technique and performance. The purpose of the study is to suggest a methodology to quantify the drag force, which was changing during front crawl swimming, and to compare the swimming drag between elite and non-elite swimmers. METHODS: The subjects were a well-trained male competitive swimmer (49.6 sec/100mFr.) and a male triathlete (82.0 sec/100mFr.). The trial was the front crawl swimming using arm only in a swim-mill, which was set the flowing velocity to 1.3 m/s. The estimation of the drag force was based on the equation of motion, that is "ma = Fp + Fd", along with swimming direction. The twelve small pressure sensors were attached on the subject's both hands in order to measure the pressure distribution and to calculate the hydrodynamic force exerted on the hands. The attitude of both hands during underwater phase was calculated by the videography and 3D-DLT method. The propulsive force Fp was calculated as a component along with swimming direction of the hydrodynamic force on the hands, assuming that the swimmers produced the propulsive force by the hands only. The swimming acceleration a in the inertial term of the equation was calculated from the position of the umbilical part, as an alternative point of the center of gravity, which was recorded using a high speed camera with 250 fps. All measurements in the experiment were synchronized. RESULTS: The inertial term, the propulsive force and the drag force during 5 seconds were obtained in each trial. The mean drag forces were 21.3 N in elite swimmer and 50.3 N in non-elite, respectively. The maximum drag forces were 90.3 N in elite and 189.4 N in non-elite. The non-elite swimmer kept producing propulsive force with high stroke frequency. The mean propulsive force of the non-elite swimmer was higher than that of the elite swimmer (25.5 N in elite and 51.4 N in non-elite). DISCUSSION: The non-elite swimmer had to keep producing the propulsive force in order to maintain the swimming velocity, because of the larger drag force and de-acceleration. The smaller drag force in the elite swimmer would make it easy to keep the swimming velocity. It was suggested that our methodology to quantify the drag force during front crawl swimming would be useful to understand the dynamics and to discuss the performance of swimming.

P-022

The Study on the Properties of Power Output of Lower Limbs in Collegiate Swimmers During Vertical Jumping Performance

Jigami, H[1]***; Takahashi, K***[1]***; Shimoyama, Y***[1]***; Endo, N***[2]
[1]***Niigata University of Health and Welfare, JAPAN;*** [2]***Niigata University Graduate School of Medical and Dental Sciences, JAPAN***

INTRODUCTION: The injuries such as muscle strain or ankle sprain of swimmers often occurred during activities on the ground. It suggests that the injuries may be caused by their hyper mobility of the ankle joint or the reduction of the performance with the antigravity movement, but the real causes have not been elucidated yet. The measurement of jumping performance is widely used to evaluate the physical condition and trainability of athletes, but not so much of swimmers. The purpose of this study is to investigate the differences in the vertical jumping performance between Swimmers (SW) and Track and Field athletes (TF) in order to elucidate their properties of power output of lower limbs and to prevent the injuries of swimmers. METHODS: 12 male SW and 9 male TF in N university were participated. All subjects performed counter movement jump (CMJ) and squat jump (SJ) on the portable force plate. The changes in jumping height, displacement and velocity of center of mass (COM) were derived from the time series of the ground reaction force (GRF) collected with sampling frequency at 400 Hz. The same measurements were performed before (Pre) and after (Post) 6 months routine training. RESULTS: For SW, a significant increase in jumping height was observed in SJ (Pre;0.36±0.04m, Post;0.44±0.05m), but not in CMJ (Pre;0.46±0.05m, Post;0.49±0.05m), as a result of 6-months routine training. In contrast, for TF, no significant changes were observed in SJ (Pre;0.43±0.09m, Post;0.48±0.08m), but their COM displacement and the time from lowest COM displacement (t0) to the time when COM velocity reached maximum (t1) were significantly smaller in the CMJ (Pre;0.27±0.02s, Post;0.23±0.03s). DISCUSSION: CMJ requires the ability to convert the eccentric contraction to concentric contraction quickly (i.e., stretch-shortening-cycle; SSC), but SJ does not require it. Therefore it is conceivable that the performance of SJ was specifically related to the muscular strength of lower limbs. For TF, who performed daily antigravity training, the parameters in CMJ were improved, while, for SW, who lacked antigravity training, the parameters only in SJ were improved during six months. Since the above difference is caused by the lack of antigravity training, the results indicate that the antigravity training is essential to improve SSC function. When SW perform activities on the ground, it might be necessary for SW to prevent in

P-024

Relationships Between Entry Skill and 15m Time in Competitive Swimming Start

Kazumasa, O.[1]***; Shinji, S.***[2]***; Masahiro, T.***[1]
[1]***Faculty of Sports and Health Science, Fukuoka University, JAPAN;*** [2]***School of Health and Sport Sciences, Chukyo University, JAPAN***

INTRODUCTION: The purpose of this study was to examine the relationships between skill in entry phase and the glide speed. METHODS: Fourteen collegiate elite male swimmers performed maximal efforts competitive swimming start followed by 25m freestyle swim. The mean value of the swimmer elapsed time at 15m was 6.81±0.17 sec. The motions above and under water were recorded by synchronized two high speed video cameras (250 fps), and two CCD video cameras (60fps), respectively. The two-dimensional analysis was used to calculate the kinematic variables, such as entry speed, angle of projection, attitude angle and angle of attack. These angles were calculated about entry and glide phase. And, also acceleration in glide phase and angular variation about angle of projection, attitude angle and angle of attack during entry phase were calculated. A correlation analysis was conducted to examine the relationships between performance of start phase (15m time) and the kinematic variables. RESULTS: About kinematic variables in entry phase, angle of projection was 34.4±2.9deg. Attitude angle was 39.5±4.9deg. Angle of attack was -4.6±6.5deg. About kinematic variables in glide phase, angle of projection was 31.0±3.0deg Attitude angle was 11.1±5.8deg. Angle of attack was 19.9±3.8deg.There was a significant negative correlation between 0-15m time and angle of attack ($p<0.05$; r=-0.534). Also, there was a significant positive correlation between 15m time and acceleration in entry phase ($p<0.05$ r=0.593). Also, there was a significant negative correlation between angle of attack and acceleration in entry phase ($p<0.05$ r=-0.599). There was no correlation between angular variation about angle of attack and acceleration in entry phase (p=0.158 r=-0.277). DISCUSSION: The result of this study showed that the angle of attack and acceleration in entry phase influence 15m time. From these result, it is consider that the entry skill explained by angle of attack influence acceleration in entry phase, and therefore 15m time is shorten. But there was no correlation between angular variation about angle of attack and acceleration in entry phase. These results suggest that angular variation about angle of attack do not influence deceleration during entry phase in expert competitive swimmers.