COMPARATIVE STUDY OF GIANT SWINGS BACKWARD ON THE PARALLEL BARS

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Research article

Abstract

Comparative data between skilled and unskilled performances in order to examine mechanical determinants affecting the level of technical execution can arguably be beneficial to coaches and sport specialists. Therefore, the purpose of this study was to provide descriptive and comparative kinematic data on giant swings backward on the parallel bars judged by internationally qualified judges as been more or less skillful. Video data was collected utilizing a 60 Hz video camera. Fourteen giant swings were studied. Results showed no significant differences between motion patterns of parallel bars giant swings backwards receiving—on a scale from 0 to 1.0—more than 0.2 (unskilled) and less than 0.2 (skilled) deductions by internationally qualified judges. However, overall data trends and comparison of the two giants receiving the most and least deductions showed that different joint motion patterns might exist.

Keywords*: giant swings, parallel bars, kinematics.*

INTRODUCTION

A contemporary parallel bar exercise consists predominantly of swing and flight elements selected from all available Element Groups in the Men's Code of Points (M.A.G, Code of Points, 2013-16) and performed with continuous transitions through various hang and support positions. Many swinging elements lead to or begin from a handstand position on/from one or two bars/rails. Giant swing backward to handstand (depicted in Figure 1) in the parallel bars is only a difficulty value C element, however it is considered a "profile" element in the process of technical preparation. "Profile" elements are considered the ones that, if correctly executed, form the technical basis for learning more difficult and complex elements from the same Element Group (Smolefski & Gaverdofski, 1999). Indeed, though the first performance of a giant swing backward from Eizo Kenmotsu in 1979 was highly appraised, this element at present is executed even by novice athletes—albeit not with the same technique as by skilled performers—and is a skill that positions one for more technically difficult elements (Fujiwara & Mizuguchi, 2001).

Biomechanical research in artistic gymnastics has grown substantially over the years; however, as reported by Prassas, Kwon & Sands (2006), the lion's share of the research focused on vaults (Lee 1998; Sands, 2000; Sands & Mc Neal, 2002; Springings and Yeadon, 1997; Takei, 1989; 1990; 1991a; 1991b; 1992; 1998), take off and landings on floor exercises (Burgess & Noffal, 2002; Geiblinger, Morrison &

McLaughlin, 1995a; 1995b; Hwang, Seo & Liu, 1990; Mc Nitt-Gray Yokoi, and Millward,1993;1994; McNitt-Gray, Hester, Mathiyakom, & Munkasy, 2001) and dismounts, flight elements and the mechanics of giant swings on high bar and uneven bars (Arampatzis & Brüggeman, 1998, 1999; 2001; Brüggeman, Cheetam, Alp & Arampatzis, 1994; Hiley & Yeadon, 2003; Kerwin, Yeadon & Harwood, 1993; Prassas, Papadopoulos & Krug, 1998; Prassas & Terauds, 1986; Yeadon, 1997). Research on the parallel bars is generally limited (Boone, 1977; Gervais & Dunn, 2003; Liu & Liu, 1989; Prassas, 1988; 1991; 1994; Prassas, Kelley & Pike, 1987; Prassas & Papadopoulos, 2001; Takei, Dunn, Nohara & Kamimura, 1995). Interestingly and although giants performed on the parallel bars are considered as "basic" skills for further technical evolution, there is scarcity of scientific data on the skill including a case study by Prassas, Ostarello and Inouye (2004) and a skilled-unskilled comparative abstract by Prassas (2011). In addition, kinetic and kinematic data comparing giants on the parallel bars and high bar has also been presented (Tsuchiya, Murata & Fukunaga, 2004).

