COMPUTER SIMULATION OF THE MOVEMENT OF BALANCE IN JUDO

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INTRODUCTION: Throwing techniques represent a substantial part during fighting as their effectiveness highly depends on the development of their technical level. Of course, breaking the opponents balance plays an outstanding role in the known phases of throwing. Therefore the Judoka must be able to perform explosively and powerfully the attacking moves from beginning to end of a fight. Regarding biomechanics, the parameter of stability and resulting from the amount of pull forces necessary to induce the balance losing are a quantity of great significance. Special care has to be given to this in technique training.

METHODS: The mechanical factors of the balance losing are presented in Figure 1.

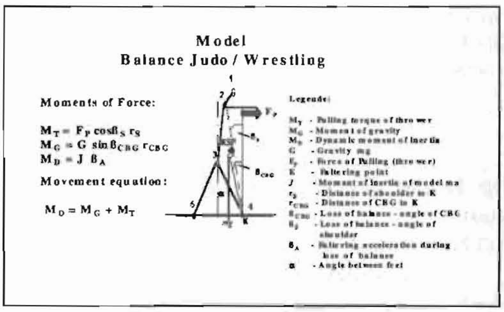

Figure 1 Simplified model of loss of balance as an effect of an outer force in forward direction (CBG – Centre of gravity) and measurement of pull force on a pulley machine (to see, Udo Quellmalz, Olympic Games Winner 1996).

For the simulation of balance losing under the influence of pull force, the analysis of the transferred forces against the opponent is necessary. For mathematical processing is necessary firstly a measure of pull force (see Figure 1). This supplies the base results, the variation intervals of the model parameters for a simulation and serves as a comparison of the simulation results to the modeled physical activity.

RESULTS AND DISCUSSION: Since 1978 more than 1000 measurements of national and international world top athletes (taken at central diagnostics of performance in training camps) were analysed, (e.g. of Loll, Silver 1988 Olympic Games; Quellmalz, Bronce 1992 and Gold 1996 Olympic Games; Stöhr, Silver 1988 Olympic Games). Example: Simulation results of the loss of balance-angle of the opponent under the impact of realistic pull forces by Stöhr (technique: harai-goshi). The necessary base of force values of the model opponent were chosen as follows (see table).
The angle position of centre of gravity (ßCBG) in starting position was calculated from these parameters. Main variation parameter or the simulation were the starting values CBG-velocities.

Mass of opponent	m_G	136 kg
Moment of inertia (model mass)	J	205 kgm
Loss of balance-angle shoulder	β_S	-24 degrees
Loss of balance-angle of CBG	β_{CBG}	-33 degrees
Distance CBG to K	r_{CBG}	1 m
Distance shoulder to K	r_S	1,62 m

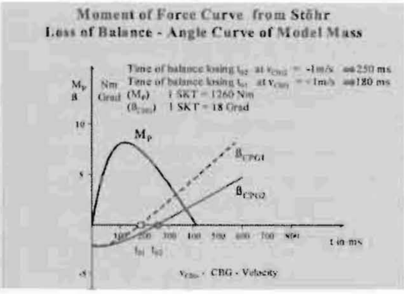

Figure 2 Angle of balance losing curve of CBG in dependence to the occurring force momentum MP and the CBG-velocity of the model opponent.

CONCLUSION: In summery it becomes clear that the following parameters only partly influence the loss of balance: Position of CBG of the opponent, height of the attacking force, mass of the opponent, CBG-angle and the thorax to faltering point, current CBG-velocity (Figure 1). The faltering movement is highly dependent on the intensity and duration (ca 600 ms) of the tractive force development in the arms. Reaction times for the mobilisation of maximal counter forces and therefore for the development of a stable defence are 400-800 ms.