PRESSURE DISTRIBUTION UNDER THE FOOT DURING TAKE-OFF IN TRAMPOLINING

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INTRODUCTION

Trampolining belongs to the most demanding sportive exercises with respect to the co-ordination. Within 10 different moves the gymnast has to perform as many somersaults and twists as possible without losing control and the precision of the movement performance. Nowadays a routine of an elite class gymnast contains more than 22 somersaults and 12 twists. After somewhat. more than 20 seconds he has finished.

In the past, biomechanical investigations in trampolining were mostly concerned with the. aerial movements, whereas the take-off was rarely in the focus of interest. One reason for this fact may be the fascination of the aerial moves, an other may be the difficulties in performing dynamic measurements.

The development of new pressure measurement devices with much better resolution encourages their use also in trampolining. At first two questions should be answered with the aid of this instrumentation:

1. Which differences in the pressure distribution occur between beginners and skilled gymnasts?
2. Are there any basic differences in the pressure distribution at take-off between exercises with and without moment of impulse?

METHOD

The pressure distribution was determined using F-SCAN (Vers. 1.22), a resistive based in-shoe measurement device. The flexible insole is 0.17mm thick and contains 960 sensors. The resolution of the insole is 4 sensors/cm. The sampling rate was 50Hz and the sampling time embraced 4s. The sole was cut to the necessary size and put in one gymnast shoe of the subject. The data transmission ensued via a cuff unit (m=300g) and a wire to a personal computer.

The experimental set-up was completed by video recordings to have qualitative information of the investigated movements. As subjects served 2 female beginners and 5 skilled gymnasts (1 female and 4 male).

The investigated movements included three categories of exercises: 1. straight jump, 2. backward somersaults (single up to double), 3. forward somersaults (single up to double). The gymnasts repeated each move at least three times to get an impression of the stability of the moves. Altogether about 130 trials were analysed.

RESULTS AND DISCUSSION

It is well known that trampolining leads to high impacts on the body during the stance phase. We found a maximum pressure of about 700 kPa and a resultant force of nearly 3000 N under one foot. This means about 7.5 times body weight. The shape of the resultant force is smooth and looks like a sine curve. This indicates the springy characteristic of a trampoline.

From physics lessons we know that an ideal spring has a constant oscillation period - the so called isochronism of a spring.

$$T = 2\pi\sqrt{\frac{m}{c}}$$

T = Time Period
m = Mass
c = Spring Constant

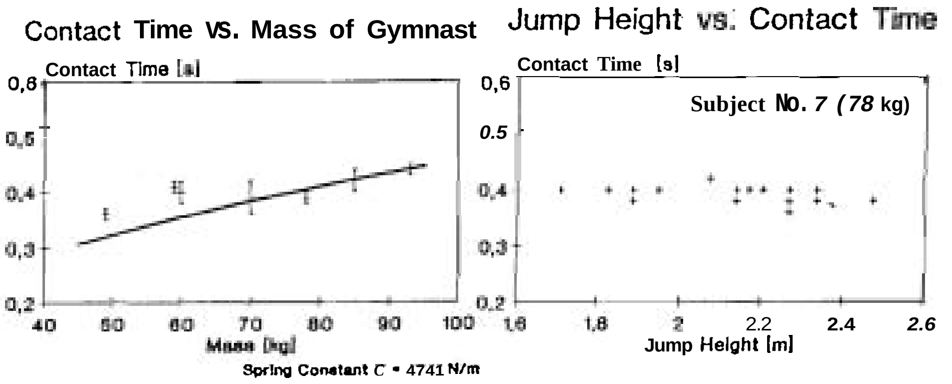

Fig.1: Relation between contact time and body mass (left). Independence of jump height and contact time (right).

The oscillation period depends only on the spring constant and the mass at the spring. In conclusion for trampolining the contact time should increase approximately with the square root of the mass of the gymnast. The results are in good agreement with the theory in a range from 70 - 95 kg. Greater differences occur for smaller masses when the neglected mass of the spring sheet gets more influence or the jump height is very different.

For one gymnast we got a nearly constant contact time in a range from 1.7 - 2.5m jump height. This means that the average load on the body increases almost linear with the jump height.

The evaluation of the pressure distribution during the stance phase makes it necessary to distinguish different regions of the foot. In agreement with CAVANAGH et al. (1987) the foot was divided into 3 regions - fore-, mid- and hindfoot. This division has be performed individually for each subject. The mean values were 36%, 33% and 31% (fore-, mid- and hindfoot) of foot length.

The history of the pressure distribution starts usually with a flat touch down of the foot. The centre of pressure lies in the midfoot region and remains there until midstance when the force reaches its maximum.

In the upward phase the centre of pressure moves towards the toes. The forefoot push off - the indicator for an active push off of the foot - was defined as the period when the centre of pressure lies in the forefoot region. This happens after about 70% of the contact time. Finally the take-off results from a push off from the toes. The centre of pressure passes near the great toe.

