RELEASE AND RE-GRASP WINDOWS FOR THE KOVACS ON HIGH BAR

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The aim of the study was to determine the size of the release and re-grasp windows used in the Kovacs release and re-grasp on high bar and compare these to the potential time available to re-grasp the bar. One elite male gymnast performed 10 successful Kovacs (out of 10 attempts) which were recorded using an automatic motion capture system. The release and re-grasp windows were determined from the range of performances and the potential re-grasp window was calculated from the period of time the mass centre was within grasping distance of the bar. The gymnast was very consistent and used a small re-grasp window (23 - 27 ms). The potential re-grasp window was large with the gymnast being within re-grasp distance of the bar for 100 ms prior to grasping the bar. It is likely that the gymnast selected a consistent point within this window for the re-grasp.

KEY WORDS: gymnastics, timing, consistency, margin for error

INTRODUCTION: The Kovacs is a release and re-grasp skill performed on the high bar in men's artistic gymnastics. From a backward giant swing the gymnast releases the bar and rotates through approximately one and a quarter somersaults, catches the bar and then continues to swing in the backwards direction. This is a popular skill in elite competitive gymnastics, although it is not uncommon for gymnasts to miss the re-grasp, resulting in a fall and a heavy points deduction from the judge. The release window (the timing window within which the gymnast can release the bar and successfully complete the following skill) has been reported for dismounts and the Tkatchev release and re-grasp skill (Hiley & Yeadon, 2003, 2005; Hiley, Yeadon & Buxton, 2007), whereas a re-grasp window (the time period during which a successful re-grasp could be made) has not. Understanding the time constraints that the gymnast works within will give insight into why some gymnasts are more successful at consistently re-grasping the bar than others.
The aim of the study was to determine the size of the release and re-grasp windows used by an elite male gymnast and compare these to the potential time available to re-grasp the bar.

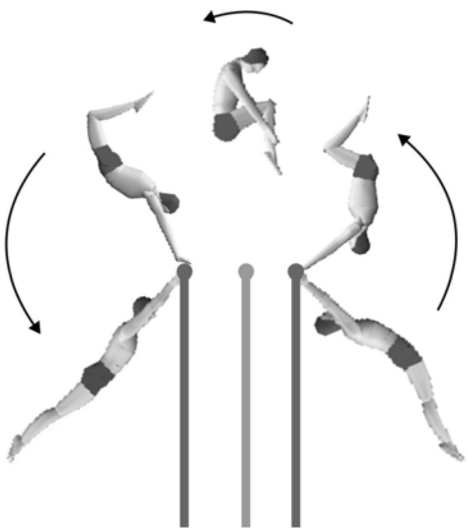

Figure 1: The Kovacs release and re-grasp on high bar.

METHODS: One male gymnast (age 21 years, mass 70.2 kg, height 1.62 m) who competed internationally gave informed consent to participate in the study which was approved by the university ethics committee. The gymnast performed 10 successful Kovacs release and re-grasps from 10 attempts which were captured using 13 Vicon MX13 cameras operating at 300 Hz. Ten trials were chosen to provide a representative spread of the gymnast's performances (James, 2004; Hamill, van Emmerik, Heiderscheit & Li, 1999). Spherical reflective markers, 25 mm in diameter, were attached to the lateral side of the wrist, elbow, shoulder, hip, knee and ankle joint centres and toes on the left side of the body. Lateral offset measurements from each marker to the adjacent joint centre were recorded for subsequent location of the joint centres. Additional markers were attached to each side of the gymnast's head (above the ear) and to the centre of the high bar. Prior to data collection a volume centred on the high bar spanning 2 m x 5 m x 5 m was wand calibrated using the motion analysis system.

Three-dimensional marker coordinates were reconstructed and joint centre locations were determined using the measured offsets. Interpolating cubic splines were fit to the reconstructed coordinate data to up-sample the data series at 1000 Hz. The gymnast mass centre was calculated from the reconstructed joint centre locations and subject specific inertia data determined from anthropometric measurements and the geometric inertia model of Yeadon (1990). All mass centre locations were expressed relative to the neutral (unloaded) bar location.

For each trial the time of release and re-grasp were determined from the recorded bar displacements. The location of the mass centre for each of these events was recorded. The release window for each trial was calculated as the period of time the mass centre was within the range of values recorded at release. A parabola was fit to the mass centre trajectory in flight in order to extend the trajectory beyond the point of re-grasp (Figure 2). The re-grasp window was calculated as the period of time the mass centre was within the range of values recorded at re-grasp. The potential re-grasp window (PRW) for each trial was calculated as the period of time during the extended flight phase that the mass centre was within reaching distance of the bar (assuming an appropriate orientation of the gymnast). The time from the start of the potential re-grasp window (sPRW) until the recorded re-grasp time was calculated.

