THE KINEMATIC DYNAMIC STRUCTURE OF EFFECTIVE GIANT SWINGS BACKWARD PRIOR TO DIFFICULT DISMOUNTS AND FLIGHT ELEMENTS ON HORIZONTAL BAR AND UNEVEN BARS

Klaus Knoll
Institute for Applied Training Science, Leipzig, Germany

The purpose of this study was to investigate into the kinematic dynamic structure of dismount giant swings backward executed effectively on horizontal bar and uneven bars. The functional dependence of angular momentum, vertical velocity and reaction force of the bar and their relation with the beat leg swing were demonstrated. A double peak in the force curve with physically determined intervals of the maximums is typical. The position of the 1st maximum, the so-called hang, determines the kind of dismount (before or over the bar) and the effectiveness of leg swing. On the uneven bars, a too late hang is a frequent mistake. A leg swing with only a low degree of efficiency and a small height in the dismount result from this. The learning time for difficult dismounts and flight elements can be shortened by feedback about the 1st force maximum in the dismount giant swing.

KEY WORDS: high bar, uneven bars, dismount giant swings, bar force, angular momentum

INTRODUCTION: Giant swings prior to dismounts and flight elements are executed with a specific technique. In this context they are accelerated elements and only have approximately ¾ turn. These giant swings have the goal to supply a high amount on kinetic energy for the dismount or the flight element. That is the basis for a big flight height and for the required turns around the body axes.

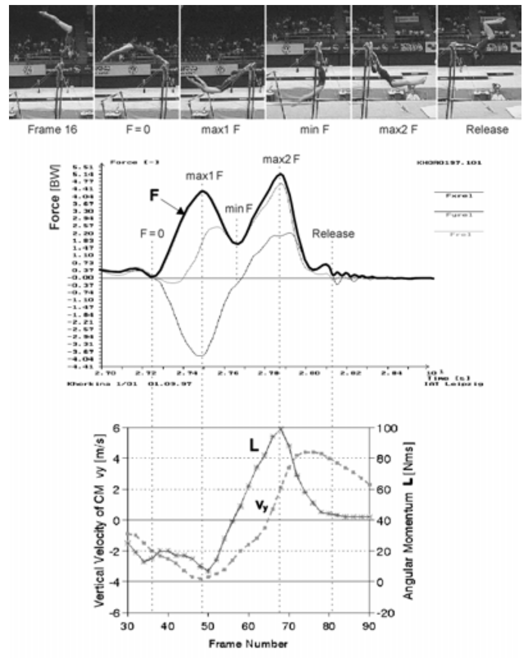
Elite male gymnasts and an increasing number of elite female gymnasts execute the dismount giant swings backward at the horizontal bar and uneven bars with a technique, that was created by the Chinese gymnast Tong Fei in the eighties. We call this technique Tong Fei Technique in accordance with the F.I.G. custom. Others use the terms *Power Technique* (Arampatzis & Brüggemann, 1999) or *Scooped Technique* (Yeadon, 1998). Khorkina executed her dismount giant swing as the first female gymnast with this technique in 1995.

Previous investigations for giant swings were above all concerned with energetic problems (for example Arampatzis & Brüggemann, 1999). In connection with force measurements only the maximum forces were interpreted (Kopp & Reid, 1980; Hay, Putnam & Wilson, 1979). We attempted to answer the question, which importance the force time structure has for an effective execution of the giant swing backward. Another important question dealt with the mechanical relationships during the upswing to the dismount or flight element. In what a way does the optimization of the rotation and translation parts become possible?

METHODS: Video recordings (50 f/s) and horizontal bar respectively uneven bars dynamometers (500 Hz) were used synchronously in order to collect kinematic and dynamic data during the 1994 and 1997 World Gymnastics Championships in Dortmund and Lausanne with confirmation of the F.I.G. The dynamometers, working with the principle of electric strain measurement, were installed to original gymnastic apparatuses with in co-operation with Spieth company (Knoll, Drenk & Krug, 1996). They were calibrated considering change of the gripping point on the bar, variable chain tension and stake position. The video recordings were analyzed with Drenk's (1994) 2D-photogrammetric procedure. Angular momentum (L) about the transversal axis, vertical velocity (v_y) of the center of mass (CM) and apparatus reaction forces (F) served as main parameters. The angular momentum was calculated with the procedure by Hay et al. (1977) and related to unified body height and body mass values.

