INFLUENCE OF A SUSPENDED AID ON THE AMPLITUDE VARIABLES OF CIRCLES ON POMMEL HORSE

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Suspended aid is a popular device used for learning and refining circles, the most basic skill on pommel horse. The aim of this study was to examine how the use of a suspended aid influences the amplitude variables of circles. Eighteen gymnasts performed three sets of 10 circles with and without a suspended aid, and several kinematic variables identified in literature were analysed. As a result, circles with the aid showed a smaller body flexion angle, a greater shoulder angle, and a greater ankle diameter, although a shoulder diameter remained relatively similar to circles without the aid. Circles with the aid appeared to be more desirable in terms of the movement amplitude. In this sense, a suspended aid could function as spotting, which is often used for a progression to learn gymnastics skills, to let gymnasts experience a desired movement pattern.

KEY WORDS: gymnastics, body weight support, kinematics, technique, bucket circles

INTRODUCTION: “Bucket-circles” is a well-known training method for practicing “circles,” the most basic skill in pommel horse exercises (Figure 1). A gymnast places his legs into a bucket that is suspended from above, and then rotates his legs with the bucket performing circles. This type of training aids – a suspended aid – is commonly used as an introductory progression in which gymnasts are first exposed to the overall motion of the skill. Coaching literature suggests the use of a suspended aid even after acquiring the skill to further improve the quality of circles (Karácsony & Čuk, 1998). The value of using a suspended aid seems to be placed on enabling gymnasts to experience a desired motion of circles.

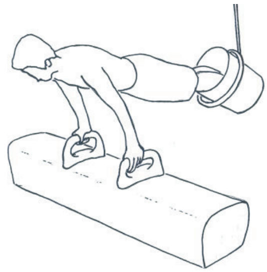

Figure 1: Bucket circles on pommel horse.

In gymnastics, maximizing the movement amplitude is one of the keys to the optimal performance (George, 2010). Baudry et al. (2009), identified four important variables to assess the amplitude of circles: shoulder extension in rear support (i.e. double-hand support phase with legs rotating in front of the horse), body alignment, shoulder diameter, and ankle diameter. The body alignment was computed based on the hip angles (Baudry et al., 2009). Fujihara and Gervais (2010), suggested that the body lateral flexion should be considered separately from the body flexion for analysing the motion of circles. The lateral body flexion might be a technical feature, whereas the body flexion is considered to be a technical fault (Fujihara & Gervais, 2010).

The aim of this study was to investigate the influence of a suspended aid on the amplitude of circles using four variables, namely, a shoulder extension angle in rear support, a body flexion angle, a shoulder diameter, and an ankle diameter.

METHODS:

Data collection: A suspended aid was constructed with a rotator twisting belt. The inside of the ring frame was arranged so that it fitted to the various sizes of gymnasts’ legs (Figure 2). The cable suspending the aid was attached to a swivel on a beam running 4.1 m above the surface of the pommel horse.

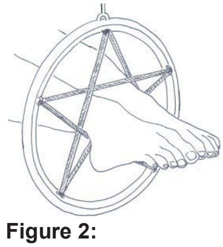

Figure 2: The suspended aid used for this study.

After general and event-specific warming ups, 18 gymnasts performed three sets of 10 circles on the pommel horse in two conditions: with and without the suspended aid. They had 9.4 ± 2.9

years of experience in competitive gymnastics, trained 20.3 ± 3.5 hours per week at the time of data collection, and were capable of performing 20 consecutive circles on a pommel horse. Either condition was randomly assigned for the first three sets of 10 circles, and then the gymnasts performed another three sets of 10 circles in the other condition. The gymnasts had enough rest between each trial to reduce the influence of fatigue. Twenty-three retro-reflective markers and four cluster marker sets (each had four markers) were attached to the gymnast's body to estimate de Leva's (1996), suggested anatomical landmarks. Three-dimensional (3-D) coordinates of these markers were captured using 13 Qualisys Proreflex motion tracking cameras operating at 100 Hz. Our local ethics committee approved all experimental protocols. Prior to the experiment, each gymnast provided written informed consent.

