GENDER DIFFERENCES AND LOWER LIMB ASYMMETRY IMPLICATIONS DURING DROP LANDINGS

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The aim of this study was to investigate asymmetry differences in landing techniques adopted by male and female athletes. Eight (4 male; 4 female) participants (age: 20.5 ±0.7 years, mass: 73.09 ±12.05 kg, height: 1.77 ±0.75 m performed drop landings from two heights (0.60 m & 0.90 m). Kinematic and kinetic data were collected during landing and used to calculated asymmetry for joint angles and kinetic variables. Significant ($p<0.05$) asymmetry was observed for all variables with larger kinetic asymmetry than observed in previous studies. Asymmetry of ankle flexion at touchdown reported for 7/8 participants may increase injury predisposition of one limb over the other. There was no clear gender difference for either the prominence or magnitude of asymmetry.

KEYWORDS: symmetry angle, screening, injury.

INTRODUCTION: Landing is an important movement associated with many fundamental skills across both individual and team sports. The occurrence of landings can be very high during sports such as basketball, netball and volleyball. The prevalence of lower limb injuries associated with landing impacts has been shown to be higher in females than in males (Agel et al., 2005; Boling et al., 2010; Iwamoto et al. 2008). Landing injuries have been attributed to lower limb joint angles at touch down (Aerts et al., 2013; Bisseling et al., 2008) and vertical ground reaction force (Aerts et al., 2013; Boling et al., 2010). Gender differences have been reported in lower limb kinematics during landing (Hughes et al., 2008), which have been suggested to influence the increased injury rates reported in female athletes. Asymmetry has been identified as increasing injury potential of one limb over the other (Jacobs et al., 2005). Recent research has developed methods of asymmetry quantification and applied these methods to the analysis of different sports (Exell et al., 2011; 2012a; 2012b). However, there is a lack of information currently available comparing lower limb asymmetry of males and females during landings. Greater understanding of gender differences in asymmetry during landing could inform athletes and coaches about potential causes of injury from landing. The aim of this study was to investigate asymmetry differences in lower limb landing techniques adopted by male and female athletes with the purpose of identifying whether asymmetry differences contribute to the increased injury potential of females.

METHODS: Data collection & processing: Ethical approval was gained from the University's Research Ethics Committee and all participants gave written informed consent prior to commencement of the study. Eight (4 male; 4 female) recreational level mixed-sport athletes participated in the study. Participants' mean age, mass and stature were 20.5 ± 0.7 years, 73.09 ± 12.05 kg and 1.77 ± 0.75 m, respectively. Three-dimensional positional (200 Hz) and ground reaction force (1000 Hz) data were collected using an automated motion analysis system (CODA, Charnwood Dynamics, Ltd) incorporating two piezoelectric force plates (Kistler 9287BA). Ten active cx1 markers were connected in pairs to 'twin-marker drive boxes' and attached to participants using adhesive tape. Markers were attached to the fifth metatarsal-phalangeal joint, lateral malleolus, lateral condyle of the tibia, greater trochanter and acromion on both side of the body. Participants performed five drop landings from two heights (0.60 m and 0.90 m), landing with one foot on each force plate. Following collection, all data were filtered using a Butterworth filter, which was customised through Winter's residual analysis (Winter, 2009). The deceleration phase of landing was selected for analysis and was defined as starting when the vertical ground

reaction force >30 N and finishing when maximum knee flexion was achieved. Filtered data were interpolated to 100% using a cubic spline.

Data Analysis: Data were analysed using a repeated single subject design. Bilateral sagittal plane joint angles were calculated for the ankle, knee and hip joints. Discrete kinetic variables of vertical impulse, peak vertical force and loading rate (peak force / time to reach peak force) were calculated for left and right limbs separately. Percentage asymmetry for discrete variables was calculated using the symmetry angle (Zifchock et al., 2008) with positive values indicating left value > right value and negative values indicating the reverse. Following tests for normality parametric statistics were used to test for significant ($p<0.05$) differences between left and right limbs. Independent t-tests were used to identify significant ($p<0.05$) differences between left and right limbs. Based on the statistical results, the difference between limbs was termed 'significant asymmetry' when there was a statistically significant difference between limbs with respect to intra-limb variability (Exell et al., 2012a; 2012c).