RESULTS AND DISCUSSION: **(1)** During giant swings prior to dismounts and flight elements the angular momentum achieves a maximum of approximately 100 Nms after the vertical due to

the leg beat action (figure 1, lower graphs). The maximum angular momentum of the giant swing ($\max L_{GS}$) is always bigger than the salto angular momentum (L_S): $\max L_{GS} > L_S$.
This biomechanical mechanism is valid in artistic gymnastics for all preparing elements (PE) prior to dismounts and flight elements on horizontal bar and uneven bars but also on parallel bars, floor, vault and rings. It includes the known reduction of the angular momentum of preparing elements in upswing (hang apparatuses as horizontal bar or uneven bars), push-off (vault) or take-off (floor, balance beam) to dismounts and flight elements (compare Knoll, 1993; 1995). It is generally valid: $L_S / L_{PE} < 1$



Fedorchenko (KAZ), WC'97, double salto bwd. stretched with 3 turns

Khorkina (RUS), WC'97, Tsukahara tucked

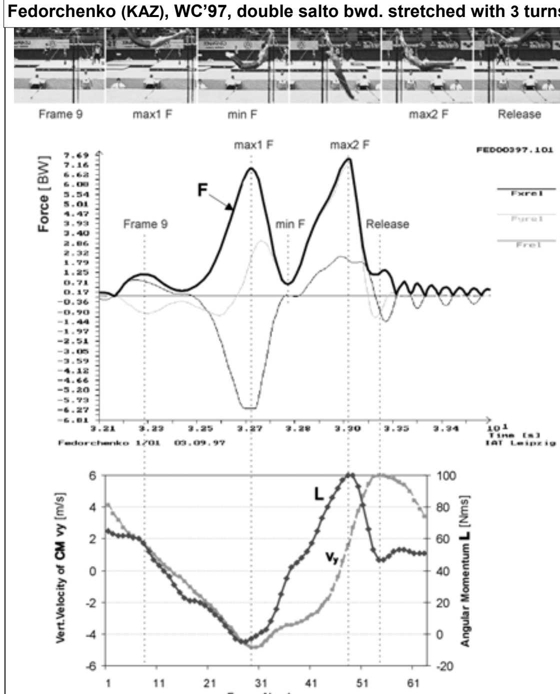


Figure 1 - Giant swing prior to dismount on horizontal bar and uneven bars – kinegram, bar force, angular momentum and vertical velocity of CM.

A transformation of translation into rotary motion occurs in further upswing. The angular momentum is reduced and the vertical velocity increases (figure 1). In addition the height of release is increased. That is an important sequence of events during the upswing. Therefore the take-off does not occur at the moment of the maximum angular momentum respectively the maximum angular velocity, as one would expect. This is due to the fact that the vertical velocity is still too small. The result would be a too small flight height. In this short movement section from maximum angular momentum up to release, essential control movements occur for the

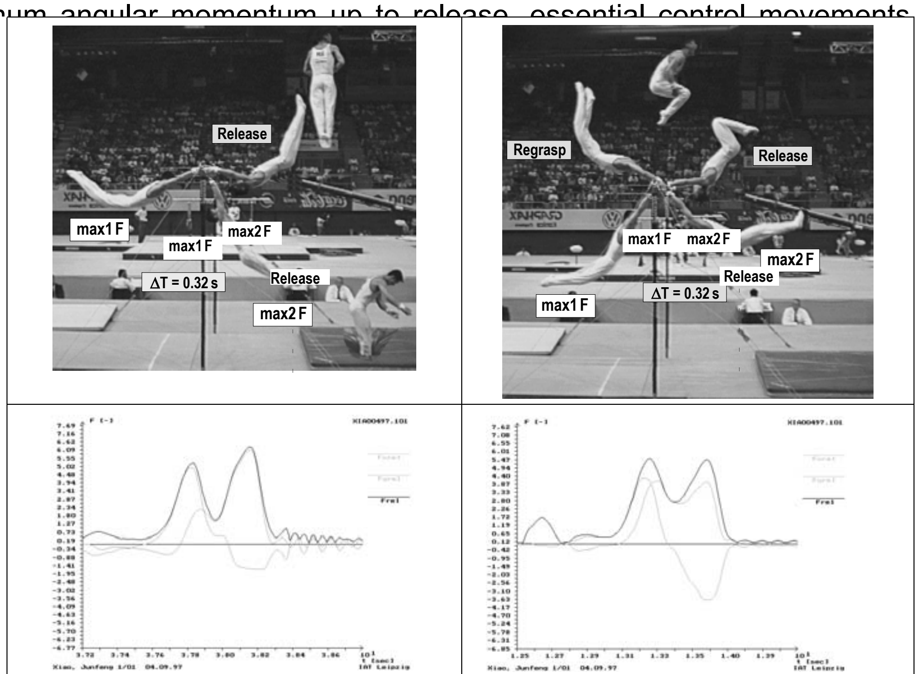


Figure 2 - Hang positions (force maxima) during giant swing prior to Tsukahara and Kovacs (Xiao Junfeng (CHN), WC'97).

gymnasts perform closer to the natural period. The force maxima are about one time body weight (BW) bigger in the case of the Tong Fei technique. A greater energy storage in the gymnastic apparatus means that the gymnast can use this for the dismount (Arampatzis & Brüggemann, 1999). **(3)** Considering the preceding giant swings on the horizontal bar for dismounts and flight elements we found different spatial positions of the force maxima when these elements were performed before resp. over the bar. During giant swings prior to Kovacs and Hoffmann the double peak appears later compared to a giant swing prior to Tsukahara (see figure 2). However, this fact does not alter the fact that the temporal distance of the force maximums corresponds to the vibration period – an effective sports technique presupposed. **(4)** Preparation giant swing plays a role in learning difficult dismounts and flight elements. At the horizontal bar the position of the double peak of reaction force is not stable at the beginning of the learning process. The time difference between the force maxima does correspond approximately with the vibration period, but the spatial position of the maxima is not correct. For safety, the gymnast executes the 1st force maximum, the hang, too soon preceding the Tsukahara and too late before the Kovacs. With a computer-aided measuring unit, equipped with video and apparatus dynamometer (Knoll, 1999), information was given about the 1st force maximum in training. With this feedback we shortened the learning time. **(5)** At the uneven bars, many female gymnasts perform the hang late. After passing the lower bar the active

