

THE INFLUENCE OF TUCK INDEX, DEPTH OF FOOT-PLANT, AND WALL CONTACT TIME ON THE VELOCITY OF PUSH-OFF IN THE FREESTYLE FLIP TURN

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INTRODUCTION

Effective turns play a critical role in the outcome of swimming competition. In short-course events, turns comprise up to one-third of the total race time. While mid-pool swimming velocity is the primary determinant of race performance at the elite level it does not necessarily indicate a similar proficiency in turning technique. At elite competitive levels, although mid-pool swimming velocity is the primary determinant of race performance, the turns have the potential to determine a winner among swimmers with the same mid-pool swimming velocities.

The purpose of this study was to examine the effect of three variables on the velocity of the push-off during the freestyle flip-turn. These variables are: (a) Distance from the wall a swimmer's hips should be at foot contact (Tuck Index); (b) the Depth of the foot plant on the wall during push-off (Foot-plant Index); and (c) Wall Contact Time (WCT).

DESCRIPTION OF MEASURES

Tuck Index: Tuck Index measures how close a swimmer's hips are to the wall at the start of push-off, relative to leg length. It is defined as the distance of the greater trochanter of the femur from the wall at foot contact, divided by the actual trochanteric height. A higher number indicates straighter legs at wall contact.

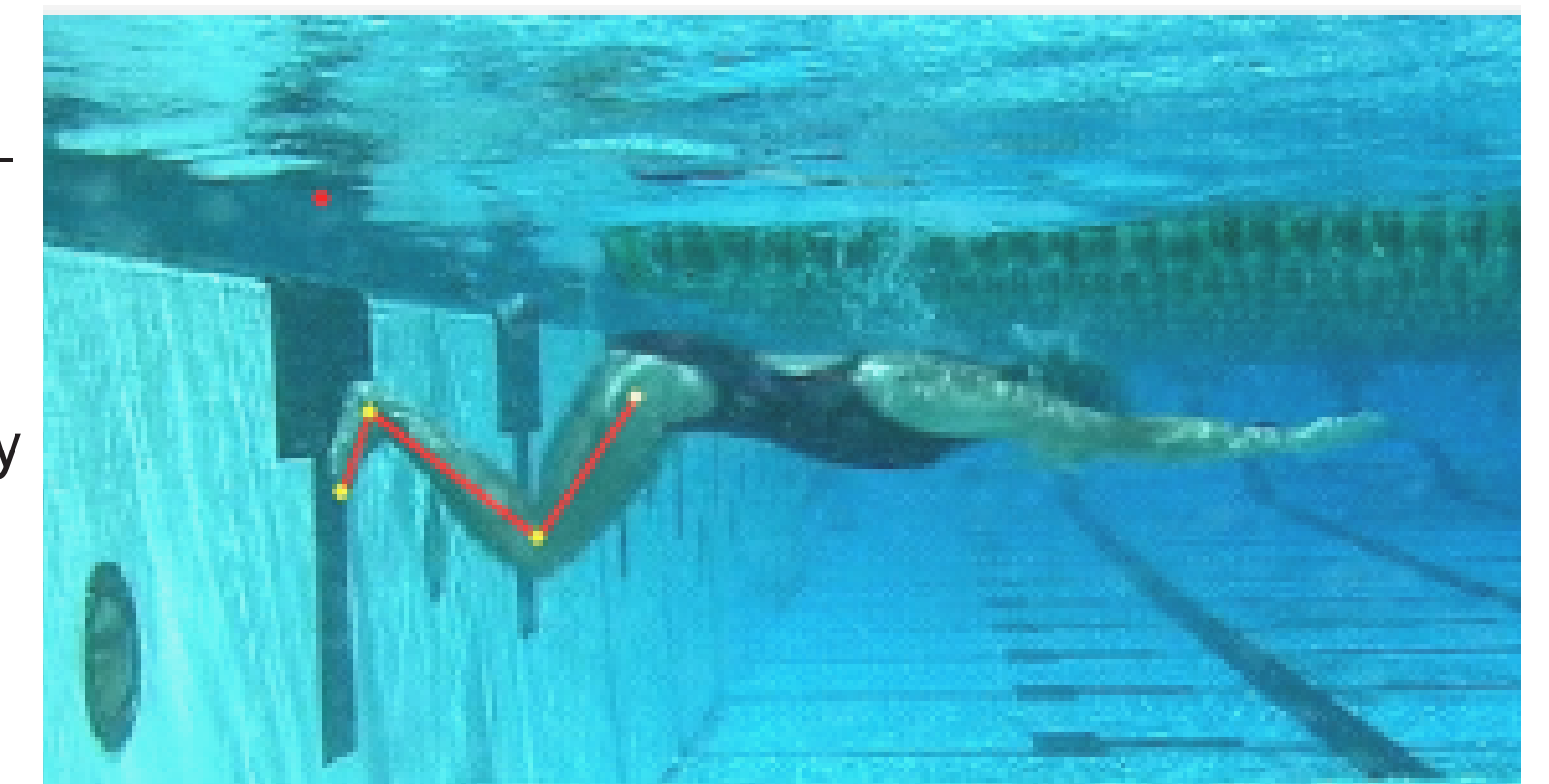
Foot-plant index: Foot plant index was developed as a way to measure the distance of the feet from the surface of the water while taking into account the length of the swimmer's leg. A higher number for foot plant index indicates a deeper foot plant.

