THE STRATEGY OF MUSCULAR PRE-TENSION DURING INITIAL BLOCK PHASE IN SWIMMING GRAB START

Ching-Wen Lee[1], Chenfu Huang[1], Der-Chia Lin[1], and Ching-Wei Lee[2]
[1]National Taiwan Normal University, Taipei, Taiwan
[2]Chung Ho Elementary School, Taipei, Taiwan

The purpose of this study was to examine the effects of muscular pre-tension on swimming grab start performance. Eight well-trained subjects participated in this study. They were instructed to perform three strategies (stretch-shortening cycle, purely concentric with and with no muscular pre-tension) in grab start. Two Peak-Performance high-speed video cameras operating at 120 Hz and one Kistler force plate (600 Hz) mounted on the starting block were synchronized to collect the data. The results showed that the block time was significantly shorter and horizontal velocity of taking off was larger in muscular pre-tension than in stretch-shortening cycle strategy. Based on the results of the present study, it has been suggested that using muscular pre-tension strategy during initial block phase in grab start could add some benefits of decreasing time.

KEY WORDS: grab start, block time, pre-tension, jumping.

INTRODUCTION: The start is one of the important factors in swimming competitions; especially because swimmers in sprints have to pay more attention to the training of the start get more benefits. The grab start technique has been almost universally accepted as the most effective start because of its potential biomechanical advantages. Breed & McElroy (2000) indicated that nearly the whole of the horizontal drive came from the legs during the grab start. The movement of lower extremity in the grab start is based on the jump movement, but needs more coordination of the whole body. Most of the researches (Welcher *et al.*, 1999; Gehllsen & Wingfield, 1998; and Gambrel *et al.*, 1991) had been involved in comparing different start techniques (grab, track, and relay starts) and analyzing biomechanical characteristics. Actually, there are more details in the start. In grab start, for example, some swimmers may squat down and then jump forwards to produce a more powerful push, others may perform without any dip to save more time. Different swimmers who focus on different points of advantage depend on their experiences or the instructions of their coaches. There should have been an examination to clarify the benefits of them. Comparing a simple vertical jump to a grab start, Voigt *et al.* (1995) indicated that the increased performance could not be explained by a contribution of elastic energy during the push off. Van Ingen Schenau *et al.* (1997) also stated that the work enhancement occurs because of the prestretch allowing muscles to develop a high level of active state and force before starting to be shortened. The average torque is increased by the use of pre-tension (Jensen *et al.*, 1991; Tis *et al.*, 1993), and this was due to the initial level of muscle tension at the beginning of the movement, allowing the muscles to work closer to its maximum in the earlier movement. Pearson *et al.* (1999) studied the different levels of pre-tension on vertical jumps. The results showed that the countermovement jump had a significant lower peak ground reaction force (GRF) than all other jumps. Countermovement jump height was significantly higher than all pre-tension jumps, but no different in jump height among the pre-tension levels. The time from a starting signal to take off was significantly less in pre-tension than in countermovement. They also indicated that the results of the study could be applied on the swimming start to decrease swimmers' starting times. The researches of application regarding the effects of muscular pre-tension strategy on swimming grab start were absent; therefore, the purpose of this study was to determine its effect on the performance of swimming grab start.

METHODS: Eight male elite competitive swimmers were asked to participate in this study. The subjects data showed that: Ages 20 ± 2.5 yr, body masses 71 ± 8.5 kg, body heights 1.76 ± 0.03 m and training years 10.3 ± 3.3 yr (mean ± S.D.). They were instructed to perform three strategies during the initial block phase in grab start (Figure 1). The definition of three strategies were as follows:
(A) Stretch-shortening cycle (SSC): a countermovement (the depth of the countermovement

was not constrained) was allowed in the beginning of the movement and then pushing off. It means that swimmers squat down and then jumped forwards after the start signal was triggered. (B) Purely concentric with no pre-tension (NPT): subjects perform grab start with no countermovement in the beginning of the block phase, but pushing off by their legs directly. (C) Purely concentric with pre-tension (PT): similar to the second type, except fot the subjects which were instructed to push downwards with their legs as hard as possible to exert forces on the force plate, and their hands grasp another bar which separated from the force plate to prevent falling into the pool before the start signal was triggered.

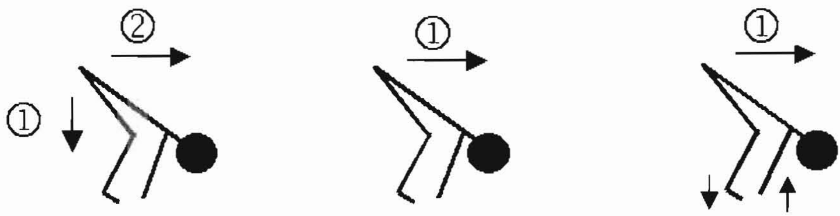

Figure 1. The definition of three strategies during initial block phase in grab start: (A) Stretch-shortening cycle (SSC) (B) Purely concentric with no pre-tension (NPT) (C) Purely concentric with pre-tension (PT).

Two Peak Performance high speed video cameras (120Hz) were synchronized to the force plate. One taped the movement from a starting signal (smoke of the gun) to take off, the other taped the movement from take off to entry (the hands touch the water) in the sagittal plane. Kinematic variables were induced from videos by using Peak Motus 7.0 system to analyze. The Inertia parameters for body segments were adopted from Dempster (1955). Horizontal and vertical components of GRF at the feet were measured by using a Kistler (model 9287) force plate (sampling rate of 600Hz) mounted on the starting block. The contribution of the hands was separated from the feet by pushing the hands on another bar. The selections of trial for analysis depended on the curve of the GRF and the film. The GRF was normalized from body weight (BW). The differences in block times, flight times, flight distances, peak GRF, horizontal and vertical velocities at take off and the entries among three strategies of start were analyzed with repeated one–way ANOVA. The statistic significant level was set at $\alpha = .05$.