Data analysis: The 3-D coordinate data were smoothed using a fourth-order Butterworth low pass digital filter at the optimal cut-off frequencies (2.4 Hz - 11.6 Hz) determined by the automatic algorithm of Yokoi and McNitt-Gray (1990). The 3-D coordinates of the anatomical landmarks on the lower extremities were reconstructed based on the coordinates of the cluster markers using the least square method (Cappozzo & Cappello., 1997). The hip joint centre was estimated using Halvorsen's algorithm (2003), and all other joint centres were estimated as the centres of two markers attached on the surface of each joint. The diameter of the horizontal rotation was determined by Grassi et al.'s method (2005) and expressed as a percentage of body height. The ankle diameter was based on the trajectory of the centre of the ankles, and the shoulder diameter was based on the trajectory of the suprasternale.

For angular computations, two local reference systems were defined using a vector product (Fujihara & Gervais, 2010). In the hip reference system (Figure 3), the projected angle between the lower trunk (xiphion– the centre of hips) and the thigh (the centre of hips – the centre of knees) on the yz-plane was defined as the flexion of the hip (Figure 3 top right). Likewise, the projected angle between the upper trunk (suprasternale – xiphion) and the lower trunk (xiphion – the centre of hips) on the yz-plane in the trunk reference system was defined as the flexion of the trunk (Figure 3 top right). Finally, the body flexion angle was determined as the sum of the trunk and hip angles. The average angle over a single circle was reported. The trunk reference system was also used for computing shoulder extension angle formed by the upper trunk segment and the upper arm segments. It was determined as the projected angle of these segments on yz-plane. The right and left shoulder angles were averaged, and the average angle over the rear support phase was reported (Figure 3 bottom right).

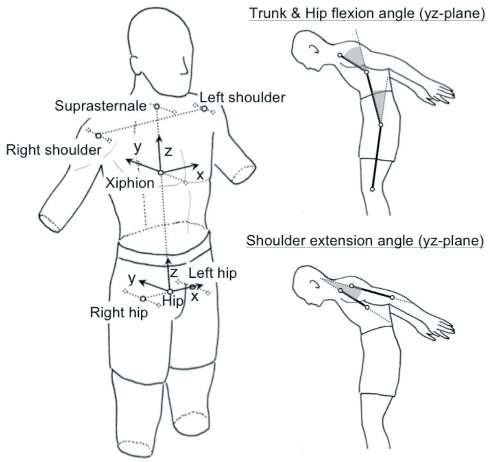

Figure 3: The definitions of the local reference systems and angles

Seven circles out of 10 (3rd-9th) were used so that the mean data for each variable were computed from the data of 21 circles (3 x 7 circles). Note that all discrete values were found for each single circle then averaged. To examine the influence of using the aid, circles with no aid were compared to circles with the aid. To find the variables that showed practical significance, the dominance statistic (Cliff's *d*, Cliff, 1993), was computed as an effect size measure for each comparison. Only for variables that showed practical significance (Cliff's *d* > 0.5), the Wilcoxon signed-rank test was performed with the Holm's correction (Knudson, 2009). The experiment-wise error rate was set at $p < 0.025$, so after the Holm's correction, a critical p value for each test ranged from 0.008 to 0.025. All statistical significance tests were performed using PASW Statistics 18.0 (SPSS Inc., 2009).

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RESULTS AND DISCUSSION:

The influence of the aid on the amplitude of circles: The results of this study confirmed that the use of the suspended aid changed the amplitude of the circles. Circles with the aid showed a smaller body flexion angle, a greater shoulder angle, and a greater ankle diameter. However, the shoulder diameter remained relatively similar to circles without the aid.

Table 1
The comparison of amplitude variables between circles with the aid and circles without the aid.

