The effect of the breathing action on velocity in front crawl sprinting

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Ten competitive, national level adult swimmers (age 25 ± 3 years (mean ± SD) swam three 25m freestyle sprints with different breathing patterns in randomised order to examine how breathing actions influence velocity during a 25m front crawl sprint. Velocity measurements were carried out using a computerized swimming speedometer and data from mid-pool free swimming (10-20m) was extracted. There was no significant difference in mean (±SD) velocity (v) between sprinting with one breath (v=1.74±0.14 m·s-1) compared to no breath (v=1.73±0.14 m·s-1). There was a significant ($p<0.05$) reduction in velocity when breathing every stroke cycle (v=1.70±0.14 m·s-1), compared to both no breath and one breath trials. Swimmers should breathe as little as possible during 50m freestyle races and breathe no more than every 3rd stroke cycle during a 100m freestyle race. Pedersen, T. and Kjendlie, P.-L. (2006). **The effect of the breathing action on velocity in front crawl swimming**. In: Vilas-Boas, J.P., Alves, F. and Marques, A. (Eds.), **Biomechanics and Medicine in Swimming X**. *Portuguese Journal of Sport Sciences Vol 6, Suppl 2,* Porto, pp. 75-77.

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INTRODUCTION

To achieve a high swimming velocity, one main goal for swimming technique is to create optimal propulsion and minimal resistance (1). For a front crawl swimmer, minimal resistance winds down to keeping an optimal streamline; the head and body in a straight line and the body as horizontal as possible. Optimal propulsion means keeping effective propulsive forces, high propelling efficiency and high power output throughout the swimming distance. The breathing action in front crawl swimming is in most cases a movement that inflicts the swimmers streamline or propulsion because the head has to move out of normal swimming position to make inspiration of air possible. How long the inspiration lasts will also inflict the swimmers streamline and propulsion (2). Both Cardelli, Lerda & Chollet (2) and Lerda & Cardelli (3) have found in previous studies that there is a connection between how good a swimmer is to coordinate the breathing action in front crawl swimming and their technical level. More expert swimmers tend to use shorter time on the inspiration of air compared to less expert swimmers (2).

Furthermore more expert swimmers were found to have an improved ability to coordinate arm-strokes and inspiration of air so that body balance and continued propulsion is more efficient also during the breathing action (3). Even so swimmers are often instructed to breathe as little as possible during 50 m sprint swimming, and during a 100 m race swimmers tend to reduce their breathing compared to longer distances.

The purpose of this study was to examine how breathing actions influence velocity during a 25m front crawl sprint by using two different breathing patterns compared to no breathing.

METHODS

Subjects:

Ten competitive, Norwegian national level, adult swimmers volunteered to participate in this study (8 males and 2 females, mean±SD; age 25±3 years, personal best 50m freestyle 25.15±1.98 sec, season best 50m freestyle 25.62±2.19 sec). All subjects signed an informed consent after having the protocol explained to them both verbally and in writing.

Test protocol:

Before start of the trial the subjects conducted a standardized warm up of about 1500m including four short sprints. The trial consisted of three 25m freestyle sprints with different breathing patterns conducted in a randomised order: a) 25m sprint with no breathing b) 25m with one breath after 15m of swimming c) 25m with one breath every stroke cycle. All breathing was to the subjects' preferred side. Each 25m sprint started every 4 minutes, giving the subjects about 3 min and 45 sec recovery between each sprint. During this recovery they had to swim one 25m to get back to start, the rest of the recovery was passive.

Measurements:

Velocity measurements were carried out using a computerized swimming speedometer, connected to the swimmer via a thin non elastic line. The speedometer, attached to the pool side, consisted of the speedometer and a digitizing unit. The speedometer had a reel for the line which was set to give a small, but constant resistance on the line to ensure a trouble free outlet of the line. The line went from the reel via a small wheel to the hip of the swimmer. The small wheel (9 cm inn diameter) was connected to the axis of an incremental encoder (Leine & Linde nr IS630, Strängnes, Sweden) which gave 250 square pulses (0-5V TTL logic) for every rotation of the wheel. The swimmers pulled the line and the incremental encoder produced impulses for every turn of the small wheel. These pulses was digitized in a computer card (DAQ 6024E, National instruments, USA), and the signal was treated with Digital acquisition software LabVIEW 7 Express (National Instruments, USA).

Every impulse from the speedometer gave position data which the program smoothened by a floating mean of 10 measurements. The velocity was then calculated in the program by a mean of two positions. Fig. 1. shows an example of the velocity output vs time. Sampled frequency was 100 Hz. The coefficient of variation for the equipment used was calculated to <2 %.

A camera (Panasonic GS3, Japan) was used to film the swimmers above water while they swam each trial. This film was later used to find out the number of strokes performed in the 10m distance of the one breath trial, and how many breaths the swimmers had on the same distance on the breath every stroke cycle trial.

Data from mid-pool free swimming (10-20m) was extracted and used in all analyses.

