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## FORCE AND TIME ANALYSIS OF BACKSTROKE TO BREASTSTROKE TURNS

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Two AMTI underwater force platforms were used to measure force and time of three different backstroke to breaststroke turns during a simulated Individual Medley (IM). The mean ground reaction force for the open turn, bucket turn, and cross over turn were  $192.4 \pm 34.7$  N,  $202.4 \pm 53.2$  N, and  $178.2 \pm 42.2$  N respectively. The mean times from hand touching to feet leaving were respectively;  $417.7 \pm 77.0$  ms,  $378.5 \pm 59.5$  ms, and  $455.8 \pm 106.7$  ms. There were no differences in the force ( $p > 0.05$ ), but there was a significant difference in the time ( $p < 0.05$ ) of the bucket turn compared to the other two turns. Athletes should become comfortable with several turns, but specifically the bucket turn because it takes less time than the others tested without compromising GRF.

**KEYWORDS:** swimming, IM, individual medley, flip turns.

**INTRODUCTION:** The Individual medley (IM) is an event in which each swimmer swims one quarter of the event in each stroke, always in the same order; butterfly, backstroke, breaststroke, freestyle. For example a 200 meter IM is 50m of each stroke in that order. In swimming, turns comprise up to 33% of total race time in the short course competitions (25 meter pool) (Thayer & Hay, 1984). Therefore turns are an important consideration of total race time and when examining race performance.

The Fédération International de Natation (FINA) rule book states that during an IM, each section must be finished in accordance with the rule which applies to the stroke concerned (FINA 2011, SW 9.3). The finishing rule for backstroke states that "Upon the finish of the race the swimmer must touch the wall while on the back in his/her respective lane." (FINA 2011, SW 6.5) This means that when switching from backstroke to breaststroke, the swimmer must touch the wall while on the back and in his/her respective lane; once a legal touch has occurred the swimmer can change directions almost any way he or she likes. Because the rules no longer permit a backstroke flip turn, swimmers frequently use one of four different turns; an open turn, a modified Naber turn (bucket turn), a modification of the old backstroke roll turn (cross over flip turn), or a somersault turn (suicide turn) (Maglischo, 1993). The purpose of this study is to see if there are differences in the ground reaction force (GRF) and time spent on the wall, between an open turn, a bucket turn, and a cross over turn when transitioning from backstroke to breaststroke during the IM.

**METHODS:** The turns of 14 division II women swimmers ( $19.07 \pm 1.27$  y;  $1.680 \pm 0.049$  m;  $65.62 \pm 7.99$  kg) were assessed for peak ground reaction forces and time spent on the wall during each turn. Each of the athletes read and signed a Physical Activity Readiness-Questionnaire and provided informed written consent. This study was approved by the Institutional Review Board of Northern Michigan University (HS 111-404). The swimmers were also asked to fill out a short questionnaire asking questions such as "What is your normal competition turn from backstroke to breaststroke during the IM?"

Two 60 cm by 40 cm, AMTI under water force platforms (OR6-WP; Advanced Mechanical Technology Incorporated, Watertown, MA USA) were used to lessen the chance of a swimmer missing the platform on her turn. The platforms were attached to the wall of a 22.86 m swimming pool. Data were collected at a sampling rate of 1000 Hz with AMTI Netforce 2.0 software. The swimmers were first taught or refreshed on all three turns, by a coach who had coached swimming for over 18 years (9 years NCAA, 11 years USA club and high school) and was certified as a level 4 ASCAP USA swim coach and level 3 NCAA coach. Practice for the turns was performed at least two weeks prior to testing, and again 1 week prior to testing.

During the first learning session the researcher requested that the athletes continue practicing all three turns regularly until testing day.

