Effects of Three Swim Strokes Over 25 Yards in Labor-Wear with a Personal Flotation Device

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Abstract

We determined how three different swim strokes (breast, back, and American crawl) were affected by standard labor-wear while wearing a personal flotation device (PFD) over 22.8 meters (25 yards). The main research questions were, (1) which stroke would yield the fastest times over 22.8 meters and (2) Would there be a difference in the swim times between male and female subjects? We addressed these questions with three hypotheses addressing whether or not there would be a statistically significant difference among the three strokes, and whether or not gender would have an effect on performance of the different strokes. The mean 22.8-m elementary back stroke swim time for all subjects (n = 51) was 59.98 sec; for the breast stroke it was 46.05 sec and for the crawl stroke it was 46.48 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 1 in favor of research hypothesis 1 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke for all subjects, with breast stroke being the fastest and the elementary back stroke being the slowest. The mean 22.8-m elementary back stroke swim time for male subjects (n = 26) was 51.04 sec; for the breast stroke it was 41.41 sec and for the crawl stroke it was 34.73 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 2 in favor of research hypothesis 2 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke, with the crawl stroke being the fastest and the elementary back stroke being the slowest. The mean 22.8-m elementary back stroke swim time for female subjects (n = 25) was 69.28 sec; for the breast stroke it was 50.87 sec and for the crawl stroke it was 58.71 sec. An ANOVA generated a P-value of .001. Thus, we rejected null hypothesis 3 in favor of research hypothesis 3 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke, with the breast stroke being the fastest and the elementary back stroke being the slowest.

Keywords: swim strokes, labor-wear, swim times, personal flotation device, life vest

Introduction

In March 2011, a train derailment along the Kootenai River in Northwest Montana required railway workers to be transported to the derailment site via jet boat and to work on an inclined embankment along the river. The ensuing clean-up effort lasted 4 months and involved over 1000 people. Many of the laborers were transported on jet-boats to islands, and worked in close proximity to the flooding river. During this time, the air temperature fluctuated between -1-12 ◦C (30-54 ◦F), the Kootenai River was flowing at about 566.34 m3/ sec (20,000 ft3/ sec), and the temperature of the water was about 3.8 ◦C (39 ◦F) (U.S. Geological Survey 2011).

A common question of the laborers during transport was, "If we fall into the drink [while working], how long would we be able to stay up before you guys are able to rescue us?" The average worker transported to the worksite was wearing standard labor-wear: a hard hat with a liner, a heavy canvas jacket with insulation under the jacket, canvas bib coveralls, and heavy leather work-boots with steel-toe protection. We tested the hypothesis that occupational clothing would impair performance during swimming and treading water (Amtmann et al. 2012).

Our research provided evidence that standard labor-wear had adverse effects on 11.4-m swim time, water treading time, and rate of perceived exertion (RPE) on the Borg Scale (1998) during water treading. The mean swim time more than doubled when the subjects wore standard labor-wear and their average rate of perceived exertion increased from 11.6 in standard swimwear to 17.1 in standard labor-wear. Because the trials excluded the use of a personal flotation device (PFD), the authors' recommendations for future research included comparing the effectiveness of different strokes with and without a PFD over 11.4 meters/12.5 yards. (Amtmann et al. 2012).

Subsequent research examined the effects of standard labor-wear with and without use of PFDs for three strokes: elementary back stroke, breast stroke and American crawl. Statistical analysis showed statistically significant differences between PFD and no PFD for the American crawl (no PFD 23.29 sec, PFD 18.29 sec, P = 0.0010), and back stroke (no PFD 36.96 sec, PFD 31.00 sec, P = 0.0223); these strokes showed shorter swim times with the PFD. We detected no statistical evidence (P = 0.2086) for the mean swim time (22.61 sec) for the breast stroke with PFD and the mean swim time (23.00 sec) for breast stroke without a PFD.

Swim time between swimmers with and without a PFD differed. The mean swim time for all swimmers with a PFD (24.17sec) was faster than the mean swim time for all swimmers without a PFD (27.75 sec, P = 0.0153). We concluded that swimming was not adversely affected by wearing a PFD over 11.4m, and that wearing a PFD would be beneficial in water emergencies requiring self-rescue. Also, we were able to determine that the American crawl produced the fastest times over 11.4 m. The recommendations for future research were to examine the effects of swimming those same strokes over a longer distance while wearing a PFD (Amtmann et al 2014).

