

EFFECTS OF STANDARD LABOR-WEAR ON SWIMMING AND TREADING WATER

John A. Amtmann, Whitewater Rescue Institute; Lolo, Montana, Montana Tech, Safety Health, Industrial Hygiene Department, Butte, Montana

Cody Harris, Whitewater Rescue Institute, Lolo, Montana

William Spath, Montana Tech, Safety, Health and Industrial Hygiene Department, Butte, Montana

Chip Todd, Montana Tech, Department of Mathematical Sciences, Butte, Montana

ABSTRACT

We tested the hypothesis that occupational clothing would impair performance during swimming. The sub questions included: (1) Will the standard work wear of a railway worker or laborer impede swimming ability? (2) Will this clothing impact the individual's ability to tread water? We addressed the research questions with three hypotheses. Analysis showed statistically significant p-values and all three null hypotheses were rejected in favor of the three research hypotheses, showing strong evidence that standard labor wear had adverse effects on 11.43 meter/12.5 yard swim time, water treading time and rate of perceived exertion (RPE) 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 swim wear to 17.1 in standard labor-wear. It may be beneficial for those workers who work near water to be exposed to educational programs that allow in-water experiences so they develop an understanding of their abilities in, and respect for, the water.

Key Words: Labor-Wear, Swimming, Treading, Effects, Swift water Rescue

INTRODUCTION

In this paper we examine the effect of standard work clothing on people's ability to maneuver in water and rescue themselves from dangerous situations. Several examples demonstrate why understanding clothing effects is important. On May 2nd, 2003, a laborer was working near a pond in Oregon. The pond was surrounded by an angled embankment where the laborer was placing rocks at strategic locations on the inclined bank to prevent erosion. The laborer fell down the embankment and into the pond. By the time that he was rescued from the water, first responders were unable to resuscitate him. It took them 47 minutes to locate and remove the body before resuscitation efforts began (NIOSH, 2003).

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. Each day the workers were transported seven miles down the river. The crew of each boat included a Swift Water

Rescue Technician (SRT) as well as the licensed boat pilot.

In July 2011, an oil pipeline on the Yellowstone River ruptured. The ensuing clean-up effort lasted four months and involved over one thousand people. Many of the laborers were transported on jet-boats to islands, and worked in close proximity to the flooding river.

The SRT personnel, who were involved in the jet-boat transportation and safety support of the laborers, conducted rescue training on a daily basis. By predicting how, when and where the workers would enter the water, they could focus training efforts to the most likely situations: a worker falling into the river during transport or during work on the steep embankment along the river. The training was successful. Each and every simulated victim was rescued during the training. But each simulated victim was wearing special equipment designed for the conditions: During the third week in March on the Kootenai River, for example, the air temperature fluctuated between about 30 and 54 degrees Fahrenheit, the Kootenai River

was flowing at about 20,000 cubic feet per second, and the temperature of the water was about 39 degrees Fahrenheit (USGS, 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 being transported to the worksite was wearing standard work-wear: a hard hat with a liner, a heavy Carhartt canvas jacket with insulation under the jacket, Carhartt canvas bib coveralls, and heavy leather work-boots with steel toe protection.

The Occupational Safety and Health Administration requires the use of personal protective equipment and personal flotation devices (PFD) when individuals are working on, over or near water when a drowning hazard exists (U.S. Department of Labor; 1926.106(a)). However, workers don’t always comply with this requirement. The purpose of this research was to determine how swimming performance, water treading time and perceived exertion are influenced when workers are wearing typical labor-wear compared to swim-wear. All study procedures were reviewed and approved by an independent investigational review board. The main research question was, what effects would standard labor-wear have on swimming ability and ability to self-rescue? The sub questions that guided the development of our hypotheses were:

Will the standard labor-wear impede swimming ability?

Will this clothing impact the individual’s ability to tread water?

Hypotheses:

Null Hypothesis 1:

The average 11.43 meter/12.5 yard swim time in standard labor-wear is \leq the average 12.5 yard swim time in standard swim-wear.

