International Journal of Aquatic Research and Education

Volume 8 | Number 4 Article 5

11-1-2014

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International Journal of Aquatic Research and Education, 2014, 8, 338-350
http://dx.doi.org/10.1123/ijare.2014-0060

International Journal of
Aquatic Research and Education
www.IJARE-Journal.com
RESEARCH

Can You Swim in Clothes? An Exploratory Investigation of the Effect of Clothing on Water Competency

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Little is known about the effect of clothing on water survival competencies such as swimming and floating in the prevention of drowning. In the first phase of a project entitled *Can You Swim in Clothes?*, ways of measuring swimming speed, endurance, and floating with/without clothing were explored. Physical education students (n = 12) with known water proficiency completed a 25 m sprint swim, a 5-min swim, and a 5-min float in swimwear and then repeated these tests a week later in clothing. Wearing lightweight clothes significantly reduced swimming speed (33%) and reduced swim endurance (28%) but no significant deterioration in flotation was found, irrespective of age or sex. Greater depreciation was noted in the sprint swim for those who self-reported low water competency. Reasons for this performance change are discussed and ways of applying the protocols developed in this initial phase of the project to other populations, especially those with less water competency and high-risk groups, are recommended.

Keywords: drowning/near drowning; survival swimming; water safety; swimming and aquatic skills

Unintentional falls into water, often when fully clothed, are a frequent source of open water drowning. In New Zealand, nonrecreational immersion incidents, where the victim had no intention of being in the water accounted for one quarter (25%) of all drowning fatalities from 2008–2012 (Water Safety New Zealand, 2014). Such incidents are likely to require immediate self-recovery or bystander intervention since the victim is unlikely to be wearing a personal flotation device and have rescue personnel at hand. Furthermore, the risk of drowning is likely to be exacerbated by adverse environmental conditions such as cold, wind chill, currents, and rough water. A widely held, and frequently reported, public perception of the impact of clothing in unintentional immersion is that clothing 'weighed the victim down' and was the cause of drowning. In spite of the frequency of such occurrences, little is known about the effect of clothing on water survival competencies such as swimming and survival floating in the prevention of drowning.

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Several studies have noted the debilitating effect of cold on swimming performance (Datta & Tipton, 2006; Ducharme & Lounsbury, 2007; Golden, Hardcastle, Pollard, & Tipton, 1986; Tipton, 2003; Tipton, Eglin, & Golden, 1998; Tipton, Eglin, Gennser, & Golden, 1999; Tipton, Stubbs, & Elliott, 1990). One study has suggested that clothing may have a beneficial effect in drowning prevention by providing immediate flotation, the consequence of trapped air in clothing layers (Barwood, Bates, Long, & Tipton, 2011). In addition to providing some insulation to the hypothermic effects of cold water immersion, the buoyancy also may help the victim to cope with laryngeal spasm associated with cold water shock and importantly provide vital seconds to allow the victim to make rational decisions about how to extricate themselves from the situation (Golden & Tipton, 2002). This new approach to sudden immersion in cold water has been termed the *float first* drowning prevention strategy (Barwood et al., 2011).

Having survived the initial response to cold water immersion, strategies on how best to return to safety vary with constraints associated with the victim (e.g., age, body composition, health and fitness, water competencies), the task required (e.g., stay afloat for a short or prolonged time, swim varying distances to safety), and the environment (e.g., cold, water currents, waves, the nature of the exit point). Advice from water safety organizations on the role of clothing in drowning prevention varies and is largely based on anecdotal evidence and expert opinion. Indeed, the effect of clothing on water survival competencies in open and closed water environments has recently been identified as a research need in the revised edition of *Drowning: Prevention, Rescue, and Treatment* (Stallman, Moran, Rahman, & Brenner, 2014). The lack of consistency in safety advice is exacerbated by an underlying lack of research as to what constitutes the water competencies required to survive any possible drowning especially unintentional immersion. In proposing a model of teaching swimming based on the causes of drowning, Stallman and colleagues have suggested a graded approach to defining water competency that includes clothing at all levels of assessment (Stallman, Junge, & Blixt, 2008).