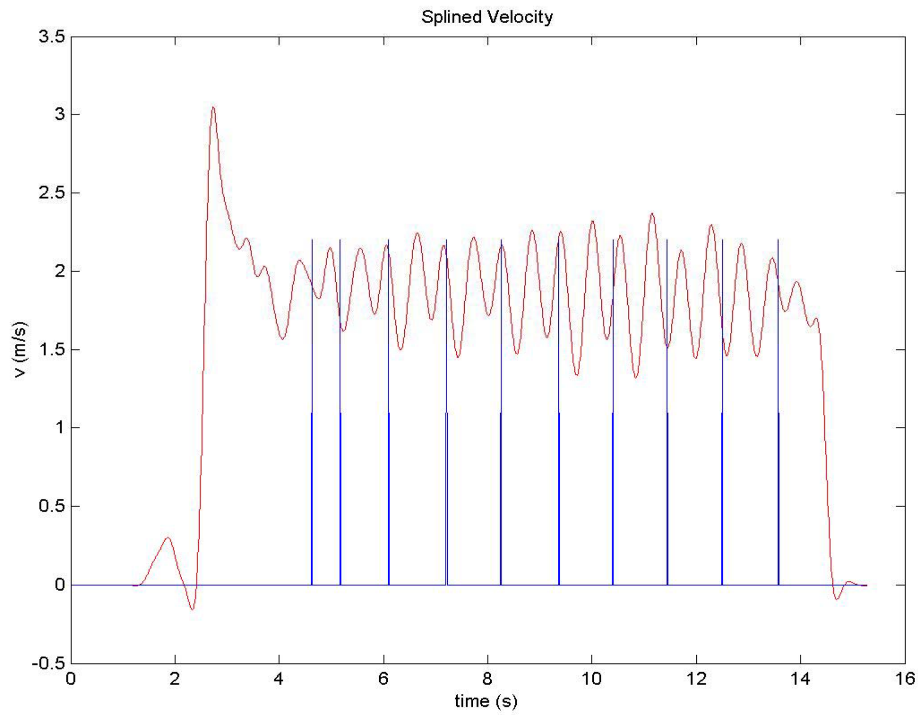

Fig. 1: Example of velocity vs time curve from the speedometer data. Vertical lines represent right arm entry.

Statistics:

All data are presented as mean ± standard deviation. A paired t-test was used to determine difference between the trials where $p<0.05$ was considered significant.

RESULTS

There was no significant difference in mean velocity (v) between 10m of mid pool sprinting when the swimmers took one breath compared to no breath. To breathe once every 10 meters equalled about one breath every 3rd stroke cycle for the swimmers in this study. There was a significant ($p<0.05$) reduction in velocity when breathing every stroke cycle, compared to both no breath and one breath trials, see table 1. The swimmers in this study breathed 5-7 times over 10m of mid pool sprinting when breathing every stroke cycle.

Table 1: Mean velocity (±SD) from the three trials.

	No breath	One breath	Breath every stroke cycle
	v_{10-20} ($m \cdot s^{-1}$)	v_{10-20} ($m \cdot s^{-1}$)	v_{10-20} ($m \cdot s^{-1}$)
Mean (±SD)	1.74 (±0.14)	1.73 (±0.14)	1.70 * (±0.14)

* significant different from both no and one breath trials ($p<0.05$)

DISCUSSION

The results indicate that swimmers at this performance level may breathe once every 3rd stroke cycle without loosing velocity due to breathing actions in front crawl sprint. If swimmers breathe every stroke cycle they may loose up to about 0.1 sec pr 10m of mid pool swimming.

Unpublished observations of 50m freestyle for males at the Norwegian Long course National championship 2004 showed that all the top 8 swimmers breathed 1, 2 or 3 times with at least 3 stroke cycles in between each breath in the final. Even though there was no significant difference between the one and no breath trial in this study, a difference of only 0.01 $m \cdot s^{-1}$ as found here represents a loss of 0.03 sec over 10 m swimming. Even at this performance level a loss of 0.03 sec because of one extra breath could mean 2nd place instead of 1st place. There were individual differences; the highest difference between no- and one breath trial was 0.04 $m \cdot s^{-1}$ or 0.15 sec. This indicates that all swimmers can gain by learning better breathing technique and breath control, but coaches should know that some individuals have even more to gain.

Furthermore, observations of the 100m freestyle race for both females and males in the same National Championship revealed that 100m freestyle swimmers seemed to vary what breathing pattern they choose, but most common was to breathe every 2nd, 3rd or 4th stroke cycle for the first part of the race, and than increase to every stroke cycle or every 2nd stroke cycle the last part of the race. Only a few swimmers choose to breathe as little as every 3rd or 4th stroke cycle throughout the race, amongst these was the winner of both male and female 100m freestyle. The main reason for swimmers to increase their breathing pattern the last part of a 100m race is caused by an urge to breathe more due to a lower partial CO_2 pressure in the blood caused by the high intensity of the swimming. Peyrebrune et al. (4) found no reduced performance based on physiological markers when swimmers breathed as little as every 4th stroke cycle, during 55 sec of tethered swimming. This indicates that the swimmers can choose to breathe as little as every 3rd to 4th stroke cycle without loss in performance due to either physiological factors or biomechanical factors (breathing action).

CONCLUSION

Coaches should stress breath control both in training and competitions and also teach effective breathing technique to avoid velocity reductions due to breathing actions. In a 50 m freestyle sprint the swimmers should breathe as little as possible, but during 100 m race swimmers must breathe more and can breath as often as every 3rd stroke cycle without to much loss of velocity compared to breathing more often. To give accurate advice about which breathing patterns to use in 100m races, both individual differences in technique and physiological and metabolic variables must be taken into consideration. A further investigation in this matter seems necessary, combining biomechanical and physiological methods.

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Reviewer comments

Accepted as it is now.