OPTIMUM SPORTS TECHNIQUE OF THE PUSH-OFF MOVEMENT IN DIFFICULT ARMSTAND DIVES

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INTRODUCTION: In 1994 important changes in diving regulations were decided upon. The International Federation FINA decided to abolish the limitation in the diving table and to introduce armstand dives with backward somersaults. Additionally it became possible to present new dives in a competition. These changes in the regulations caused an accelerated performance development in diving, especially with respect to armstand dives with backward somersaults. At present the most complicated dive of that category is the triple somersault backward piked (626 B) with a degree of difficulty of 3.5 presented by Liang Tian (China) in the four countries competition between the USA, China, Russia and Germany 1996 in Leipzig. During the 43rd International Diver's Day in Rostock armstand dives with half a twist were presented.
The energy for the somersault turn is produced by the pushing-off movement in the armstand. The lowest kinetic energy during take-off from the platform would be produced when the diver falls forward from the armstand position with extended body. By an adequate bending and stretching of body joints this minimum value is increased. The diving technique presented in actual competitions is not yet optimum. This is shown, for example, by a comparison with the pushing-off for the flic-flac in gymnastics.
The aim of the investigation was the analysis of actual pushing-off techniques and of possibilities to optimize them. An effective diving technique during the push-off produces a greater somersault angular momentum and makes even more complicated dives possible.

METHODS: For our study we analyzed the armstand dive with 3.5 somersaults backward tucked (626 C). Video recordings of the four-nations-meet 1996 in Leipzig between the USA, China, Russia and Germany were analyzed by Drenk (1994) with the 2D-photogrammetric analyzing procedure and by Hildebrand (1985) with the 3D-photogrammetric analyzing procedure. Additionally, the pushing-off phase was analyzed using a strength platform by Kistler which was attached to the edge of a soft foam pit (see Figure 1). The video recording was synchronized with the platform. We executed computer simulations with the Alaska (1993) simulation system using a seven-limb body model (Figure 2). To validate the simulation results we used i.a. the measured reaction forces.
Angular momentum about the transversal axis, flight height and joint torques served as main parameters. Angular momentum is related to unified body height and body mass values.

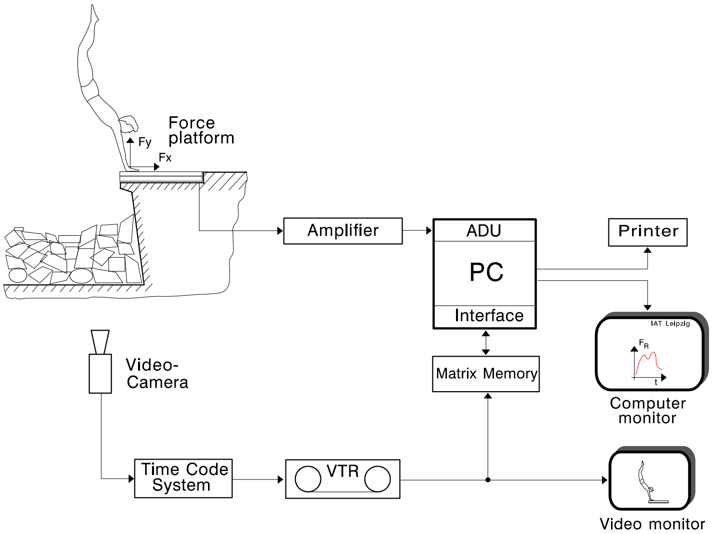

Fig. 1: Measuring system for armstand dives

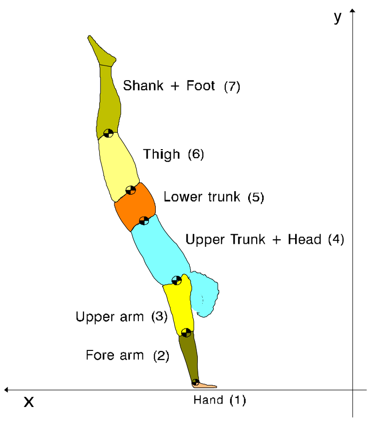

Fig. 2: Body model for computer simulation of push-off

RESULTS: The major biomechanical movement task in a take-off or push-off for a somersault in diving or in related sports such as artistic gymnastics, sports acrobatics or trampolining is an optimization of somersault angular momentum and driving height (Knoll 1993). The push-off in armstand dives is focused on a maximization of angular momentum. The driving height is only a little more than zero. The reason for that movement technique is the low strength abilities of the arms compared with the legs at take-off. The measured reaction forces hardly amount to the threefold of body weight (Figure 5).

The distinct bending and extension of the knee joints is typical for the actually performed diving technique in the push-off from the armstand for the backward somer-

Fig. 3: Kinegram of the pushing-off movement for 626 C

sault (compare Figure 3). Consequently the segments lower leg and foot produce the main share of angular momentum L (compare Figure 4).

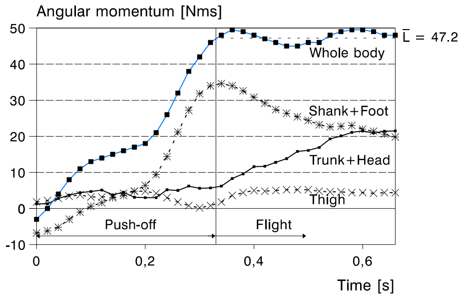

Fig. 4: Course of angular momentum for the body segments during push-off for 626 C

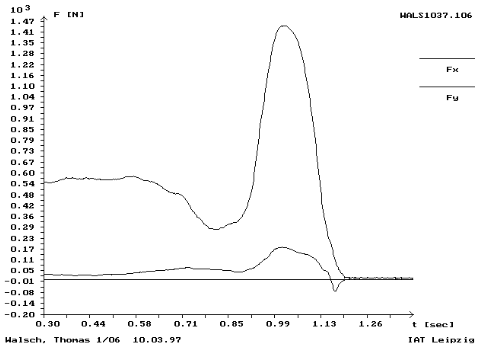

Fig. 5: Dynamogram of a push-off for a backward somersault into a soft foam pit

But in the near future it can be expected that referees will punish divers for knee bending with a lower point value. Therefore alternative diving techniques must be found. Using computer simulation the following variants were investigated with respect to their effect on angular momentum:

- extended knee
- more distinct bending of elbow
- better use of the arched body posture

The pushing-off technique of bending the elbow produces the greatest angular momentum, but requires the highest level of strength abilities, as can be seen in the joint torque.

CONCLUSIONS: The diving technique which is used at present for the pushing-off in armstand dives with multiple backward somersaults can be optimized in three directions:

1. longer forward falling with extended body (turning around the wrist),
2. making complete use of the accessible joint angle amplitude of lower back,
3. more distinct bending of the elbow.

Thus a greater angular momentum around the transversal axis is produced during take-off. The analyzed pushing-off techniques require a higher level of conditioning, especially the third solution with a more distinct bending of the elbow.
Using such a technique even more complicated armstand dives can be created and performed. For example, it becomes possible to integrate twists or to perform piked-extended somersaults.

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