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Technique Adjustments Influence the Performance of Sprint Paddling in Competitive Male Surfers

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ABSTRACT
The present study evaluated what are considered common and contentious differences in paddling technique within the surfing population, across the three distinct categories of: 1) Paddle Stroke length (Reach); 2) Torso Inclination (Chest Position); and 3) Arm Recovery. To assess the differences among paddling techniques, this study employed a within-subjects comparison of sprint paddling kinematic performance differences. Twenty competitive male surfers (19.1±6.8 years, 168.2±11.3 cm, 61.7±13.6 kg) performed 2 maximal trials each of Long vs. Short Reach, Chest Up vs. Down Position, and High vs. Low Arm Recovery during 15 m sprint paddle trials. The sprint paddle efforts were initiated from a stationary, prone lying position, using a horizontal position transducer attached to the rear waistline of each subjects' board-shorts such that kinematic data was obtained for 5 m, 10 m, and 15 m distances, and peak paddling velocity determined. There was no difference observed between Short and Long paddle strokes for any of the distance intervals, nor for peak paddling velocity ($p>0.05$). For chest position, the Down condition was found to be faster than the Chest Up position for all criterion variables ($p=0.01$-0.05), with moderate magnitude ($d=0.25$-0.43). The Low Arm Recovery resulted in superior performance compared to the High Arm Recovery ($p=0.02$-0.04), with low and moderate magnitudes ($d=0.19$-0.47). Sprint paddling is likely best conducted with the surfer's chest low to the board, without considerable extension through the back, and with a low arm recovery.

Key words: Kinematics, Sprint Paddling, Surfing, Technical Skills

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INTRODUCTION

Surfing (riding waves) as an elite competitive sport involves competition for youth (U16), junior (U18), professional-junior (professionals U20) and senior elite athletes for both genders in nearly every country with a coastline that has surf. International competitions exist for junior surfers, such as the International Surfing Association's World Junior Championship, and for professional-junior and senior elite competitors through the Association of Surfing Professionals World Tour.

The surfing industry itself is of considerable size; the board sport market and beach wear constitute ~5.5% of the total sports market worldwide [1]. Surfing competition at the elite level is well supported by prize-money through sponsorship from within this market, as well as from non-surfing companies such as technology, beverages, and automobiles. Although prize-money varies greatly between events, top-tier men's competitions attract between 40,000 – 100,000 USD for first place, and involves a year round tour, culminating in a world title.

Paddling the surfboard is done so by alternating left and right strokes while maintaining position on the board, and is the only means of locomotion to access the surf break and move into position to catch waves, as well as to create enough momentum to paddle into the wave itself. Although the sport of surfing takes place in a variety of conditions that have a large effect on activity patterns such as duration of wave-riding and time spent paddling [2-4], both competitive and recreational surfing can be characterized as requiring multiple short duration intermittent paddle efforts [2, 3]. In a competition, wave riding duration was found to be only 3.8% of total time, with paddling accounting for 51.4% of time, and no activity (i.e., stationary/sitting on board) representing 42.5% of total time (miscellaneous activities 2.2%)[3].

Although the mean paddling bout in a surfing competition was found to be ~30 seconds, the majority (~60%) of these paddling bouts were only 1-20 seconds (~25% <10 seconds, ~35% 10-20 seconds), highlighting the importance of shorter bouts of potentially intense paddling efforts [3, 5]. Sprint paddling is likely one of the important features of competitive success [6]. In 3- and 4-person competitive heats, strong paddling ability is used to gain and maintain a position advantage for wave selection. In 2-person (i.e., 'man on man') competitive heats, sprint paddling is often employed when surfers are battling for allocation of wave priority, done so by being the first surfer to arrive at the priority buoy when priority has not been established by previous wave order. In all circumstances, fast entry speed into waves through sprint paddling is important to optimize position on the wave face for the execution of manoeuvres that will maximize the judges' score [5, 7, 8]. As such, sprint paddling is generally considered to be an important performance criterion for surfers.

