The Effects of a Taping Technique on Foot Motion and Joint Displacement During Gait

UMA MHARREH, KEVIN O SULLIVAN
Dept. of Physiotherapy, University of Limerick, Ireland

Low-die (LD) taping is a commonly used physiotherapy technique to treat symptoms in the lower limb related to excessive pronation. Various measures of pronation including vertical surcaval height, navicular drop, plantar pressure patterns and 2D video analysis have been used to assess the effectiveness of LD taping in subjects with excessive pronation. However, no studies have previously investigated the effects of LD taping at the subtalar joint using 3-D analysis. The aim of this study was to investigate the effects of LD taping on pronation, supination and total range of motion at the subtalar joint in healthy subjects with increased pronation using 3-D CODA motion analysis. A convenience sample of 20 healthy university staff and students participated in the study. A repeated measures crossover study design was used, where subjects were assessed under both taped and non-taped condition. Pronation, supination, mean joint position and total subtalar ROM were analysed and compared between the two conditions. Descriptive statistics were used to determine whether differences at the subtalar joint under both conditions were statistically significant. The results demonstrated statistically significant differences were found between taped and non-taped conditions for pronation, supination and total subtalar ROM. Pronation (p<0.01) supination (p<0.05) and total subtalar joint ROM (p<0.05) decreased significantly under the taped condition compared to the non-taped condition. No statistically significant differences were however found between taped and non-taped conditions for mean subtalar joint position. These findings support previous research findings that suggest that LD taping reduces pronation at the subtalar joint. However, it appears, however, that LD taping reduces supination and overall ROM at the subtalar joint. Therefore, the mechanism of action may be more related to limiting mobility in general, rather than having a specific anti-pronation effect at the subtalar joint. Key words: Taping, CODA, pronation, supination

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Full body motion analysis of trip recovery in younger and older adults

We compared tripping responses of a group of nine younger women (aged 20 to 35 years) with a group of eight older women (aged 65 to 75 years). We wanted to investigate the influence of the lower limbs as well as the arms on trip recovery success. Movements during trip recovery occur in planes, therefore three-dimensional full body kinematic data were collected at 200 Hz with the Coda cl1 system (Cherwood Dynamics Ltd). A total of 27 markers were used in a combination of a custom triad set-up and the Codamotion sagittal plane analysis marker setup. The marker setup is shown in the figure below. In static trials, the relative positions of the joint centres to the triad markers were recorded. For dynamic trials, virtual markers were defined based on this information. This specific set-up was defined to be able to measure three-dimensional kinematics with the use of a single scanner. Additional measurements taken were ground reaction forces with a force plate (Kistler 9287BA), to be able to calculate the joint moments at the lower limbs, and muscle activity with EMG (Neoline, Telenez). In the experimental protocol the women walked over a walkway and they were tripped in random trials. A tripping device was custom designed for this experiment. This device consisted of plates that could be rotated upwards and obstruct the left or right foot to cause a trip. To ensure the participants could not fall if they were unable to recover from a trip, all participants were secured in a safety harness that was attached to an overhead rail. The outcomes of this research showed that younger adults used their arms effectively during trip recovery to prevent them from falling. Older adults on the contrary used their recovery limb to prevent falling after a trip and reached their arms in a more protective way and reached their arms more related to limiting mobility in general, rather than having a specific anti-pronation effect at the subtalar joint. Key words: Taping, CODA, pronation, supination

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The identification of the instants of touchdown and take-off are important in defining step characteristics in sprinting. Furthermore, previous studies of sprinting have identified the magnitude of key kinematic variables at touchdown and take-off as being important indicators of performance. Examples include high knee flexion velocity at touchdown (Mann & Herman, 1985) and reduced hip extension angle at take-off (Kunz & Kaufmann, 1981). The purpose of this study was to evaluate the accuracy in determining the instants of touchdown and take-off during a sprint run using a single CODA motion scanner unit, based on: (i) The vertical displacement of toe markers from a standing trial; (ii) The peak vertical acceleration as a threshold value for ground contact.

