KINEMATICS OF GIANT SWINGS ON THE PARALLEL BARS

S. Prassas[1] and G. Ariel[2]
[1]California State University East Bay, Hayward, CA USA
[2]Coto Research Center, Coto De Caza CA USA

The purpose of this study was to investigate the kinematics of giant swings on the parallel bars. A secondary purpose was to compare giants executed from a cast to the giants following, and to compare skilled vs. unskilled performances. A total of eight giants were studied. Results showed that, with few exceptions, giant swings performed on the parallel bars exhibit similar motion patterns to giants performed on other apparatuses. Between-apparatus differences in motion patterns of the knee (quantified), elbow and radioulnar (not quantified due to substantial out-of-plane components) joints were attributed to limitations mostly imposed by apparatus design. Skilled vs. unskilled differences—most pronounced at the shoulder joint—were related to both timing and ROM issues.

KEY WORDS: giant swings, parallel bars, gymnastics

INTRODUCTION: Giant swings have been routinely performed by gymnasts on the high bar, rings, and uneven bars and have been the subject of several investigations (Arampatzis & Brüggemann, 1998; Prassas et al., 1998; Yeadon & Brewin, 2003). However, there is only one scientific inquiry on the recently introduced giant swings on the parallel bars (Prassas et al., 2004). Although there are similarities between the mechanics of giant swings already studied and one might expect similar mechanics for parallel bar giants (depicted in Figure 1), the scarcity of data on the latter precludes definite conclusions. The purpose of this study was to investigate the kinematics of giant swings on the parallel bars. A secondary purpose was to compare giants executed from a cast and following a previous giant and to compare skilled vs. unskilled performances.

METHODS: Each of four collegiate gymnasts performed 2 consecutive giant swings beginning from a high cast. The performances were videotaped with a 60 Hz video camera and analyzed independently utilizing the Ariel Performance Analysis System (APAS). The left foot; the knee, shoulder, and elbow joints; the hand, the top of the head, and a point on the bar were digitized. The raw data was digitally smoothed with a cut-off frequency of 7 Hz before being submitted to further analysis. Dempster's (1955) data as presented by Plagenhoef (1971) was utilized to predict the segmental and total body anthropometric parameters necessary to solve the mechanical equations. Data from the APAS was downloaded to EXCEL for further processing and presentation of results.

RESULTS AND DISCUSSION: Mean kinematic results for all 8 giants are shown in Table 1. Since the height of the cast varied between gymnasts, results are presented commencing with each gymnast's center of mass positioned 45 degrees above the bars. Bar levels I/II represent the instant when the gymnast's center of mass (CM) was level with the bars in the downswings/upswings, respectively. Bottom represents the point below the bars where the CM vertical velocity changed from negative to positive. Vertical represents the point above the bar where the CM is vertically aligned with the gymnast's hands. Data in Table 1 show that gymnasts perform giants on the parallel bars in a similar fashion as in apparatuses such as the high bar and uneven bars with a noticeable exception regarding knee joint motion.
This exception, however, is due to apparatus' restrictions, i.e. gymnasts must flex their knee joints as they pass through the bottom to accommodate for the physical dimensions (height) of the parallel bars. Another difference exists in the motion at the elbow and radioulnar joints. The motion at these joints, however have a substantial out of plane component, which could not be quantified in the present study.
Although the main purpose of the study was neither to compare giants performed from a cast and as a follow up to a previous giant, nor to compare skilled vs. unskilled performances,

some comparative preliminary results are presented. Table 2 shows generally no substantial or unexpected differences between cast and follow up giants. In addition, comparisons of center of mass velocity, hip, shoulder, and knee joint motions of the most and least skilled giants (Figures 2, 3, 4, and 5, respectively), show similar motion patterns with some differences in CM velocity (less erratic in the skilled giant) and shoulder joint motion—greater range of motion for the unskilled subject.

Table 1 Kinematic results (8 giants).

Variable	45 Deg.	Bar Level I	Bottom	Bar Level II	Vertical
CM v_x (m/sec)	1.7	0.3	-6.1	0.6	0.7
CM v_y (m/sec)	-0.96	-3.5	0.17	3.5	-0.05
CM vel. (m/sec)	1.97	3.56	6.12	3.6	0.7
KJ angle (deg.)	182	176	97	101	181
HJ angle (deg.)	167	185	185	170	190
SJ angle (deg.)	160	177	165	128	142
HJ ang. vel. (° /sec)	18.2	104.4	-150.6	509.5	-38.3
SJ ang. vel. (° /sec)	48.2	27.6	-198	-107	14.4
Time (% of total)	0	17.5	18	17.5	47

Notes: 1) negative hip joint angular velocity denotes flexion;
2) negative shoulder joint angular velocity denotes extension.

