

## THE APPROACH, VAULTING PERFORMANCE, AND JUDGE'S SCORE IN WOMEN'S ARTISTIC GYMNASTICS

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The approach step, hurdle, and round-off length characteristics of women's vaulting were examined in relation to post-flight performance and judge's score during five trials for five gymnasts. Two reference strips with alternating 50cm black and white intervals were placed on either side of the approach area. One 50Hz panning camera filmed the approach, with two stationary 250Hz cameras filming the post-flight vaulting performance. Two qualified judges viewed each trial and provided a performance score. A significant correlation was found between velocity during visual control of the approach, post-flight time ( $p \leq 0.01$ ) and judge's score ( $p \leq 0.01$ ). Specifically, increased approach velocity leads to an increase in round-off velocity ( $p \leq 0.01$ ), resulting in a short high velocity take-off from the board ( $p \leq 0.01$ ).

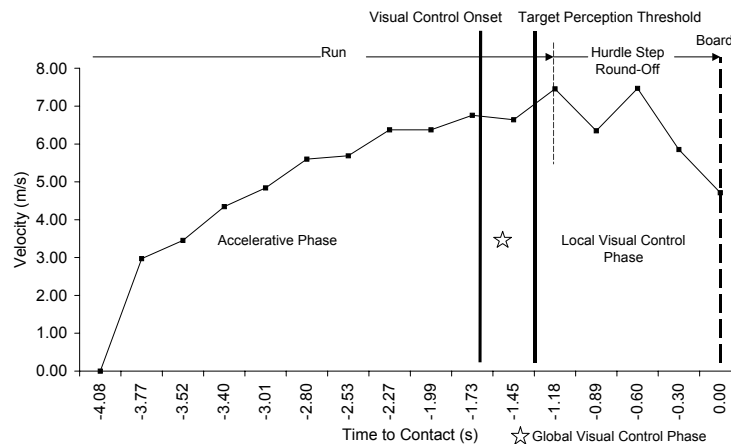
**KEY WORDS:** gymnastics, vault, approach gait, visual control, performance

**INTRODUCTION:** Gymnastics vaulting provides an opportunity to examine the relationship between the approach towards multiple obstacles and performance. A precise and consistent high-velocity approach in gymnastics vaulting leading to optimum foot-placement on the take-off board is the key to successful performance. Bruggemann and Nissenen (1981), for example, demonstrated that a higher approach velocity in gymnastics vaulting resulted in a superior performance score from qualified judges. This association was due to a high correlation between approach velocity and post-flight height and distance. It appears, therefore, that in order to improve performance, gymnasts should be trained to run faster during the approach when vaulting. In gymnastic vaulting, however, the gymnast must not only approach at high speed, but also negotiate multiple obstacles before executing the required movement when in flight. Considerable research has focused upon the kinematic characteristics of gymnastics vaults (e.g. Takei et al, 2000). One shortcoming of the extant literature is that the key kinetic input for vaulting, the running approach, has received very little attention. It is commonly accepted that the final approach velocity and take-off velocity from the board provide essential take-off kinetics for successful vaulting. It is, therefore, of paramount importance that the initial phases of gymnastic vaulting receive greater attention. Considerable attention has been paid to the step length characteristics and control mechanisms underlying the approach towards the take-off board in the sport of long jumping (e.g. Lee, Lishman, & Thomson, 1992; Hay, 1988; Berg, Wade, & Greer, 1994), and also in approaches towards targets and obstacles when walking and running (e.g. Bardy & Laurent, 1991; Buekers et al, 1999; De Ruyg et al, 2000; Bradshaw & Sparrow, 2000). Of specific interest to the current study was the interaction found in earlier work between approach speed and final foot placement during the hurdle step when novice performers approached a gymnastic take-off board (Bradshaw & Sparrow, in press). The interaction between approach speed and placement of the foot during the hurdle allowed the feet to be placed in a consistent position on the take-off board across a wide range of approach speeds. Also, in previous research on novice performers, visual control onset time was found to decrease linearly with an increase in approach speed, such that fewer adjustments to the step kinematics can be made at higher approach velocities (Bradshaw & Sparrow, in press). The current study was designed to examine the underlying characteristics of the approach towards the take-off board and the vaulting horse in elite women's gymnastics, to determine what characteristics of the approach affects vaulting performance and judge's score. It was expected that approach velocity, visual control onset time, hurdle and hand position prior to the take-off board would be directly related to performance score.

