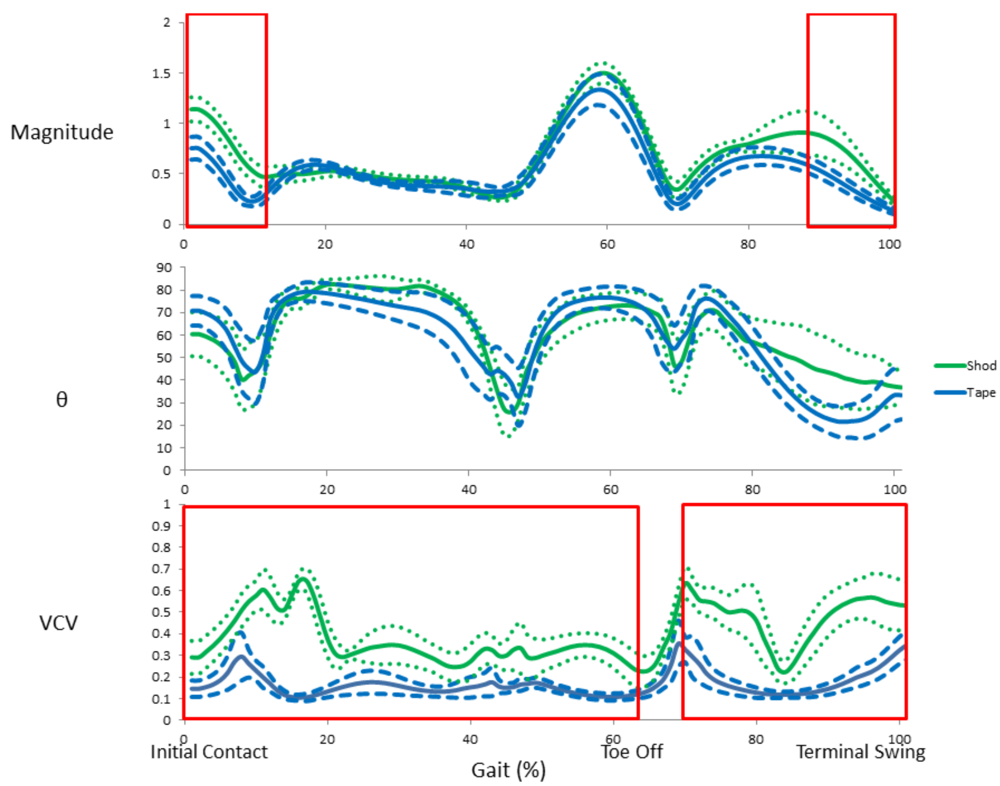

Figure 1: Joint coupling between the shank and rearfoot in healthy subjects.

In CAI patients (Figure 2) coupling magnitude was lower with tape from 1-12% (tape:0.50±0.23, no tape:0.74±0.24) of the gait cycle. While taped, VCV was lower during all of the gait cycle (tape: 0.41±0.14, no tape:0.15±0.24). No θ differences were found in either group between tape and no tape conditions.

