POTENTIAL INFLUENCE OF FOOTWEAR ON ANKLE INVERSION INJURY RISK DURING LATERAL JUMPS IN OLDER ADULTS

Joanna Reeves[1,2], Louise Baker[1],
Bee Chambers[1], James Brownjohn[1], Sharon Dixon[1]
University of Exeter, Exeter, UK[1]
University of Bath, Bath, UK[2]

The purpose of this study was to explore the effect of footwear on the ankle inversion and plantar pressure experienced by older females performing change of direction tasks. Eight older female tennis players performed five lateral side jumps and five 180° turns in a running shoe and tennis shoe. Peak ankle inversion angle and time of peak plantar pressure were recorded. A case study approach revealed reduced rearfoot loading and increased forefoot loading of two participants in the running shoe compared to the tennis shoe when performing the lateral side jumps. Greater peak inversion angle was also recorded in the running shoe compared to the tennis shoe for these participants. While the cushioning properties of running shoes may be appealing for some older tennis players, wearing running shoes during tennis may increase the risk of incurring an ankle sprain.

KEYWORDS: footwear, tennis, older adults, ankle sprain, cushioning

INTRODUCTION: It is well known that physical activity is important for health and quality of life throughout the lifespan (Pate et al., 1995; Pucci; Rech; Fermino, & Reis, 2012). As well as health benefits, reasons for engaging in sport as a physical activity that are reported by older adults include seeking social connections, support from others, achievement and competition (Stenner; Buckley, & Mosewich, 2020). Racket sports are particularly popular with older adults (Arkenford Ltd & Act2, 2006), with tennis being one of the most popular physical activities in later life ((Cozijnsen; Stevens, & Van Tilburg, 2013)).

Racket sports involve frequent turns and changes of direction, which are a common cause of lower limb injuries (Paterson; McMaster, & Cronin, 2016). An important factor that can influence injury risk is footwear and response to footwear has been shown to be highly individual (Nigg; Stefanyshyn; Cole; Stergiou, & Miller, 2003). For example, to reduce the risk of injury from sideward movements in court sports, it has been suggested that court shoes should be generally stable to avoid excessive supination, as well as have adequate cushioning in the forefoot and rearfoot, midfoot flexibility in the frontal plane and moderate sagittal plane stiffness (Bouché, 2010). Good cushioning is arguably important in footwear for racket sports at any age because of the high impact forces involved (Bouché, 2010). However, there may also be increased need for cushioning in athletic footwear for older participants due to reduced elasticity of plantar fat tissue (Bus, 2003) and stiffer joints associated with osteoarthritic changes leading to less effective lower limb cushioning (Lilley; Dixon, & Stiles, 2011). Cushioning of court shoes may have traditionally been seen as less important than cushioning in running shoes (Reinschmidt & Nigg, 2000). Some older adults report choosing to play tennis in a running shoe rather than a tennis shoe due to the superior comfort and cushioning of the running shoe (Reeves et al., in press). Wearing running shoes during turns and changes of direction may lead to injurious movement patterns and predispose the athlete to ankle sprain injury due to the lack of lateral support. Therefore, the purpose of this study was to compare the ankle joint kinematics and plantar pressure experienced by older females performing change of direction tasks in a running shoe and a tennis shoe.

METHODS: Eight older female tennis players (mean ±SD age: 63 ±5 years; height: 1.63 ±0.04 m, 64.7 ±10.2 kg) performed five successful trials of both a run with a 180° turn and a lateral side jump in two footwear conditions over an acrylic hard court surface. The tennis shoe was a New Balance 976 and the running shoe was an Asics Phoenix. The order of shoe condition was randomised. Movements were performed without a racket. Participants were given a few practice trials of each movement before data collection. Similar to previous methods (Starbuck et al., 2016), for the 180° turn participants were instructed to run at a fast pace towards the acrylic surface over the AMTI force plate, to plant their right foot perpendicular to the running direction and turn 180° and run back to their starting position. Mean speed of the entire180° turn movement was established in practice using timing gates and a successful trial was required to be within ±5% of the pre-determined mean. For the side jump participants started from a standardised position equal to the height of their greater trochanter from the lateral border of their right foot to the centre of the force plate. Participants were instructed to jump sideways on to the force plate as quickly as possible (maximal effort) then immediately jump back to the starting position (Damm et al., 2013).