Research Hypothesis 1:

The average 11.43 meter/12.5 yard swim time in standard labor-wear is $>$ the

average 12.5 yard swim time in standard swim-wear.

Null Hypothesis 2:

The average time to failure when treading water in standard labor-wear is \geq the average time to failure when treading water in standard swim-wear.

Research Hypothesis 2:

The average time to failure when treading water in standard labor-wear is $<$ the average time to failure when treading water in standard swim-wear.

Null Hypothesis 3:

The average rate of perceived exertion (RPE) when treading water in standard labor-wear is \leq the average RPE when treading water in standard swim-wear.

Research Hypothesis 3:

The average RPE when treading water in standard labor-wear is $>$ the average RPE when treading water in standard swim-wear.

METHODS

We tested the hypotheses in a controlled indoor pool environment. The subjects participated in four trials:

- *Trial 1:* Timed freestyle swim of 11.43 meter/12.5 yards in standard swimwear.
- *Trial 2:* Timed freestyle swim of 11.43 meter/12.5 yards in standard labor-wear.
- *Trial 3:* Timed water tread in standard swimwear.
- *Trial 4:* Timed water tread in standard labor-wear.

Nine volunteer subjects were chosen based on current or previous experience and credentials. The inclusion criteria was set so only those who have swiftwater rescue technician (SRT) certification, lifeguard certification, and/or competitive swimming experience were considered. The SRT has demonstrated swimming abilities that meet the Whitewater Rescue Institute’s (WRI) minimum standards to self-rescue and to rescue victims of swiftwater

accidents, and certified lifeguards are required to pass a swim test to demonstrate proficiency.

The exclusion criteria included any current student of the researcher's and was 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 to identify anyone who should be eliminated. Additionally, all subjects were under the age of 50 years.

Safety of the subjects for the 11.43 meter/12.5 yard swim was ensured in two ways. First, the 11.43 meter/12.5 yard swim was conducted in water that is 4 feet 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 also surrounded by lifeguards in the water and on the deck with appropriate rescue equipment as back-up measures.

Safety for the subjects during the treading consisted of three lifeguards/SRTs monitoring the subject with rescue flotation devices. Using Borg's Rate of Perceived Exertion (RPE) Scale, the subjects were

required to verbally communicate their exertion level on a scale of 6 to 20. When the subject neared the extreme end of the scale and their efforts could no longer continue, they were instructed to reach for the gutter to self-rescue. If they were unable to self-rescue the rescuers planned to use the rescue/flotation equipment to assist the subject.

Prior to the trials, each subject was given the following instructions regarding the use of the RPE Scale to ensure safety:

"While performing the treading, we want you to rate your perception of exertion. This feeling should reflect how heavy and strenuous the treading feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. Do not concern yourself with any one factor such as leg pain or shortness of breath, but try to focus on your total feeling of exertion. Look at the rating scale below while you are treading; it ranges from 6 to 20, where 6 means 'no exertion at all' and 20 means 'maximal exertion'. Choose the number from below that best describes your level of exertion. This will give us a good idea of your intensity level and how much longer the treading will continue." The RPE scale with related descriptions includes (Borg, 1998, pg. 47):

6	.....	No exertion at all
7	.....	Extremely light
8		
9	.....	Very light - (easy, comfortable pace)
10		
11	.....	Light
12		
13	.....	Somewhat hard (It is quite an effort; you feel tired but can continue)
14		
15	.....	Hard (heavy)
16		
17	.....	Very hard (very strenuous, and you are very fatigued)
18		
19	.....	Extremely hard (you cannot continue for long at this pace)
20	.....	Maximal exertion

The subjects were all read an informed consent form that emphasized the voluntary nature of this study, and that if they were uncomfortable doing anything in the study assessment they had the option to not participate. The decision to take part in this research study was entirely voluntary, and subject withdrawal from the study could have occurred at any time.