Variables	With the aid	No aid	Difference	Cliff's *d*	*z*-statistic (*p*)
Shoulder extension (°)	36 ± 6	18 ± 8	18	0.94	3.73 (0.0002)*
Body flexion (°)	4 ± 8	15 ± 11	11	0.58	3.50 (0.0005)*
Ankle diameter (%)	115 ± 4	98 ± 3	17	1.00	3.73 (0.0002)*
Shoulder diameter (%)	27 ± 3	29 ± 2	- 2	- 0.44	No test

The values are shown as (mean ± standard deviation).
The stars next to the *p* values indicate statistical significance.

A primary reason for the use of a suspended aid is to allow gymnasts the opportunity to experience a desired or optimal motion of circles. The results of this study showed that circles performed with the aid approach what may be considered the ideal. Baudry et al. (2009) identified four variables to assess the amplitude of circles: the body segment alignment, the shoulder extension angle during the rear support, the diameter of ankles, and the diameter of shoulders. The body flexion angle decreased with the aid. The shoulder extension angle in the rear support and the ankle diameter increased with the aid. These changes seem preferable in terms of the kinematics of circles.
Importantly, the shoulder diameter remained unchanged despite achieving such a high body position with the greater shoulder angle and the smaller body flexion angle. Figure 4 was drawn based on the average results of this study. It depicts the difference between the two conditions, which resulted in a larger ankle diameter and a similar shoulder diameter. The figure also implies the higher mass-centre rotation with the aid. Fujihara (2011) argued that a higher mass-centre rotation would require the greater centrifugal force, which results from the greater centripetal force. The horizontal component of the pommel reaction forces is responsible for producing the necessary centripetal forces during circles (Fujihara et al., 2009). The direction of force vectors from the pommels generally corresponds to the arm segment angle (Fujihara et al., 2009). Therefore, such a high rotation of the body would be associated with the greater leaning arms and the larger shoulder diameter. However, the shoulder diameter remained similar. With the suspended aid, the gymnasts had a support at their ankles, making seemingly unrealistic movement amplitude possible.

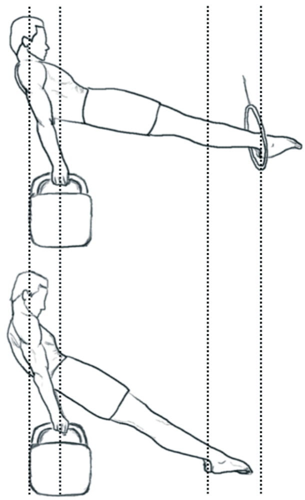

Figure 4: The comparison of circles with the aid and circles without the aid.

The implication and limitation of the study: The suspended aid was shown to be helpful for gymnasts to experience a more desired motion of circles, so it can be used as a training aid for kinematic guidance. In gymnastics training, spotting is indispensable and is used for a variety of purposes (Sands, 1996). Kinematic guidance is one of these purposes, and it can be defined, in this context, as physical assistance that can make it possible for a gymnast to perform a skill or a desired motion in the process of learning. Direct spotting by a coach is not a common practice for learning circles due to the nature of its movement, but a suspended aid could “spot” a gymnast. Even though a suspended aid does not actually

"guide" a gymnast, it helps them experience a desired motion or free attention for focusing on any specific aspect of circles in the process of learning.
Several limitations of this study should be addressed here. First of all, the actual influence of a suspended aid on motor learning was beyond the intended scope of this study. Second, the results were based on only one type of a suspended aid. With a different variation of suspended aids, the motion of circles might vary. Especially, the height of the aid might have a large influence on the kinematics because it almost solely determines the height of the ankles during circles. Consequently, gymnasts would accommodate the body and shoulder angles to the prescribed positions of the legs. Finally, the influence of expertise was not considered in this study. It is possible that circles performed by an expert would be different from circles performed by a developing gymnast even if both use the aid.

CONCLUSIONS: When circles were performed with the suspended aid, the amplitude of circles increased in terms of the ankle diameter, the body extension, and the shoulder extension. This means that the aid functioned as spotting, which is often used by a gymnastics coach to let gymnasts experience a more desirable motion of a skill. Together with the following study focusing on a kinetic comparison, the effects of a suspended aid on circles technique should be more thoroughly understood.

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