

## **ASYMMETRY ANALYSIS OF THE ARM SEGMENTS DURING FORWARD HANDSPRING ON FLOOR**

**Timothy Exell<sup>1</sup>, Gareth Irwin<sup>2</sup>, Stacey Godden<sup>2</sup> and David Kerwin<sup>2</sup>**

**School of Electronics and Computer Science, University of Southampton, UK<sup>1</sup>  
Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK<sup>2</sup>**

The aim of this study was to examine kinematic and kinetic asymmetries of the arm segments during the contact phase of the forward handspring on floor. Four female National level gymnasts (19 y, 58.64 kg, 1.62 m) performed 15 forward handsprings whilst synchronised 3D kinematic and kinetic data were collected. Percentage differences in symmetry angles between the left and right arms were quantified. Significant kinetic asymmetry was observed for all gymnasts ( $p < 0.05$ ) with the direction of the asymmetry being related to the lead leg. Kinematic asymmetry was present at the shoulder, but not at the distal segments. These findings provide useful information for coaching gymnastics skills, which may subjectively appear to be symmetrical.

**KEYWORDS:** gymnastics, coaching, injury.

**INTRODUCTION:** In the sport of artistic gymnastics the forward handspring on floor is a fundamental skill which represents a foundation for developing gymnasts and an acceleration skill for more established performers who wish to generate the correct take off conditions to performed more complex movements (e.g. multiple somersaults). The assessment of this skill is based on criteria outlined by the International governing body (FIG, 2010), based on these recommendations one would expect the movement patterns undertaken by the gymnast to have little or no asymmetry. The coaching recommendations concur with the belief that the handspring is a symmetrical movement and consequently this forms the guidance for the development of this skill via preparatory activities. A conceptual understanding or “mind set” of the handspring is key to its development, which was highlighted by Irwin, Hanton & Kerwin (2004, 2005); these authors showed that gymnastics coaches replicate the spatio-temporal characteristics of the target skill in the preparatory activities, which was validated in the subsequent biomechanics of skill development research (Irwin & Kerwin, 2007). A greater understanding of the level of asymmetry of a skill will allow a more accurate mind-set to be achieved and consequently impact on how these skills are developed. In addition, implications for loading and injury may be revealed from kinetic asymmetry. Recent research has shown that biomechanical asymmetry can provide useful information regarding performance, injury and methods of data collection (Exell, Kerwin, Irwin & Gittoes, 2011; Exell, Gittoes, Irwin & Kerwin 2012; Exell, Irwin, Gittoes & Kerwin, 2012). The aim of this study was to examine the kinematic and kinetic asymmetry of the arm segments during the contact phase of the forward handspring on floor. The hypothesis of this research was that there would be athlete-centric asymmetry profiles influenced by the technique employed.

### **METHODS:**

**Data collection & processing:** Ethical approval was gained from the University’s Research Ethics Committee prior to commencement of the study. Four female National level gymnasts performed 15 forward handsprings on a mondo surface. Gymnasts mean age, mass and stature were 19 [ $\pm 1.5$ ] years, 58.64 [ $\pm 3.72$ ] kg and 1.62 [ $\pm 0.41$ ] m, respectively. Three-dimensional positional data were collected from a 2.00 m section encompassing the ground contact phase of the handspring using an automated motion analysis system (CODA, Charnwood Dynamics, Ltd) operating at 200 Hz. Twelve active cx1 markers were connected in pairs to ‘twin-marker drive boxes’ and attached to gymnasts using adhesive tape. Markers were attached to the proximal inter-phalangeal joint, and joint centres of the wrists, elbows, shoulders and hips. Kinetic data were collected via two piezoelectric force plates (Kistler 9287BA), mounted end-to-end, perpendicular to the direction of the performed handspring. Force plates were mounted in recessed customised housings and covered with a mondo

surface. Kinematic data was filtered using a Butterworth filter, which was customised through Winter's residuals analysis (Winter, 2009).