PROCEDURES

The subjects were read the informed consent form, and were instructed on the proper use of Borg's (RPE) scale. Resting heart rate and blood pressure were measured at this time. The subjects were informed that the RPE scale were to help the rescuers by providing them information that will prepare them to assist the subject. The order of the timed trials included:

- First all subjects swam the 11.43 meter/12.5 yard swim in standard swim-wear
- 15-minute rest
- All subjects swam the 11.43 meter/12.5 yard swim in standard labor-wear
- 15 minute rest
- Water treading test in standard swim-wear
- One week rest
- Water treading test in standard labor-wear

RESULTS

Table 1 shows the complete results of the trials. The mean 11.43 meter/12.5 yard swim time for subjects in standard swim-wear (Sw) was 10.05 seconds and the mean swim time for subjects in standard labor-wear (Sw L) was 23.37 seconds. The Wilcoxon Signed Rank test is appropriate for relatively small sample sizes, and showed a p-value of 0.0039. Based on this result we reject null hypothesis 1 in favor of research hypothesis 1 at a significance level of 0.05. Table 2 shows the statistical results for the 12.5 yard swim.

The mean treading time for subjects in standard swim-wear (Tr) was 12.99 minutes while the mean treading time for subjects

in standard labor-wear (Tr L) was 8.41 minutes. The Wilcoxon Signed Rank test showed a p-value of .0156. Based on this result we reject null hypothesis 2 in favor of research hypothesis 2 at a significance level of 0.05. Table 3 shows the statistical results for the water treading tests.

The mean RPE for subjects treading in standard-swim wear (RPE Tr) was 11.67 seconds, and the mean RPE for subjects treading in standard labor-wear was 17.11 seconds. The Wilcoxon Signed Rank test showed a p-value of 0.0156. Based on this result we reject null hypothesis 3 in favor of research hypothesis 3 at a significance level of 0.05. Table 4 shows the statistical results for the subjects' RPE for the water treading.

The limitations to the study include the non-randomized order of trials which could have caused an order effect. We did this because we felt it would be the safest way to conduct the trials but acknowledge that it could have an effect either way on the results. Additionally, a small sample size and the lack of objective fitness data, body composition in particular, for each subject, would have allowed us to discuss the possible effects of differences in body composition on the treading results. The subjects were very fit and may not be the best representatives of the average work-force representative; again pre-test fitness measurements may have allowed us to compare the subjects with average fitness levels in the American work-force. We established and adhered to the subject guidelines for safety purposes because we did not want any of the subjects to be traumatized by the experience. That is, we had all subjects begin each trial with swim-wear to prepare them for the more difficult labor-wear trial. Each subject was allowed to rest for at least 15 minutes, and heart rates were monitored prior to the labor-wear trials to ensure the subject was in a resting state. We acknowledge, however, that the non-randomized order in which this was conducted may have had an order-effect.

Also, the labor-wear only consisted of boots and the coveralls; no inner layers were worn. Insulation layers may have

Table 1. Results

Subject	Age	RHR	Sw	Sw L	Tr	Tr L	RPE	RPE L
1	46	60	8.29	18.5	15:00	10:54	15	20
2	21	66	8.61	23.9	10:50	1:06	20	20
3	21	60	10.34	15.3	5:25	55.07	20	20
4	22	78	11.68	33.03	10:40	56	20	20
5	23	78	10.24	30.3	15:00	8:35	6	20
6	21	72	9.46	20.9	15:00	15:00	6	8
7	20	78	8.54	17	15:00	8:18	6	20
8	22	84	11	23	15:00	15:00	6	14
9	21	95	12.33	28.44	15:00	15:00	6	12

Table 2. Means 11.43 meter/12.5 Yard Swim

	N	Mean	St. Dev.	Min.	Max.	Range	p-value
Sw	9	10.05	1.44	8.29	12.33	4.04	
Sw L	9	23.37	6.15	15.3	33.03	17.73	0.0039

Table 3. Means Treading

	N	Mean	St. Dev.	Min.	Max.	Range	p-value
Tr	9	12.99	3.38	5.42	15	9.58	
Tr L	9	8.41	6.14	0.92	15	14.08	0.0156

Table 4. Means RPE

	N	Mean	St. Dev.	Min.	Max.	Range	p-value
RPE Tr	9	11.67	6.89	6	20	14	
TRPE Tr L	9	17.11	4.59	8	20	12	0.0156

had 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.

