LANDING WITH A SUPINATED ANKLE JOINT COULD INCITE AN INVERSION SPRAIN INJURY

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Ankle sprain injury mechanism has been recently analysed quantitatively. This study further investigated if a supinated ankle joint at landing is an aetiology of the injury. One inversion ankle sprain case from a previous study was selected, and the video sequences of two similar play movements performed by the same athlete without injury were collected and analysed by a model-based image-matching motion analysis method. The ankle joint orientations at the moment of landing in these three cases were compared. Results showed that the ankle joint was in a supination orientation with a combined 14 degrees inversion and 16 degrees plantarflexion at landing, while it was neutral in the inversion/eversion plane and dorsiflexed to 10-21 degrees in the non-injury cases. The supination ankle joint at landing was suggested to be the inciting event of the injury.

KEY WORDS: sports medicine, ankle sprain, ligamentous sprain, sport injury.

INTRODUCTION: Lateral ankle ligamentous sprain is one of the most common injuries in sports (Fong, Hong, Chan, Yung & Chan, 2007). Repeated ankle sprains may cause ankle instability and early osteoarthritis, therefore, it is worth to research in strategies to prevent the injury. In a widely adopted ‘Sequence of Injury Prevention’ proposed by van Mechelen and coworkers (1992), the aetiology and mechanism should be investigated after the target population is identified from epidemiology studies. Then, preventive strategies can be designed to stop the aetiology and mechanism in order to reduce the injury incidence, which can be tested by re-performing an epidemiology study with the measure implemented.

The injury mechanism was first studied in 1977 by clinical observation (Garrick, 1977), and was then commonly reported in qualitative video analysis as excessive inversion or supination (Andersen, Floerences, Arnason & Bahr, 2004). Since 2009, Fong and colleagues published a series of quantitative case reports of ankle sprain injury in sports (Fong et al, 2009b; Mok et al, 2011a; Fong, Ha, Mok, Chan & Chan, 2012b) and suggested that the range of ankle inversion can be within a normal range during an injury (e.g. 48 degrees), but the peak inversion velocity was found to be 2- to 8-times faster (600 to 1,800 deg/s) than that recorded in normal sporting activities (within 200-250 deg/s, Chu et al, 2010). The ankle inversion velocity was then monitored by a uni-axial gyroscope to drive a patented technology (Chan, Fong & Yung, 2012) to stimulate the peroneal muscles to accommodate the fast injurious motion (Fong, Chu & Chan, 2012a) in a pair of intelligent anti-sprain sport shoes (Fong, 2012).

While the mechanism is the process, and the aetiology is the cause or the inciting event, and injury prevention should target at both stopping the process and also preferably avoiding the cause. The two commonly suggested aetiologies are an incorrect ankle orientation at landing and the delayed reaction time of the peroneal muscles (Fong, Chan, Mok, Yung & Chan, 2009a). With the previous forensic analysis on injury incidents as the basis, the purpose of this study is to conduct additional analysis on similar movements performed by the same athlete without sustaining an injury to investigate the dangerous pre-landing mechanics leading to injury. It is hypothesised that the ankle joint was in a more supinated orientation at landing in the injury case when compared to non-injury similar motions.

METHODS: An online video search was performed. We aimed for two play movements performed by the same tennis player similar to his or her injury case report presented in our earlier study (Fong et al, 2012b). The play movements must be a successful and injury-free cutting motion with the same direction of approach to the tennis ball during a competitive match of an international level. A video was being regarded as suitable for the analysis should have at least two camera views showing the shank, the ankle joint and the foot segment during the non-injury motion, and with a rear camera view clearly showing the motion. After the search, two non-injury cases from a female tennis player who had her injury case reported as Case 4 in our previous study (Fong et al, 2012b) were identified. The university ethics committee approved this study.

