ANALYSIS OF ACROBATIC TUMBLING EXERCISES ON FLOOR AND BALANCE BEAM

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INTRODUCTION

Acrobatic tumbling exercises on floor and balance beam belong to the movement structures which are decisive for performance. The development in floor and balance beam gymnastics is characterised by a permanent increase in degree of difficulty of the acrobatic tumbling combinations and elements. Most of the complicated tumbling combinations are performed backwards. The reason for it are the advantageous anatomic conditions for the backward take-off. the most complicated somersaults variants are mostly performed following preparing elements as rondat and flic-flac. To perform the complicated somersaults on the floor as well as on the balance beam a big amount of kinetic energy has to be supplied by the preceding elements. The conditions for the performance of tumbling combinations on the balance beam are disadvantageous:

- length of the balance beam 5 m
- width of the balance beam 10 cm
- low elasticity.

The sports technical solutions for this energy production as well as for the take-off for both apparatuses are analysed. Differences between the two apparatuses are illustrated.

METHODS

The comparative studies were done as case study with the example of the tumbling set rondat, flic-flac, double somersault tucked res. Tsukahara. The exercise was performed by female and male gymnasts on the floor and by female gymnasts on the balance beam. Using 2D and 3D procedures to process images, combined with algorithms which have been developed at our Institute video recordings (50 f/s) of the individual Gymnastics World Championships 1994 in Brisbane and World Team Championships in gymnastics 1994 in Dortmund were analysed.

The body was separated into 10 segments. Kinetic energy, angular momentum on the transversal axis, horizontal speed of the centre of gravity and flight height served as main parameters. The calculation of the energy is an approximate procedure without the relative movement of the segments. To gain parameters which can be compared energy and angular momentum were related to unified values concerning bodyheight and bodyweight.

RESULTS

During take-off for the somersault succeeding the preparing combination rondat and flic-flac the initial angular momentum L_0 is reduced to a smaller somersault angular momentum L (compare figure 1):

$$L/L_0 < 1$$

This was sufficiently studied on the floor (Knoll 1981, Brüggemann 1983).

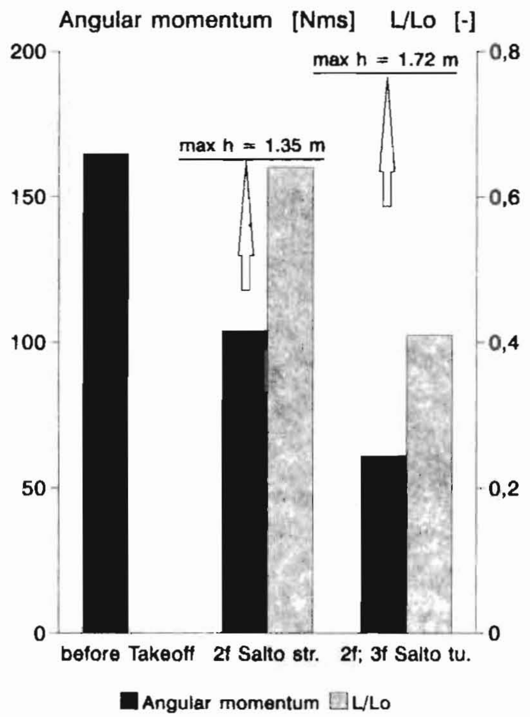

Figure 1: Angular momentum, relation between angular momentums L/Lo and driving height h in somersaults on floor

The studies on balance beam proved this biomechanical effect. But there is the peculiarity that the reduction of the angular momentum in tucked double somersaults is smaller than on the floor. Consequently the somersault take-off on the balance beam is less set against. The reduction is similar to a stretched double somersault on the floor: $L/L_0 \approx 0.6$. Thus we found bigger driving heights h on the floor (h: difference of the centre of gravity between take-off and peak value of the air-borne movement):

	max. h [m]
balance beam	0.75
floor	1.72 (1.35)

Kinetic energy permanently increases during acrobatic tumbling exercises. Before take-off for a complicated somersault variant it accounts to approx. 1500 Nm (compare figure 2). It is quite similar for male and female gymnasts. The fact that male gymnasts perform bigger driving heights is due to bigger strength abilities. On balance beam a significantly smaller kinetic energy was found. Before take-off for a somersault it accounts to approx. 600 Nm (compare figure 3). This smaller amount of energy causes a somersault take-off with less set again effect and consequently this smaller driving height mentioned above.
Energy can be produced during supporting phase of the feet and the hands in the flic-flac.

CONCLUSIONS

The same biomechanical mechanisms - the reduction of the angular momentum in the somersault take-off when the somersault is preceded by rondat, flic-flac act on the floor and the balance.

