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Effect of taping on foot kinematics in persons with chronic ankle instability

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ABSTRACT

Objectives: To investigate differences in rigid-foot and multi-segmental foot kinematics between healthy (control) and chronic ankle instability (CAI) participants during running and to evaluate the effect of low-Dye (LD) and high-Dye (HD) taping on foot kinematics of CAI subjects.
Design: Cross-sectional, comparative study.
Methods: Kinematic data of 12 controls and 15 CAI participants were collected by a 3D motion analysis system during running. CAI participants performed barefoot (CAI_BF) running trials as well as trials with taping. A rigid Plug-in gait Model and the Rizzoli 3D Multi-Segment Foot Model were used. Groups were compared using one-dimensional statistical parametric mapping.
Results: An increased inversion, a decreased dorsiflexion between the foot and tibia and a decreased external foot progression angle were found during terminal swing and early stance in the CAI_BF group. With respect to the taped conditions, post-hoc SPM{t} calculations highlighted a more dorsiflexed rearfoot (38–46% running cycle) in the CAI_HD compared to the CAI_LD, and a more inverted Mid-Met angle (6–24% running cycle) in the CAI_LD compared to the CAI_BF condition.
Conclusions: This study revealed significant differences in rigid foot and multi-segmental foot kinematics between all groups. As high-dye taping embraces shank-rearfoot and forefoot, it seems to have better therapeutic features with respect to low-dye taping as the latter created a more inverted forefoot which may not be recommended in this population.

1. Introduction

It has been estimated that 32–74% of people with a history of lateral ankle sprains (LAS) develop chronic ankle instability (CAI).[1,2] Multiple definitions and models have been used to define CAI.[3,4] However, because of its multi-faceted and heterogeneous character, CAI has recently been defined by the International Ankle Consortium (IAC) as being a chronic condition including three major aspects: (1) a history of at least one significant ankle sprain, (2) a history of ankle joint ‘giving way’ and/or recurrent sprain, and/or ‘feelings of instability’, (3) a poor disability status according to specific questionnaires.[5–7]

Many factors may have an effect on the occurrence of LAS. Extrinsic risk factors of LAS are typically related to environmental variables whereas intrinsic factors may include age, previous injuries, inadequate treatment, psychosocial variables,[8] neurological and biomechanical abnormalities.[9–11] In order to adequately appreciate the contribution of biomechanical abnormalities, researchers have typically focused on particular dynamic tasks.[12] The role of running mechanics has been particularly appealing. The strongest evidence for the latter is probably provided by the pedobarographic study of Willems et al.[13] who demonstrated prospectively that subjects at risk of having an ankle inversion sprain have a more laterally located center of pressure at last foot contact and an increased lateral displacement of the center of pressure in the forefoot push off phase.

The role of foot and lower limb kinematics during running[14,15] has also received considerable attention in the literature.

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Alterations in shank-rearfoot coupling during terminal swing and loading response have been reported in this population during running, whereby it has been observed that the ankle is significantly less dorsiflexed during 9 to 25% of the running cycle.[14,15] In those studies, the foot was modeled as one rigid segment, thereby ignoring its multi-segmental character. Recently, De Ridder et al.[16] published a study that focused on the foot using a multi-segmental model. They found a more everted position of the rearfoot from 56% to 73% of the stance phase during running in participants with CAI compared to controls. The CAI group showed significantly more inversion of the medial forefoot in relation to the midfoot from 56 to 91% of stance phase.[16]

Correcting the different joints of the foot in the pre-landing to post-landing period is an imperative issue for participants with CAI. Taping has proved to be more effective in reducing the incidence of recurrence rather than first-time ankle sprains.[17] There are two common types of ankle joint taping. High-Dye (HD)[18] taping starts at the foot and extends onto the lower aspect of the lower leg, whereas Low-Dye (LD)[19] taping is limited to the foot. Therapists typically use HD taping in participants with CAI as it is believed to better protect the rearfoot structures compared to the LD taping. Recent evidence suggests that HD taping has proved to be more effective in reducing the incidence of recurrent rather than first-time ankle sprains.[20] The clinical features of taping encompass motion control and improving proprioception through cutaneous feedback.[21] The therapeutic efficacy of the abovementioned taping techniques has mainly been oriented towards motion control, but to the best of our knowledge, no literature addressed the influence of taping on multi-segment foot kinematics in CAI patients. Additionally, critical appraisal of the literature highlights that those researchers who have focused on foot kinematics during running, omitted to report the striking pattern and disregarded the swing phase in their study. However, both are critical aspects to consider within a pathomechanical reasoning process. Therefore, the objective of the current study was twofold. First, we aimed at investigating the differences in multi-segmental foot kinematics between healthy and CAI participants during running. Second, we aimed to understand the effect of LD taping and HD taping on these foot kinematics in participants with CAI during running.