The video recordings were transformed from the original format into uncompressed AVI image sequences by using Adobe Premiere Pro (version CS4, Adobe Systems Inc, San Jose, California). The image sequences were synchronized and rendered into 1-Hz video sequences by Adobe After-Effects (version CS4, Adobe Systems Inc, San Jose, California). Poser 4 and Poser Pro Pack (Curious Labs Inc, Santa Cruz, California) were used to perform a model-based image-matching motion analysis. The surroundings were built in the virtual environment according to the real dimensions of the tennis court. A skeleton model (Zygote Media Group Inc, Provo, Utah) was used for the skeleton matching with her height as the only available anthropometrical information obtained from the International Tennis Federation webpage. Marching started from the hip, femur, shank, and then the foot and toe segments. Both the environment and the skeleton models were matched simultaneously frame by frame. The details and the reported excellent reliability and validity of the motion analysis method can be found in a previous study (Mok et al, 2011b).

Since the procedure of the analysis technique is very time consuming and it was the fact that we could only find two successful and injury-free movements for comparison, direct comparison of the ankle joint orientation data was performed without statistical analysis.

RESULTS: Ankle joint orientations in the three cases were presented in terms of joint angles and angular velocities in three planes (inversion/eversion, plantarflexion/dorsiflexion, internal/external rotation) at the moment of landing (Table 1). In the two non-injury cases, the ankle was in a neutral position in the inversion/eversion plane, and was dorsiflexed for 10 and 21 degrees. In the injury case reported in an earlier study (Fong et al, 2012b), the ankle joint was inverted for 14 degrees and plantarflexed for 16 degrees, thus a supinated ankle joint. No obvious difference in internal rotation was observed. Figure 1 graphically illustrated the ankle joint orientation at the moment of landing in all three cases.

Table 1: Ankle joint orientations at landing in the non-injury cases and injury case

	Non-injury		Injury case
	Case 1	Case 2	Case 4 from Fong et al, 2012b
Inversion, deg	0	-1	14
Plantarflexion, deg	-10	-21	16
Internal rotation, deg	11	1	7

DISCUSSION: Ankle joint orientation at the moment just before landing is a key factor causing the injury, but previous studies reported different findings. Wright and coworkers (2000) did a computer simulation and suggested that a plantarflexed ankle but not an inverted ankle at touchdown caused a higher risk on sprain, while Andersen and colleagues (2004) performed a video analysis on injury incidents and suggested that an ankle inversion sprain is caused by the player landing with a vulnerable inverted ankle position. An inverted ankle orientation ranging from 10 to 24 degrees at landing was also found in the eight cases reported by Fong and colleagues (Fong et al, 2009b; Mok et al, 2011a; Fong et al, 2012b).

The two non-injury cases in this study were chosen because the cutting motions performed by the athlete were very similar in terms of the play movement and the direction of approach to the tennis ball. She was running diagonally from back court to the right hand side of the front court in order to perform a forehand drive return. In these two non-injury cases, the ankle was at a neutral orientation in the inversion/eversion plane and slightly dorsiflexed at the moment of landing. In the injury case, the ankle was inverted for 14 degrees, which is a lot in this plane of motion at the ankle joint and can be consider with a significant clinical difference. The ankle joint was also plantarflexed for 16 degrees, so this combination was a supination. Based on the findings in this study, it is suggested that a successful strategy to perform this running forward, cutting and stopping movements which is common in tennis would be to keep the ankle straight and slightly dorsiflexed, in order to maintain a stiff ankle joint to resist the high twisting forces in the ankle.