The current research included (1) what effects would standard labor-wear have on the American crawl, elementary back stroke, and breast stroke while wearing a PFD over 22.8 m (25 yards)? (2) Would there be a difference in the swim times between male and female subjects?

Null Hypothesis 1: There will be no statistically significant ($p > .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for all subjects.

Research Hypothesis 1: There will be a statistically significant ($p < .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for all subjects.

Null Hypothesis 2: There will be no statistically significant ($p > .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for male subjects.

Research Hypothesis 2: There will be a statistically significant ($p < .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for male subjects.

Null Hypothesis 3: There will be no statistically significant ($p > .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for female subjects.

Research Hypothesis 3: There will be a statistically significant ($p < .05$) difference between the mean times for elementary back stroke, breast stroke and American crawl for female subjects.

Methods

We tested the hypotheses in a controlled indoor pool environment. Each subject swam one trial each of the three strokes. Each trial was performed wearing standard labor-wear, including coveralls and boots, and a PFD. The PFD used was a United States Coast Guard Approved Type V PFD that provides about 20 lb. of buoyancy (United States Coast Guard 2013). The labor-wear consisted of canvas coveralls worn over the subjects' swim-suit and steel-toed work-boots.

Fifty one volunteer subjects were chosen based on current or previous experience and credentials. The exclusion criteria were guided by the American College of Sports Medicine risk stratification process. American College of Sports Medicine (ACSM) guidelines suggest a pre-participation screening that identifies current medical conditions that would exclude those who are at risk for adverse cardiovascular, pulmonary, metabolic, as well as other conditions that would cause adverse responses to exercise (ACSM 2009). The list of conditions that excluded a subject included:

- Pregnancy
- Diabetes
- Hypertension or are taking blood pressure medication
- Asthma
- Concerns about safety of exercise or swimming ability
- Heart surgery
- Chest discomfort with exercise
- Unreasonable breathlessness with exercise
- Unexplained dizziness or fainting
- Musculoskeletal problems that limit functional capacity
- Current smoker

All subjects completed the pre-participation screening intended to identify anyone who should be eliminated. Additionally, all subjects chosen were under the age of 50 years.

Safety of the subjects for the swim was ensured in two ways. First, the swim was conducted in water that was 4 ft. deep, in which all of the subjects were able to stand. The subjects were instructed to simply stand up if they were in distress. The subjects were surrounded by a lifeguard in the water and a lifeguard on the deck with appropriate rescue equipment as back-up measures. Additionally, each subject was wearing the aforementioned PFD.

The subjects read an informed consent form that emphasized the voluntary nature of this study, and that if they were uncomfortable doing anything related to this study they had the option to not participate. The decision to take part in this research study was entirely voluntary, and the subject could withdraw from the study at any time. Additionally, all procedures were presented to, and authorized by, an institutional review board.

After the subjects read the informed consent form, they were informed of the order of the randomly selected trials. Each subject would swim each stroke with a PFD; we randomly assigned the order in which testing was conducted. Resting heart rate and blood pressure was measured on each subject prior to the start of testing, and each subject was allowed to rest following each trial until their heart rate and blood pressures reached resting states. The subject's heart rate was recorded by palpation of the radial artery immediately following completion of each trial. Additionally, each subject's rating of perceived exertion was recorded. The subjects performed the next time trial when their heart rate returned to their resting norms.

Results

The mean 22.8-m elementary back stroke swim time for all subjects (n = 51) was 59.98 sec; for the breast stroke it was 46.05 sec and for the crawl stroke it was 46.48 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 1 in favor of research hypothesis 1 at a significance level of 0.05. There was a difference in swim times over 22.8-m for each stroke for all subjects, with the crawl stroke being the fastest and the elementary back stroke being the slowest.

The mean 22.8-m elementary back stroke swim time for male subjects (n = 26) was 51.04 sec; for the breast stroke it was 41.41 sec and for the crawl stroke it was

34.73 sec. An ANOVA generated a P-value of less than .0001. Thus, we rejected null hypothesis 2 in favor of research hypothesis 2 at a significance level of 0.05. There was a difference in swim times over 22.8-m among strokes, with the crawl stroke being the fastest and the elementary back stroke being the slowest.