RESULTS & DISCUSSION: Table 1 includes joint angle asymmetry values at touchdown. The magnitudes reported for joint angle asymmetry at touchdown (0.44 – 2.39%) were similar to values reported during gymnastics landings (0.87 – 3.30%; Exell et al., 2012b). For both genders, a larger number of participants displayed significant asymmetry in the knee angle for the 0.60 m drop height compared to 0.90 m. Contrasting results were found for hip angle, with a larger number of participants displaying significant asymmetry at the larger drop height for both genders.

Table 1
Participant symmetry angle values (%) for joint angles at touchdown

Gender	Participant	Drop height 0.60 m			Drop height 0.90 m		
		Ankle	Knee	Hip	Ankle	Knee	Hip
Male	1	1.21	-0.34	0.31	1.10	-0.09	0.14
	2	-1.55	-0.46	1.69	-0.65	0.40	1.83
	3	2.14	0.23	0.44	2.39	0.38	0.98
	4	0.91	-0.97	-1.64	1.14	-0.70	-1.54
Female	5	-0.13	-0.18	-0.84	-0.37	0.05	-0.84
	6	2.17	0.32	0.86	1.84	0.23	1.28
	7	0.49	0.73	1.45	0.93	0.34	1.23
	8	-0.55	-1.52	-2.13	-0.62	-0.51	-1.66

Positive values = left > right, negative values = right > left
Shaded values indicate significant asymmetry

Table 2
Participant symmetry angle values (%) for key kinetic variables following landing

Gender	Participant	Drop height 0.60 m			Drop height 0.90 m		
		Peak Force	Loading Rate	Impulse	Peak Force	Loading Rate	Impulse
Male	1	27.92	39.01	7.58	20.17	20.21	10.99
	2	15.86	16.17	10.81	16.91	16.68	6.44
	3	12.40	10.58	2.70	24.46	24.61	8.35
	4	6.74	10.75	5.93	0.08	0.19	3.97
Female	5	24.56	25.03	17.04	21.94	22.38	11.99
	6	2.19	2.68	3.34	-6.29	-6.31	1.01
	7	-6.18	-13.82	-2.14	-3.08	-3.14	-8.34
	8	2.57	6.56	4.40	0.68	-6.64	6.71

Positive values = left > right, negative values = right > left
Shaded values indicate significant asymmetry

The consistency of small asymmetry magnitudes reported for joint angles at touchdown indicates that this may be a requirement of general landing to prevent collapse of the landing limb. All participants except Participant 5 displayed significant asymmetry for ankle flexion at touchdown. The association of ankle flexion at touchdown with injury prevalence (Aerts et al., 2013; Bisseling et al., 2008) and the large number of participants displaying asymmetry for this variable could indicate the increased likelihood of injury in one limb over another.

All participants showed asymmetry for discrete kinetic variables during landing (Table 2). The magnitude of asymmetry was large for peak vertical force, with the largest asymmetry value (27.92) being almost three times as large as that reported during the handspring in gymnastics (10.70, Exell et al., 2012b) and more than six times larger than the greatest value reported during sprint running (4.33, Exell et al., 2011). The influence of drop height on kinetic asymmetry appeared to change on an individual participant basis. For example, Participant 6 did not display significant asymmetry for any kinetic variables during the landings from 0.60 m, with two of the three variables displaying significant asymmetry when landing from 0.90 m; conversely, Participant 7 showed significant asymmetry for all three variables when landing from the 0.60 m height and only one whilst landing from the greater height.

