COMPARISON OF REARFOOT INVERSION ANGLE AT INITIAL FOOTSTRIKE MEASURED FROM FRONT AND BACK VIEW VIDEOS

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Crossover running gait patterns can obstruct the measurement of 2D rearfoot inversion angle typically determined from back view video recordings. This study aimed to compare the rearfoot inversion angle at the initial footstrike of running measured from front and back camera views. Twenty healthy female runners were recruited and 2D kinematic analysis was employed to analyse 7 consecutive gait cycles. Rearfoot inversion angles measured from both front and back camera views were compared using paired t-test. Results showed that 6 participants (30%) displayed a crossover gait. There was a significant difference between the front (11.7° [10.1°, 13.3°]) and back (7.2° [4.7°, 9.8°]) camera views ($p < 0.001$, $d = 0.883$). This indicates rearfoot inversion angle measured from the front and back camera views cannot be used interchangeably. While the method offers a possibility to measure rearfoot inversion angle from the front view, the results cannot be directly compared to those obtained from the back camera view. In conclusion, this study demonstrated that rearfoot inversion angle at the initial footstrike could be quantified from front view videos for runners with crossover gait.

KEYWORDS: running, crossover, gait, 2D analysis, kinematics.

INTRODUCTION: Running is a common form of exercise due to its ease of accessibility and low cost. However, the incidence rate of running-related injuries (RRIs) is reported to be as high as 85% (Kluitenberg et al., 2015) and studies have attempted to link biomechanical factors with the various RRIs (Ceyssens et al., 2019). One common injury in the lateral knee is the iliotibial band syndrome (ITBS) (Foch et al., 2015), which have been associated with increased rearfoot inversion at initial foot strike (Grau et al., 2008).
While 3D motion analysis has been recognised as the gold standard for analysing running movements, the method involving a high-speed camera with 2D video analysis has received increasing attention. Recent studies have established good reliability and validity of 2D video analysis in running-related research (Dingenen et al., 2019; Maykut et al., 2015). Furthermore, 2D video analysis has greater practicality for practitioners due to its lower cost and less time-consuming procedures in setting up.
When utilising 2D video analysis, rearfoot inversion angle is generally measured from the back view. However, there are instances where runners have a crossover gait (Figure 1), hindering practitioners to measure accurately from the back view. Thus, a front-view camera could be an alternative method to supplement the measure of rearfoot inversion when necessary. Therefore, the present study aimed to explore the differences in rearfoot inversion angle at the initial footstrike taken from the front and back views. It was hypothesised that the rearfoot inversion angle measured from the front view would be comparable to that from the back view, since Johanson et al. (2010) reported that the rearfoot valgus was correlated with forefoot varus in the static position. The findings would support practitioners to adopt a new method in performing the 2D video analysis, especially for runners with crossover gait.

METHODS: This study was approved by the Nanyang Technological University Institutional Review Board (IRB-2021-124). Twenty healthy female runners (age 24.1 ± 5.16 years; height 162.2 ± 4.2 cm; body mass 57.3 ± 5.6 kg) provide written informed consent to enrol in the study.

Figure 1: An example of a crossover gait that prevents rearfoot inversion angle to be measured from the back-view camera.

All participants attended a single running session on a treadmill (h/p/ cosmos saturn®, h/p/cosmos® sports & medical gmbh, Nusseldorf-Traunstein, Germany). Before running on the treadmill, cloth tapes were placed on anatomical points by a single researcher as marker placement for video analysis. The anatomical points in the front view were the 2nd metatarsophalangeal joint and anterior talus, while the calcaneus, posterior talus and mid-gastrocnemius were for the back view. Participants were given 5 minutes of walk-run as warm-up and familiarisation. Immediately after, participants continued running on the treadmill with the speed increased to their self-selected comfortable speed (8.68 ± 0.48 km/h). Participants maintained their self-selected speeds till the video recording was completed for both front and back views.

A single video camera (Casio Exilim EX-100) was used in the present study to record from the front and back views at 120 Hz. The camera was placed 1.5 m away and perpendicular to the participant. The height of the camera was set at hip and ankle level for the front and back view, respectively. Each video was recorded for 30 gait cycles for both limbs. The video was exported to Kinovea (Version 0.8.27) for 2D kinematic analysis. Seven consecutive gait cycles were used for analysis since Dingenen et al. (2018) found that minimally 7 gait cycles were necessary to achieve stable results in 2D video analysis. In the front view, the rearfoot inversion angle was measured with a line from the base of the foot to the anterior talus and the vertical line of the forefoot position (Figure 2a). In the back view, the rearfoot inversion angle was measured from the line of the posterior talus to the middle of the gastrocnemius and the calcaneus (Figure 2b).

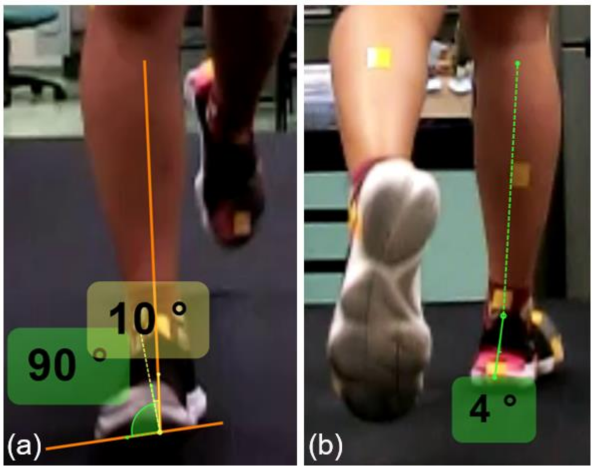

Figure 2: Example of 2D kinematic measurements of rearfoot inversion angle at initial foot strike from (a) front view, and (b) back view.

