REVERSE HECHT (TKACHEV) ON THE HORIZONTAL BAR : A CASE STUDY

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Success in high level gymnastics competition to date depends heavily on the ability of gymnasts to demonstrate the elements of risk, originality and virtuosity in their routines. Gymnasts, in order to win, are expected to perform the most difficult of the existing skills, to invent new ones and execute them with the greatest amplitude and form. As a result, a plethora of new skills has been invented for all apparatuses. On the horizontal bar and uneven bars a variety of new airborne movements has been developed, a fact that increased the danger of failure and/or injury manyfold.

Traditionally gymnasts invent new techniques which in turn may be the focus of research. The Reverse Hecht (Fig.1) on the horizontal bar is an exception. It was proposed first by the biomechanist Smolevskij (1969) before it was performed by Tkachev in 1975. Longer after its first execution, the skill is still spectacular, hard to master and considered of high difficulty.

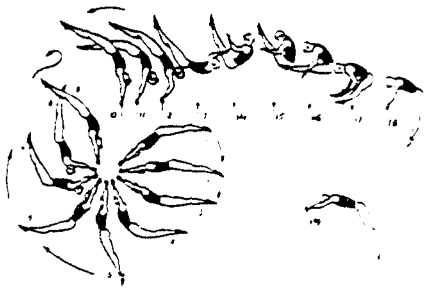

Figure 1: Reverse Hecht as proposed by Smolevskij

To this day, experimental data on the movement is non-existent. It was, thus, the purpose of this project to investigate the mechanics of the skill and to explain, on a case basis, the reasons of its success or failure.

METHODS

The horizontal bar optional routines performed by junior elite athletes during a 1990 USA-Mexico (junior) gymnastics meet were videotaped utilizing a NAC 400 video recording system (set at 200 fps) and a Panasonic PV-330 60Hz video camera. A cube of known dimensions, placed underneath the horizontal bar, four points of which were also marked, was videotaped at the conclusion of the meet for calibration purposes. One successful Reverse Hecht, performed by two different gymnasts, was digitized utilizing an Ariel Performance Analysis System. Three-dimensional coordinates of 12 body points modeling the human body as a 12 rigid link system were calculated by combining the video images of the two cameras, utilizing the direct linear transformation (DLT) method (Abdel-Aziz & Karara, 1971).

The raw data was digitally smoothed with a cut-off frequency of 5 Hz before being submitted to further analysis. Dempster's (1955) data as presented by Plagenhoef (1971) was utilized to predict the segmental and total body anthropometric parameters necessary to solve the mechanical equations.

RESULTS

For this study, the coordinates of the 12 body points were calculated by considering the X axis in the anterioposterior direction, the Y in the vertical and the Z in the mediolateral. Figure 2 presents stick figure sequences of the two analyzed performances as well as the trajectory path of each subject's center of mass (CM) as viewed from the Z (transverse) axis.

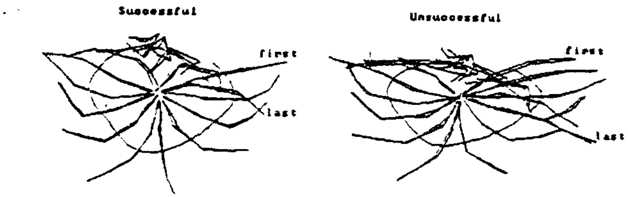

Figure 2: Stick figure sequences and center of mass trajectories of the two analyzed trials.

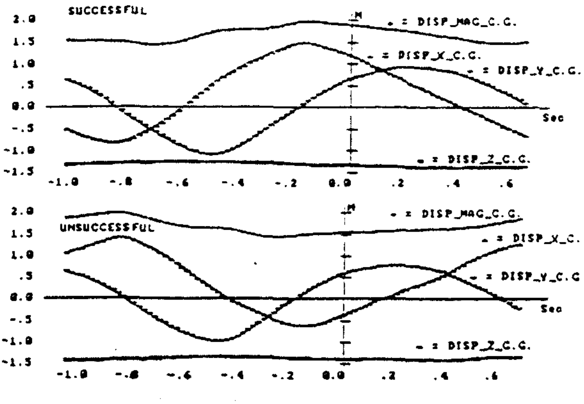

Figure 3: Center of mass displacement from the tip of the horizontal bar.