Total wall contact time (WCT): It is divided into two segments, a "preparatory" segment and an "active" segment. The "preparatory" segment occurs prior to forward motion, beginning when feet make contact with the wall, and ending at the moment before the hips make their first forward displacement. The "active" segment of WCT begins at the first forward displacement of the hips and ends when the feet leave the wall.

METHODS

Twelve male and eleven female members of a Division One - University swimming team participated in the study.

- Subject ages ranged from 19 to 25 years.
- Each subject was required to perform a series of trials, each trial consisting of a 50-yard freestyle swim over a 25 yard (22.5 m) course which included one turn.
- Subjects were instructed to perform the flip turn at race pace, swimming at maximum speed for 5 meters before and after the turn.
- Each turn was videotaped from underwater using a single digital camera. The camera was placed at a depth of half a meter below the surface, and located 2 meters from the end of the pool and 7 meters laterally to the turning surface.
- A four-point calibration rod was used as a scaling factor for the kinematic analysis.
- Two-dimensional analyses of saggittal planar movements were conducted using motion analysis software (Vicon/Peak, Denver, Colorado).
- The dependent variable selected was the push-off velocity, the average velocity taken to cover the first 60 centimeters upon leaving the wall, as measured by displacement of the hips. Independent variables selected for analysis included tuck index, foot plant index and % WCT Active.
- A Pearson correlation matrix was established to investigate the strength of the bivariate association between each independent variable (tuck index, foot-plant index and %WCT Active) and the dependent variable (push-off velocity). Simultaneous regression analysis was conducted using the push-off velocity as a dependent variable to determine the overall predictive characteristics of the variables.