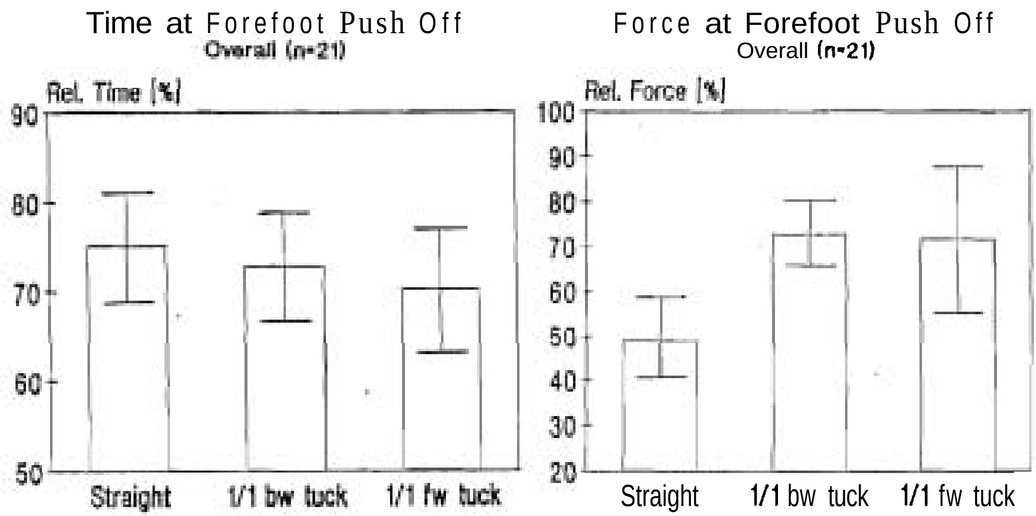

Fig.2: Time at beginning of forefoot push off (left). Force at beginning of forefoot push off (right).

Analysing the forefoot push off of different moves revealed almost the same starting time of little more than 70 % of the support time. The forces at this time reach about 70 % of the maximum force, except the straight jump where it is about 50 %]. It can be noticed that the variance of the forefoot push off of the single somersault is significantly greater than that of the other moves. The reason can be assumed in the bad command of this movement because - with exception of beginners - forward somersaults without twists are never performed in training or competition.

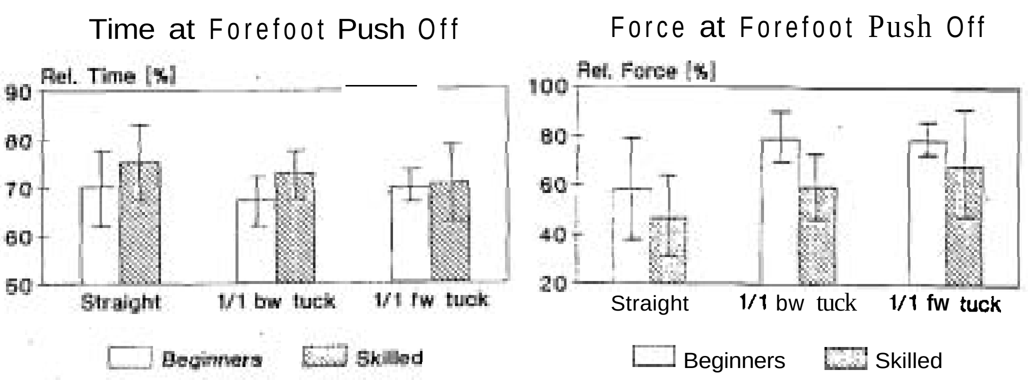

Fig.3: Time at beginning of forefoot push off (left). Force at beginning of forefoot push off (right).

The analysis of the beginners and skilled revealed no significant differences in the forefoot push off. Remarkable is only the smaller variance of the beginners' somersault forward. They have more training in this move than the skilled.

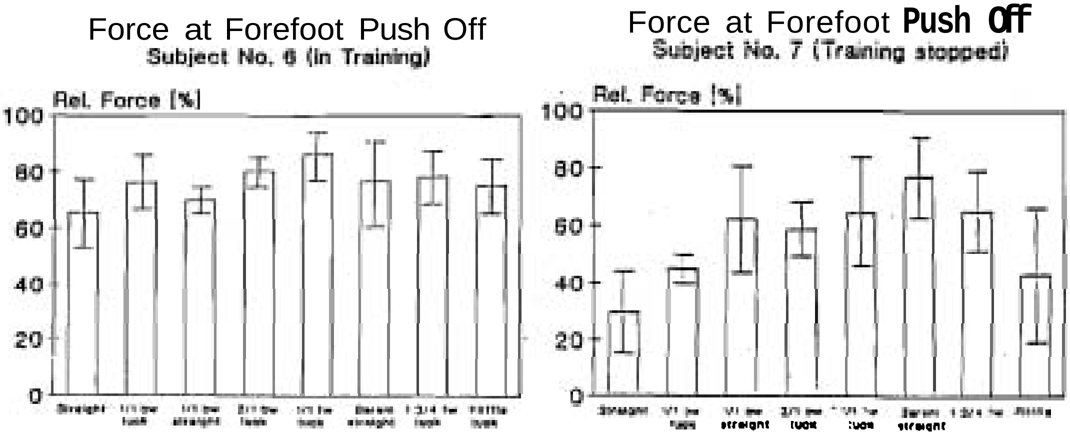

Fig.4: Jump profiles of two skilled subjects.

The comparison of the "jump profiles" of two skilled shows significant differences in the mean values of forelbot push off and in the variance. Subject No. 6 performs all moves with a similar push off and a small variance whereas No. 7, who had stopped training one year ago, produces greater variances and for each move individual push offs.

CONCLUSIONS

No general differences in the pressure distribution could be found between beginners and skilled subjects. For somersaults the forefoot push off starts alter about 70 % of support time and reaches about 70 % of maximum force. Except for the straight jump, it was not possible to distinguish the different somersaults (forward - backward) in terms of pressure distribution by the use of statistical methods. But the intraindividual analysis of the exercises showed a relation between the skill and the variance of the pressure distribution. It can be concluded that the dynamic of the foot contact always has the same characteristic. The moment of impulse is produced by the movements of the upper parts of the body.

REFERENCES

- Cavanagh, P.R., M.M. Rodgers, A. Iiboshi (1987): Pressure distribution under symptom-free feet during barefoot standing. In: Foot & Ankle, 7, No 5, pp. 262-276.