The mean 22.8-m elementary back stroke swim time for female subjects (n = 25) was 69.28 sec; for the breast stroke it was 50.87 sec and for the crawl stroke it was 58.71 sec (=0.001). Thus, we rejected null hypothesis 3 in favor of research hypothesis 3 at a significance level of 0.05. There was a difference in swim times over 22.8-m among strokes for females, with the breast stroke being the fastest and the elementary back stroke being the slowest.

Discussion

In our previous studies, we established the fact that self-rescue in labor-wear may be physically exhausting, and that wearing a PFD improves swim times (Amtmann et al. 2012 & 2014). When a person treads water and/or swims, it takes energy to stay on the surface of the water and to propel themselves forward (McArdle 2010). Labor-wear adds drag making swimming more difficult. Although wearing a PFD will add more surface area creating extra drag (Parsons and Day 1986, Benjanuvatra et al. 2002, Vennell et al. 2006), the PFD keeps the person on the surface so there is no need to expend energy to stay afloat. The person can use that energy to propel themselves forward, making the swim faster.

In our previous study, we found that there was no statistically significant difference in swim times between the breast stroke and the crawl stroke at a distance of 11.4 yards (Amtmann et al. 2014). The results of this study suggest that there is a difference in which stroke produces faster results over a longer distance, 22.8-m, for each gender. For men the crawl stroke produced the fastest results, but for women the breast stroke was the fastest stroke. Why is there a difference between the male and female subjects? Upper body strength may be the reason. Beyond a certain distance it may be more prudent to make efficiency and endurance a priority over speed. If that is the case, then everyone, males and females, will have a point where the focus will change from choosing to move as swiftly as possible to a safe area to moving as efficiently as possible over a greater distance to a safe area. It is important for the victim to be able to assess the distance they need to swim for self-rescue to be successful, and use the appropriate stroke for the situation.

Over shorter distances, it appears the crawl stroke will be the best choice, but for longer distances, it may be some other more efficient stroke. In water rescue situations it may be important for the victim to be able to decide whether to sprint a shorter distance using a more exhausting stroke, or cruise a longer distance with a more efficient stroke. Essentially, it means having the mind-set of being prepared to survive the marathon if you can't win the sprint.

The limitations to this study included lack of objective fitness data and lack of our ability to classify the subjects according to swimming skill. Most of the subjects were young, ranging from 18 - 30 years, with only eight subjects being older than 30 years of age. This age distribution may not accurately reflect the age of the work-force. The subjects were relatively fit with some being collegiate athletes and firefighters, this degree of fitness also may not be a true representation of the work-force. Also, the labor-wear only consisted of boots and coveralls; no inner layers were worn. Insulation layers may have a further impact on the measurements. The environment was controlled; the water was warm, clear and non-moving when, in reality, many water incidents occur in cold, dark moving water.

Suggestions for Future Research

To gather more information, conducting fitness assessments on each subject would be beneficial. Also, adding the insulation layers that are normally worn may more accurately reflect a laborer's physiological response in water. Monitoring heart rates and oxygen consumptions and comparing the different strokes would provide information on energy expenditure. It would also be important to compare the effect of different water temperatures and environments on swim times and strokes.

Practical Application

When recreating or working on or near water where there is a drowning hazard, wearing a PFD will ensure an easier self-rescue. The Occupational Safety and Health Administration requires workers to wear a PFD when working near a drowning hazard, and we recommend that employers strictly follow that requirement. Simply wearing a personal flotation device will improve the efficiency of self-rescue, making swimming easier. However this rule is not always followed and wearing a PFD will not always prevent the loss of a life. If there is a need for self-rescue we recommend using the stroke with which the person is most comfortable. The breast stroke was the fastest stroke for women over 22.8-m. The American crawl was the fastest for men. The crawl stroke appeared to be the most exhausting, so distance to safety may need to be considered during self-rescue. If the distance is great enough that exhaustion will set in prior to reaching the safe zone, the victim must be able to recognize the situation and choose an efficient stroke that will conserve energy while moving toward the safe zone.

We also recommend that any company requiring their employees to work on or near water consider implementing water safety plans that may include swift water rescue professionals to conduct training and to be on-site to help prevent water injury and death. Finally, we recommend training that allows in-water experiences so employees develop an understanding of their abilities and limitations over varying distances, and practice the different strokes in the water to find out which stroke they are most comfortable with if water-based self-rescue is required.

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