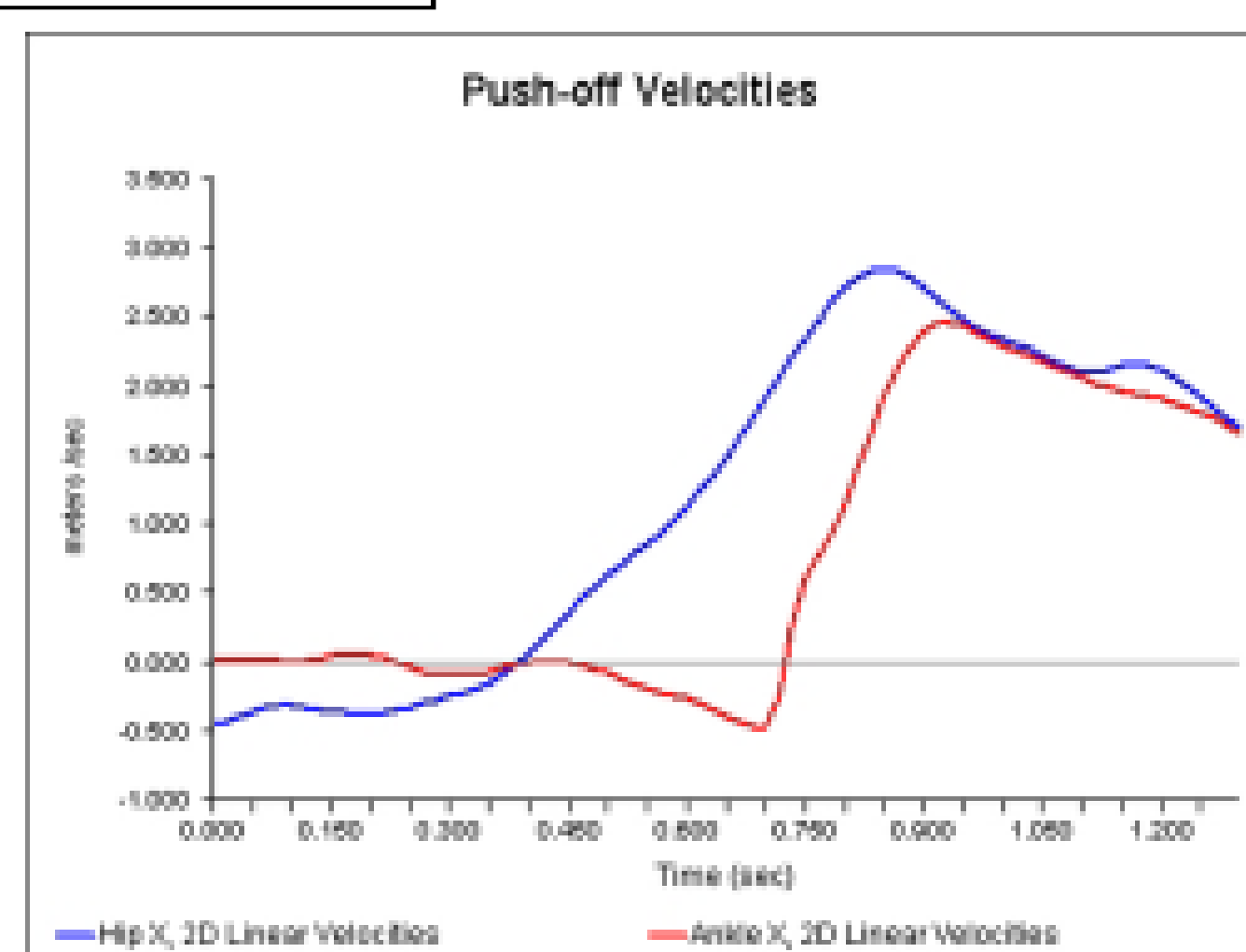
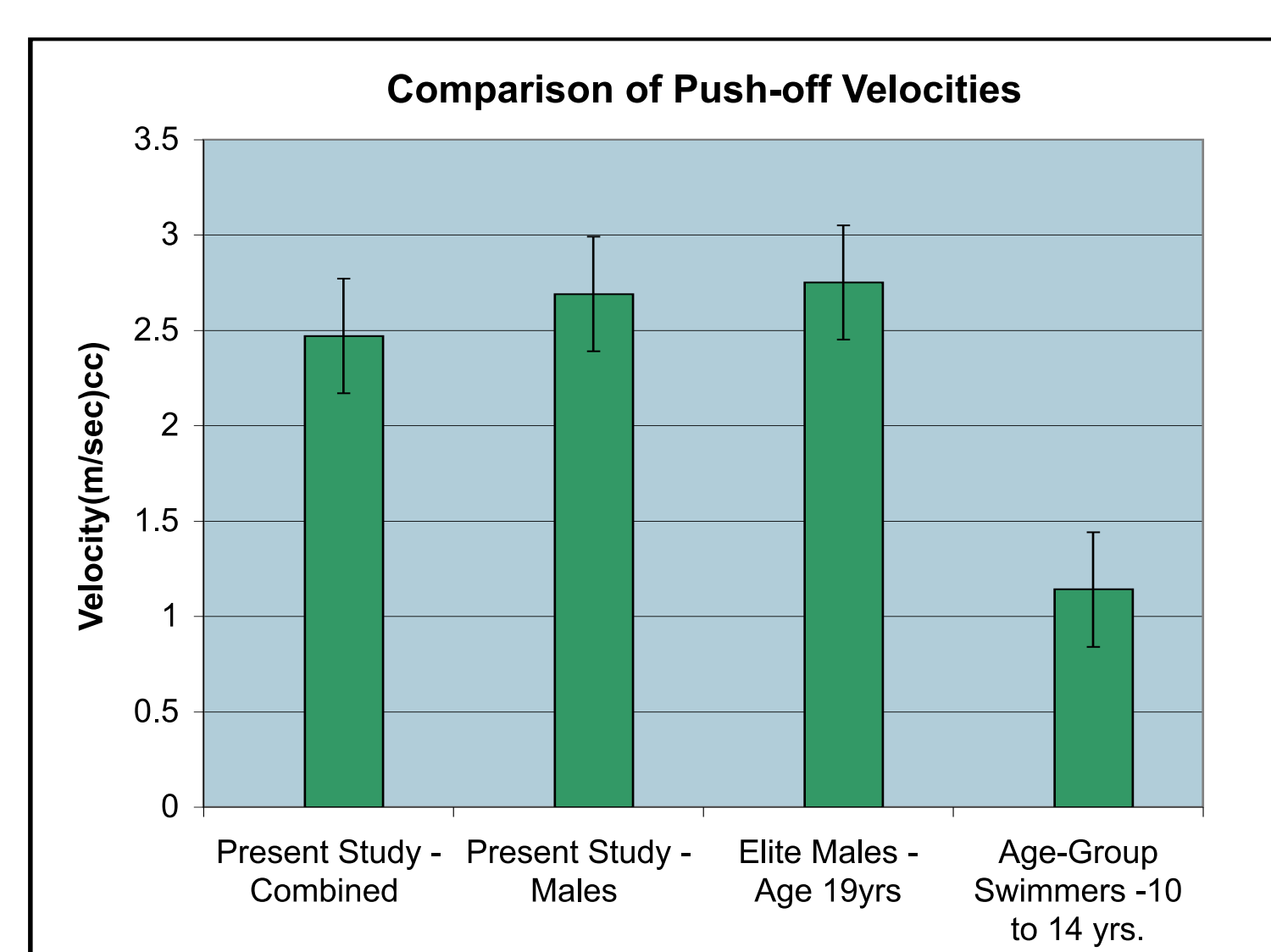