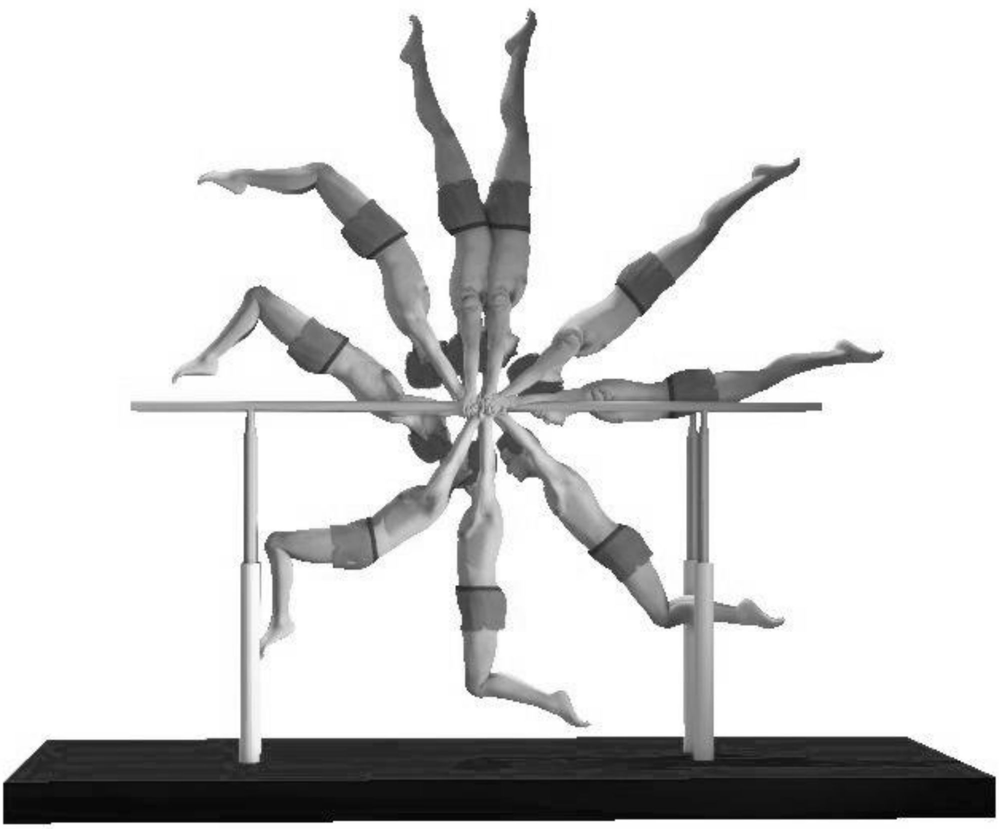

Figure 1. *Representative giant swing backwards on the parallel bars at selective positions. Motion is in the clockwise direction.*

Comparative data between skilled and unskilled performances, in order to examine mechanical determinants affecting the level of technical execution, can be beneficial to coaches and sport specialists. According to Gervais & Dunn (2003), much can be discovered about performance from studying different levels of execution of an element. Therefore, the purpose of this study was to provide descriptive and comparative kinematic data on giant swings backward on the parallel bars judged by internationally qualified judges as been more or less skillful.

METHODS

Six gymnasts (Age: 19.7±1.63yrs; Mass: 60.7±6.34Kg; Height: 1.6±0.02m) participated in the study. Four were collegiate level gymnasts (USA, Division I University) and two were members of the Greek national gymnastics team. The subjects signed a consent form prior to data collection. All gymnasts performed a series of giants and their performance was captured utilized a 60 Hz video camera. The videotaped performances were viewed by two internationally qualified gymnastics judges and scored (deductions according to FIG Code of points, with 1.00 being a perfect score). Skilled giants were deemed the ones with less than 0.2 points deductions. Fourteen (2 of each of the collegiate gymnasts and 3 of each member of the Greek national team) giants were chosen for analysis utilizing the Ariel Performance Analysis System (APAS). Six body points (the left ankle, knee, hip, shoulder and elbow joints and the left hand), resulting in a 5-segment model, were digitized. In order to measure the hand displacement during the release/re-grasp phase, an additional point on the bar, where the gymnast held it initially, was also digitized. All digitizing was done by a single and experienced individual. 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. Body angular velocity (**ω**) was defined as the angular velocity of the line connecting the CM with the bars. It was calculated utilizing the equation $v_{cm} = \omega r$, where v_{cm} was the linear velocity of the CM and r was the length of the aforementioned line. The raw data was digitally smoothed with a cut-off frequency of 7 Hz before being submitted to further analysis. Mann-Whitney rank sum tests (SigmaStat 3.5) were conducted to compare performance variables for giants receiving more (Unskilled) and less (Skilled) deductions.

RESULTS

Since the time during the first and the last few degrees of rotation varied considerably among the giants, results are presented commencing with the gymnast's center of mass (CM) 10 degrees past the vertical position in the downswing and ending with the gymnast's CM 10 degrees prior to reaching the vertical position in the upswing. Therefore, the data for the first and fourth quadrants have 80 degrees of rotation instead of 90 degrees.

Table 1 presents temporal and linear kinematic results. In addition, the Table presents deductions given to the giants by qualified judges. No significant differences between skilled/unskilled giants were found for any of the variables.