Some evidence has emerged to inform our thinking on the impact of clothing on survival in a drowning situation. Choi and colleagues used maximal oxygen uptake (VO_2max) to analyze the cardiovascular demands of swimming using different strokes, at different speeds, and with/without clothes (Choi, Kurokawa, Ebisu, Kikkawa, Shiokawa, & Yamasaki, 2000). They found significant increases in maximal oxygen uptake (VO_2max) as a consequence of swimming in clothes especially at higher swimming speeds. An exploratory study by Stallman, Laakso, and Kjendlie (2011) reported a deleterious effect of clothing when performing a 200 m combined test compared with the same test performed in swimwear among 10-year-old children (n = 63). Follow-up studies in 2013 (n = 128; Stallman, Laakso, & Hornemann, 2013) and 2014 (n = 490; Laakso, Horneman, Grimstad, & Stallman, 2014) using the same 200 m combined competency test found that a significant number of children able to swim in swimwear were judged unable to swim with outer clothing.

One study that focused specifically on the effects of standard work-related clothing on unintentional immersion in an occupational context found that the attire of railway workers (included work boots and canvas coveralls) had adverse effects on a short swim (11.43 m) and treading water (Amtmann, Harris, Spath, & Todd, 2012). The authors concluded that for workers who work near water, educational programs that allow in-water experience of wearing work clothes in the event of an unintentional immersion might be beneficial. Similar recommendations were made by the authors of a pilot study that explored the effects of specific attire on immersion related to fly fishers wearing waders (McElroy, Blitvich, Petrass, & McKinley, 2011).

The water competencies thought pertinent to the prevention of drowning have been the subject of recent research in a collaborative project entitled *Can U Swim?* (Moran et al., 2012). In this study, participants were asked to estimate their capacity to perform a range of skills deemed relevant to drowning prevention and then compare these estimates with practical assessment of the skills. The study found low associations with the participants' capacity to swim distance compared with floating, swimming on the back, and underwater swimming competencies. As a follow-up, further studies on the influence of rough water on the same water competencies called the *Can You Swim in Waves?* project have been reported (Kjendlie, Pedersen, Thoresen, Setlo, Moran, & Stallman, 2013).

In response to the lack of knowledge about water competencies identified in previous *Can You Swim?* studies and the need for clothing-specific research to inform drowning prevention in general and water safety education in particular, an extension project called *Can You Swim in Clothes?* was established. The overall aims of this project are:

1. To establish measurement protocols and procedures to quantify the demands of aquatic activity in clothes to guide further research
2. To ascertain the effects of clothing on water competencies required for self-rescu as a consequence of sudden immersion in deep water
3. To explore the relationship between real and perceived water competencies when wearing clothing

The purpose of this paper is to report on the first phase of the project that focused on the first two aims, by establishing measurement protocols and procedures as well as providing information on the effects of wearing clothing when performing water competencies believed to be critical to drowning prevention.

Method

The study design chosen for this pilot phase of the *Can U Swim in Clothes?* project was a paired, repeated measures (test-retest) experimental design where the participants served as their own controls. Ethics clearance for the study was obtained from the University of Auckland Human Participants Ethics Committee (UAHPEC) as part of the *Can You Swim in Clothes?* project (case number 010667).

Participants and Procedures

Participants in this initial phase were a subsection (n = 12) of a cohort of students (N = 37) taking part in the larger project. All students were enrolled in a physical education undergraduate degree program that included an aquatics education course as part of their professional teacher education degree. The participants were volunteers with a proven swimming capacity who agreed to take part in extracurricular sessions outside their normal timetabled classes. Individualized testing of water competencies was completed over two weeks during the summer term (March–April 2014).

For each individual, the testing required approximately 20 min of in-water work in two successive weeks with each session at the same time each week. The week-long interval between testing was intended to minimize both fatigue and learning effects. A total of four sessions (six participants per 2 hr session) were required to test all 12 participants twice, once in swimwear and once in clothing. Testing took place in an outdoor 25 m × 12 m, 6-lane pool (water temperature 21 °C). Appropriate lifeguard supervision and safety equipment were available at all times.