Surf coaches often have discussions about technique considerations and potential alterations which may enhance paddling performance. An elite surf coach sought the involvement of the authors to help evaluate technique alterations as they relate to sprint paddling performance, as no formal studies to our knowledge have examined the different technique considerations in surfboard paddling. Considering the high volume of paddling that surfers typically perform and the relevance it likely has to the competitive outcome, this information would be useful in guiding coaching decisions on paddling technique. The authors, using video analysis and in consultation with elite surf coaches, identified 3 specific categories in which to examine paddle technique, as these are considered common and contentious differences in paddling technique seen amongst the surfing population: 1) Paddle Stroke length (Reach); 2) Torso Inclination (Chest Position); and 3) Arm Recovery.

METHOD

To assess the differences among paddling technique adjustments, this study employed a within-subjects comparison of sprint paddling kinematic performance differences. Twenty competitive male surfers (19.1±6.8 years, 168.2±11.3 cm, 61.7±13.6 kg) participated in this study. At the time of the study, the subjects had competed, as a minimum standard, in domestic 'open' competition (n = 9), with some subjects having represented Australia, Indonesia, or Japan at International Surfing Association World Junior Championships and/or the Association of Surfing Professionals (ASP) World Tour events (n = 11).

All subjects received a clear explanation of the study, including the risks and benefits of participation and if following this explanation their decision was to not be included in the analysis it did not adversely affect any current or future competitive or team opportunities. All subjects provided written informed consent for testing and data analysis. Approval for this investigation was granted from the Australian Institute of Sport Research Ethics Committee, and the study conformed to the Declaration of Helsinki for medical research involving human subjects.

Sprint paddle testing was conducted in an outdoor 50 m swimming pool. This allowed for easy outline of distances for the subjects, control for the potential effect of tides and currents experienced in most local open water spots, and provided for professional supervision by lifeguards and elimination of potential dangers from marine creatures. Subjects performed a progressive warm-up, consisting of 200 m of low-intensity paddling, followed by a specific sprint paddling warm-up of 4 x 15 m sprint paddling efforts at 60, 70, 80, and 90% volitional effort on ~2 minute time intervals. After 3-4 minutes rest, the subjects then performed 2 maximal effort sprint-paddling time-trials (i.e., 2 x 15 m) to determine maximum sprint paddling performance, without coaching cues to influence paddling technique. The fastest time (15 m criterion distance) of these trials was retained for analysis as a reference point for comparison with technique alterations. Following this, 2 trials each of the technique manipulations were conducted, allocated to subjects' in a random order, with 2-3 m rest provided between each trial. The fastest time of the two trials of each condition was used in the analysis. The technique categories and the coaching cues were identified to all subjects, exactly as follows:

1. Reach
"Emphasize long, full strokes" (Long) vs. 'Emphasize short, rapid strokes" (Short)

A long stroke (Long) was accomplished when the subject's arm entered the water as far forward as possible, whilst short strokes (Short) utilized approximately half of the subject's potential range of motion in the paddle stroke. Figure 1 demonstrates the arm entry during a Long paddle stroke, with illustrations indicating entry for a more typical entry, and an entry for a Short paddle stroke.

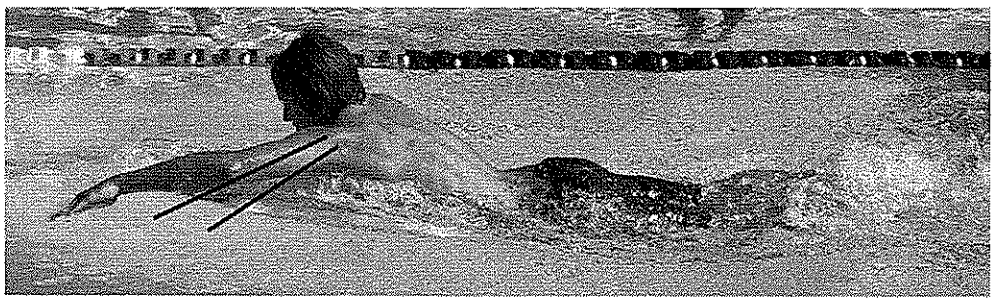

Figure 1. Subject Performing a Long Paddle Stroke
The illustrations outline the arm entry for a moderate and Short paddle stroke.