**Data Analysis:** All analysis focused on the ground contact phase of the hands during the handspring. Kinetic variables included peak vertical and antero-posterior ground reaction forces and temporal characteristics of these forces. Kinematic variables included sagittal plane wrist, elbow and shoulder angles. Data were analysed using a repeated single subject design. Following tests for normality (Peat and Barton, 2005) parametric statistics were used to test for significant ( $p < 0.05$ ) differences between left and right limbs. Percentage differences between left and right values were calculated using the symmetry angle method (Zifchock, Davis, Higginson & Royer, 2008) with positive values indicating that the left value is greater than the right value and negative values indicate the reverse. Statistical results were used to indicate whether or not the asymmetry reported for each variable was significant, compared with intra-limb variability (Exell et al, 2012a).

**RESULTS & DISCUSSION:** Individual gymnast kinetic asymmetry values are presented in Table 1. All gymnasts demonstrated significant kinetic asymmetry and three gymnasts also showed significant asymmetry for timing of maximum force. The direction of asymmetry for maximum Fz values that were significantly related to the gymnasts' lead leg, with larger values observed for the side of the lead leg. The magnitude of asymmetry for significant maximum Fz values was larger for all gymnasts compared to values reported during sprint running (Exell et al., 2011). With gymnasts' performing high volumes of these skills within a session and across a season the implications for micro traumas become apparent, the load will affect the nature and severity of injury (Irwin, 2011) particularly at vulnerable joints such as the wrist. Knowledge of these asymmetries can facilitate the development of a sound understanding of the mechanisms of this gymnastic skill which in turn can inform strength and condition regimes (Arkaev & Suchilin, 2009).

**Table 1**  
Individual gymnast symmetry angle values (%) for magnitude and timing of maximum vertical (Fz) and antero-posterior (Fy) ground reaction forces

Gymnast	Time of maximum Fz	Maximum Fz	Time of maximum Fy	Maximum Fy
1 (R)	-0.35	1.05	5.98 *	-4.43 *
2 (L)	-1.29	7.90 *	-0.64	3.43
3 (R)	7.79 *	-6.61 *	-7.83 *	-3.53
4 (L)	12.34 *	10.70 *	25.11 *	-2.18

(R) = right leg lead, (L) = left leg lead

Positive values = left > right, negative values = right > left, \* = significant asymmetry

Table 2 contains kinematic asymmetry values at instants of touchdown and take off. The number of kinematic variables displaying significant asymmetry ranged from 3/6 (Gymnast 2) to 6/6 (Gymnast 4). The same numbers of significantly asymmetrical kinematic variables were reported for touchdown and take off (wrist = 2, elbow = 3, shoulder = 4). Kinematic asymmetry did not appear to be related to the lead leg side for wrist and elbow results. For the shoulder, all four gymnasts demonstrated significant asymmetry at touchdown and take off, with touchdown values being larger for the opposite side to the lead leg and take off values being larger for the lead leg side. The greater asymmetry at the shoulders may represent a compensatory mechanics to allow the increased symmetry at the more distal segments.

	TD	TO	TD	TO	TD	TO
1 (R)	-2.32 *	0.34	-0.64	-1.15 *	2.11 *	-1.56 *
2 (L)	-0.28	-0.43	-0.87 *	0.10	-3.30 *	2.32 *
3 (R)	-0.22	-1.10 *	-0.86 *	-1.98 *	2.65 *	-5.64 *
4 (L)	-0.90 *	-1.62 *	0.97 *	1.83 *	-1.96 *	2.27 *

(R) = right leg lead, (L) = left leg lead

Positive values = left > right, negative values = right > left, \* = significant asymmetry