Research Instruments

Two main sources of data were developed. First, data were collected via a self-completed questionnaire based on the original *Can You Swim?* study (Moran et al., 2012) before practical testing of water competencies. Second, data on water competencies were gathered on participants performing a series of practical tests via researcher observation. The questionnaire sought information on sociodemographic characteristics (including age, sex, and ethnicity). Self-estimates of swimming competency included the use of a 4-point scale of *high, good, low,* or *no competence,* an estimate of how far participants thought they could swim nonstop in a pool, and a question on how confident they were of swimming their estimated distance in open water using a 4-point scale from *extremely confident* to *extremely anxious*. Participants were also asked to estimate, both pre- and posttesting, their predicted competency in swimming/floating in swimwear and in clothing. The results of this part of the study measuring real versus perceived competencies, the third goal of the *Can You Swim in Clothes?* project, will be reported in a follow-up study.

Three water competencies were selected for assessment—a 25 m sprint swim (for survival speed measured in seconds), a 5-min continuous swim (for survival endurance measured in meters swum), and a 5-min stationary float in deep water (for survival endurance measured on a 1–10 rating scale). Each competency was measured when wearing swimwear and when wearing clothing. Protocols for the tests were based on the protocols developed for the original *Can U Swim?* project (Moran et al., 2012), the subsequent *Can U Swim in Waves?* project (Kjendlie et al., 2013), and were modified to suit the wearing of clothing. Content validity was determined in consultation with researchers previously and currently involved in the *Can U Swim*? international collaboration and a local panel of water safety experts (n = 5). The clothing worn was standardized and included the wearing of a t-shirt, long-sleeved sweatshirt, long-legged trousers/track pants, and swimwear underneath the clothing as illustrated in Figures 1 and 2. Footwear and outer clothing was not included at this initial stage of development because of the possible effects the variability of the attire might have on performance (such as buoyancy of shoes, air trapped, and increased drag on outer clothing).

Each trial (with swimwear in week 1, with clothing in week 2) began in the water with a 25 m sprint from a standardized push-off. Swimmers were asked to swim as hard as they could as if escaping from an emergency situation using their fastest stroke. The sprint was timed on a Seiko handheld stopwatch and recorded to the nearest one tenth of a second. After 1 min of rest, participants were asked to swim continuously for 5 min using any strokes of their choice as strenuously as

Figure 1 — Swimming in clothes.

Figure 2 — Floating in clothes.

they could but to place priority on completing the full 5-min duration as was the practice in previous studies (Kjendlie et al., 2013; Moran et al. 2012). The strokes used and distance achieved in meters were logged. Upon completion of the swim, participants were given another 1-min rest before attempting a deep water float.

Participants were asked to perform a stationary supine (face up) float as efficiently as possible for a period of 5 min. The performance was observed and notes taken every 30 sec on the observed performance using an expanded 10-point scale adapted from the 1–5 scale used in the Aquatic Readiness Assessment (Langendorfer & Bruya, 1995) and the 1–5 scale used in the *Can You Swim in Waves?* project (Kjendlie et al., 2013). Table 1 shows the characteristics that were considered indicative of floating capacity (for a group of young adults with variable body composition and water competency). To accommodate for differing body types and composition, supine floating was not differentiated according to vertical or horizontal position as in the previous study (Kjendlie et al., 2013), but rather on economy of movement (arms and legs), ease of breathing (head position), and level of comfort/relaxation (motionless position).

Table 1 Flotation Test Characteristics

Score	Characteristic observed
0	Cannot supine float (on back) in a stationary position without sinking or swimming
1–2	Floats supine with great difficulty. Excessive movement of both arms and legs, difficulty maintaining head above water, cannot maintain stationary position
3–4	Floats supine with difficulty. Persistent movement of arms and legs, can maintain breathing position, some of the time in a relaxed stationary position
5–6	Floats supine with slight difficulty. Sporadic movement of arms and/or legs, comfortable breathing position, most of the time in a relaxed stationary position
7–8	Floats supine with ease, occasional slight movements of the arms and/or legs, comfortable breathing position all of the time in a relaxed stationary position
9–10	Floats motionlessly with no movement of arms and legs, easy breathing position all of the time in a relaxed stationary position

The order of testing the competencies, the instructions given, and the resting times between each test in swimwear in the first week of testing were repeated when the participants were wearing clothing in the second week of testing. For the clothing tests, participants were instructed to swim the same stroke in the sprint and the same pattern of strokes in the endurance swim that they had used in the initial testing. Where necessary, swimmers were reminded of the pattern of their previous swimwear swim from the written performance log.

