KINEMATIC ANALYSIS OF SURFACE AND UNDERWATER FIN-SWIMMING.

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The aim of the study was to perform a comparative kinematic analysis of surface and underwater fin-swimming. Results of the experiments were obtained in terms of motion as well as maximum and minimum differences between the technique of surface and underwater fin-swimming.

KEY WORDS: biomechanics, motion analysis, fin swimming

INTRODUCTION: Surface and underwater diver swimming contain symmetrical and cyclical movements. Their technics are special but simple. The cause of the advancement is the movement of the fin (Fins,1995; Kerll and Karl-Meinz, 1989; Shuping,Li, 1989).
The aim of the study was to perform a comparative kinematic analysis of surface and underwater fin-swimming. According to our research, this kind of an investigation is relatively new and has not been carried out before in widely known international literature. Results of the experiments were obtained in terms of motion as well as maximum and minimum differences between the technique of surface and underwater fin-swimming. The experiments were further expanded and a new application of 'Phase Diagrams' was also used to successfully characterise the motion.

METHODS AND PROCEDURES: An Ariel Performance Analysis System (APAS) was used to obtain the data for this investigation. In short, the motion of the swimmers is filmed, each frame is tediously digitised and further processed to obtain the appropriate data for the body segments, joint angles etc. Fourteen male swimmers, persons of the Hungarian representative team and 1st class competitors, were taken for the recording, of which only three swimmers were digitised. The results of the two Hungarian champions have been documented. In a swimming pool three underwater cameras were placed. One on each side and one facing the swimmer. One over-water camera was also strategically placed on each side of the pool making it a total of five cameras to complete the video recording process. The extended 'Hanavan' model developed by Kocsis (1994) was used as a base body model for the investigation. The model was extended because of the use of added objects, such as fins, oxygen-tank and snorkel. 'Passive contrast markers' were attached to the subjects at 23 different points on the body, which can be seen under water. The sampling frequency was 50 frames/second. The data obtained from the APAS were further processed by the 'Motion Analysis System' developed by the Department of Applied Mechanics at Technical University of Budapest (Kocsis, 1998). With the help of this system, the kinematic data were determined, taking the effect of the oxygen-tank, carried by one of the swimmers, into consideration.

RESULTS: The knee was specifically chosen for our investigation, as this joint greatly contributes to the forward propulsion of the swimmer. An important part of the investigation is focused on the knee because of its complicated structure and non-conventional motion that causes most of its ligament injuries. Figure 1 and Figure 2 depict the motion of the underwater swimmer. These diagrams are very similar to the ones of the surface swimmer and hence we have not shown them in this short summary. The right knee angle, velocity and acceleration can be seen in the phase diagrams. Characteristic differences can be read from Figure 3, comparing the surface and underwater swimmers' motion of the knee, ankle and toe respectively. The surface of the water reduces the freedom of motion of the knee, which results in lower efficiency of that joint of the surface swimmer. This aspect coincides

with the opinion of experts and coaches. In Figure 4 and Figure 5 the hip and ankle can be seen to be moving in opposite phase to each other. The freedom of the knee is highly reduced in the case of the surface swimmer. The vertical velocity of the ankle (Figure 6), as compared to the horizontal velocity of the centre of gravity of the swimmer (Figure 7) shows that the horizontal velocity is greater when the fin moves upwards, than vice versa.

CONCLUSIONS: The position, velocity and angular kinematics of the two swimmers were extensively analysed. The comparison of the motion diagrams of the two swimmers as well as those of other athletes, gives us a new possibility to characterise their motion. According to our investigation the techniques of the surface and underwater swimmers are extremely different because of the effect of the surface of water. Diver swimmers perform 1500-2500 strokes with their fins during every training. Such a high number of cycles require optimal technical execution in the respect of velocity, work and power. We tried to answer some questions in connection with prevention or rehabilitation of injuries caused by the movement specialties and the training problems.

A very important part of the motive power comes from the movement of the thoracic - lumbar section of the trunk. The most working muscles are below the waist. The greatest motive power section is the result of the movement of limbs. The spine performs high inclinations, the thigh, shanks and feet perform high and quick near vertical movements. These movements represent very high loads for the spine and the joints of the limbs (hips, knees, ankles). The high loads in many cases result in injuries and pain at the waist area. On the basis of our investigation we can identify the main causes of the injuries and we can suggest solutions for preventing and rehabilitating them.

This analysis also helps us in characterising the swimmers in terms of their techniques and performance. Though only by obtaining more accurate data and more precise investigations can one draw conclusions and results in order to improve the athletes' performance.

