*Coaching Applications*

# Pre-Race Deep-Breathing Improves 50 & 100-yard Swim Performance in Female NCAA Swimmers

**Trever O. Gray[1], Robert Pritchett[1], Kelly Pritchett[1], and Tim Burnham[1]**

[1] *Department of Health Sciences, Central Washington University, Ellensburg, WA, USA*

## Abstract

*The purpose of this study was to examine the effects of a 30sec or 2min deep-breathing exercise on a 50-yard and 100-yard freestyle performance. Methods: Seven competitive female NCAA (Division I and Division III) swimmers performed a 50-yard and 100-yard freestyle sprint either in normal conditions ($DB_{NO}$) after deep-breathing of 30sec ($DB_{30}$) or 2min ($DB_2$) of deep-breathing. Results: Average velocity for the 50-yard freestyle was not significantly faster after the $DB_{30}$ ($DB_{NO}$ 1.76 ± 0.12 y/s vs. $DB_{30}$ 1.77 ± 0.10 y/s P = 0.37). Average velocity for the 100-yard freestyle was also not significantly faster for the $DB_{30}$ ($DB_{NO}$ 1.63 ± 0.11 y/s vs. $DB_{30}$ 1.63 ± 0.13 y/s P = 0.62). However, faster swim times were observed in both the 50-yard freestyle (50 free: $DB_{NO}$ 28.45 ± 1.90sec vs. $DB_{30}$ 28.18 ± 1.59sec, P > 0.23).and 100 freestyle (100 free: $DB_{NO}$ 61.73 ± 4.33sec vs. $DB_{30}$ 61.54 ± 5.11sec P = 0.79) after $DB_{30}$. The $DB_2$ resulted in slower swim times for both 50 and 100-yard swims when compared to $DB_{NO}$ ($DB_{NO}$ 28.45 ± 1.90sec vs. $DB_2$ 28.85 ± 2.21sec P = 0.29; $DB_{NO}$ 61.73 ± 4.33sec vs. $DB_2$ 62.15 ± 5.52sec P = 0.58, respectively). Conclusions: A pre-race, voluntary 30sec deep-breathing procedure resulted in slight improvement in time for the 50-yard and 100-yard freestyle race, which could potentially translate to a competitive advantage.*

## Introduction

The depth of competition in elite swimming continues to increase with time deficits between first and last place decreasing (Stanula et al., 2012). The separation between first and second, or eighth place, is differentiated by hundredths of a second. Athletes will continue to search for legal ways of enhancing performance in order to gain that edge over their competitors. Most ergogenic aids, usually nutritional in nature, are expensive and perhaps not available to everyone. However, voluntary deep-breathing before a sprint event could provide a free, effective performance enhancement.

To date there has been few published studies investigating the performance benefits of deep-breathing prior to a swim performance. Jacobs et. al. (2015) put elite level swimmers through a 30sec deep-breathing protocol prior to a 50-meter swim and found improvements in time (sec) and fewer breathing cycles. Other studies have shown a positive correlation to performance enhancement when deep-breathing ranged from 30sec to 15min (Ward, 1983; Cummin, 1991; Jacob, 2008). To date no research has looked at deep-breathing prior to a 100-meter/-yard event. Furthermore, no studies have explored an extended deep-breathing protocol of

2min in swimming. A 15min DB procedure is not practical as swimmers usually arrive behind the starting blocks a few minutes before their race. However, a 2min bout of DB could be performed prior to a 50-yard/meter or 100-yard/meter swim to evaluate the positive results of previous DB studies utilizing a longer than 30sec protocol (Whipp, 2007; Ozcelik et. al., 1999).

The purpose of this study is to determine whether a 30sec or 2min deep-breathing protocol has performance benefits on a 50 and 100-yard freestyle swim. Furthermore, to determine if there is an improvement in stroke rate, stroke count, stroke length, and to look at blood lactate levels after each swim to determine if these levels are significantly increased after deep-breathing.

## Methods

### *Subjects*

Seven female (170.1 ± 7.1cm, 67.09 ± 10.9kg) Division I and Division III NCAA college swimmers volunteered to participate in this study. Subjects performed all testing in the post-season, after conference championships. All participants consented to the study and all procedures were approved by the Human Subjects Review Board at Central Washington University.