Data Gathering and Analysis

All data were collated on an Excel spread sheet and transferred to SPSS (Version 22, Armonk, NY, USA) for statistical analysis. Descriptive statistics were reported via numbers and percentages while measures of central tendency were reported using means, standard deviation, and ranges for each task. Significant differences between tests in clothing versus tests in swimwear were analyzed using the Wilcoxon Signed Rank test and chi-square analysis. The Wilcoxon Signed Rank test is especially appropriate for relatively small sample sizes (O'Gorman, 2012) and for detecting any differences in test-retest performance such as the water competencies tested in this pilot study.

Results

The participants (n = 12) were young adults (20–25 years of age), half were female (n = 6), and most (92%) self-reported their swimming competency as high (25%) or good (67%). When asked to estimate how many far they could swim without stopping, most (83%) estimated that they could swim 200 m or more, one quarter (25%) of these suggesting that they could swim 400 m or more. Most (58%) were confident of their ability to swim the distance in open water, although significantly more females (83%) than males (8%) were anxious about swimming in open water ($\chi^2(1) = 8.800.806$, $p = .012$).

Table 2 shows the results of the 25 m sprint trial with/without clothing. All participants performed the 25 m sprint slower when wearing clothing with times ranging from 25–44% decrement.

Table 3 shows significant differences in the group scores, collectively the mean increase in time taken for the group to swim the 25 m sprint in clothes was 9 sec slower–a group performance decrement of one third (33%). No significant differences were found when performance change in sprinting with/without clothes was analyzed by sex and age. Those participants who self-reported low water competency swam more slowly in clothes (compared with their sprint swim in swimwear) than those who self-reported high water competency (low 38%, high 32% performance decrease).

Table 4 shows that all participants swam less distance when performing a 5-min continuous swim in clothes (using the same stroke sequence) than they did in the swim in swimwear, with distances ranging from 30–100 m less in clothes ($M = 62$ m), a performance deficit ranging from 19–35%.

Table 5 shows a significant difference in the mean group scores for the 5-min swim with/without clothes, a group mean of 62 m less distance, a performance

Table 2 Change in Performance of 25 m Sprint With/Without Clothing in Seconds

Swimmer	Age	Sex	Competency	25 m sprint in swimwear (s)	25 m sprint in clothes (s)	Change %
1	21	M	Good	17.9	23.8	+24.8%
2	20	M	Good	18.4	28.7	+35.9%
3	25	F	Low	21.2	31.6	+32.9%
4	22	F	Good	20.4	28.5	+28.4%
5	20	F	Low	22.4	39.7	+43.6%
6	20	F	Good	17.3	24.5	+29.4%
7	21	M	High	16.2	23.0	+29.6%
8	21	M	Low	17.8	27.9	+36.2%
9	21	M	High	15.6	21.6	+27.7%
10	23	F	Good	19.0	29.0	+34.5%
11	20	F	Good	20.5	30.8	+33.4%
12	25	M	High	15.4	24.8	+37.9%

Table 3 Mean Group Scores for 25 m Sprint Swim in Seconds

	N	*M*	*SD*	Min.	Max.	Range	*p* value
Swimwear	12	18.51	2.26	15.4	22.4	7.0	
Clothes	12	27.82	4.91	21.6	39.7	18.1	0.002*

Note. *Significant at the 0.05 level.

Table 4 Change in Performance of 5-min Swim With/Without Clothing in Meters

Swimmer	Age	Sex	Competency	5-min swim swimwear (m)	5-min swim clothing (m)	Change %
1	21	M	Good	175	135	-29.8%
2	20	M	Good	190	140	-26.3%
3	25	F	Low	150	120	-20.0%
4	22	F	Good	225	170	-24.4%
5	20	F	Low	150	115	-23.8%
6	20	F	Good	300	200	-33.3%
7	21	M	High	256	170	-33.6%
8	21	M	Low	200	130	-35.0%
9	21	M	High	260	188	-27.7%
10	23	F	Good	212	170	-18.9%
11	20	F	Good	210	145	-31.0%
12	25	M	High	270	175	-35.2%

Table 5 Mean Group Scores for 5-min Swim in Meters

	N	*M*	*SD*	Min.	Max.	Range	*p* value
Swimwear	12	216.50	47.64	150	300	150	
Clothes	12	154.83	27.57	115	200	85	0.002*

Note. *Significant at the 0.05 level.

decrement of 28%. No significant differences were evident when the 5-min swims with/without clothes were analyzed by sex and age.