**Methods**

Six athletes (5 male, 1 female; age 22.8 ± 1.6 years) participated in the study. As marker locations: superior to the distal end of the first toe [A]; lateral to the distal end of the third toe [B]; superior to the first interphalangeal joint of the second toe [C]; lateral to the distal end of the fifth toe [D] and lateral to the fifth toe from a standing trial; (i) The vertical displacement of toe markers and (ii) The peak vertical acceleration as a threshold value for ground contact.

**Results**

Mean RMS differences across six subjects for each condition are displayed in Table 1. The lowest individual RMS differences between the criterion measures and marker derived event time occurred when using coordinates from the static trials.

**Discussion**

The instants of touchdown and take-off during sprint running contacts could be determined to within 0.005 and 0.003 s of the force data-derived criterion measure when using coordinate data of lateral and medial foot markers. The presented RMS differences were equivalent to a resolution of measurement of at least 200 Hz. This provided a similar level of accuracy to that reported by Hunter et al. (2004), who identified the instant of touchdown to within one field at 240 Hz in 93% of trials when using the method of Heiple and Marshall (2000). The findings of this study suggest that two markers located on each of the lateral and medial aspects of the foot could be used to identify the instants of sprint running touchdowns and take-off. Lateral and medial marker sets of the foot were necessary to accommodate laboratory-based data collections in which a bilateral CODA scanner was used to track bilateral sagittal plane motions. The peak vertical acceleration threshold could be used when the collection of a standing trial is not possible; for example, the vertical displacement threshold for sprint contacts on a banked curve may be difficult to derive.

**Conclusion**

Identification of contact events are important for the determination of step characteristics and event-specific kinematics during sprint running. Using vertical displacements for touchdowns and take-off were determined from force data. Marker derived touchdowns and take-off times were determined using the standing trials as a criterion and, separately, using peak vertical acceleration. Mean RMS differences across all subjects between force plate marker and marker derived criteria were calculated.

**Table 1**

<table>
<thead>
<tr>
<th>Marker</th>
<th>Marker RMS Differences with respect to Force Plate Criterion [s]</th>
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<tr>
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<td>Flat-footed Coordinate</td>
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<tr>
<td>Lateral</td>
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**References**


**Human walking and running forces: novel experimental characterisation and application in civil engineering dynamics**

**Student Paper**

Dept. of Civil & Structural Engineering, University of Sheffield, Sheffield, UK

The Vibration Engineering Section in the Department of Civil & Structural Engineering, University of Sheffield, is utilising the Codamotion (Charnwood Dynamics, UK) and ADSL 3D (Medical Development, France) instrumented treadmill to study how people walking and running affect civil engineering structures, such as footbridges, floors and staircases, prone to vibrations when occupied and dynamically excited by humans. Of all dynamic forces induced by humans, such as jumping, bouncing, bobbing and swaying, the dynamic forces induced by human walking and running are the least understood and most complete to deal with when considering performance of civil engineering structures that are dynamically excited by these activities. This is because they change simultaneously in time and space, being random in nature and varying considerably not only between different people but also for a single individual who cannot repeat two identical steps. The variation in how people walk and run makes the effect of such movements on engineering structures unpredictable and hard to be quantified in order to provide adequate guidance to designers. There are various opinions on the extent to which the constrained motion on a treadmill can represent normal walking. Hence data on variability and statistics of the loads induced by individuals and groups when walking and running will be gathered using the Codamotion treadmill system. There are two key novelties in the proposed approach:

1. Utilisation of ‘live field’ measurement of three-component continuous walking/running forces by measuring movement of the human body or bodies without artificial restrictions such as handrails or the controlled speed of the treadmill belt. Procedures for identifying these forces will be calibrated by comparison with standard direct measurement of forces on a treadmill.
2. The investigators aim to establish a database of measured time-varying traces of walking/running forces to develop stochastic models that can predict more realistically the vibration behavior of realistic engineering structures under pedestrian-induced excitation leading to more rational and efficient designs.