2. Chest Position
"Chest up high' (Up) vs. 'Chest down and low on the board" (Down)

A high chest position (Up) was considered to be achieved when the subject was extending through the lumbar and thoracic spine, such that their sternum and pectoral muscles were clear of the board, while a low chest position (Down) involved the subject maintaining contact with the board with his pectoral muscles, and a relatively neutral spine position (Figure 2).

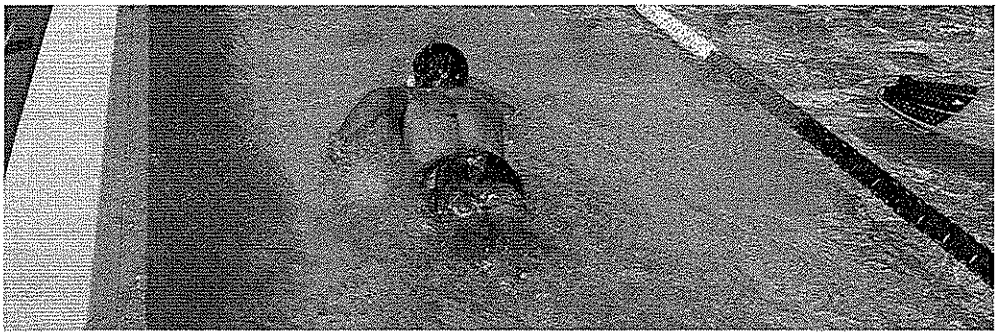

Figure 2. Subject Performing Sprint Paddling with a Down Chest Position Action is characterised by a relatively neutral spine with the chest and sternum in contact with the surfboard.

3. Arm Recovery
"Bring arm through with high elbows" (High) vs. "Bring arms through with arms out and low to the water" (Low)

A high elbow recovery (High) was achieved when the subject cleared the water leading with the elbow rather than the hand and whole arm, and bent the elbow, maintaining the elbow at a position higher than that of the hand. The lower arm recovery position (Low) involved the subject maintaining a straight arm throughout the recovery, and no part of the arm was raised higher than the torso, such that the arm was low to the water as it rotated out and around the subject's body. Figure 3 demonstrates a High recovery, with illustrations outlining the relative position for a Low recovery.

Sprint paddle efforts were closely observed by the expert surf coach and the primary researcher in order to ensure that the subjects' complied with the coaching cues. Only one trial was repeated due to a subject not executing the technique modification properly.

The sprint paddle efforts were initiated from a stationary, prone lying position. Using a purpose-built horizontal position transducer (I-REX, Southport, Australia) attached to the rear waistline of each subjects' board-shorts (Figure 4, arrow outlining attachment of position transducer on rear waistline of board-shorts), kinematic data was obtained and stored for analysis on a personal computer. The position transducer recorded a time-stamp for each 0.02m of displacement, thereby allowing for determination of sprint time from the start to each interval (5m, 10m, and 15m) and by differentiation to determine peak sprint paddle velocity [9]. The percentage Typical Error (%TE) for 5m, 10m, 15m, and peak velocity were found to be 4.4%, 2.6%, 2.1%, and 2.2% respectively.