Plantar pressure was recorded using insoles (Pedar-X®, novel GmbH, Munich, Germany). Kinematic markers (CODA, Charnwood Dynamics) were positioned on the (1) greater trochanter, (2) lateral femoral condyle, (3) medial femoral condyle, (4) lateral malleolus, (5) medial malleolus, (6) calcaneus (heel) and (7) first distal phalanx of the foot. Marker clusters were placed on the thigh and shank. Plantar pressure, kinematic and force data were collected at 100 Hz, 200 Hz and 1000 Hz respectively.

Data were processed using MATLAB (R2017b, Mathworks Inc.) and CODA (Codamotion Odin, Charnwood Dynamics, UK) and further analysed in Microsoft Excel. Plantar pressure was analysed with respect to medial/lateral heel, media/lateral midfoot and medial/lateral forefoot segments. The outcome variable was time of peak pressure of the area as a percentage of total foot contact duration (De Cock; De Clercq; Willems, & Witvrouw, 2005). Peak pressure was defined as the maximum value from any sensor within a given segment across stance. Onset and offset of pressure across the whole foot was determined as two standard deviations above baseline for 10 frames, with a visual confirmation. The kinematic outcome variable was peak inversion angle over stance.

RESULTS: Three participants were excluded from the plantar pressure data analysis due to faulty sensors leading to noisy data which prohibited statistical analysis. The remaining sample (n=5, mean ±SD age: 63 ±5 years; height: 1.63 ±0.04 m, 65.1 ±12.6 kg) were treated as a case-series. From **Table 1.** it can be seen that the mean time of peak pressure in the majority of regions of the foot was similar in the running shoe and tennis shoe for both the lateral side jump and 180° turn. There was however a shorter average time to peak pressure in the medial forefoot and lateral forefoot in the tennis shoe than the running shoe in the lateral side jump, with a high standard deviation. This difference was driven by participants 1 and 2.. Closer inspection of the mean pressure of each segment for participants 1 (**Figure 1)** and 2 revealed a lower magnitude and duration of loading of the heel in the running shoe than the tennis shoe. There were lower peak pressures across the foot in the running shoe than the tennis shoe for these participants. Additionally, there was greater loading of the forefoot in early stance than later stance in the tennis shoe, while in the running shoe there was loading of the forefoot across stance, with a greater peak in late stance than early stance for participant 1. In addition, despite no group difference in average peak inversion angle for the running shoe compared with the tennis shoe (mean ±SD: 19.5° ±4.9° v 19.6° ±3.7°), in participant 1 and 2 peak inversion angle was greater in the running shoe than the tennis shoe during the Jump (participant 1 mean ±SD: peak inversion 24.7° ±1.5° v 20.4° ±1.6; participant 2: 24.1° ±0.5 v 15.7° ±0.8°).

Table 1. Time of peak pressure (% of stance) in each foot region during the lateral side jump and 180° turn in the running shoe and tennis shoe (n=5)

	Lateral side jump												180° turn											
	Running shoe						Tennis shoe						Running shoe						Tennis shoe					
ID	**MH**	**LH**	**MMF**	**LMF**	**MFF**	**LFF**	**LH**	**MH**	**MMF**	**LMF**	**MFF**	**LFF**	**MH**	**LH**	**MMF**	**LMF**	**MFF**	**LFF**	**LH**	**MH**	**MMF**	**LMF**	**MFF**	**LFF**
1	30	29	10	9	55	72	25	12	12	12	6	5			17	20	56	35	12	18	23	22	22	18
2	28	15	26	22	78	66	22	22	22	21	9	9	5	5	29	39	26	30	34	52	27	32	46	49
3	14	14	14	14	83	82	15	15	18	18	81	82	11	11	11	11	82	83	11	10	10	10	53	62
4	6	6	5	6	85	69	3	3	3	3	89	89	13	13	13	13	37	29	10	10	10	10	77	39
5	16	21	13	25	7	23	17	14	14	14	6	47	17	17	12	17	5	51	14	14	13	13	6	38
Mean	**19**	**17**	**14**	**15**	**62**	**63**	**17**	**13**	**14**	**14**	**38**	**46**	**11**	**11**	**16**	**20**	**41**	**46**	**16**	**21**	**17**	**18**	**41**	**41**
SD	**10**	**9**	**8**	**8**	**33**	**23**	**9**	**7**	**7**	**7**	**43**	**39**	**5**	**5**	**7**	**11**	**29**	**23**	**10**	**18**	**8**	**9**	**28**	**16**