The project is fully funded by UK Government’s Engineering and Physical Sciences Research Council (EPSRC, reference No. EP/E010734/1). Contacts: Prof. James MW Brewster; james.m.brewster@sheffield.ac.uk
The identification of the instants of touchdown and take-off are important in defining step characteristics in sprinting. Furthermore, previous studies of sprinting have identified the magnitude of key kinematic variables at touchdown and take-off as being important indicators of performance. Examples include high knee flexion velocity at touchdown (Menn & Herman, 1985) and reduced hip extension angle at take-off (Kunz & Kaufmann, 1981). The purpose of this study was to evaluate the accuracy in determining the instants of touchdown and take-off during a sprint run using a single CODA motion analysis system (6 HGR-CU-MPXM30) were acquired for each subject (capture time: 10 s). Subjects then performed ten running trials, in which a single subject (capture time: 10 s). Subjects then performed ten running trials, in which a single

Methods

Six athletes (4 males, 1 female; age 22 ± 1.8 years, body mass 75.5 ± 9.4 kg, height Table 1: Mean RMS Differences in Touchdown (TD) and Take-off (TO) Times between Force Plate Criteria and Marker Derived Criteria from Three Experimental Conditions Across Six Subjects.

<table>
<thead>
<tr>
<th>Marker</th>
<th>Flat-footed Motion</th>
<th>Tip-toed Motion</th>
<th>Vertical Acceleration</th>
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<tr>
<td></td>
<td>TD</td>
<td>TO</td>
<td>TD</td>
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</table>
| Lat.   | 0.007             | 0.015          | 0.026                | 0.012          | 0.006 | 0.009
| B      | 0.005             | 0.008          | 0.047                | 0.008          | 0.005 | 0.017
| C      | 0.015             | 0.006          | 0.033                | 0.004          | 0.007 | 0.007
| D      | 0.003             | 0.012          | 0.023                | 0.024          | 0.005 | 0.022
| E      | 0.004             | 0.048          | 0.004                | 0.040          | 0.005 | 0.009
| Med.   | 0.005             | 0.015          | 0.031                | 0.011          | 0.007 | 0.009
| G      | 0.047             | 0.009          | 0.025                | 0.006          | 0.007 | 0.008
| H      | 0.017             | 0.009          | 0.019                | 0.015          | 0.007 | 0.006
| J      | 0.017             | 0.030          | 0.013                | 0.026          | 0.007 | 0.008

for touchdown and take-off were determined from force data. Marker derived touchdown and take-off times were determined using the standing trials as a criterion and, separately, using peak vertical acceleration. Mean RMS differences across all subjects between force plate and marker derived criteria were calculated.

Results

Mean RMS differences across six subjects for each condition are displayed in Table 1. The lowest individual RMS differences between the criterion measures and marker derived event time occurred when using coordinates from the static trials. Discussion

The instants of touchdown and take-off during sprint running contacts could be determined to between 0.003 and 0.005 s of the force data-derived criterion measures when using coordinate data of lateral and medial foot markers. The presented RMS differences were equivalent to a resolution of measurement of at least 200 Hz. This provided a similar level of accuracy to that reported by Hunter et al. (2004), who identified the instant of touchdown to within one foot at 240 Hz in 91% of trials when using the method of Heirle and Marshall (2000). The findings of this study suggest that two markers located on each of the lateral and medial aspects of the foot could be used to identify the instants of sprint running touchdown and take-off. Lateral and medial marker sets of the foot were necessary to accommodate laboratory-based data collections in which a infrared CODA scanner was used to track bilateral sagittal plane motions. The peak vertical acceleration threshold could be used when the collection of a standing trial is not possible; for example, the vertical displacement threshold for sprint contacts on a banked curve may be difficult to derive. Conclusion

Identification of contact events are important for the determination of step characteristics and event-specific kinematics during sprint running. Using vertical displacements of foot markers, touchdown and take-off events in sprinting could be identified to between 0.003 and 0.005 s of a force data derived criterion measure.

References

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