On the balance beam the acrobatic tumbling combination rondat, flic-flac, somersault variant only produces about 40 % of the kinetic energy compared with the floor. Thus the angular momentum provided by the somersault and the driving height are smaller than on the floor.

The degree of difficulty on the balance beam can therefore only be enhanced to a limited extend despite the almost identical flight time with the floor.

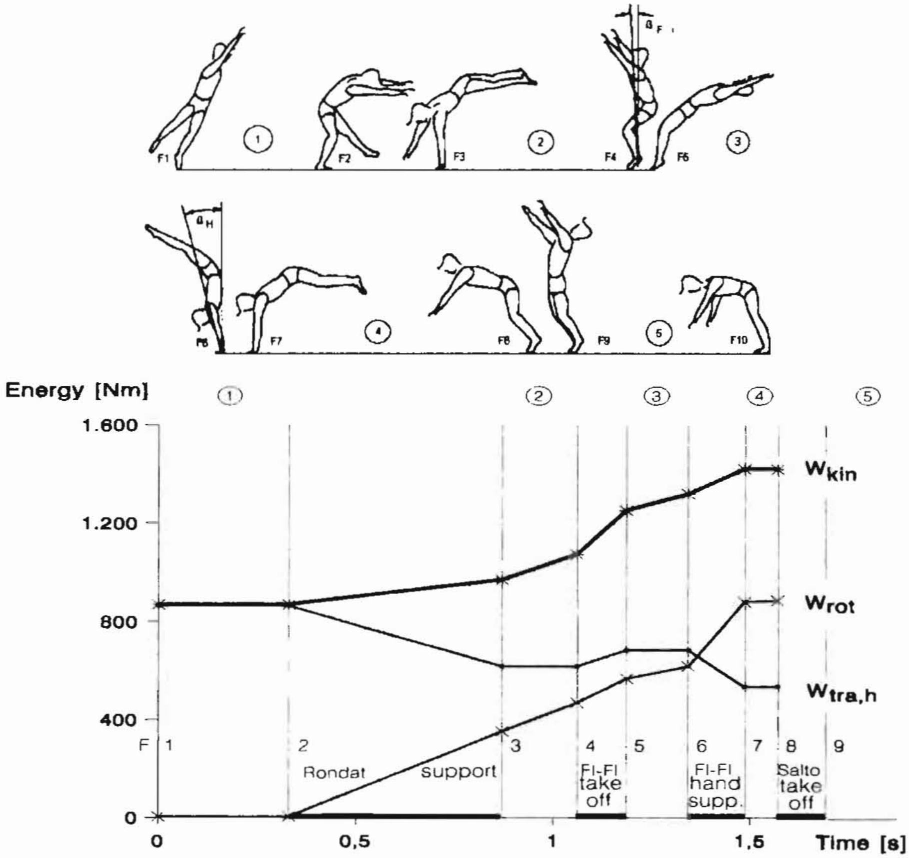

Figure 2: Schematic representation of energy during acrobatic series (W_{kin} - kinetic energy; W_{rot} - rotational energy; $W_{tra,h}$ - horizontal translational energy)

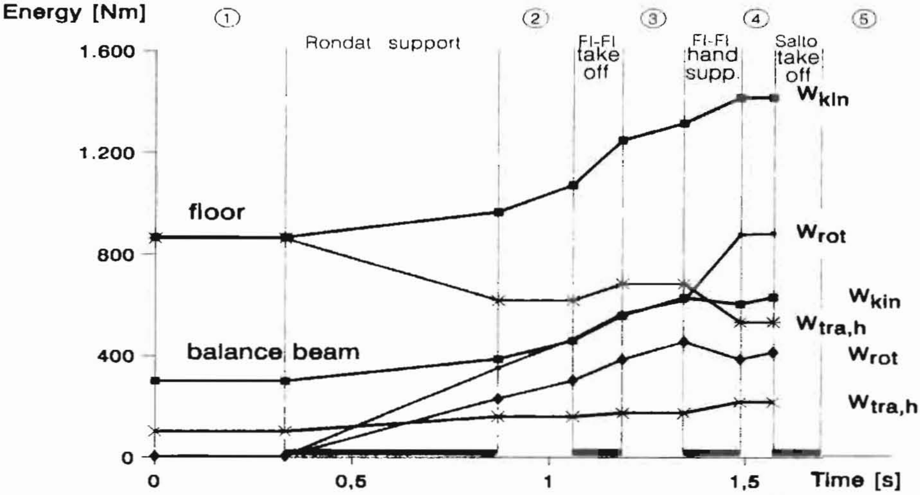

Figure 3: Energy comparision between acrobatic series on floor and beam

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