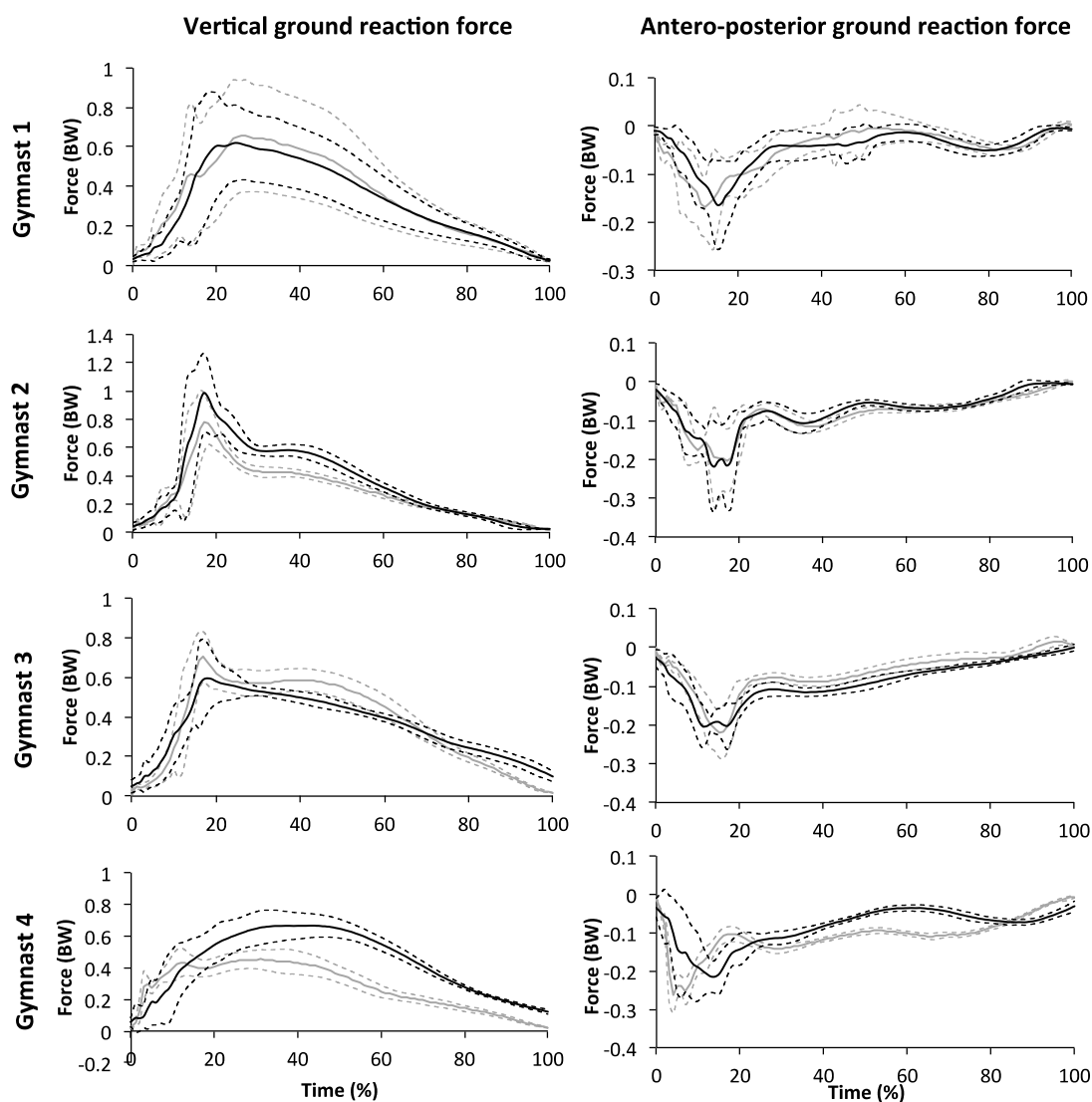
**Table 2**

**Individual gymnast symmetry angle values (%) for wrist, elbow and shoulder joint angles at instants of touchdown (TD) and take off (TO)**

**Figure 1: Mean [±SD] vertical and antero-posterior ground reaction force profiles for all gymnasts. Black = left, grey = right.**

Figure 1 includes mean [±SD] vertical and antero-posterior ground reaction force profiles for all gymnasts. The profiles highlight the individual nature of kinetic asymmetry, in particular for Fz. Gymnast 4's Fz profile was the most asymmetrical, this finding was reflected by the discrete results, where both timing and magnitude were significantly asymmetrical and asymmetry values were larger than for the other gymnasts.

**CONCLUSIONS:** This study aimed to increase understanding of the kinematic and kinetic



asymmetry of the arm segments during the contact phase of the forward handspring on floor. The main findings include significant kinetic asymmetries during the hand contact from touch down to take off and a possible compensatory mechanisms with decreased asymmetry from proximal to distal segments. These findings provide useful information regarding the understanding of gymnastics skills, which may subjectively appear to be symmetrical. The implications could help coaches, biomechanists and clinicians.

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