IMPULSE-MOMENTUM RELATIONSHIPS IN GIANT SWING MOVEMENTS

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INTRODUCTION

The purpose of this study was to investigate the forces applied to an instrumented top bar of the uneven parallel bars by female gymnasts performing an overgrip giant swing. This movement is considered a basic uneven parallel bar skill and is a prerequisite to the more difficult release moves that gymnasts are expected to perform at optional competitions. Until recently, the overgrip giant swing was looked upon as a difficult skill and was only performed by advanced gymnasts. In 1992, the overgrip giant swing was devalued to a "B" (a category denoting intermediate-level skill) by the International Federation of Gymnastics. As a result, young female gymnasts are performing this skill very early in their optional competitive careers.

It was hypothesized that information derived from the time histories of horizontal and vertical forces applied to the bar would provide insight into how gymnasts perform these swinging movements.

METHODS

The subjects for this study were 15 Class I and Elite level female gymnasts whose age ranged from 10 to 16 years. Each gymnast was videotaped performing the following sequence of skills: kip, cast, clear hip to handstand, overgrip giant swing, and flyaway dismount. The videotape of each subject's performance of the overgrip giant swing, isolated from the other skills, was shown to four Elite and Level 10 judges, who independently rated the performances of this skill on a 10-point scale. Based on the judges' ratings, the top four [highly skilled (HS)] and bottom five [less skilled (LS)] gymnasts were selected for further study.

A 233.7 cm American Athletic Incorporated Graphite X rail, with a wood-laminate surface, which was used for the top bar, had been instrumented with strain gauges. The 40 mm diameter bar was constructed from composite materials consisting of graphite and fiberglass. Four

Measurement Group CEA-06-250UWw-350 electrical resistance strain gauges had been bonded to the surface of the bar 25 cm from the end in a differential configuration. One set of gauges had been placed on the top of the bar to collect vertical strain values, and another set had been placed orthogonally to collect horizontal strain values. A sampling rate of 100 Hz was used for these strain gauges.

Prior to the gymnasts' performances of the sequence of skills, a series of calibration tests were performed on the bar, The bar was calibrated statically by suspending known loads ranging from 9.8 to 133.7 kg. A metal device was constructed to hold the weights during calibration. The device was constructed so that two clamps could be placed on the uneven parallel bar and hold weights which were placed in a basket suspended from the clamps. The loads were applied first in one direction, and then the bar was rotated 90 degrees and the loads were reapplied. This procedure permitted the calibration of the bar for both horizontal and vertical strain. The calibration process included tests for linearity and independence of vertical and horizontal forces. Cross talk was determined by applying a force to one channel while measuring outputs to the other channel. Results of the calibration tests showed linearity to within 1.1 % and nearly complete independence of the horizontal and vertical strain.

Additional details of the methods employed in this study can be found in a prior study by Witten, Brown, Witten, and Wells (1996).

RESULTS AND DISCUSSION

The overgrip giant swing was the only element of the sequence of skills, performed by the gymnasts, investigated in this study. Table 1 contains a summary of the horizontal and vertical impulses applied to the bar in the overgrip giant swing and their influences on the velocities of the subjects' centers of gravity.

Table 1.

Performance Parameters in the **Overgrip** Giant Swing

Parameter*	Group HS				
subject no.	1	4	5	16	
mass (kg)	39.49	40.29	34.59	44.05	
Zstatic imp.$_y$ (Ns)	-759.3	-762.8	-739.7	-1201.	
Σimpulse$_y$ (Ns)	-786.0	-778.6	-763.6	-1224.	
Σimpulse dif.$_y$ (Ns)	-26.7	-15.8	-23.9	-23.2	
Σimpulse$_x$ (Ns)	-33.1	9.7	8.2	-36.8	
ΔV$_x$ (m/s)	0.83	-0.24	-0.24	0.83	
ΔV$_y$ (m/s)	0.68	0.39	0.69	0.53	
	Group LS				
subject no.	6	8	9	11	17
mass (kg)	31.17	44.41.	31.07	29.45	45.89
Zstatic imp.$_y$ (Ns)	-636.0	-1006.	-566.9	-479.6	-1188.
Σimpulse$_y$ (Ns)	-623.5	-1020.	-579.2	-497.0	-1212.
Zimpulse dif.$_y$ (Ns)	12.5	-13.9	-12.3	-17.4	-24.0
Σimpulse$_x$ (Ns)	-32.0	-40.4	-35.4	-18.2	-17.6
ΔV$_x$ (m/s)	1.03	0.91	1.14	0.62	0.38
ΔV$_y$ (m/s)	-0.40	0.31	0.39	0.59	0.52

*The following definitions apply to the parameters included in this table:

Zstatic imp.$_y$ - sum of the static impulse applied to the bar in the vertical direction which is equal to the product of the subject's weight and time to complete the **overgrip** giant swing.

Zimpulse - sum of the impulse applied to the bar in the vertical direction which is equal to the area under the vertical force-time curve in the performance of the **overgrip** giant swing.

Zimpulse dif.$_y$ - difference between **Σimpulse$_y$** and Zstatic imp.$_y$

Σimpulse$_x$ - sum of the impulse applied to the bar in the horizontal direction which is equal to the area under the horizontal force-time curve in the performance of the **overgrip** giant swing.

ΔV$_x$ (m/s) - change in horizontal velocity of the center of mass of the gymnast from the start to the finish of the **overgrip** giant swing associated with **Σimpulse$_x$**.

ΔV_y **(m/s)** - change in vertical velocity of the center of mass of the gymnast from the start to the finish of the overgrip giant swing associated with Cimpulse dif._y

If a subject started the overgrip giant swing in a stationary handstand position and completed the skill in the same stationary handstand position, the expected total impulse in the horizontal direction would equal zero. However, the (impulsex for all subjects (range of -40.4 to +9.7 Ns) except Subjects 4 (+9.7 Ns) and 5 (8.2 Ns), in Group HS, were negative. Because of the direction of movement of the gymnasts, a negative horizontal impulse adversely decreased the velocity of their center of gravity, reducing the velocity from the start to the finish of the skill. Similarly, if a subject's vertical velocity is unchanged from the start to the finish of the skill, Cimpulse dif._y would equal to zero. From Table 1 it is evident that all subjects, except Subject 6 in Group LS, had a greater magnitude for $\Sigma\text{impulse}_y$ than for Cstatic imp._y. This implies that eight of the nine subjects positively increased the vertical velocity of their center of gravity from the start to finish of the overgrip giant swing.

CONCLUSIONS

The benefit of increasing, or decreasing, the horizontal and/or vertical velocity of the center of gravity of the body from the start to the finish of a gymnastic skill is determined by the requirements of the next skill in the sequence. In this study, a flyaway dismount was performed after the overgrip giant swing. Therefore, it was desirable for the gymnasts to increase the velocity of their center of gravity to aid in the performance of the dismount. It was determined that only Subjects 4 and 5 (both in Group HS) were able to effect a desired influence on the horizontal and vertical velocity of their center of gravity from the start to the finish of the overgrip giant swing. This provides some support for the use of strain gauges in the evaluation and differentiation of performance of various skills on the uneven parallel bars. A similar investigation is recommended for the use of torque gauges to determine the relationships between torque applied to the bar and its influence on a gymnast's angular velocity.

REFERENCE

Witten, W. A., Brown, E. W., Witten, C. X., Wells, R. (1996). Kinematic and kinetic analysis of the overgrip giant swing on the uneven parallel bars. Journal of Avvlied Biomechanics, 12, 431-448.