### *Testing Protocol*

All swimmers underwent a standardized 600 -yard warm-up to prepare for two daily individual sprint swims: a 50-yard freestyle and a 100-yard freestyle, each separated by thirty minutes. Each swim was randomized to prevent order effect. After warming-up each participant was randomly assigned one of three protocols: a control (no deep-breathing, $DB_{NO}$) or a deep-breathing protocol, either 30sec ($DB_{30}$) or 2min ($DB_2$). Each deep-breathing procedure was performed once for both the 50-yard and 100-yard distance. A few microliters of arterialized capillary blood were drawn to determine blood lactate immediately after each sprint. Blood lactate concentration was determined enzymatically using a lactate analyzer (LactatePro, Australia). A cool-down of 300 -yards ended each sprint swim. After cool-down the swimmers performed 30min of passive rest. Participants would then re-warm up to complete the second sprint.

### *Deep-Breathing Procedure*

Two experimental deep-breathing procedures were utilized, one for 30 seconds and one for 2 minutes. Each cycle (inhalation and exhalation) of deep-breathing lasted for 5sec, with a 2sec deep inhalation and 3sec of deep exhalation. Each cycle of deep-breathing was visually guided by hand raising for 2sec and lowering the hand for 3sec in accordance with a digital pace clock. After deep-breathing, subjects had 30sec of passive rest to prepare for the start of the sprint.

## Discussion

*Thirty Seconds Deep-Breathing*

The main finding of this study revealed increased velocity and an improved time to completion after the $DB_{30}$ for both the 50 and 100-yard freestyle swims. Although no statistical difference was detected, a mean time improvement of 0.27sec would have competition ramifications and are similar to the time improvements observed by Jacob et al. (2015) for the 50-meter freestyle. Individual performance improvements for the current study ranged from 0.10sec to 1.1sec under $DB_{30}$ conditions and all but one participant improved. The one non-responder added 0.6sec.

To date, no study has established the effects of deep-breathing on a 100-yard swimming performance. Although not statistically significant, an improvement of 0.19 could result in a competitive advantage. Seventy one percent of the participants responded positively to the $DB_{30}$ protocol in the 100-yard trials. The two non-responders added 0.8sec & 3.2sec.

This study indicated an increased lactate production for both the 50 and 100-yard trials immediately post swim. Changes in blood lactate levels will follow changes in expired $CO_2$ levels demonstrating that lactate and $CO_2$ are closely linked (Anderson & Rhodes, 1991). Deep-breathing will drop baseline $CO_2$ levels and thereby signal the aerobic energy system to abate by down-regulating the pyruvate dehydrogenase (PDH) complex (Fujii et al., 2015). To compensate for the down-regulation of aerobic pathways, anaerobic systems will be up-regulated. Low $CO_2$ levels have been shown to up-regulate phosphofructokinase (PFK) activity (Fujii et al., 2015) thus increasing lactate production.

While stroke count (SC) and stroke rate (SR) were similar across all DB protocols, stroke length (SL) was improved in the $DB_{30}$ trials, though not statistically significant. Improved distance per stroke (SL) is considered a major factor for improved swimming efficiency (Smith et al., 2002) and the SL improvements in this study would equate to a 5.5cm lead in the 50-yard event and a 3cm lead in the 100-yard event. These results are contrary to Jacobs who determined no difference in SL from their DB protocol (Jacob et al., 2015).

*Two Minutes Deep-Breathing*

Two minutes of deep-breathing ($DB_2$) negatively affected 50-yard freestyle performance when compared to baseline conditions ($DB_{NO}$) resulting in slower velocities and therefore slower swim times (Figure 1). A 0.35sec increase in time would result in a competitive disadvantage in the 50 freestyle. Under normal exercise conditions there is an increase in extra cellular levels of $CO_2$ which signals vasodilation, sanctioning a decrease in peripheral resistance, and positively affecting performance. However, a few minutes of DB causes excessively low $CO_2$ levels and has shown to vasoconstrict relevant blood vessels increasing peripheral resistance and negatively affecting performance (Gilbert, 1999). Additionally, low $CO_2$ reduces sympathetic vagal activity and, consequently, reduces blood pressure (Joseph et at., 2005; Mori et al., 2005). If vasodilation and an increase in blood pressure are normally seen at exercise onset, it could be that performance is compromised in the 50 freestyle where vasoconstriction and low blood pressure concurrently present themselves explaining the slower times associated with $DB_2$. Furthermore, a loss of 2% blood flow occurs for every 1mmHg drop in $CO_2$ pressure (Gardner, 1996). Indeed, some participants reported minor perceptions of light-headedness prior to their swim trials which could affect their swims.