**METHODS:** Five elite female gymnasts ranging in age from 13-15 years participated in the study. The mean height and weight of the gymnasts was 1.54m and 43.42kg respectively. Each

gymnast completed five 'yurchenko' round-off entry vaults of a start value of at least 8.9 as governed by the International Gymnastics Federation (FIG) Code of Points 2001-2004. Two qualified judges viewed each vaulting trial and provided a performance score. Two marker strips were placed on either side of the 20m-approach strip, with alternating 50cm black and white intervals that provided a scale-reference for subsequent analysis of the videotape. One panning digital camera (50Hz Pal 15 $\mu$ m) was set-up on an elevated platform, at one side of the approach strip. The accuracy of the panning video footage was determined in pilot testing utilizing cardboard footprints placed along the approach strip. Measurements of the toe-to-board distances were found to be within an accuracy level of +0.5cm. Two high-speed stationary cameras operated at 250Hz and a shutter speed of 1/500, were set-up oblique left-back and oblique right-front in relation to the vaulting horse, at the side of the vaulting area. A 4.0m high calibration rod (2.5cm<sup>3</sup>) marked with 0.5m intervals was filmed in six positions to provide a three-dimensional scale-reference for the stationary cameras. Videotape from the panning camera was analysed consistent with the procedures of Bradshaw and Sparrow (in press). Videotape of the post-flight phase from the two stationary cameras was analyzed three-dimensionally using APAS 2000 software. Statistical analysis was conducted using Pearson's correlations and regressions using SPSS for Windows and Microsoft Excel to determine the relationship between the approach gait, performance measures, and the judge's score. Velocity during each phase of the approach was also averaged and analysed statistically.

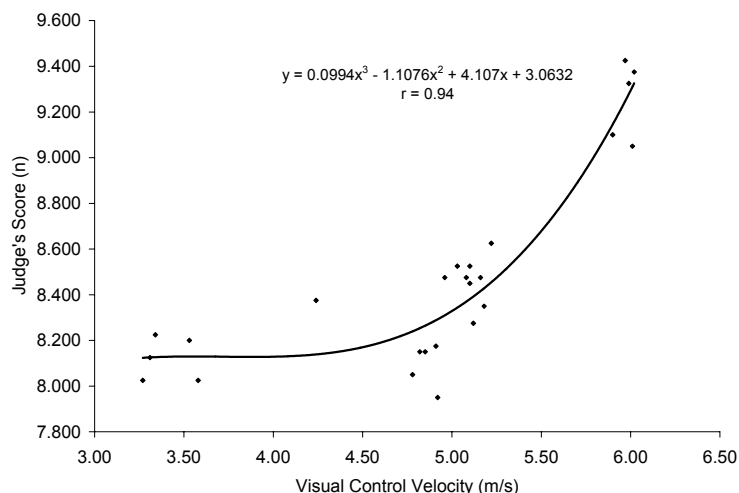
**RESULTS AND DISCUSSION:** Consistent with earlier work on running towards a double-boundary target (Bradshaw & Sparrow, in press), the approach towards the take-off board and vaulting horse in gymnastics comprises of three phases, shown in Figure 1. An accelerative



**Figure 1 - The velocity/time profile for the approach towards a gymnastic take-off board in yurchenko-entry vaulting. The approach comprises of three phases, an accelerative phase, a global visual control phase, and a local visual control phase.**

phase preceded a visual control phase, where the steps are controlled in the direction of the take-off board, and a local visual control phase; where step, hurdle, and round-off length adjustments are made to negotiate the take-off board for the required backward-entry vault. Increased velocity during the visual control phase of the approach in yurchenko-entry vaulting was found to increase post-flight time ( $r=0.555$ ,  $p\leq 0.01$ ) and judge's score ( $r=0.765$ ,  $p\leq 0.01$ ) as shown in Figure 2. No significant relationship was found between the velocity during the accelerative phase of the approach and the post-flight characteristics or performance score. Average approach velocity, as found by previous researchers (eg. Krug, Knoll & Zocher, 1998), was related to judge's score ( $r=0.683$ ,  $p\leq 0.01$ ). A fundamental characteristic of increasing approach velocity and, therefore, performance score, was the early onset of visual control with respect to distance ( $r=0.830$ ,  $p\leq 0.01$ ), footfalls ( $r=0.824$ ,  $p\leq 0.01$ ), and time ( $r=0.776$ ,  $p\leq 0.01$ ), as

summarized in Table 1. The control of the approach to the take-off board and horse in gymnasts differs to that of novices in related forms of target-directed locomotion. Visual control onset in novices occurs at a consistent location prior to the target or obstacle, with the amount of time during the approach that is visually regulated, decreasing linearly with an increase in approach speed (Bradshaw & Sparrow, in press). Visual control in gymnasts increases linearly with respect to distance ( $r=0.816$ ,  $p\leq 0.01$ ;  $y=12.231x-59.961$ ,  $R=0.80$ ) and time ( $r=0.846$ ,  $p\leq 0.01$ ;  $y=1.8054x-8.3221$ ,  $R=0.84$ ) prior to the take-off board, when approach speed increases.