Table 2 presents joint range of motion and body angular velocity. As with the linear results, no significant differences between the two groups of giants were also found in the angular variables.

DISCUSSION

The purpose of this study was to provide descriptive and comparative kinematic data on giant swings backward on the parallel bars judged by qualified judges as being more or less skillful. Results showed that, overall, the motion pattern of giants on the parallel bars was similar to patterns on other apparatuses like the high bar and uneven bars. As expected, due to apparatus' constrains, exception to this was seen with the knee joint motion. To clear the floor, gymnasts must flex the knee joint as they pass through the bottom of the swing. Interestingly, however, data showed that the greatest knee joint flexion angle wasn't at the bottom of the swing, but past that about mid-way into the third quadrant. A plausible explanation to this may be that this action is necessary to minimize the loss of angular momentum resulting from the "negative" effect of the gymnast's weight.

Temporal results (Table 1) showed that the gymnasts spent more time in the first and last quadrant. This was expected as the gymnasts progressively gain angular momentum in the downswing and (progressively) loose some in the upswing. For giants seen performed clockwise, this gain/loss in angular momentum is, to the greatest extent, the result of the effect of the athlete's weight, which acts clockwise in the downswing and counterclockwise in the upswing. CM maximum velocity was similar between the two groups of giants. It should be noted that direct comparisons between CM velocities in this study and previous ones on high bar and uneven bars may not be appropriate since this study reports CM maximum velocity while in most previous studies, CM "release" velocity for flight elements, or dismounts was presented (Arampatzis & Brüggemann, 1999; Cuk, 1995; Gervais & Tally, 1993; Hiley & Yeadon, 2003; Hiley, Yeadon & Buxton, 2007; Holvoet, Lacouture and Duboy, 2002; Prassas et al., 1998). Results for horizontal hand displacement revealed no significantly differences during the release/re-grasp phase between the skilled/unskilled giants.

Table 1. *Descriptive and Comparative Temporal and Linear Results.*

Variable	All Giants (n=14)	Skilled (n=6)	Unskilled (n=8)	t-score
Total time (TT) (s)	1.90 ± 0.111	1.92 ± 0.104	1.89 ± 0.121	-0.548
T Quadrant 1 (%)	35.90 ± 2.676	35.42 ± 2.748	36.39 ± 2.728	0.657
T Quadrant 2 (%)	17.40 ±1.173	17.13 ± 1.412	17.59 ± 1.015	0.703
T Quadrant 3 (%)	17.03 ± 1.474	16.23 ± 0.712	17.63 ± 1.65	1.921
T Quadrant 4 (%)	29.68 ± 3.611	31.22 ± 3.586	28.39 ± 3.332	-1.525
CM max. vel. (m/s)	5.96 ± 0.697	6.08 ± 0.688	5.88 ± 0.745	20.5^{+}
Hand horiz. displ, (m)	0.29 ± 0.150	0.24 ± 0.134	0.33 ± 0.150	1.133
Deductions^{++}	0.21 ± 0.154	0.09 ± 0.049	0.29 ± 0.150	48.0^{+}

Note: CM, center of mass; $^{+}$ Mann-Whitney U Statistic; $^{++}$ (1=perfect score)

Table 2. *Descriptive and Comparative Angular Results.*

Variable	All Giants (n=14)	Skilled (n=6)	Unskilled (n=8)	t-score
Knee J. ROM (rad)	1.90 ± 0.122	1.94 ± 0.113	1.88 ± 0.133	-0.697
Hip J. ROM (rad)	1.29 ± 0.324	1.32 ± 0.187	1.27 ± 0.412	-0.261
Should. J. ROM (rad)	1,24 ± 0.429	1.03 ± 0.232	1.40 ± 0.485	1.724
Elbow J. ROM (rad)	0.87 ± 0.597	0.71 ± 0.448	1.00 ± 0.694	36.0+
AV Quadr. 1 (rad/s)	2.06 ± 0.056	2.10 ± 0.236	2.04 ± 0.198	-0.489
AV Quadr. 2 (rad/s)	5.00 ± 0.086	5.14 ± 0.290	4.97 ± 0.341	-0.971
AV Quadr. 3 (rad/s)	5.10 ± 0.124	5.46 ± 0.371	4.89 ± 0.562	-2.134
AV Quadr. 4 (rad/s)	2.30 ± 0.124	2.50 ± 0.694	2.20 ± 0.162	22.5^{+}