On testing day, the swimmers were asked to complete three of each of three backstroke to breaststroke turns, in random order, at race pace against the force platform, swimming from mid pool to the wall and back to mid pool. Each swimmer completed three open turns: in which the swimmer must touch the wall in the supine and simply switch directions on the wall, pushing off in a prone streamlined position. The swimmer also completed three bucket turns: during which the swimmer touches the wall in the supine and spins her feet around, keeping her back parallel to the bottom of the pool, and finally pushing off the wall in streamline on her side and rolls to a prone position. The swimmer also completed three cross over turns: in which she crosses her arm over her face to touch the wall with her hand, while in the supine position, pushes her head down and her hips over to do a flip so that her feet are on the wall ready to push off in a prone position. An experienced swim coach observed each of the turns and eliminated any that weren't properly completed. If a subject performed all three turns correctly, an average of the first two was taken.

Statistical comparisons were made for Peak GRF and time in contact with the Force Platform using SPSS (v.18) via One-Way Repeated Measures ANOVA. Significance was set at  $\alpha=0.05$  and follow-up pair-wise comparisons were performed with Fisher's Least Significance Difference when significant differences were found. Effect size was calculated and based on a scaled classification (Hopkins, 2002) of  $\eta_p^2$  values converted to  $f = \eta_p^2 / (1 - \eta_p^2)^{0.5}$ . Scale of  $\eta_p^2$  was classified as  $<0.04$ =trivial,  $0.041-0.249$ =small,  $0.25-0.549$ =medium,  $0.55-0.799$ =large, and  $>0.8$ =very large.

**RESULTS:** The means and standard deviations of the data for GRF and time for each turn are presented in Table 1. There were no significant differences ( $p > 0.05$ ) in the force values for all three turns, however, there was a significant difference ( $p < 0.05$ ) between the amount of time the bucket turn took compared with the open turn and the cross over turn, which did not differ.

**Table 1: Mean  $\pm$  standard deviation for the peak ground reaction forces and the time of the open, bucket, and cross over turns (n=14).**

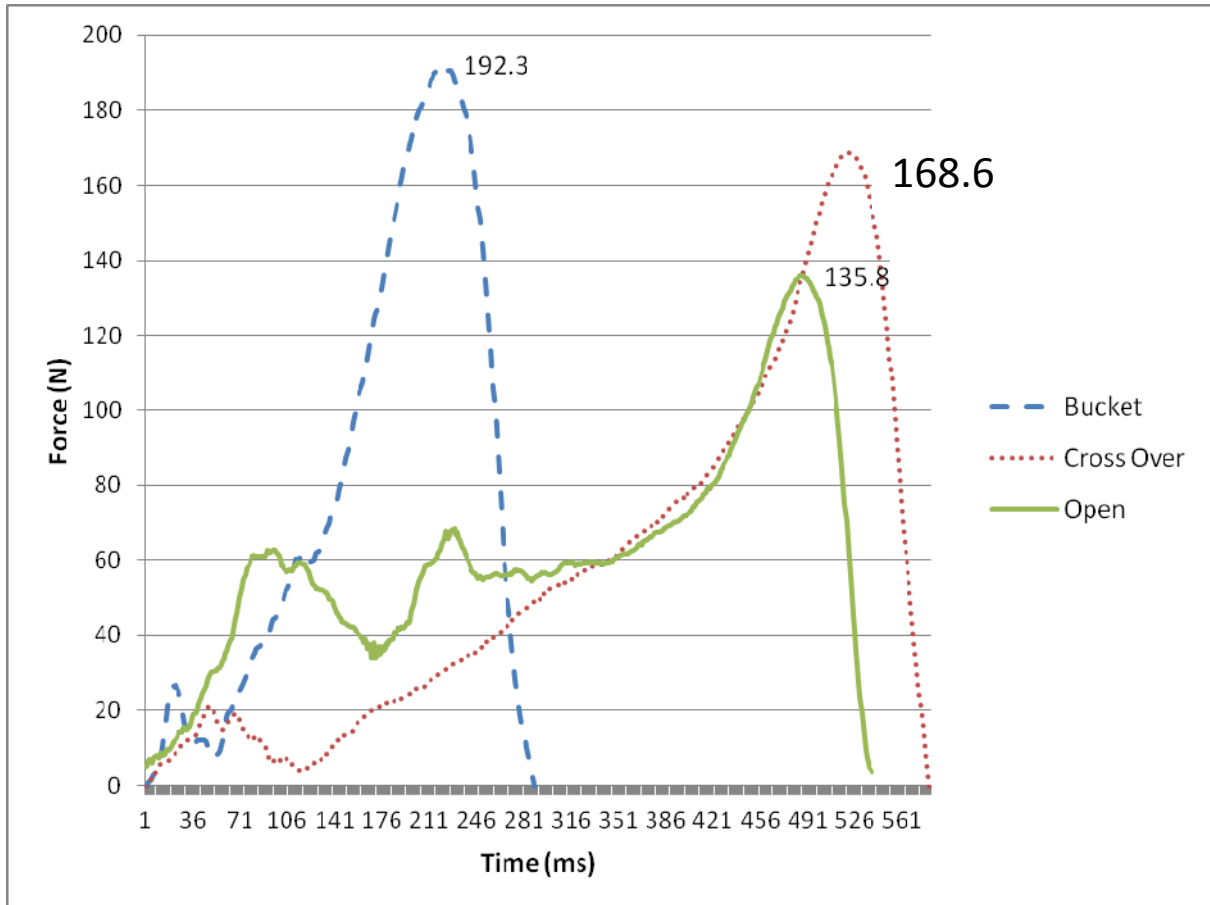
	Open	Bucket	Cross Over	Effect Size
<b>Peak GRF (N)</b>	192.4 $\pm$ 34.7	202.4 $\pm$ 53.2	178.2 $\pm$ 42.2	0.101
<b>Time (ms)</b>	417.7 $\pm$ 77.0	378.5 $\pm$ 59.5*	455.8 $\pm$ 106.7	0.250