DISCUSSION

Based on the results described above, we can say with confidence that it is more difficult to tread water and swim 12.5 yards in coveralls and heavy work boots when compared to wearing a swim-suit. An individual who ends up in the water with standard labor-wear should expect the physical requirements needed for self-rescue to be much more difficult than if they had simply fallen into a swimming pool with their swim suit on. Three of the subjects who were able to tread water for more than 5-10 minutes in their swim trunks were only able to tread water for around one minute

in the labor-wear. All nine subjects showed slower swim times with labor-wear. One subject only required an extra 5 seconds, but the other 8 subjects all required double or triple their swim-wear times.

All of the subjects were current or former athletes. Two were college football players, two were college basketball players, and one was a college volleyball player. Though standard fitness assessments were not part of the protocol, the subjects were given an initial swim test as part of the institutional review board procedure agreement, and they all appeared to have a high level of physical fitness. We believe the effects on swimming and treading efficiency would be much more pronounced on physically unfit individuals.

All of the subjects reported higher levels of difficulty when swimming or treading in the labor-wear, but there was

disagreement on whether the treading with the labor-wear or swimming with the labor-wear was harder. Out of the nine subjects, all four of the men believed that the treading was more difficult than the swimming, and all five women believed that the swimming was more difficult than the treading.

The distance of 11.43 meters/12.5 yards is a short swim; five of the nine subjects stated that the swim was much more difficult than the treading. For them, self-rescue of distances greater than this may not be possible. Additionally, the controlled environment and relatively warm water is not universally applicable. Self-rescue in cold, dark, moving water is different, and probably more difficult, than self-rescue in a warm pool with non-moving, clear water.

The original question can now be answered: In some cases complete exhaustion occurs in less than one minute. This is one reason the Occupational Safety and Health Administration requires a life-vest when workers are near a drowning hazard. Simply wearing a life-vest, a personal flotation device (PFD), will prolong this time; however this rule is not always followed and wearing a PFD will not always prevent the loss of a life.

Based on the results of this study we believe it may be beneficial for those who work near water to participate in educational programs that allow in-water experiences so they develop an understanding of their abilities in, and respect for, the water. We also recommend that any company requiring their employees to be working on or near water to 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.

RECOMMENDATIONS 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 the water. Though it may be difficult to receive institutional review board approval, conducting this research in moving water, such as an actual river would be more realistic. The addition of a PFD would also have an effect on self-rescue; treading would not be as difficult if a PFD is worn. Self-rescue swimming with a PFD should be addressed as well; wearing a PFD doesn't always mean self-rescue is guaranteed. Monitoring heart rates and comparing different strokes would provide information about which strokes would be more efficient in standard labor-wear.

REFERENCES

- American College of Sports Medicine. (2009). *ACSM's Guidelines for Exercise Testing and Prescription 8th Edition*. Baltimore, MD: Lippincott, Williams & Wilkins.
- Borg, G. 1998. *Borg's Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics.
- NIOSH FACE Program (2003). Hispanic Laborer Drowns After Falling Into Landscape Pond. Internet Available: <http://www.cdc.gov/niosh/face/stateface/or/03or008.html>. Date of Download: October 10th, 2011.
- USGS. Water Information System. Kootenai River at Bonner's Ferry, ID. March 2011. Internet Available:<http://waterdata.usgs.gov/nwis/> Date of Download: October 8, 2011.
- United States Department of Labor. Occupational Safety and Health Administration website. Internet available: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&P_ID=10669. Date of Download: October 5, 2011.

Received July 24, 2012
Accepted September 5, 2012