ID= participant number; MH= medial heel; LH= lateral heel; MMF= medial mid-foot; LMF= lateral mid-foot; MFF= medial forefoot; LFF= lateral forefoot; SD= standard deviation

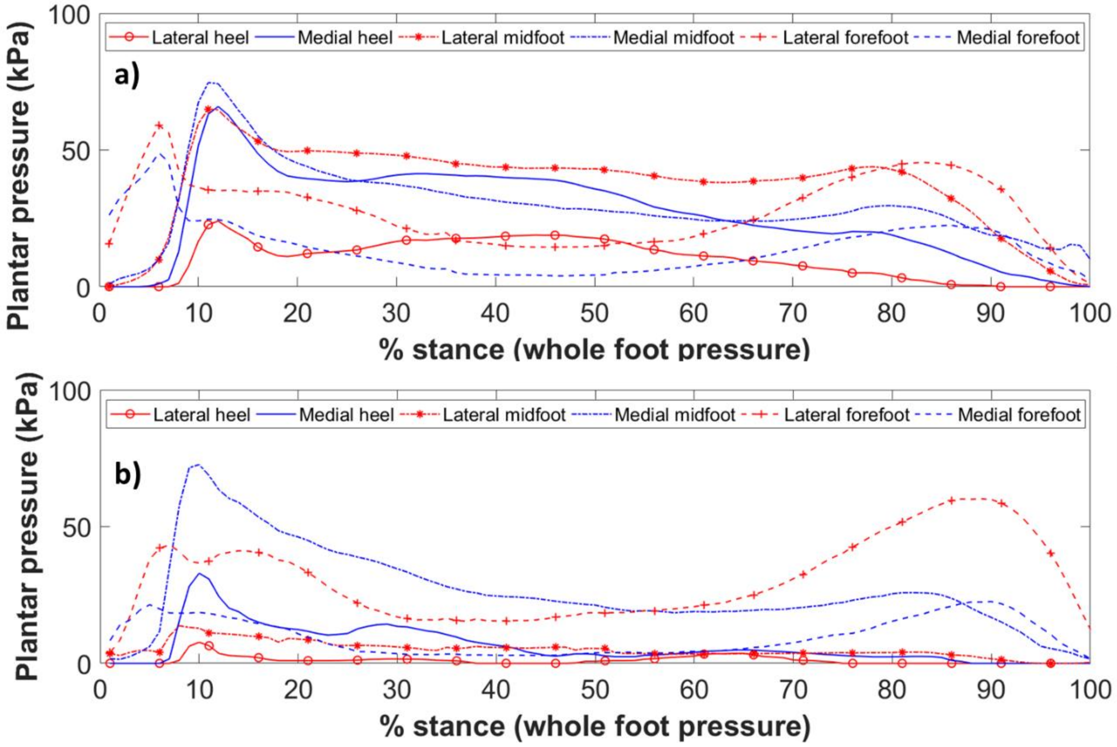

Figure 1: Mean pressure of each foot region across stance for participant 1 during the lateral side jump in a) the tennis shoe and b) the running shoe

DISCUSSION: This study explored the loading pattern and ankle joint kinematics of older female tennis players performing standardised lateral movements in a running shoe and tennis shoe. In 2 of 5 participants there was reduced rearfoot loading and increased forefoot loading in the running shoe compared to the tennis shoe during the lateral side jump. When accompanied by increased maximum inversion this loading pattern may place these individuals at a greater risk of ankle sprain in the running shoe than the tennis shoe. A case study of an ankle sprain sustained during a lateral movement in the laboratory revealed a rapid reduction in pressure at the heel and a shift in pressure to the forefoot region (Fong et al., 2009). In the running shoe participant 1 demonstrated greater lateral forefoot pressure in late stance compared to early stance and greater peak inversion angle than in the tennis shoe, suggesting a rolling over pattern of loading. A lateral shift in the centre of pressure would increase the external moment arm at the ankle joint, increasing the external ankle inversion moment (Fong et al., 2009), increasing the load on the anterior talofibular ligament and increasing the chance of an ankle sprain. Future work could examine the rearfoot and forefoot inversion angle separately along with plantar pressure from these foot segments to improve our understanding of relative loading during the lateral side jump in different footwear.

