MOTOR LEARNING AND MUSCULAR REQUESTS FOR RAPID AIR-BORNE ROTATIONS OF ATHLETES

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INTRODUCTION

Air-borne human rotational movements represent a complicated problem of theoretical mechanics. Many studies have been presented during the recent years by Yeadon (1984,1993) and Hildebrand (1985) and other authors to gain new knowledge on mechanic principles. In these studies the athlete was considered to be a multi-link system of rigid bodies. Besides these studies there is a variety of publications on general physiological phenomena during human rotational movements. It is interesting to know that there is until now no publication on motor learning and muscular requests for rapid air-borne rotations of athletes.

METHODS

The research design is made up of state-of-the-art analyses in figure skating, trampolining, diving and gymnastics to determine recent performance limits, biomechanical studies including 3D-analyses and electromyographic procedures as well as training-scientific studies (specific measuring devices for biomechanical and EEG studies). The myoelectric activities were recorded during several trials with surface electrodes and a frequency of 500 Hz (NORAXON, MYO 2000). The beginning and the end as well as the integral of activity of all muscles were obtained from the rectified EMG-signal.

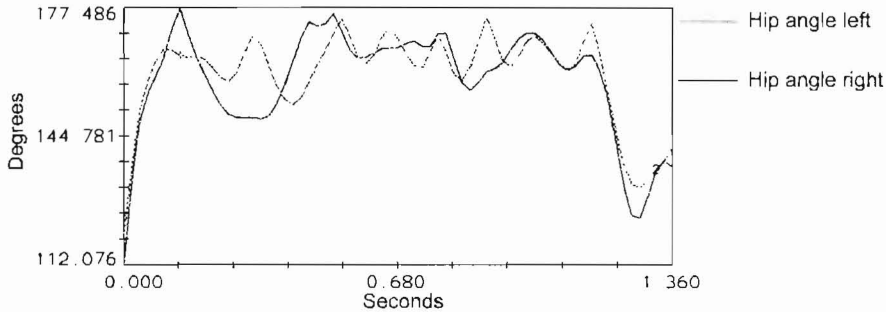
RESULTS

In analyses of different rotational movements of international top athletes in the sports mentioned above we found high angular velocities in different disciplines (table 1).

Table 1: Angular velocities (deg/s) in different disciplines

	Transversal axis	Longitudinal axis	Twisting Somersaults (Longitudinal axis)
Diving	1300 3 1/2 salto fwd		1385 1 1/2 bwd with 4 1/2 twist
Gymnastics	1200 double salto vaulting horse		
Figure skating		1800 quadruple toeloop	
Sport acrobatics			1500 4 time twist

The calculation of the angular velocity relating to the longitudinal and transversal body axis is an approximate value. It would be more exact calculating the angular velocity relating to the principal axes. These velocity values prove extremely high requests for the information processing systems of movement co-ordination. Figure 1 shows the analysis with peak performance of a 4 time twist in sport acrobatics. The curve of the hip angle and the torsion angle between the shoulder and the pelvis illustrate the hula-movement during the twist.



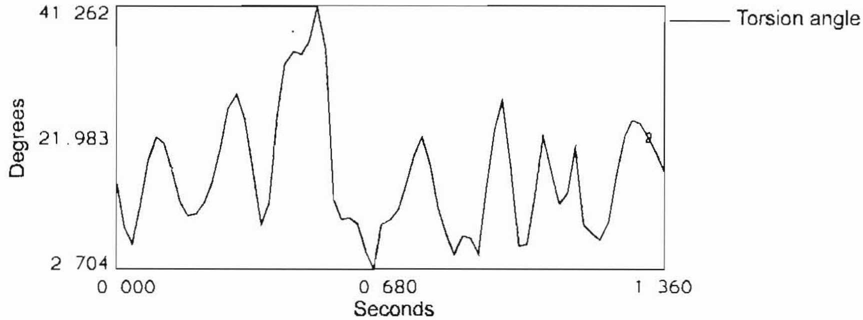


Figure 1: Hip angle and torsion angle between the shoulder and the pelvis during a 4 time twist.

Athlets performed different methodical exercises and jumps in figure skating, diving and gymnastics. During these exercises electro-myographical studies of 12 relevant muscles of the trunk and neck were conducted as well as 3D-analyses.The results were linked and co-ordination patterns were compared. The rotation exercise on one ring is similar to hula-movement in a twisting somersault (figure 2).

The comparison shows different muscular activities during twisting somersaults in diving and gymnastics and jumps with rapid rotations in figure skating. Figure 3 illustrades a special rotation exercise of the hula-movement on one ring. Activation waves of trunk muscles prove cycles of the recruited muscles with a frequency ranging from 3 to 4 Hz (depending on angular velocity in rotational movements on the longitudinal axis). Here obviously movement automation occur since interviews with athletes on what they are focusing on in orientation during movement regulation only produced a few and simple „control impulses". Using EEG procedures we could verify that active movement imagery or movement performance imagery is an important part of learning complicated air-borne rotations.