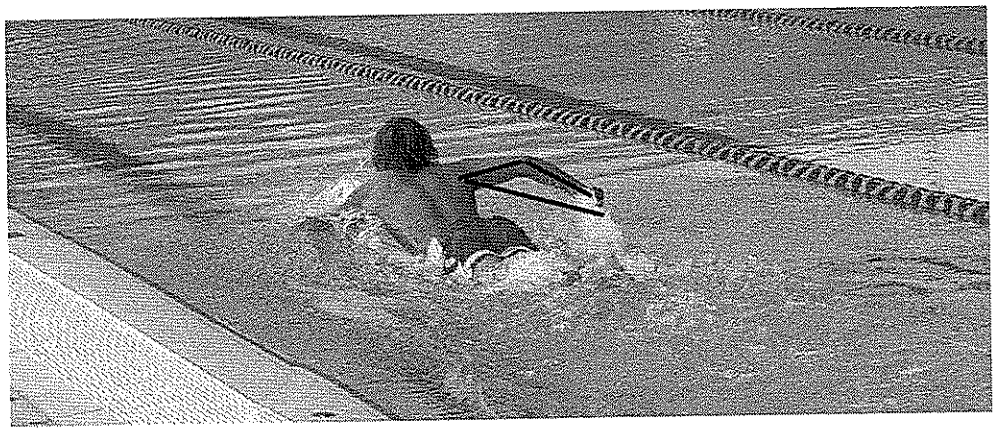

Figure 3. Subject Performing a High Elbow Recovery during Sprint Paddling
The action is characterised by a bent elbow that is higher than the torso, with arm lower. Illustrations outline the relative position for a Low Arm recovery.

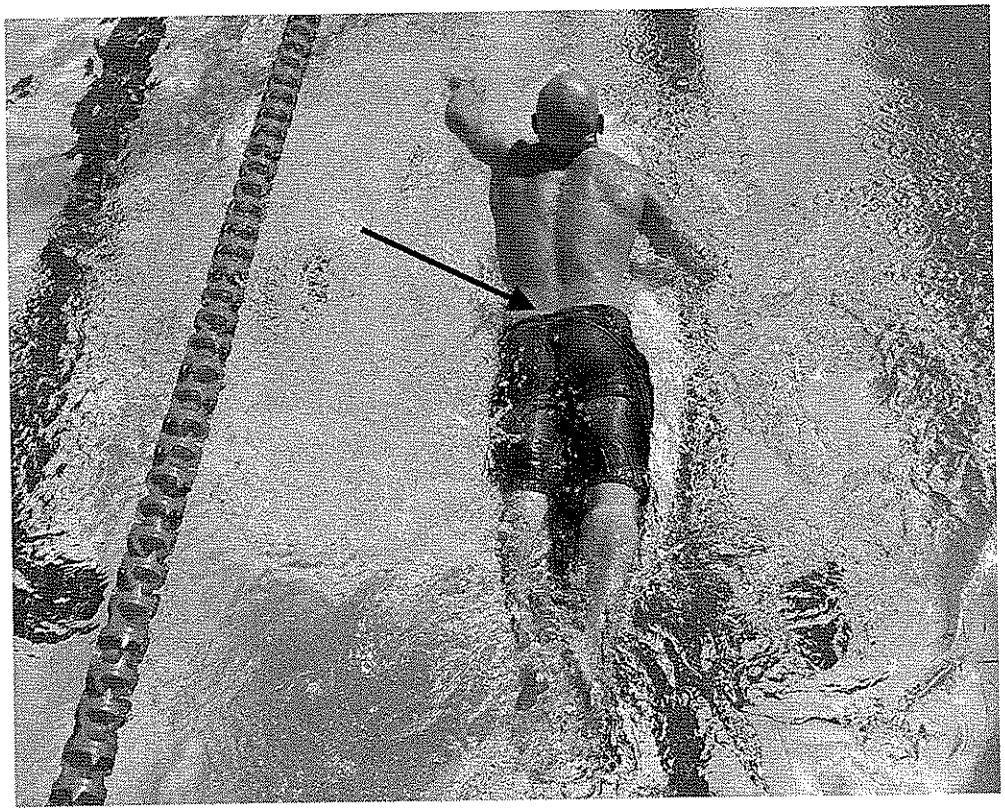

Figure 4. Subject Performing a Sprint Paddle Effort
Horizontal position transducer is attached to the rear waistline of the subject; board-shorts (arrow outlining attachment of position transducer on rear waistline of board-shorts).

Paired samples t-tests were applied to compare the differences between the two technique manifestations within each of the 3 coaching cue categories, with Cohen's effect size (*d*) applied to reflect the magnitude of any differences, with the criteria of <0.40 small; 0.40-0.70 moderate; and 0.70-1.00 large. For all tests, minimum significance was considered to be achieved when $p \leq 0.05$.