Although the main purpose of the study was neither to compare giants performed from a cast and as a follow up to a previous giant, nor to compare skilled vs. unskilled performances, some comparative preliminary results are presented. Table 2 shows generally no substantial or unexpected differences between cast and follow up giants. In addition, comparisons of center of mass velocity, hip, shoulder, and knee joint motions of the most and least skilled giants (Figures 2, 3, 4, and 5, respectively), show similar motion patterns with some differences in CM velocity (less erratic in the skilled giant) and shoulder joint motion—greater range of motion for the unskilled subject.

Table 2 Comparative kinematic results.

Variable	45 Deg.		Bar Level I		Bottom		Bar Level II		Vertical	
	Cast	Giant	Cast	Giant	Cast	Giant	Cast	Giant	Cast	Giant
CM v_x (m/sec)	1.67	1.74	0.2	0.5	-6.2	-6.1	0.56	0.58	0.79	0.59
CM v_y (m/sec)	-.09	-1.0	-3.4	-3.6	0.15	0.18	3.56	3.4	0.08	-0.2
CM vel. (m/sec)	1.9	2.0	3.5	3.64	6.2	6.11	3.6	3.47	0.81	0.67
KJ angle (deg.)	182	182	177	174	97	96	99	102	183	178
HJ angle (deg.)	164	170	185	185	186	183	169	172	188	193
SJ angle (deg.)	161	159	179	175	163	168	127	129	149	135
HJ ang. vel. (° /sec)	26	10	123	85	-186	-115	487	532	-62	-14
SJ ang. vel. (° /sec)	13.7	83	-5.1	60	-148	-248	-45	-170	29	-0.5
Time (% of total)	0	0	19	16	19	18	18	17	44	49

Notes: 1) negative hip joint angular velocity denotes flexion;
2) negative shoulder joint angular velocity denotes extension.

It should be noted again that additional differences were qualitatively observed in elbow joint motion, which as explained, were not possible to quantify. As was reported previously, it is possible that success or failure in the performance of giant swings on the parallel bars may be related more to issues of timing of the actions of the gymnast than to any other issue (Prassas, et al., 2004). The timing argument is apparent in Figures 6 and 7 where the hip and shoulder joint angle for each skilled/unskilled performance is depicted.

CONCLUSION: With few exceptions, results of giant swings performed on the parallel bars revealed similar motion patterns to motion patterns of giant swings performed on other

apparatuses. Marked differences seen in motion patterns of the knee (quantified), elbow and radioulnar joints (the last two were not quantified due to substantial out-of-plane components) were attributed to limitations imposed by apparatus design. Quantitative and qualitative comparisons between the most and least skilled giants suggest both timing and selective joint range of motion differences between them.

REFERENCES:

Arampatzis, A. & Brüggemann, G. P. (1998). A mathematical high bar-human body model for analyzing and interpreting mechanical-energetic processes on the high bar. *Journal of Biomechanics*, 31, 1083-1092.

Dempster, W.T. (1955). Wright-Patterson Air Force Base. *Space requirements of the seated operator* , pp. 55-159. WADC Technical Report, Dayton, Ohio.

Plagenhoef, S. (1971). *Patterns of human motion: A cinematographic analysis*. Prentice-Hall, Englewood Cliffs, New Jersey.

Prassas, S., Ostarello, J. & Inouye, C. (2004). Giant swings on the parallel bars: a case study. In, M. Lamontage. D. Gordon & H. Sveinstrup (Eds). *Proceedings the XXII International Society of Biomechanics in Sports* (p 345), University of Ottawa, Canada.

Prassas, S., Papadopoulos, C. & Krug, J. (1998). Kinematic comparison of overgrip and undergrip dismount giant swings on the uneven parallel bars. In, Hartmut J. Riehle & Manfred Vieten, M. (Eds.). *Proceedings of XVI International Symposium on Biomechanics in Sports*, (pp. 219-222), UVK - Universitatsverlag Konstanz, Germany.

Yeadon, M. & Brewin, M. (2003). Optimal performance of the backward longswing on rings. *Journal of Biomechanics*, 36,542-552.