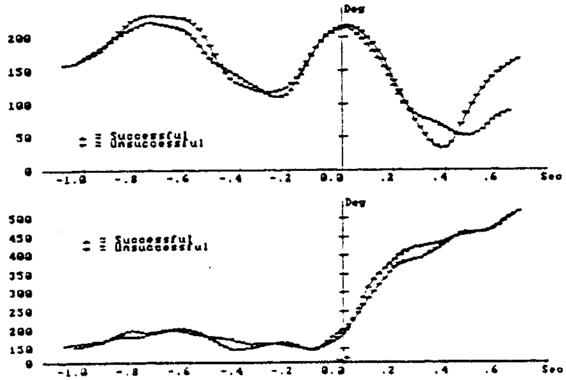

Figure 4: Hip (top) and shoulder (bottom) joint intersegmental angles.

Although the figure indicates CW rotation for both trials, it should be mentioned that the stick figures of the successful trial have been rotated 180 degrees about the vertical (Y) axis to facilitate visual comparions; the reader should keep this in mind when the remaining results are examined. Notice in the figure the different "shapes" of the CM trajectories with the trajectory of the successful trial being more circular and the trajectory of the unsuccessful being flatter at the top portion.

Figure 3 presents CM displacement from the (end of the) horizontal bar. Since the net motion of both gymnasts in the Z direction is negligible, only XY parameters are reported in subsequent results. Figure 4 shows no substantial differences in the patterns of hip and shoulder joints intersegmental angles. Similar patterns between all velocity components of the CM are revealed in Figure 5. Table 1 presents selective kinematic parameters at the moment of release.

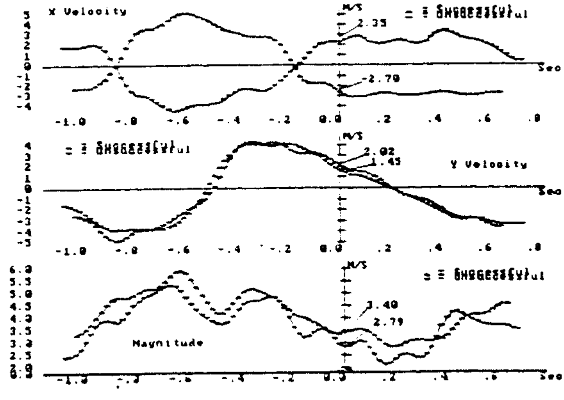

Figure 5: Linear velocity of the center of mass.

The data reveals substantially higher CM velocities for the sucessful RH as well as substantially earlier release of the bar.

TABLE 1
Selective Kinematic Parameters of the Reverse Hecht at the Point of Release

	Successful	Unsuccessful
Shoulder Joint Angle (deg)	201.9	189.0
Hip Joint Angle (deg)	214.6	216.2
CM Vertical Displacement (m)	.656	.598
CM Horizontal Displacement (m)	1.207	-.358
CM Vertical Velocity (m/sec)	2.657	2.330
CM Horizontal Velocity (m/sec)	2.061	1.606
CM Velocity (magnitude) (m/sec)	3.385	2.832
CM Velocity (maximum) (m/sec)	5.930	5.326
CM Angle to Horizontal (deg)	29	59

Newtonian mechanics show that the trajectory path of a projectile's CM is pre-determined at the moment of release , with angle, relative height and release velocity being the physical quantities governing its motion. Re-grasping of the bar, of course, could be achieved by numerous combinations of the three parameters involved. And although the airborne gymnast cannot alter the motion of his CM he can create a different "reach" and possibly re-grasp the bar by re-configuring the various body segments. Figure 4 shows insufficient compensation in body configuration of the unsuccesful trial which, when is coupled with the differences in the initial release conditions, might explain the different outcome.

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