RESULTS

There were no differences observed between Short and Long paddle strokes for any of the distance intervals, nor for peak paddling velocity (p>0.05). For chest position, the Down

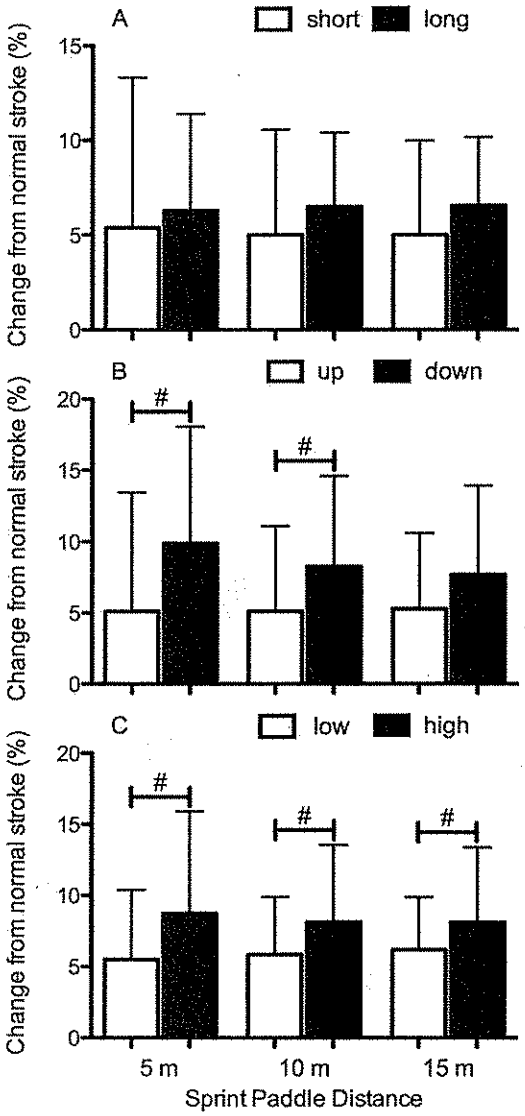

Figure 5. Percentage Differences between Conditions
The differences are relative to their change from the subjects' initial sprint paddle (i.e., normal paddle technique) for time to 5 m, 10m, and 15 m (# denotes difference ≤ 0.05).

condition was found to be faster than the Up position for all criterion variables (p=0.01-0.05), with small-moderate magnitude (d=0.25-0.43). The Low arm recovery resulted in superior performance compared to the High elbow recovery (p=0.02-0.04), with low to moderate magnitudes (d=0.19-0.47). The percentage differences between conditions, relative to their change from the subjects' initial sprint paddle (i.e., normal paddle technique) is displayed graphically in Figure 2 for time to 5m, 10m, and 15m, and in Figure 3 for differences in peak velocity (m/s).

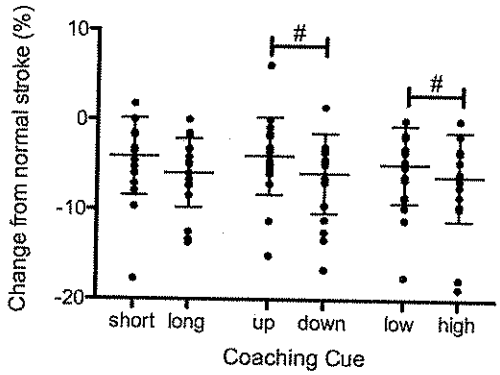

Figure 6. Percentage Differences between Conditions
The differences are relative to their change from the subjects' initial sprint paddle (i.e. normal paddle technique) for differences in peak velocity (m/s) (# denotes difference ≤ 0.05)

DISCUSSION

The purpose of this study was to evaluate the potential influence that paddling technique may have on paddling performance variables. The results of this investigation provide useful and novel information for coaches who work with surfers to consider, as several practically important findings were observed. Compared to all technique variations, the surfers' normal paddling technique (i.e., without coaching intervention) was superior. This was anticipated for two reasons. Firstly, this is the technique that the individual would be most habituated to. Secondly, the coaching technique interventions we employed represented a singular (i.e., one cue) coaching cue, and therefore was representative of what could be an extreme manifestation of each cue for comparison purposes.