We hypothesized that (1) participants with CAI demonstrate a more inverted and adducted rearfoot kinematic pattern as well as an inverted mid- and forefoot kinematics. With respect to the second objective, we hypothesized that HD taping would considerably decrease frontal plane kinematics of rear- and midfoot, whereas for the LD taping this effect would be restricted to the midfoot.

2. Methods

Twenty-seven recreationally active university students (defined by at least 1.5 h of cardiovascular activity per week) participated in this study. Recruitment occurred at the faculty of Kinesiology and Rehabilitation Sciences of the KU Leuven through advertisement between February 2013 and February 2014. Recruitment period was limited to one year and a convenience sample was targeted. Participants were categorized in either the CAI group (6 men, 9 women) or the control group (5 men, 7 women). A self-report questionnaire was used to determine if they met the inclusion criteria. Inclusion criteria for the CAI group were: (1) a history of at least one significant ankle sprain and (2) a history of the ankle joint giving way as defined by Delahunt et al.[22] This self-reported ankle instability was confirmed with the Cumberland Ankle Instability Tool (CAIT),[23] a validated ankle instability-specific questionnaire using a cut-off score of ≤24. Exclusion criteria for both groups were (1) being younger than 18 years or older than 30 years, (2) previous surgery or fracture in either lower extremity, (3) other lesions to the musculoskeletal structures of either lower extremity and/or back at the moment of testing that have an impact on joint integrity and function (except for CAI in the CAI group), (4) recent participation in a rehabilitation program and (5) systemic, neurological and orthopaedic diseases. The current study was initiated prior to the position statement of the IAC,[5] however, our criteria matched those of the IAC in the majority of cases. Exceptions with those proposed by the IAC are the exclusion criteria (1) and (4). The study was approved by the local ethical committee and all participants signed a consent form.

Running analysis was performed in a university motion-analysis laboratory using the following measurement devices: a 3D motion analysis system, a plantar pressure platform and a force platform. A passive optoelectronic motion analysis system (Vicon Motion System Ltd., Oxford Metrics, UK) consisting of 10 T-10 cameras was used to track the kinematic data (100 Hz) of all participants while running over a 10-m walkway. In this walkway, a custom-made force plate was imbedded in the middle (Advanced Mechanical Technology Inc., Watertown, MA, USA), covered with a pressure plate (Footscan, dimensions 0.5 m × 0.4 m, 4096 sensors, 2.8 sensors per cm^2, RSscan International, Olen, Belgium). The current set-up provided an objective measurement of the foot strike pattern and formed the basis for calculating spatiotemporal parameters. Data from the force plate and pressure plate were sampled at 200 Hz.

Prior to testing, CAI participants were asked to fill in the CAIT (Version 3).[23] Reflective markers were placed using double-sided tape on foot and lower limb anatomical landmarks according to the Plug-in gait model[24] and the Rizzoli 3D multi-segment foot model.[25] Subsequently participants were instructed to run barefoot at a constant speed of 3.3 m s^{-1} (±10%) and adopt a heel-strike running strategy. Running speed was measured by monitoring the velocity of the reflective marker on the sacrum. The control group only performed barefoot running trials whereas the CAI group additionally performed trials with LD and HD taping. The order of these test conditions was randomly assigned. Every condition was repeated until at least three valid trials were registered.

Non-elastic sports tape (38 mm, All Products BVBA, Belgium) was applied when the subject was lying in supine position with the feet in a n neutral position. All tapes were applied by the same investigator (BD). High-dye taping technique was performed according to MacDonald,[18] whereas LD taping technique was performed according to Vincenzino et al.[19] (additional files 1 and 2).

Kinematic data from the Rizzoli foot model were computed throughout the Vicon Foot model Plug-in (Aurion Srl, Milano, Italy) using Nexus 1.5 software. This five-segment model defines the 3D rotations between the shank (Sha), calcaneus (Cal), midfoot (Mid), metatarsus (Met) and hallux as rigid segments. The sagittal plane angle of the first metatarsophalangeal joint (hallux) will be referred as F2Ps. Other dependent variables which were considered were the talocrural kinematics (Sha-Foo) and the foot progression angle both from the Plug-in gait model, embodying motion data in which the foot is considered as one rigid segment. Spatiotemporal variables measured were running speed, stride time, stance time and swing time. Normalization of the data to 100% of the running cycle was performed within Matlab 2012a. Statistical analysis on demographical and spatio-temporal parameters was performed using Wilcoxon Test and ANOVA respectively.

In order to track significant differences between the kinematic profiles in an objective way, one-dimensional statistical parametric mapping (1DSPM) was used.[26] We included four different groups: CAI barefoot (CAI_BF), CAI high-Dye (CAI_HD), CAI low-Dye (CAI_LD) and the control group. The most affected limb of the CAI group participants, which was determined by the CAIT, was matched with the limb of the control group participants for the purposes of making between-side comparisons. In case of an identical CAIT score