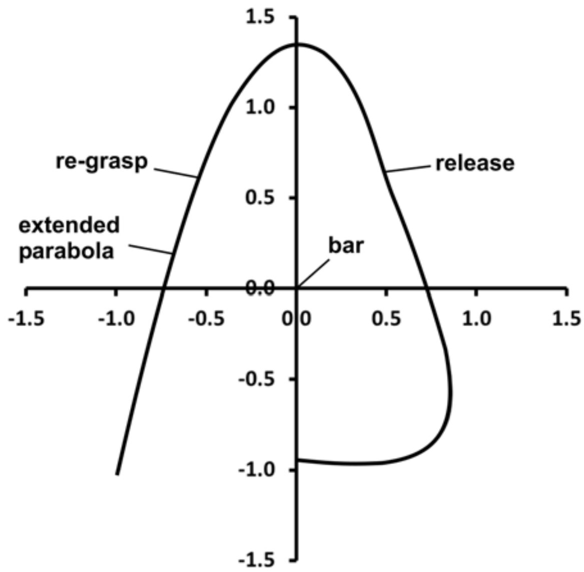

Figure 2: Path of the mass centre leading up to release and during flight (flight phase extended using a parabola).

RESULTS: The range of horizontal and vertical mass centre locations at release and re-grasp for the 10 successful Kovacs were small (Table 1). The sizes of the release and re-grasp windows (53 – 63 ms and 23 -27 ms respectively) were remarkably consistent (Table 2).

Table 1
Mass centre locations at release and re-grasp

Trial	Release [m]		Re-grasp [m]	
	Horizontal	Vertical	Horizontal	Vertical
1	0.54	0.46	-0.61	0.45
2	0.57	0.40	-0.70	0.53
3	0.59	0.38	-0.61	0.51
4	0.62	0.32	-0.47	0.53
5	0.51	0.56	-0.86	0.51
6	0.60	0.36	-0.68	0.52
7	0.62	0.30	-0.61	0.49
8	0.61	0.34	-0.61	0.52
9	0.59	0.39	-0.63	0.56
10	0.60	0.35	-0.67	0.50
range	0.12	0.26	0.39	0.11

Table 2
Release and re-grasp windows

Trial	Release window [ms]	Re-grasp window [ms]	PRW [ms]	sPRW to re-grasp [ms]
1	60	27	317	130
2	63	24	247	77
3	60	23	290	113
4	56	27	340	130
5	63	27	83	23
6	60	26	260	97
7	64	27	304	104
8	60	24	297	117
9	53	27	277	103
10	60	24	273	107
mean	60	26	269	100

DISCUSSION: The average release window (60 ± 3 ms) obtained from the repeated trials was smaller than the average for the eight double layout dismounts from the 2000 Olympics high bar final (117 ± 26 ms from Hiley & Yeadon, 2003). This might be expected based on the constraint of re-grasping the bar and being calculated from repeated trials by a single gymnast. Compared to the successful Tkatchev release windows (29 ± 21 ms), the gymnast in the present study had larger release windows and was considerably more consistent. In the Tkatchev study (Hiley et al., 2007) the gymnast was only successful in 10 out of 60 trials compared to 10 out of 10 for the Kovacs gymnast.
On first observation the re-grasp window appeared to be surprisingly small (26 ± 2 ms). However, the gymnast's technique resulted in a trajectory in flight that placed the mass

centre within re-grasp distance of the bar for an extended period of time (Table 2). On average this period of time started 100 ms before the recorded re-grasp was initiated (i.e. re-grasp was defined as when the bar first moved due to contact with the hands). Given the proximity of the gymnast and the orientation of the gymnast's head, he was able to view the bar in advance of re-grasping on each attempt. On one attempt (trial 5) the gymnast's flight path resulted in re-grasping close to the limit of the mass centre – bar distance.
The path of the mass centre (Figure 2) in the preceding giant swing demonstrated the same flattening seen in the "scooped" backward giant circle prior to release for a double layout (Hiley & Yeadon, 2003). Even though the gymnast released at different heights (Table 1) the mass centre was moving on a straight line which leads to a more consistent flight path. In turn the consistent flight path places the gymnast in a good position to view and then re-grasp the bar leading to successful performances of the Kovacs.

CONCLUSION: The reasons for the consistent success of this gymnast are his consistency of timing together with large windows for release and re-grasp generated by his giant circling technique. The implication for coaching is that a gymnast needs to use a giant circle technique in which the body moves from a pronounced back arch beneath the bar into a flexed position prior to release in order to flatten the mass centre path and reduce the variation in flight trajectory arising from release timing variability.

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