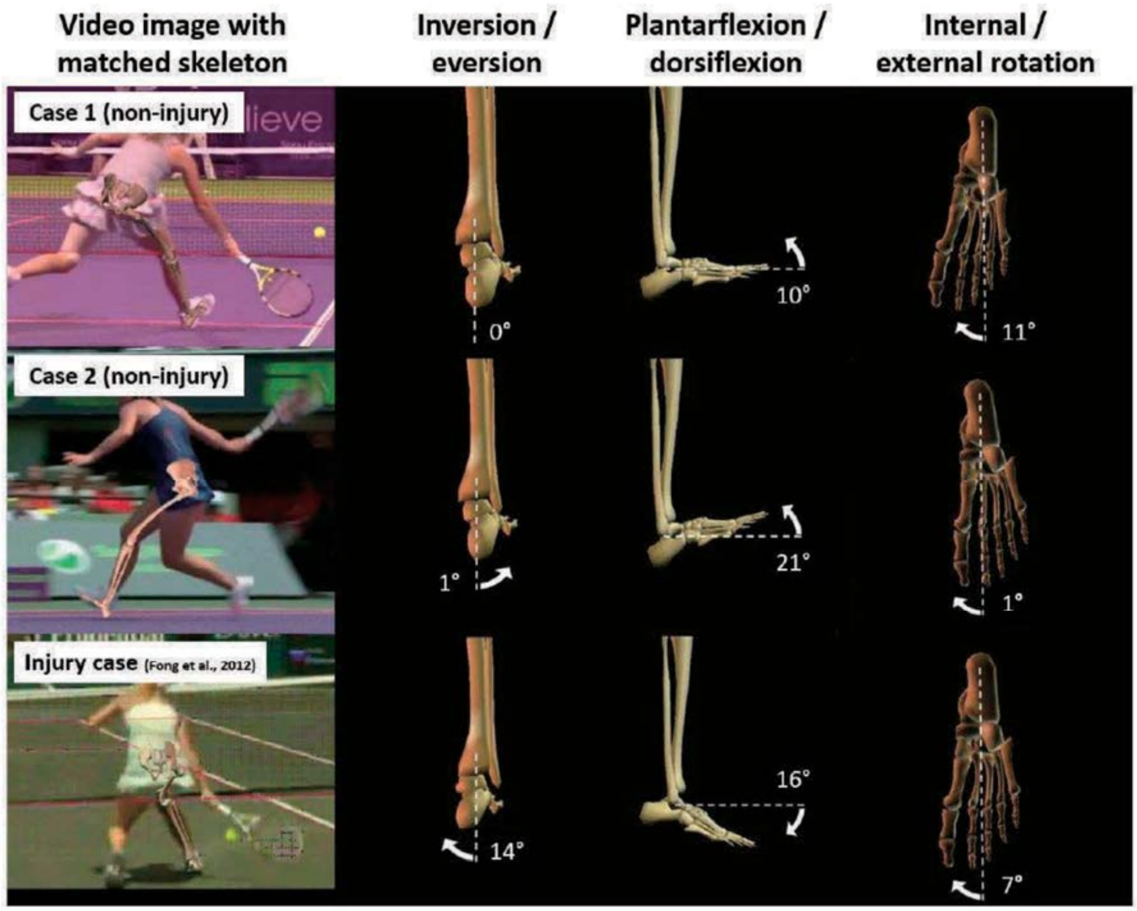

Figure 1: Left column: screenshots from 1 view showing the moment of landing. Other columns: the ankle joint orientation presented in the inversion/eversion, plantarflexion/dorsiflexion, and internal/external rotation planes at landing.

A limitation which the research team could not tackle was the extremely small sample size. It was thought that the athlete must have performed a lot of similar movements in tennis as she is a professional player in the top levels, and therefore these movements should have been captured in televised programs. However, as at least two camera views showing the shank, the ankle joint and the foot segment during the non-injury motion, and a rear camera view clearly showing the motion were required, the search was unexpectedly difficult and resulted in only two eligible video sequences.

The small number of quantitative ankle sprain injury case report was also a limitation. To dated, there were only 10 reported cases from five studies in the literature (Fong et al, 2009b; Mok et al, 2011a; Fong et al, 2012b; Gehring et al, 2013; Kristianslund et al, 2011). Since injury can happen in many ways, there is a great need to perform more analyses in this area before a conclusion on the patterns of the injury aetiology and mechanism can be drawn.

CONCLUSION: A comparison of two non-injury cases and one ankle sprain injury case on the same tennis player was performed. A supinated ankle joint orientation at foot strike is suggested to be the inciting event of a lateral ankle sprain injury, and this is in agreement with the clinical suggested injury mechanism. Further research on the prevention of ankle sprain injury can focus on avoiding this incorrect landing posture in sports.

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