Data are expressed as mean (95% confidence intervals). The rearfoot inversion angles of the left and right strides of the same view were combined. Thereafter, a paired t-test was performed to compare the differences in the rearfoot inversion angle between the ventral and dorsal views. Effect size (d) was calculated from Cohen's d and interpreted as small ($0.2 \le d < 0.5$), medium ($0.5 \le d < 0.8$), or large ($d \ge 0.8$). Statistical significance was set at $p < 0.05$ and all statistical analyses were performed using SPSS (Version 28; SPSS Inc., Chicago, IL, USA).

RESULTS: This study observed a total of 6 participants (30%) having at least one crossover step in 7 gait cycles in either limb upon initial footstrike. Rearfoot inversion angles measured from the front view were larger than the back view with a mean difference of 4.4° [2.1°, 6.8°]. Paired t-test also showed that there was a significant difference ($t(19) = 3.950$, $p < 0.001$, $d = 0.883$, large effect size) in the rearfoot inversion angle at initial footstrike between the front (11.7°, [10.1°, 13.3°]) and back (7.2°, [4.7°, 9.8°]) views (Figure 3).

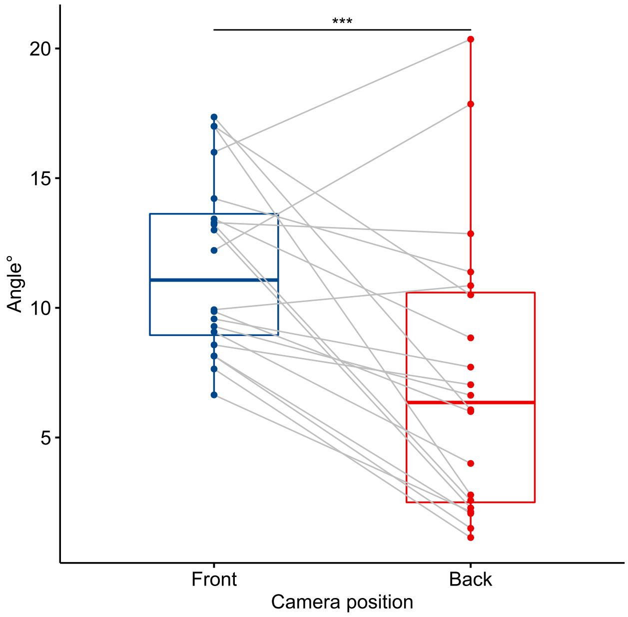

Figure 3: Results of rearfoot inversion angles between the front and back camera positions.

DISCUSSION: The purpose of the present study was to compare the rearfoot inversion angles at the initial footstrike measured from the front and back camera views. It was observed that 30% of the participants exhibited the crossover gait pattern within the 7 gait cycles investigated, while the participants were all healthy with no serious lower limb musculoskeletal injuries in the past six months. The crossover gait could be due to a narrow base of support associated with various running injuries (Souza, 2016). Injured runners are likely to increase the frequency of crossover gait. Therefore, researchers and practitioners should note this crossover gait pattern as it may be an early sign of ITBS (Meardon et al., 2012) and tibial stress fractures (Meardon & Derrick, 2014). In addition, the crossover gait could also lower the measurement accuracy for the rearfoot inversion angle from the back view.

The present study found significantly different rearfoot angles when measured from the front and back views. This indicated that the position of the camera could affect the measured angle. The inconsistent angles could be due to the differences in height of the camera in both views. The differences in camera height were to establish ecological validity as practitioners often use one camera position to record and analyse multiple kinematic variables in one instance. Hence, the front-view camera, which was set at the hip level, could have contributed to greater angles compared to the back-view (at ankle level) results. In addition, it is plausible that rearfoot inversion at the initial footstrike requires more than 7 steps to reach a stable mean as rearfoot inversion alone was not included in Dingenen et al. (2018). As this study observed significantly greater rearfoot inversion angle measured from the front view than the back view, practitioners are to be mindful of the differences when comparing values measured from different camera views. Further studies are called to validate the difference in male runners and establish the relationship between the angles measured from different camera views.

CONCLUSION: This study found that 30% of the participants had a crossover gait pattern when running, preventing rearfoot inversion angle at initial footstrike to be measured from back-view video recordings. When measuring the rearfoot inversion angle from the front view, the values were significantly greater than those measured from the back view. The presented method offers a possible solution for the practitioner to measure rearfoot inversion angle even when the foot is blocked from the back view camera. Researchers and practitioners should be aware of the difference in rearfoot inversion angle measurements and not use the values obtained from front and back views interchangeably.

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ACKNOWLEDGEMENTS: We wish to acknowledge the funding support for this project from the Research Support for Senior Academic Administrator Grant (RS 2/21 KPW) of the National Institute of Education, and Nanyang Technological University under the URECA Undergraduate Research Experience on CAmpus programme.