Kinematic Comparison of Circles in Cross Support and Circles in Side Support

Toshiyuki Fujihara and Pierre Gervais

Sports Biomechanics Laboratory, Faculty of Physical Education and Recreation, University of Alberta, Edmonton, AB, Canada, toshiyuk@ualberta.ca

INTRODUCTION

“Circles” is one of the most basic skills on pommel horse. Circles can be divided into two types in terms of their supporting orientation with respect to the horse: Circles in side support—when gymnasts face perpendicular to the long axis of the horse (Side-Circles, see Fig.1) and Circles in cross support—when gymnasts face parallel to the long axis of the horse (Cross-Circles, see Fig.2). Although both types of Circles are equally essential for pommel horse performance, most attention has been devoted exclusively to Side-Circles. Clarifying the difference between these two types of Circles will be important for better comprehension of the skill. The purpose of this study is to investigate the kinematic difference between Side-Circles and Cross-Circles on pommel horse.

METHODS AND PROCEDURES

Four national level male gymnasts performed three sets of ten Cross-Circles and Side-Circles on a pommel horse. The gymnasts were fitted with 37 retro reflective markers attached at anatomical landmarks to facilitate analysis using de Leva’s (1996) suggested body segment parameters. Either Side-Circles or Cross-Circles were randomly assigned as their first set of ten. Gymnasts alternated between the two types of Circles in subsequent sets. All the experimental protocols were approved by our local institutional ethics committee. Details of the experiment were explained to all the gymnasts and each gave written informed consent prior to participating in the study. Kinematic data was acquired using twelve Qualysis Proreflex motion tracking cameras operating at 120 Hz. Temporal information related to duration of the Circles was derived from the 3-D time-histories of the data collected. The velocity for the body’s center of mass and for the ankle centers were found using central differences. Angles between body segments were calculated based on the three-dimensional coordinate of the segments. For each set of Circles, seven were used for analysis (from the third to ninth Circle). Therefore, mean data for each variable was computed from the data of twenty one Circles (three sets of seven Circles). The data are compared between Cross-Circles and Side-Circles. The repeated measures $t$-test was used to compare the mean data of the four subjects’ Cross-Circles to their Side-Circles. Within each subject, an independent $t$-test was used to compare the mean data of his twenty-one Cross-Circles to his Side-Circles. The statistical significance was set at $p < 0.05$.

RESULTS

The data for the Side-Circles in this study agreed with results from previous research (Fujihara and Fuchimoto, 2006). In the horizontal plane, the center of mass rotates elliptically, with the major axis parallel to the way in which the gymnasts faced. In general,
Cross-Circles involved similar horizontal movement of the center of mass. Regarding the vertical movement of the center of mass, however, they were different from each other. The center of mass reached the lowest position in the double-hand rear support during Side-Circles, although it dropped in the double-hand front support during Cross-Circles (Fig. 3). While average velocity of the center of mass in the front support was significantly greater than that in the rear support during Cross-Circles (0.48 ± 0.08 m/s vs. 0.38 ± 0.06, \( t = 4.6, p < 0.05 \)), it was significantly less in the front support than in the rear support during Side-Circles (0.28 ± 0.07 m/s vs. 0.39 ± 0.03, \( t = 3.9, p < 0.05 \)).

The duration of a single Side-Circle (0.95 ± 0.02 s) was significantly longer than that of a single Cross-Circle (0.92 ± 0.03 s, \( t = 3.2, p < 0.05 \)). Also, Cross-Circles had the shorter duration for the double-hand rear support phase than Side-Circles (0.15 ± 0.02 s, 0.18 ± 0.03 s, \( t = 4.2, p < 0.05 \)). When gymnasts performed Cross-Circles, they placed their hands closer to each other (0.32 m in the front support, 0.34 m in the rear support) than when they did Side-Circles (0.52 ± 0.00 m in the front support, 0.53 ± 0.01 m in the rear support). All gymnasts tended to bend their hip (omphalion - center of hips - center of knees) more in the double-hand rear support of Cross-Circles (150 ± 8°) than in Side-Circles (159 ± 6°, \( t = 4.4, p < 0.05 \)). Their lower trunk (xiphion - omphalion - center of hips) had greater angles in the same phase as well (166 ± 5°, 170 ± 4°, \( t = 4.4, p < 0.05 \)).

**DISCUSSION**

To avoid collision with a pommel horse during Cross-Circles, gymnasts must raise their body high in the rear support (Fig. 3). High rear support position with narrow hands-distance requires excellent shoulder flexibility.

In fact, the results of this study showed that a gymnast tended to bend their body more in the rear support during Cross-Circles than during Side-Circles, in which there was no obstacle in the rear support position. This difficulty in maintaining shoulder hyper-extension along with hip extension in the rear support may also result in the shorter rear support durations. The fact that the center of mass moved faster in the lower side—the front support during Cross-Circles and the rear support during Side-Circles—implied that gymnasts took advantage of gravity to accelerate their Circles. According to Fujihara and Fuchimoto (2006), the vertical movement of the center of mass corresponded to the vertical component of the reaction force. Therefore, it was suggested that gymnasts exert their force on a pommel horse differently according to the orientation of the pommel horse on which they are so that they can avoid collision with the pommel horse and utilize gravity to preserve the rotation of the center of mass.

**REFERENCES**