**Figure 2 - The relationship between velocity during visual control of the approach and judge's score in yurchenko-entry vaulting.**

**Table 1 The average point of visual control onset during the approach towards the take-off board for the five gymnasts, as characterised by the distance to the board, the number of steps prior to the hurdle, or the actual hurdle (H) step (S) round-off (R) phase, and time as a percentage of total approach time. Also included is the average velocity during visual control, the hurdle to board velocity, post-flight time during vaulting performance, start and judge's score.**

Gymnast	Visual Control				Hurdle to Board Vel. (m/s)	Post-Flight Time (s)	Start Score (n)	Judge's Score (n)
	Dist. (m)	Steps (n)	Time (%)	Velocity (m/s)				
1	17.20	6	77.74	5.98	5.31	0.874	9.70	9.255
2	6.71	1	36.77	5.10	5.03	0.726	9.07	8.564
3	5.39	H	29.18	4.94	4.94	0.824	9.12	8.445
4	6.84	1	37.01	4.86	4.81	0.730	8.90	8.095
5	3.08	S	28.26	3.41	4.82	0.739	8.90	8.120
Mean	7.83	1	41.79	4.86	4.98	0.779	9.12	8.495

During the visual control phase of the approach, the hurdle-step-round-off velocity was found to be the section that increased with higher approach velocities ( $r=0.616$ ,  $p\leq 0.01$ ), resulting in superior vaulting performance ( $r=0.705$ ,  $p\leq 0.01$ ). The hurdle itself acts as a transition movement linking the approach run to the round off and vaulting movement. The hurdle increases in length ( $r=0.401$ ,  $p\leq 0.05$ ) and duration ( $r=0.663$ ,  $p\leq 0.01$ ) with higher approach speeds, but not in velocity. An interaction was found between the actual hurdle position in relation to the take-off board and approach velocity ( $p\leq 0.01$ ), similar to the pattern found for novice performers (Bradshaw & Sparrow, in press). The interaction between the hurdle position and approach

velocity enables the gymnast to land in a consistent position on the take-off board, regardless of the approach velocity. The round-off increased in length ( $r=0.456$ ,  $p\leq 0.05$ ) but decreased in duration ( $r=-0.614$ ,  $p\leq 0.01$ ) with a faster approach, thus, increasing in velocity ( $r=0.686$ ,  $p\leq 0.01$ ). Of particular interest was that the position of the hands with respect to the board decreased with an increase in velocity ( $r=-0.663$ ,  $p\leq 0.01$ ), producing a quicker snap-down component to the round off onto the take-off board ( $r=0.478$ ,  $p\leq 0.05$ ). The compression section of the board contact phase was unrelated to the approach velocity; however, the repulsion section was shorter in duration when approach velocity increased ( $r=-0.651$ ,  $p\leq 0.01$ ). An explosive take-off from the board, characterized by a short repulsive board contact time, resulted in an increased post-flight time ( $r=-0.405$ ,  $p\leq 0.05$ ) and thus performance score ( $r=-0.592$ ,  $p\leq 0.05$ ).

**CONCLUSION:** The results demonstrated that when step length regulation occurred earlier during the approach towards the take-off board and horse in yurchenko vaulting, approach velocity and vaulting performance increased as indicated by the judge's scores. A fundamental feature of target-directed running in gymnasts is their capacity to visually regulate the approach earlier, enabling smaller progressive foot-positioning adjustments to occur, and resulting in the capacity to accurately accommodate the hurdle-step-round off onto the take-off board with attenuated effects on approach velocity. Recommendations for training include the early inclusion of different targeting activities whilst running, such as that seen in long jumping and hurdling, and completing vault timers from different approach distances. Whilst the approach towards a take-off board has been investigated for novice performers (Bradshaw & Sparrow, in press), further research is needed to determine the pattern governing step length regulation in forward entry vaults for elite gymnasts, including the effects on vaulting performance.

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