Note: ROM, range of motion; AV, angular velocity; + Mann-Whitney U Statistic

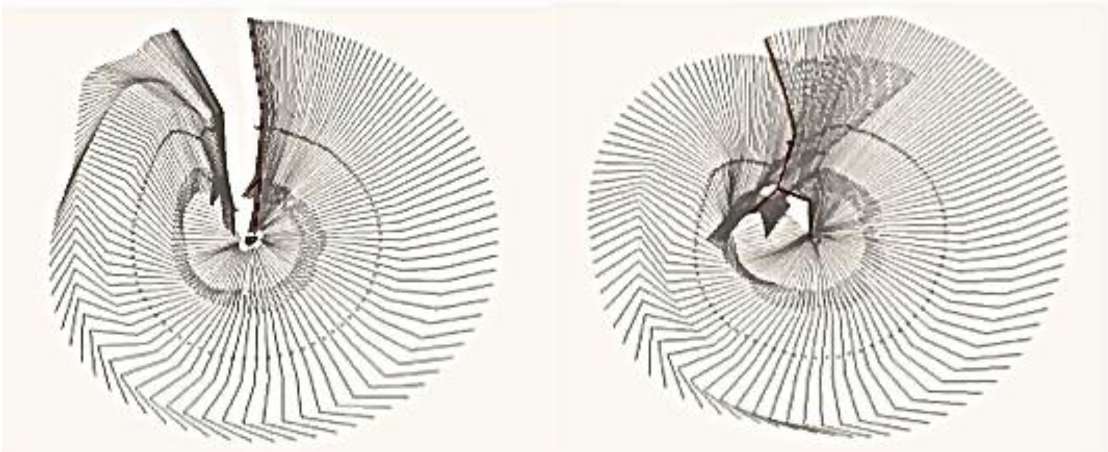

Figure 2. *Stick figures of of the giant swings with the least (Unskilled—left) and most (Skilled—right) deductions. Motion is in the clockwise direction.*