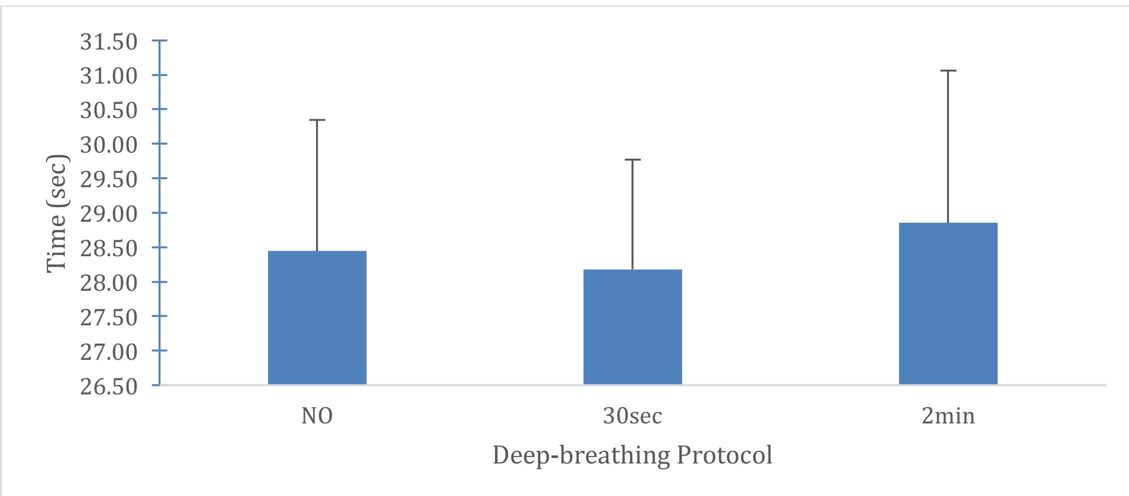


*Figure 1*. Mean times for the 50-yard freestyle for all seven female swimmers for each deep-breathing protocol.

$DB_2$ also revealed slower velocities and an increase in time for the 100-yard swims, respectively. All participants superseded the :55sec threshold where the aerobic system starts to dominate over the declining anaerobic system (Rodríguez & Mader, 2011). The same up-regulation of PFK and down-regulation of PDH from DB (Chin et al, 2007; Chin et al., 2010; Jacob et. al., 2008) would explain the poorer performance in the $DB_2$ 100-yard swims.

Higher lactate values post swim for $DB_2$ over control in the 100-yard trials suggest up-regulation of the anaerobic system pre-swim from DB (Chin et al, 2007; Chin et al., 2010; Jacob et al., 2008). Despite the increase in anaerobic metabolism pre-race, the down-regulation of aerobic metabolism due to DB (Sakamoto et al., 2014) suppressed performance in the 100 because of the length of the swim trial – i.e., being longer than the proposed :55sec where aerobic metabolism begins to dominate in its role in performance.

As seen in the $DB_{30}$ swims, SC and SR were similar for $DB_2$ swims in both the 50 and 100-yard trials. Distance per stroke (SL) was slightly lower for $DB_2$ compared to $DB_{NO}$ 100-yard swims indicating a reduction in swimming efficiency.

## Conclusion

In conclusion, this study showed that 30 seconds of deep-breathing prior to a 50 or 100--yard freestyle can improve race performance in NCAA collegiate female swimmers.  Lowering baseline $CO_2$ levels prior to a race can delay the onset of perceived fatigue, improved race times, and provide the swimmer with a competitive advantage. Two minutes of deep-breathing, however, could negatively affect 50 and 100--yard swimming performances. Further studies should investigate the effects of 30 seconds of deep-breathing on longer races distances, i.e. 200-yard freestyle. In addition, a one-minute deep-breathing protocol on swim races should be investigated.