When interviewed some older adults who played racket sports recognised the need for lateral support in footwear to “prevent any turn in the ankles”, however, others reported wearing running shoes for tennis and that their playing level was not sufficient to require sport specific shoes (Reeves et al. in press). The preliminary results of this study revealed that some older adults may benefit from increased awareness of the influence of footwear on injury risk. This study was limited by a small sample size and missing data, nevertheless a subject specific approach has previously been taken to footwear research to account for varying responses (Nigg et al.,2003).

CONCLUSION: The differences in loading pattern and ankle angle during a lateral side jump in a running shoe compared to a tennis for two individuals were indicative of a potentially injurious movement pattern. Players are therefore advised to be cautious when selecting to wear running shoes for racket sports owing to the limited lateral support.

REFERENCES

Arkenford Ltd, & Act2. (2006). *Understanding participation in sport: What determines sports participation among recently retired people?* London.

Bouché, R. T. (2010). Racquet sports: Tennis, badminton, squash, racquetball, and handball. In *Athletic footwear and orthoses in sports medicine* (pp. 215-223): Springer.

Bus, S. A. (2003). Ground reaction forces and kinematics in distance running in older-aged men. *Medicine and Science in Sports and Exercise, 35*, 1167-1175.

Cozijnsen, R., Stevens, N. L., & Van Tilburg, T. G. (2013). The trend in sport participation among Dutch retirees, 1983-2007. *Ageing and Society, 33*, 698.

Damm, L. c., Low, D., Richardson, A., Clarke, J., Carre, M., & Dixon, S. (2013). The effects of surface traction characteristics on frictional demand and kinematics in tennis. *Sports Biomechanics, 12*, 389-402.

De Cock, A., De Clercq, D., Willems, T., & Witvrouw, E. (2005). Temporal characteristics of foot roll-over during barefoot jogging: reference data for young adults. *Gait and Posture, 21*, 432-439.

Fong, D. T.-P., Hong, Y., Shima, Y., Krosshaug, T., Yung, P. S.-H., & Chan, K.-M. (2009). Biomechanics of Supination Ankle Sprain:A Case Report of an Accidental Injury Event in the Laboratory. *The American journal of sports medicine, 37*, 822-827.

Lilley, K., Dixon, S., & Stiles, V. (2011). A biomechanical comparison of the running gait of mature and young females. *Gait & Posture, 33*, 496-500.

Nigg, B. M., Stefanyshyn, D., Cole, G., Stergiou, P., & Miller, J. (2003). The effect of material characteristics of shoe soles on muscle activation and energy aspects during running. *Journal of biomechanics, 36*, 569-575.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., et al. (1995). Physical-Activity and Public-Health - A Recommendation from the Centers-For-Disease-Control-And-Prevention and the American-College-Of-Sports-Medicine. *Jama-Journal of the American Medical Association, 273*, 402-407.

Paterson, S., McMaster, D. T., & Cronin, J. (2016). Assessing Change of Direction Ability in Badminton Athletes. *Strength and Conditioning Journal, 38*, 18-30.

Pucci, G., Rech, C. R., Fermino, R. C., & Reis, R. S. (2012). Association between physical activity and quality of life in adults. *Revista De Saude Publica, 46*, 166-179.

Reinschmidt, C., & Nigg, B. (2000). Current issues in the design of running and court shoes. *Sportverletzung· Sportschaden, 14*, 72-81.

Reeves, J., Williams, A. & Dixon, S. (in press). "I'm more comfortable with a wide fit shoe": The footwear needs and preferences of older adults in racket sports. *Journal of the American Podiatric Medical Association.*

Starbuck, C., Damm, L., Clarke, J., Carré, M., Capel-Davis, J., Miller, S., et al. (2016). The influence of tennis court surfaces on player perceptions and biomechanical response. *Journal of Sports Sciences, 34*, 1627-1636.

Stenner, B. J., Buckley, J. D., & Mosewich, A. D. (2020). Reasons why older adults play sport: A systematic review. *Journal of Sport and Health Science, 9*, 530-541.

ACKNOWLEDGEMENTS: This study was performed as part of an Industrial Strategy Challenge Fund Healthy Ageing Catalyst Award project funded by UK Research and Innovation. We would like to acknowledge Jia Rui Lawrence Kwek and Yasmin Palejwala for support with pilot work for this project.