THE COORDINATION AND DYNAMICS OF BUTTERFLY STROKE

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INTRODUCTION: The movement characteristics of the butterfly stroke make it the most energy demanding style among the four styles in competitive swimming. Therefore the coordination between the arm and the leg becomes extraordinarily important for a successful butterfly swimmer. The aim of this study was to examine the difference of the arm-leg coordination patterns in the butterfly stroke between two levels of swimmers who were specialized in butterfly stroke at three race paces (50M, 100M and 200M).
METHOD: Eight Taiwanese elite swimmers and eight division B college swimmers participated in the study. Two underwater high-speed cameras (200 Hz) were set in the transverse and sagittal plane under the water and synchronized to capture the swimming movement. The kinematics data were digitized and calculated with the Kwon 3D software. The shoulder and knee joint angles were used to derive the continuous relative phase and the timing difference between the arms' entry to water and the occurrence of the first minimum knee angle was used for the discrete relative phase. Furthermore, catch, pull, push and recovery phases were determined from one butterfly cycle to observe the proportional duration of each stage. The 2(level) X 3 (velocities) were used repeated -measures ANOVA to examine the pacing and level.
RESULTS: The results show the significant difference between the two performance levels, $F(1,14)=21.336$, $p<.05$ and among the three different velocities in each group, $F(2,14)=5.056$、$F(2,14)=6.720$. Although both levels of swimmers demonstrated a 1 to 2 ratio between the arms and the legs movement, elite swimmers had a more consistent relative phase among different pace and among different stages of the cycle. For the percentage of each stage, the swimmers of both levels demonstrated the decreasing duration along the increasing pace for the catch phase and the increasing duration along the increasing pace for the recovery phase.
DISCUSSION: By observing three different paces in the swimmers, it becomes clear that the velocity is an important factor in modulating arm-leg coordination. Furthermore, by comparing the coordination pattern in Chollet (2006), the swimmers in the current study did not show the best coordination in the temporal domain in slow (200M) pace which may indicate the inability to control the movement optimally with ample time.
CONCLUSION: In conclusion, the velocity can be an important control factor in butterfly arm to leg coordination. The different temporal characteristics of the stroke at the slow pace between the reported data and those of Chollet et al. (2006) may indicate that the techniques of butterfly stroke in slow velocity need to be improved. Finally, the horizontal velocity fluctuated over one cycle butterfly stroke. The peak velocity occurred in the push phase which coincided with the peak angular velocity of the knee joints and the peak linear velocity of the finger in elite level.

REFERENCES:
Chollet, D., Seifert, L., Boulesteix, L., & Carter, M. (2006). Arm to leg coordination in elite butterfly swimmers. *International Journal ofSports Medicine, 27*(4), 322-329.

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