RESULTS AND DISCUSSION: Grab start is more complex than any other vertical jumps. The differences between vertical jumps and grab start were the jump direction, trunk posture during the flight phase and the end posture (the feet contact ground in vertical jumps and the hands touch the water). As a result, the GRF of grab start was different from the vertical jumps. In countermovement jump, the movements of the body segments during the prestretches led a forward rotation and during the take off, induced a backward rotation of the body (Voigt *et al.*, 1995). In grab start, swimmers have to jump forwards, the mass center of the body rotates around the fore edge of the starting block, therefore the knee joint still flex before pushing. In figure 2 (A), the characteristics of GRF curve for SSC showing that they were different than purely concentric (with and with no pre-tension) ones. In SSC strategy, the curve decreased below the body mass while swimmer squat down increased to a peak. The muscle prestretched, and contracted to produce force. In figure 2 (B) and (C), there was no decrease of GRF, instead the curves showed two peaks. It means that swimmers did not squat down in the beginning, but pushed (the first peak) directly during the initial block phase. Because of the properties of the grab start movement, as mentioned before, the lower limb has to wait until the hip joint extended and the knee joint extended. During this period, knee joint flexed more than the set posture, then the joint was pushed (the second peak) to extend before take off. In other words, the legs pushed the ground twice during the block phase. Once these two peaks had been compared, the first peak was higher than the second one in some subjects, but others were converse. Table 1 showed the results of different variables in three strategies during the initial block phase in grab start. The GRF of set posture in vertical component obtained in PT strategy was significantly higher than SSC and NPT strategies. The result of Pearson *et al.* (1999) showed that the countermovement jump had a significantly lower peak GRF than all the other jumps. But in the present study the peak GRF (horizontal and vertical components) among three different strategies was not different. In time variable, the block time was shorter in PT than in NPT and in SSC. These results were similar to the results of Pearson et al. (1999). The grab start, decreasing the time available in swimming competitions is very important, it may obtain time-advantage from using muscular pre-tension during initial block phase.

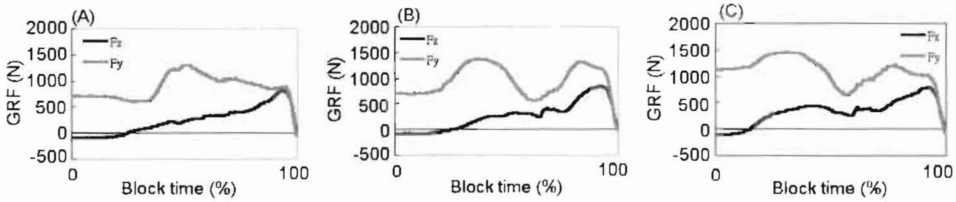

Figure 2. The ground reaction force during block phase in three strategies of grab start: (A) Stretch-shortening cycle (SSC). (B) Purely concentric with no pre-tension (NPT). (C) Purely concentric with pre-tension (PT) of one subject.

Table 1. The results of three strategies during initial block phase in grab start.

	(A) SSC	(B) NPT	(C) PT	
Fy of Set posture (N/BW)	1.04 ± 0.04	1.10 ± 0.07	1.37 ± 0.30	(C)>(A), (B)
Peak Fy (N/BW)	1.95 ± 0.15	1.28 ± 0.11	1.26 ± 0.14	NS
Peak Fx (N/BW)	1.21 ± 104	865 ± 118	844 ± 115	NS
Block time(s)	0.91 ± 0.07	0.82 ± 0.06	0.77 ± 0.07	(A)>(B)>(C)
Flight time(s)	0.38 ± 0.05	0.37 ± 0.06	0.37 ± 0.08	NS
Flight distance (m)	3.42 ± 0.28	3.40 ± 0.35	3.41 ± 0.35	NS
Takeoff Vx (m/s)	4.22 ± 0.36	4.44 ± 0.25	4.50 ± 0.25	(B), (C)>(A)
Takeoff Vy (m/s)	0.35 ± 0.32	0.23 ± 0.51	0.26 ± 0.47	NS
Entry Vx (m/s)	4.10 ± 0.43	4.19 ± 0.37	4.19 ± 0.40	NS
Entry Vy (m/s)	-3.25 ± 0.22	-3.23 ± 0.22	-3.18 ± 0.29	NS

N=8; Mean ± S.D.; $p < .05$; NS: not significance SSC: Stretch-shortening cycle
Fx: Horizontal GRF; Fy: vertical GRF NPT: Purely concentric with no pre-tension
Vx: Horizontal velocity; Vy: vertical velocity PT: Purely concentric with pre-tension

The take-off horizontal velocities were significantly greater in NPT and in PT than in SSC. But the entry velocities (horizontal and vertical components), and flight distance were not significantly different. In other words, the performance did not slow down while using muscular pre-tension strategy during initial block phase in grab start. Pearson *et al.* (1999) indicated that the countermovement jump was the most effective jump for height in the cases when the time to perform the jump was not a critical factor. In grab start, the judgments of good performance dependon the time, velocity, and distance variables at the moment of entering the water. It is important to limit the starting time, so if using muscular pre-tension strategy during the initial block phase can decrease the time and increase the horizontal velocity of taking off, then this strategy could be considered as an advantage for the performance.

CONCLUSIONS: the benefits of muscular pre-tension strategy during initial block phase in grab start were to decrease the block time, and to increase the horizontal velocity in the take off. The results of this study suggest that swimmers could save more time by pushing the legs downwards to activate the leg muscles before the start signal was triggered in swimming competitions.

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