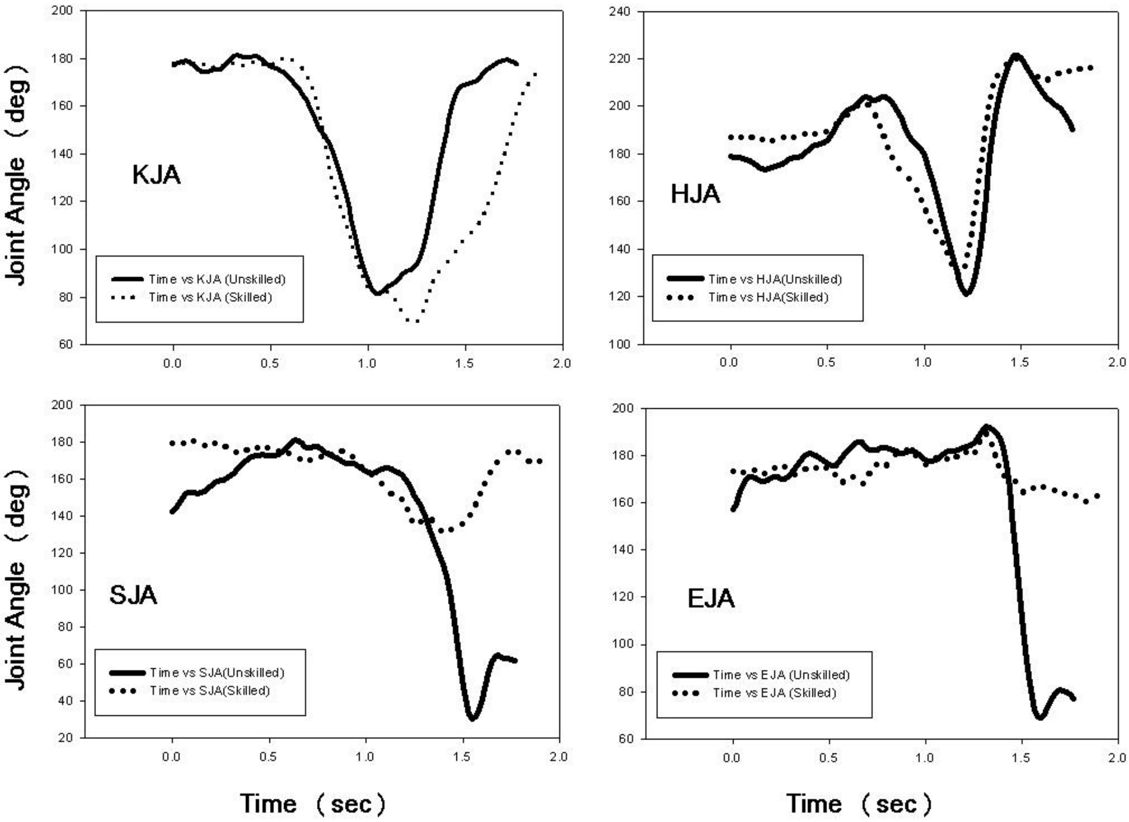

Figure 3. *Knee (posterior), hip (anterior), shoulder (anterior) and elbow (anterior) joint angles (KJA, HJA, SJA, and EJA, respectively) of the giant swings with the smallest (Skilled) and most (Unskilled) deductions.*

The results of this study (Table 2) indicated that joint angles of parallel bars giant swings were similar to results in the literature concerning giants on high bar with the noticeable exception of larger ROM at the knee and shoulder joints (Prassas, 2011). In “traditional” giant swings backward on the high bar the aim is merely to swing from handstand to handstand position using as little flexion and extension as possible

(Cheetam, 1984). However, on parallel bars, constraints in apparatus height, bars orientation and "gripping" force the gymnast to modify shoulder, hip and knee joints range of motion in order to positively influence, through muscular work, the energy exchange between his body and the bars. Brüggeman et al., (1994) and Arampatzis & Brüggemann (1998, 1999) reported that energy exchange between the bars and the gymnast's body is an important parameter for the quality of giants. The shoulder joint angle is always smaller in the parallel bars compared with high bar while the pattern of hip joint angle is roughly identical for parallel bars and high bar (Tsuchiya et al., 2004). It has been reported previously that hip joint extension in the downswing and hip joint flexion in the upswing are needed more in performing a giant swing backward on the parallel bars than on the high bar (Tsuchiya et al., 2004). The height limitation of the apparatus (180±1 cm above the mat) requires the gymnasts to swing with knees bent at the hang position in contrast with giants on high-bar (placed 260±1cm above the mat) and uneven bars (230±1 cm above mat) that allow execution with extended knee joints.

Joint ROM and angular velocity results showed no significant differences between skilled and unskilled giants (Table 2). A trend, however, was seen with skilled giants showing greater knee joint ROM and unskilled more shoulder joint ROM. Regarding shoulder and especially elbow joint motion, it should be noted that possible out of plane components may exist and those—if present—couldn't be measured utilizing only one camera. As expected and in accordance with the temporal results, angular velocity increased during downswing and decreased in the upswing.

It is hypothesized that at least some of the non-significant skilled/unskilled comparative results were due to the relatively high skill level of the gymnasts. This is supported by examining data of the two giants receiving the least (0.05 pts) and most (0.6 pts) deductions (referred to as Skilled/Unskilled, respectively in Figures 2 and 3). As seen in the stick figures diagram (Figure 2), the trajectory of the CM is more round and symmetrical on the skilled giant and flatter and asymmetrical on the unskilled one. The diagram also shows the pronounced difference in knee joint motion, especially in the fourth quadrant. Joint angle data in Figure 3 shows that the "skilled" gymnast, by flexing and, perhaps most importantly, maintaining the knee joint flexion for longer time in the upswing, was able to substantially reduce the body's moment of inertia and thus to complete the giant with less hip, shoulder, and elbow joint action. In contrast, the earlier initiated and faster progressing knee joint extension of the "unskilled" subject increased the moment of inertia to levels beyond his ability to effectively pull and sufficiently elevate his CM.

Thus, in order to complete the giant, he was forced to further decrease the shoulder joint extension angle and to substantially flex the elbow joint. In essence, the "unskilled" subject, unable to elevate the body by pulling it towards the bars, shifted the axis of rotation closer to the body by pulling the handgrips towards the shoulders, re-grasped, and then pushed toward the handstand as he continued the rotation.

CONCLUSION

Results of this study showed no significant differences between motion patterns of parallel bars giant swings backwards receiving—on a scale from 0 to 1.0—more than 0.2 (Unskilled) and less than 0.2 (Skilled) deductions by internationally qualified judges. However, overall data trends and comparison of the two giants receiving the most and least deductions showed that different joint motion patterns might exist. In particular, it appears that less skilled gymnasts may extend the knee joint prematurely in the upswing, leading to greater elbow joint flexion and shoulder joint extension.

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