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## ***The Relationship of Gymnastics Experience and Hand Placement Technique on Peak Ground Reaction Forces Through the Elbow***

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### **CONTEXT**

Gymnastics has a lifetime cumulative injury rate of 58%, with 13-53% of injuries occurring at the upper limb.<sup>1-3</sup> Back handsprings (BHS) are a common skill used in gymnastics.<sup>3</sup> BHS and similar upper limb loading skills may occur over 100 times per practice.<sup>4</sup> Current literature states, a turned-in hand position reduces peak ground reaction force at impact on floor, thus reducing the risk of injury.<sup>5,6</sup> To our knowledge no studies analyzing the role of gymnastics experience and hand placement during a BHS on the balance beam (BB) exist.

### **OBJECTIVE**

The purpose of this study was to identify how gymnastics experience and hand placement during a BHS on BB affects peak ground reaction forces.

### **DESIGN**

Cross-sectional.

### **SETTING**

Two gymnastics facilities.

### **PARTICIPANTS**

18 competitive female gymnasts with height (cm): 153.7 ±8.3; mass (kg): 43.1 ±7.8; age (years): 12.7 ±1.5. Inclusion criteria included ability to compete a BHS on BB and no practice limitations due to injury.

### **INTERVENTIONS**

Subjects completed a demographic survey, anthropometric measurements, and 3 BHS on a BB. Hand placement technique, skill height (vertical), skill length (horizontal), angle of impact, and peak ground reaction force at impact were analyzed using high-speed cameras and portable force plates. Video analysis was completed using Dartfish Champions Software (Dartfish, Alpharetta, GA).

### **MAIN OUTCOME MEASURES**

Gymnastics experience was quantified by years participating in gymnastics. Hand placements were grouped into categories in relation to parallel axis of the BB; neutral (both hands parallel), turned-out (one hand > 120°), turned-in (one hand < 60°), and "other". Analysis of variance (ANOVA) and pair-wise comparisons were used to identify if experience and hand placement contribute to increased force at initial hand contact.

### **RESULTS**

Mean gymnastics experience was 7.5 ±3.5 years. No significant difference (p=0.58) was found in years of experience and peak reaction force during a BHS on BB. Significance was found between hand placement and peak reaction force ( $F_{(3,27)} = 15.62$ ;  $P < .001$ ). Turned-in hand placement had significantly higher peak reaction force compared to all other groups ( $P < .05$ ). BHS height (m) and length (m) was scaled from standing height (m). Mean skill height: 0.61

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$\pm 0.06$  m and skill length:  $0.58 \pm 0.1$  m. Angle of impact:  $93^\circ \pm 5.8^\circ$ . Mean peak vertical reaction force (N) was normalized to mass (kg):  $2.5 \pm 0.5$  N/kg. Correlation coefficients found poor correlations between skill height, length, and angle of impact in relation to peak reaction force.

### **CONCLUSIONS**

Results of this study suggest gymnastics experience has minimal effect on hand placement technique and peak ground reaction force upon initial impact during a BHS. Hands in a turned-in position upon landing significantly increased forces through the upper extremity, which is contrary to technique recommendations for floor exercise. Based on these data, proper hand placement technique may require additional emphasis to try to reduce forces transmitted through the upper extremity upon impact potentially reducing the risk of injury.

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**KEY WORDS:** *back handspring, force, gymnastics, upper extremity*