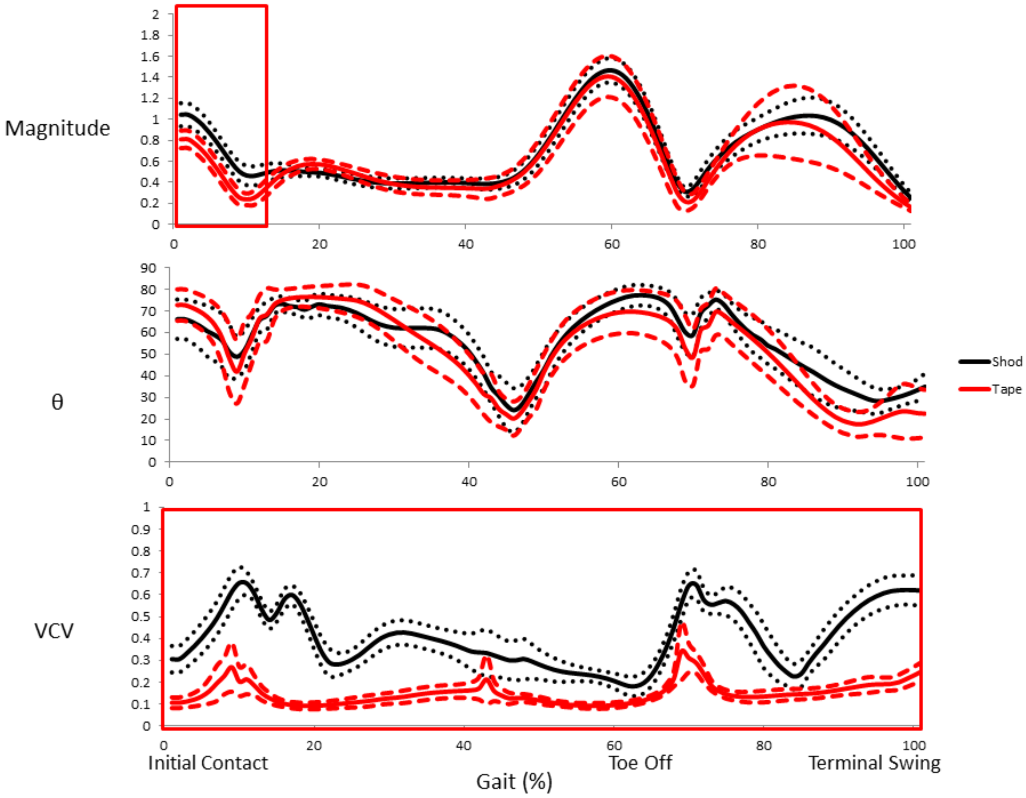

Figure 2 : Joint coupling between the shank and rearfoot in CAI subjects.

DISCUSSION: Both CAI and healthy groups had similar decreases in the magnitude of transverse plane coupled motion between the shank and rearfoot, and the stride to stride variability of shank-rearfoot coupling parameters during walking gait with the application of ankle taping. Magnitude changes indicate a decrease in relative motion between the shank and rearfoot of approximately 0.24º in patients with CAI and approximately 0.26º in health patients. In healthy patients, these findings indicate less relative motion prior to and following initial contact. A similar decrease was identified in CAI patients following initial contact. Ankle taping may limit the motions during this period and protect the ankle from getting into a position which may lead to injury.

Lower VCV indicates a more rigid coupling pattern throughout most of the gait cycle. This reduction agrees with previous findings of less frontal and sagittal plane motion in patients with the application of tape.(Stoffelet al., 2010; Chinn, 2013) This decrease in motion between the segments may be related to more consistent stride-to-stride coupling pattern. In patients with CAI, altered sensorimotor function and decreased joint stability may lead to a heavier reliance on the support of the tape, which may explain its role in prevention of ankle sprains. As healthy patients has similar results in joint coupling, taping may also decrease the risk of first time ankle sprains when participating in athletics that have a high risk of ankle sprain.

Decreases in VCV indicate lower stride-to-stride variability in the coupling parameters while subjects were taped. More reliance on stability of the tape leads to a more deterministic coupling pattern during gait which may protect patients from aberrant ankle position. However, less variability may lead to alterations in the adaptability of the sensorimotor system. Long term use of ankle taping may be hypothesized to lead to alterations in coordination of the joint coupling at the ankle and may put these individuals at higher risk if the constraints change, for example when the patient is not taped or during more difficult tasks. The pace of the walking trials was selected by researchers and a patient selected pace may alter the joint coupling. Patients experience with ankle taping was not taken into account and may have an impact on the results of this study.

CONCLUSION: Transverse plane shank-rearfoot joint coupling is altered during walking gait with the application of ankle taping in patients with CAI and healthy controls. Lower magnitude and variability in coupling parameters may explain the protective mechanism of ankle taping due to a decrease in the relative motion between these segments and lower variability in the coupling. The use of ankle taping as a protective mechanism may be useful to reduce risk of injury in patients with and without CAI.

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