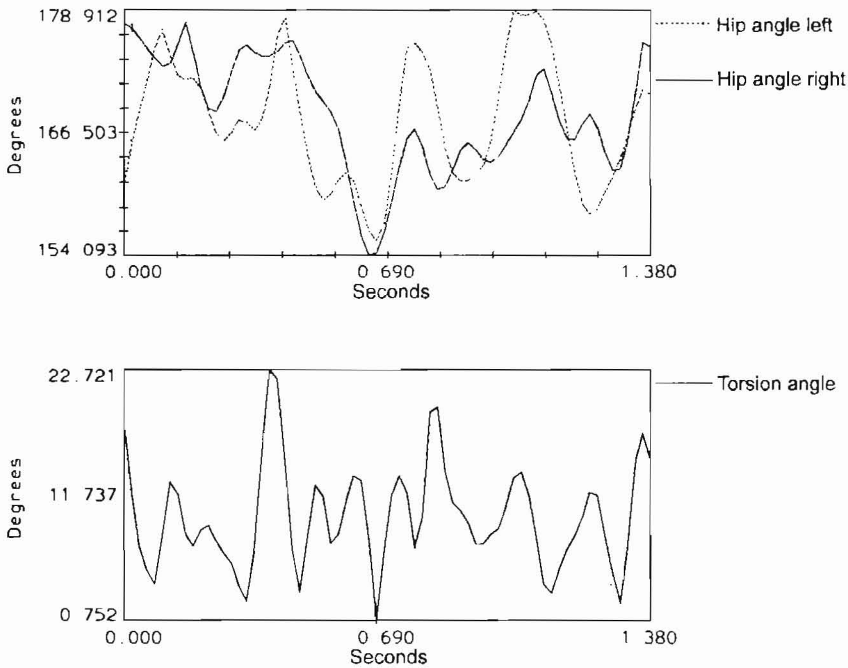


Figure 2: Hip angle and torsion angle between the shoulder and the pelvis on one ring.

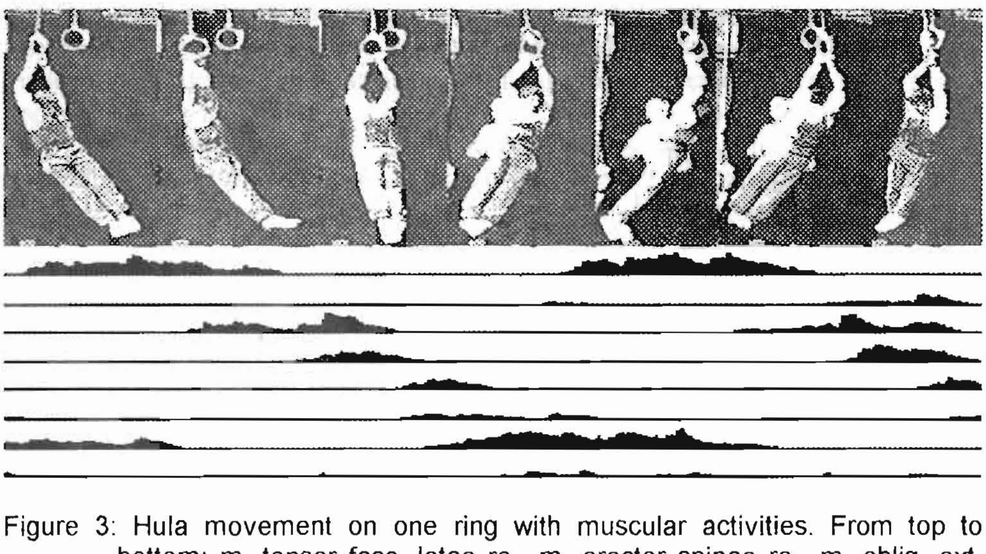


Figure 3: Hula movement on one ring with muscular activities. From top to bottom: m. tensor fasc. latae re., m. erector spinae re., m. obliq. ext. abd. re., m. rectus abd. re., m. rectus abd. le., m. obliquus ext. abd. le., m. erector spinae le., m. tensor fasc. latae le.

CONCLUSIONS

Rapid air-borne rotations of athletes are not only a scientific problem of description of a multi-link system of rigid bodies. These movements are also a problem of physiological phenomena and motor learning.

Consequently the stability of rapid air-borne rotations of athletes is an interesting scientific field (Nigg 1974, Krug 1983, Yeadon 1984, 1993). Special rotation exercises in training sessions with many repetitions prove that the investigations have to continue with neurophysiological topics (Kelso-movement) and non-rigid body models (Lapunow-Exponents).

The learning of rapid rotations with special methods for a better adaption will make a velocity's increase during rapid air-borne rotations possible in the near future.

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