Comparisons of a long paddle stroke to a shorter paddle stroke did not result in any differences. In the longer paddle stroke, the surfer is aiming to reach as far forward as possible, and pull through as far back as possible with each stroke. With the short paddle stroke, the surfer will achieve a higher cadence (i.e., stroke rate). We hypothesized that the shorter and higher cadence stroke would assist the surfer for initial acceleration (e.g., 0-5 m), while the longer paddle stroke would be superior for higher and top speed components of the sprint paddle time trial, but we did not observe this. A longer paddle stroke would theoretically enable force to be applied over a longer period of time, and likely a larger impulse from each stroke. However, consideration must be made to the efficiency of the application of force, as this is paramount to its effectiveness. When the hand and arm is in a vertical position, the surfer is best able to 'catch' and the paddle action is most effective in having the surfer pull himself forward over the water. With a very long reach, the arm enters

the water well ahead of this catch position, and the long pull continues well past the point where the hand and arm maintain a vertical position. It is possible that the potential benefit of a longer force application is negated due to the hand and arm being in a poor position to apply appropriate force at the start and finish of the stoke action. In other words, a moderate stroke length, not either extreme, is likely optimal.

A high chest position (Up) was found to be detrimental to sprint paddling performance compared to a low chest position (Down). It was observed during data collection that the higher (Up) chest position resulted in considerable yaw of the surfboard, perhaps because too much of the subject's mass was shifted to the back of the board. This inefficiency would likely have contributed to the poorer performance observed. Furthermore, the upright chest position might place the shoulder and arm in a poor position from which to provide propulsion during the paddle stroke, despite this being a common technique in surfers. However, this cannot be confidently asserted from the findings of the present study.

High arm recovery (High) was significantly slower than a low arm recovery (Low). Unlike swimming, where the paddle stroke can include torso roll to accommodate a higher elbow and arm position, surfers roll only a negligible amount when performing their paddle stroke so that they do not slip off of their board. It is likely that for this reason, a high elbow and arm recovery in surfing is not advantageous to stroke impulse or efficiency in arm recovery.

This study assessed sprint paddling performance as a criterion only. The potential injury avoidance implications of different paddling techniques were not addressed in this study, and can only be speculated upon. Our observations and reasoning suggest that certain techniques may invite injury unnecessarily. An upright chest position (Up) while paddling on a surfboard may place additional stress on the lower back of a surfer, in order to maintain the additional and potentially extreme extension required. A high elbow and arm recovery (High) technique would appear to promote increased internal rotation of the arm at the gleno-humeral joint in order to allow for elbow and arm lift while keeping the hand clear of dragging on the water surface, a position that increases the likelihood of shoulder impingement. Considering that many surfers experience low-back and shoulder soreness and injury [10], and that these paddling techniques do not appear to offer any performance benefit, the risk-benefit trade-off with this technique makes it unattractive.

Although female surfers were not a part of the present study's cohort of subjects, future endeavours examining the effect of anatomical differences between male and female surfers, and its potential influence on paddling technique, would seem worthwhile. For example, adult female surfers who likely have a larger chest girth than their male counterparts, may require greater lumbar and thoracic extension (i.e., 'chest up'), a position we found to lead to slower sprint paddle times. It would likely be of practical importance to elucidate the effects of these differences through research initiatives, perhaps with a view to refine surfboard design, as well as technique, so that it better suits the differences between male and female characteristics.

CONCLUSION

Alterations to paddle technique result in significant changes in sprint paddle performance in surfers. It is quite likely that the specific technique for paddling will vary somewhat based on dimensionality, maturation, gender, and physical qualities. However, in general, coaches and practitioners working with competitive surfers should not promote extreme extension through the spine (i.e., high chest position), as this is markedly slower than a low chest position, and may be less likely to stress the surfer through prolonged lumbar extension. A

low arm recovery offers superior performance benefits compared to promoting a high recovery of the elbow and arm during surf paddling.

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