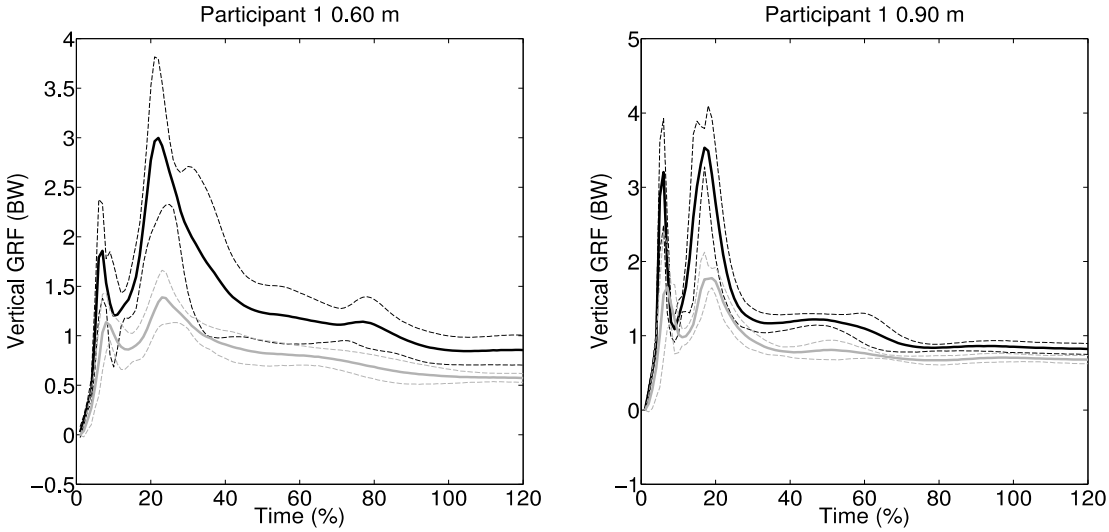

Figure 1: Mean [±SD] vertical ground reaction force profiles for Participant 1 (male) at both drop heights. Black = left, grey = right.

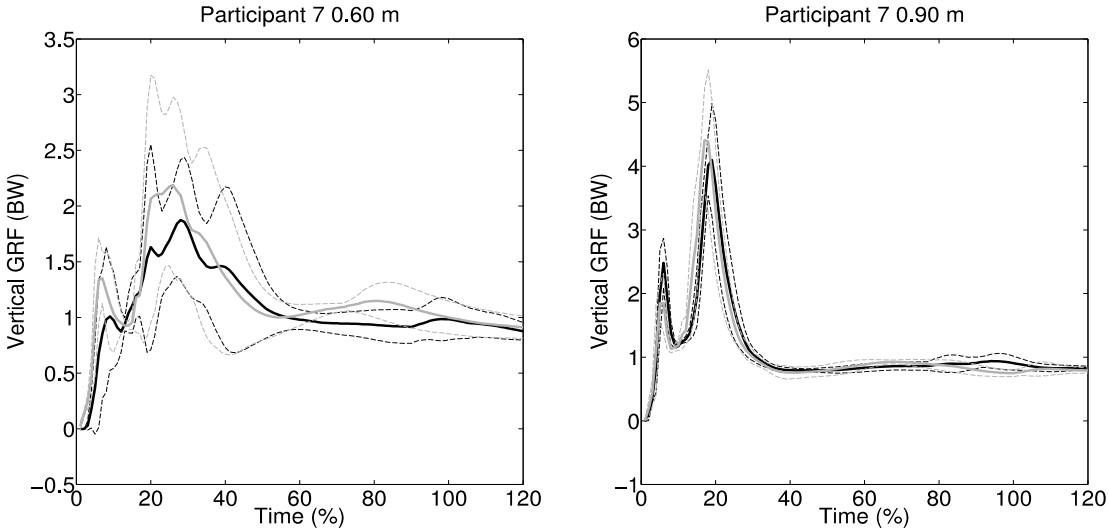

Figure 2: Mean [±SD] vertical ground reaction force profiles for Participant 7 (female) at both drop heights. Black = left, grey = right.

Figures 1 and 2 show example vertical ground reaction force profiles for Participants 1 (male) and 7 (female), respectively. Both participants displayed less variability when landing from 0.90 m than 0.60 m, as can be seen by the smaller standard deviations in Figures 1 and 2 for the 0.90 m landings. The similar difference between mean left and right profiles in Figure 1 indicates the similar asymmetry in landing kinetics across heights for Participant 1. The contrasting results for Participant 7 are indicated in Figure 2 by the greater similarity of left and right force profiles during landing from 0.90 m than 0.60 m.

CONCLUSIONS: This study aimed to investigate asymmetry differences in lower limb landing techniques for male and female athletes with the purpose of identifying whether asymmetry differences contribute to the increased injury potential of females. Results show that both genders displayed asymmetry for key kinetic and kinematic variables during landing but that asymmetry varied on an individual basis, with no overall trend between genders. A high occurrence of ankle joint asymmetry at touchdown could expose athletes to increased injury in one limb over the other.

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