RESULTS AND DISCUSSION

Push-off velocity

The mean push-off velocity for all turns analyzed, males and females combined, was $2.47 \pm .40$ ms⁻¹, with a minimum value of 1.3 ms⁻¹ and the maximum value of 3.29 ms⁻¹. The mean push-off velocity for males in the present study was

$2.69 \pm .34$ ms⁻¹. As a means of comparison, the mean push-off velocities of 30 experienced male swimmers with a mean age of 19.8, were reported as $2.75 \pm .25$ ms⁻¹, and trained young swimmers aged 10 to 14 years old reported average values of 1.14 ms⁻¹.



Tuck Index

In the present study, the mean Tuck Index of all turns was 0.57 ± 0.14 , indicating that the hips were at a distance from the wall that was approximately 57% of the trochanteric height.

- Tuck Index was the only significant predictor of push-off velocity in the present study. Tuck Index was negatively correlated with push-off velocity, indicating that the more tucked position (lower Tuck Index) predicted higher push-off velocity. When using push-off velocity, the overall time it takes to perform the turn is not taken into account. As a result, the optimal Tuck Index value of 0.46 is specifically for optimizing push-off velocity, and may not result in an optimal round-trip time.

Foot-plant index

The mean foot plant index in the present study was 0.45 ± 0.10 , indicating that the mean foot plant was approximately 45% of the swimmers' leg length below the water.

- Thirty-three of the 109 turns in the present study resulted in glides that were performed above the 0.40 meter depth.
- While no significant relationship was found between foot plant index and push-off velocity, further examination of the present data could examine the link between foot plant index and push-off depth.

Wall Contact Time

The mean WCT of turns rated "normal" was 0.28 seconds. This value was the lowest when compared to other studies which reported times ranging from 0.29 to 0.32 seconds in experienced adult swimmers who have been studied.

- The mean percentage of the wall contact spent in the "active" push-off phase was 74.3%. The minimum percentage was 35%, and the maximum was 95%. The positive correlation in that study indicated that longer active segments resulted in faster final push-off velocities.
- However, in the present study, no significant relationship was found between % WCT active and push-off velocity.

CONCLUSIONS WITH PRACTICAL VALUE FOR THE COACH:

- Since the values of the push-off velocities in this study reasonably matched with other studies of elite swimmers, ie. those competing at the national and international levels, we can deduce that once a certain level of performance is achieved, swimmers tend to drive off the wall at a fairly predictable velocity. The fact that younger swimmers tested show velocities that are almost half that of the elite groups, implies an on-going need to address this aspect of the turns.
- When examining how close the wall should be approached, as measured by the Tuck Index, the study found that, up to a point, the closer the hips are to the wall at foot-plant, which imply a higher degree of knee flexion, the higher the velocities of push-off. Therefore, it is better to be closer than further from the wall when starting the push-off.
- The depth of the foot-plant for elite swimmers performing the freestyle flip turn appears consistent. However, the range of values that are seen with less experienced swimmers, clearly affecting the trajectory of the body, is a strong reminder of the need to refine turning skills.
- Although this study did not find a clear association between how long the feet should remain on the wall once the knees start to extend, ie. the "active phase of wall contact time", it may be counterproductive to shorten this period of the turn. Consequently, it is better for the swimmer to maintain a firm footing on the wall during the push-off rather than attempting to "bounce" the feet off the wall during the turn.