

ATTENUATION OF GROUND REACTION FORCES IN DISMOUNTS FROM THE BALANCE BEAM

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Epidemiological studies have documented the incidence of injuries in female gymnasts. In comparison to other sports, the incidence of injury in gymnastics is high. One epidemiological study prompted the author to state that "... women's gymnastics should be recognized as a hazardous sport" (Snook, p. 242). To understand the etiology of injury, researchers (e.g., Caine, Cochrane, Caine & Zemper, 1989; Clark & Buckley, 1980; Garricke & Requa, 1980; Garrick & Requa, 1978; Lindner & Caine, 1990; Lowry & Leveau, 1982; Martin, Yesalis, Foster & Albright, 1987; Pettrone & Ricciadelli, 1987; Sands, 1985; Sands, Newman, Harner, Paulos & Shultz, 1987; Snook, 1979; Splain & Rolnick, 1984; Vergouwen, 1986; Weiker, 1985; Zaricznyj, Shattuck, Mast, Robertson & Delia, 1980) have identified injuries by sites, types, and/or events (floor, uneven bars, vault, and balance beam). Dismounts, considered an element of all events, have drawn attention as an injury mechanism. Studies have shown the dismount, especially when gymnasts attempt to "stick" their landing to be a major component of the incidence of injury. The purpose of this study was to determine and compare ground reaction forces in sticking and rolling out of roundoff and barani dismounts from the balance beam. It was the belief of the authors that by using a backward roll, out of the landing, ground reaction forces could be attenuated.

Methods and Procedures

The recruitment of subjects for this study was in accord with policies of the University Committee on Research Involving Human Subjects at Michigan State University. Potential subjects were identified through coaches at youth gymnastics clubs. After completing informed consent forms, subjects were invited to campus to receive a medical screening administered by a sports medicine physician. Those passing the medical screening were permitted to participate in the dismount phase of this study (Table 1). This resulted in 23 participants with various gymnastics rankings (2-level 5, 8-level 6, 4-level 7, 1-level 8, 5-level 9, and 3-level 10).

After warming up, subjects practiced dismounting onto a specially designed gymnastics mat that was adhered via double-sided carpet tape to an AMTI force platform. This mat was surrounded by and isolated from other matting of the same material. Subsequently, subjects were asked to perform two types of dismounts (roundoff and barani) from the balance beam and to complete each type with two different styles of landing (stick and roll out). All subjects had ground reaction forces for the roundoff for both styles of landing and 14 subjects had ground reaction forces for the barani for both styles of landing. Data analysis consisted of t-test comparisons of ground reaction forces (medial-lateral, anterior-posterior, and vertical) for the two styles of landing for the roundoff and barani dismount from the balance beam.

Table 1 **Subjects**

	Age (mo)	Height (cm)	Weight (kg)
Mean	158.8	152.4	42.7
SD	23.7	8.5	9.9
Range	118-201	135.0-165.1	24.2-60.1

Results and Discussion

Table 2 contains a summary of the ground reaction forces in units of the subjects' body weights. Our results indicate that, by rolling out of the landing, ground reaction forces are significantly reduced in the vertical direction for both types of dismounts and in the anterior-posterior direction for the roundoff dismount.

Table 2 **Summary of Ground Reaction Forces in Units of Subjects' Body Weight**

Dismount	Landing	Medial-Lateral		Anterior-Posterior*		Vertical	
		Stick	Roll	Stick	Roll	Stick	Roll
Roundoff (N= 23)	Mean Max	0.50	0.46	2.41 ^a	1.60 ^a	8.31 ^a	5.90 ^a
	Min	0.17	0.19	0.59	0.8	6.66	5.29
	Max	1.00	0.87	4.18	2.42	10.7	7.21
	SD	0.21	0.21	0.77	0.42	1.14	0.60
Barani (N= 14)	Mean Max	0.80	0.57	2.63	1.98	9.18 ^a	7.33 ^a
	Min	0.36	0.18	1.40	1.19	7.41	4.89
	Max	1.47	1.07	4.01	2.60	12.0	8.49
	SD	0.42	0.24	0.99	0.46	2.79	1.04

* Absolute values used.

^aSignificant difference between stick and roll for specified forces at $p < 0.05$.

Suggestions for Further Study

In order to obtain a more complete understanding of the kinetics and kinematics of the dismount and landing from the balance beam the following suggestions for further study are proposed:

1. determine and compare ground reaction forces in sticking and rolling out of other dismounts requiring a backward roll and various dismounts requiring a forward roll,
2. determine and compare moments generated in sticking and rolling out of various dismounts,
3. determine and compare joint reaction forces and moments associated with sticking and rolling out of various dismounts,
4. determine and compare the kinematics of the same type of dismount for both styles of landing, and
5. determine and compare the ratings by expert judges of the same type of dismount for both styles of landing.

Applications

Based on the results of this study, two suggestions for safety are warranted.

1. Minimize the exposure of gymnasts to relatively high ground reaction forces from roundoff and barani dismounts by teaching and permitting gymnasts to roll out of their landings in practice.
2. Consider permitting gymnasts to roll out of various forward and backward landings from dismounts from the balance beam.

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Acknowledgement

Support for this project was provided by American Athletic Inc. of Jefferson, Iowa. The authors wish to thank Mr. Larry Fie for the design and fabrication of the mat used to isolate the force platform from the surrounding matting.