\* Indicates significantly different from Open and Cross Over turns ( $p < 0.05$ ).

Figure 1 illustrates all three turns as completed by a swimmer who was representative of the group. It can be seen that the bucket turn (blue) occurs in less time than the cross over turn (red) and the open turn (green). These data were similar for all subjects with minor variations for the different athletes.

**DISCUSSION:** During a tumble turn one is trying to reverse the direction of the body in the shortest of time and regain the same or increased speed in the opposite direction (Blanksby Gathercole, & Marshal, 1996), the same is true for any turn in swimming. The idea is to change directions as quickly as possible without compromising the GRF. The results of this study show that the bucket turn is faster than the other two turns, making it the best choice for many swimmers. It is possible that the reason that one turn might be faster than another is that the athletes will be better at turns they are more comfortable with, but after reviewing the questionnaires, 10 of the athletes preferred the open turn, two prefer the Cross over turn, one prefers a turn that isn't listed and only one prefers the bucket turn. This suggests that even though most athletes prefer the open turn more often than any other turn, the bucket turn is still faster than both the open turn and the cross over turn. If the athletes had more time to learn and practice each of these turns the results may have been different, however considering that the turn that took the least amount of time was a new turn to most of the athletes, practice might only enhance the current findings.

The wave that contacts the wall, and thus the force platform, as the swimmer approaches the wall may account for some of the GRF that occur in each of the turns, specifically right before the swimmer touches the wall with her hand (Roesler, 1997). In the current study nothing was done to counter the effects of the water on the force at the beginning of the turn, however in every trial the peak GRF was at the end of the turn, when the swimmer was pushing off the wall with her feet.



**Figure 1: Shown are the force-time data from the force platform for a bucket turn, a cross over turn, and an open turn, all performed by the same athlete.**

**CONCLUSION:** In swimming, young athletes are often first taught the open turn because it is the turn that swimmers can use for any transition on the wall before they know how to do more complicated turns. It is only after the swimmer gets older and more experienced that coaches teach different, more complicated turns such as a flip turn for freestyle or backstroke events, and the bucket turn or cross over turn for transitions from backstroke to breaststroke in IM events. The implications of this study for coaches as well as competitive swimmers are that of the three turns tested, the turn that takes the least amount of time is the bucket turn, so as a coach it would be beneficial to teach athletes this turn, as opposed to the open turn or cross over turn, for quicker times in the IM.

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