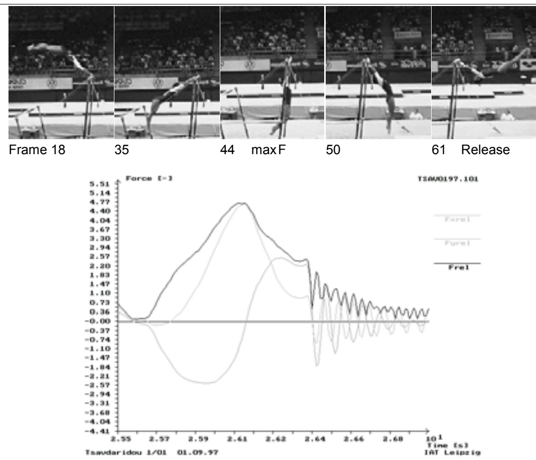


Figure 3 - Giant swing prior to dismount on uneven bars – kinegram and bar force with only a force maximum.

stretching into the arched posture is missing. Often there is only a single force maximum close to the vertical and it is hardly possible to execute a beat leg swing (see Figure 3). The angular momentum cannot be increased.

CONCLUSIONS: The two peak reaction force indicates an effective leg swing generating a high amount of kinetic energy. The precondition to form the two peaks of the reaction force is the generation of the 1st force maximum by turning actively into the arched posture. A condition for it is the preceding "scooped" upswing with passing of the perpendicular in slightly bent posture. At the horizontal bar, the extreme Tong Fei skill (strong flexion in shoulder and hip joint) does not need to be applied. Technical solutions with harmonious over-swinging the handstand position and greater joint angles are possible. At the uneven bars, the Tong Fei skill is useful especially for taller female gymnasts. For faster dismount giant swings the hang has to be performed earlier, i. e. the 1st force maximum must be reached earlier. That is necessary because the sector between the 1st and 2nd maximum is passed in a shorter time due to the fixed position of the 2nd maximum. For dismount giant swings forward the same functional relationships (double peak) apply. The anatomical conditions (joint barrier in the shoulder joint) limit the effects.

REFERENCES:

Arampatzis, A. & Brüggemann, G.-P. (1999). Der Einfluß des Energie-Austausches zwischen Athleten und elastischen Widerlagern auf die sportliche Leistung – am Beispiel der Riesen-felgen vor Abgängen am Reck und am Stufenbarren. *Sportwissenschaft* 29(2), 216-228. Schorndorf, Germany.

Drenk, V. (1994). Photogrammetric Evaluation Procedure for Pannable and Tiltable Cameras of Variable Focus Length. In *Proceedings of the 12th International Symposium on Biomechanics in Sports* (pp. 27-30). Budapest-Siofok.

Hay, J.G., Putnam, C.A. & Wilson, B.D. (1979). Forces exerted during exercises on the uneven bars. *Med. Science Sports*, 11(2), 123-130.

Hay, J., Wilson, B., Dapena, J. & Woodworth, G. (1977). A computation of technique to determine the angular momentum of a human body. *Journal Biomechanics*, 10, 269-277.

Knoll, K. (1993). Zum biomechanischen Wirkungsmechanismus von Flugelementen aus vorbereitenden Bewegungen und Ableitungen für die Technik von Rondat und Flick-Flack am Boden. In G.-P. BRÜGGEMANN & J.K. RÜHL (Eds.), *Biomechanics in Gymnastics. Conference Proceedings* (pp. 115-126). Köln: Sport und Buch Strauss.

Knoll, K. (1999). Entwicklung von biomechanischen Messplätzen und Optimierung der Sport-technik im Kunstturnen (Development of Biomechanical Measuring Units and Optimization of the Sports Technique in Artistic Gymnastics). Köln: Sport und Buch Strauß.

Knoll, K., Drenk, V. & Krug, J. (1996). Dynamometric measuring procedures for horizontal bar and uneven bars. In J.M.C.S. Abrantes (Ed.), *Proceedings of the 14th International Symposium on Biomechanics in Sports* (pp. 177-180). Funchal, Madeira, Portugal.

Kopp, P.M. & Reid, J.G. (1980). A force and torque analysis of giant swings on the horizontal bar. Canadian *Journal Applied Sport Science.*, 5(2), 98-102.

Yeadon, F.R. (1998). Computer Simulation in Sports Biomechanics. In H. Riehle & M. Vieten (Eds.), *Proceedings I of the 16th International Symposium on Biomechanics in Sports* (pp. 309-318). Konstanz, Germany.