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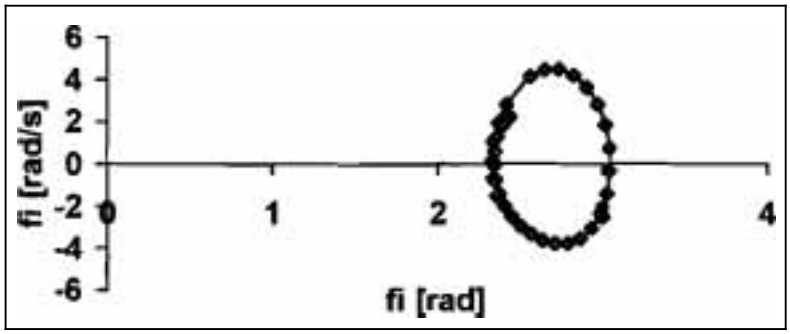

Figure1 -Angular velocity versus angle of the right knee

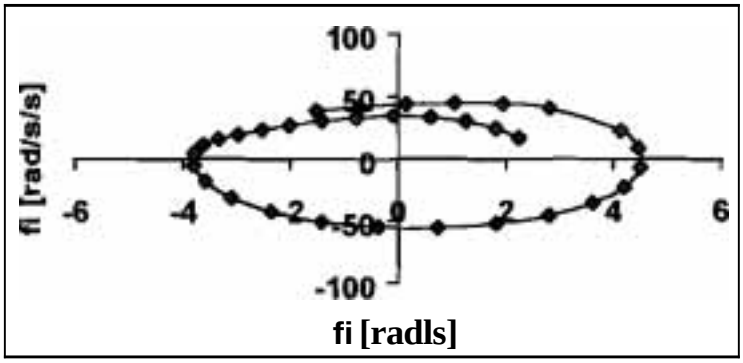

Figure 2 - Angular acceleration versus angular velocity of the right knee

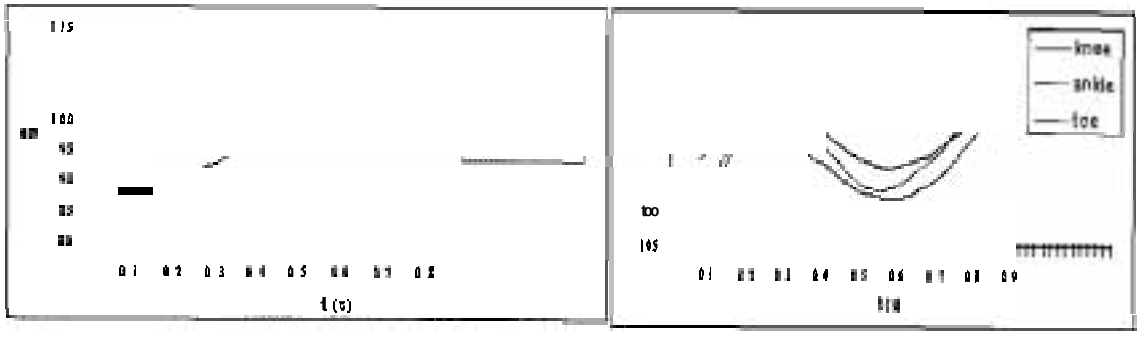

Figure 3 - Vertical displacement
(Surface swimmer with snorkel-left, Underwater swimmer with tank –right)

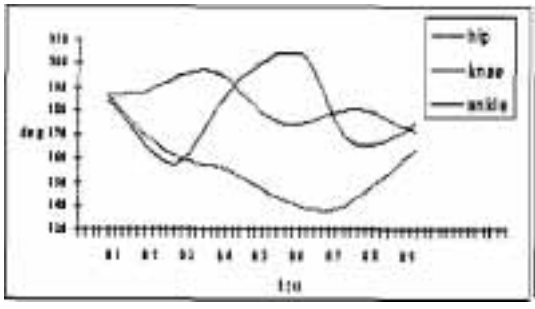

Figure 4 - Surface swimmer with snorkel

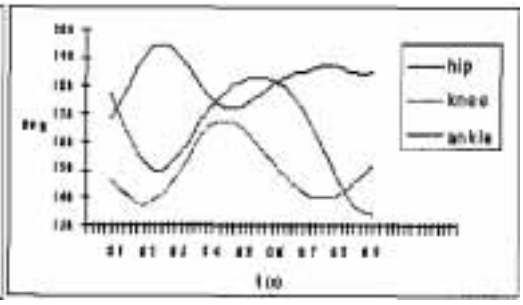

Figure 5 - Underwater swimmer with tank

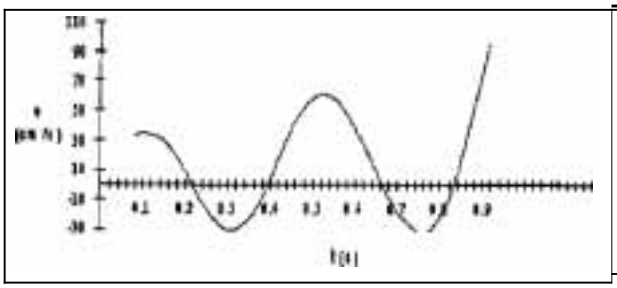

Figure 6 - Vertical velocity of the ankle

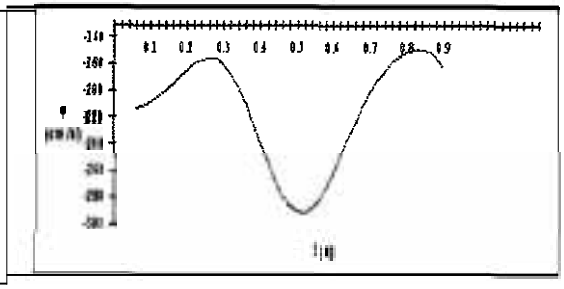

Figure 7 - Horizontal velocity of CG