Table 6 shows that all participants were able to complete the 5-min float with good form in swimwear and in clothes. In addition, all participants completed the 5-min float in clothes in a very similar manner to that which they had completed the task when in swimwear. Most participants (67%, $n = 8$) showed no observable difference in the ease/difficulty in which they performed the floating task in swimwear or in clothing.

Table 7 shows that, unlike performances in the sprint swims and the endurance swims, no significant difference were found in the mean group scores for the 5-min float with/without clothes, although some slight deterioration in mean scores was evident. In addition, no significant differences were found when the 5-min swims with/without clothes were analyzed by sex, age, and self-reported water competency.

Discussion

The purpose of this first phase of the *Can You Swim in Clothes?* project was to develop and test a series of assessment activities that might be used to discern change in the water competencies of swimming speed, swimming endurance, and floating

Table 6 Changes in Performance of 5-min Floating With/Without Clothing

Swimmer	Age	Sex	Competency	Floating swimwear (1–10)	Floating clothing (1–10)	Change %
1	21	M	Good	6	5	-10.0%
2	20	M	Good	7	5	-20.0%
3	25	F	Low	9	9	0.0%
4	22	F	Good	9	9	0.0%
5	20	F	Low	9	9	0.0%
6	20	F	Good	9	9	0.0%
7	21	M	High	7	6	+10.0%
8	21	M	Low	7	7	0.0%
9	21	M	High	9	8	-10.0%
10	23	F	Good	9	9	0.0%
11	20	F	Good	8	8	0.0%
12	25	M	High	6	6	0.0%

Table 7 Mean Group Scores for 5-min Floating With/Without Clothing

	N	*M*	*SD*	Min.	Max.	Range	*p* value
Swimwear	12	7.92	1.24	6	9	3	
Clothes	12	7.5	1.62	5	9	4	0.059

as a consequence of being clothed in the water. In addition, by using a test-retest experimental design, performance comparisons were made so as to provide empirical evidence of the impact of clothing on swimming and floating competencies.

The 25 m sprint swim was included because it was deemed relevant to some drowning scenarios (such as catching a wave, avoiding hazards) where rapid movement is integral to survival. The advice given before the sprint test to swim as fast as possible over the short distance was easily understood by this group of proficient swimmers who all decided that front crawl was the quickest stroke for them. When the sprint was completed in clothes, a 33% decrement in group performance was evident. Similar results have been reported in other studies of railway workers taking twice as long to swim in work clothes over a short distance (11.4 m; Amtmann et al., 2012). Several possible reasons may have accounted for this reduced speed. First, clothing may have increased drag resistance by increasing surface, form, or turbulent drag friction. Second, clothing may have restricted range of motion of propulsive limbs. Third, since all swimmers chose to repeat the sprint when clothed using front crawl, the out–of-water arm recovery may have necessitated increased energy consumption. Further investigative studies are required to refute/support this speculation.

One interesting finding was that those participants who self-reported low water competency sprinted more slowly in clothes (compared with their sprint swim in swimwear) than those who self-reported high water competency (i.e., low = 38%; high = 32% performance decrement). Tipton and colleagues (2008), studying the transfer of skills from pool to open water conditions among lifeguards, concluded that economy of movement is more likely to transfer among the more proficient. Stallman (2011) suggests that similar economies of movement may apply to the wearing of clothes and concluded that "If one is skillful without clothing, it will be easy with. If one is unskillful, weak without clothing, they will be even weaker with" (p. 29).

The 5-min endurance swim was included because it was considered sufficiently long to observe any change in performance and approximated the minimum time that open water incidents might require self-supporting action before rescue. The pretest instruction to swim strenuously but to place priority on completing the full 5-min duration appeared effective with this group of competent swimmers. Again performance was adversely affected (28% less distance) when the swim was repeated in clothes for all participants. Similar findings were reported in testing of children in a 200 m combined swim tests (Stallman et al., 2011, 2013, 2014; Laakso et al., 2014). Unlike performances in the sprint swims, the participants in the current study who self-reported low water competency did not experience a greater relative loss of distance in their endurance swim when wearing clothes (i.e., low competence = 22%; high competence = 32% performance decrement).

One possible reason for this lack of a decrement is that the initial selection of strokes differed for good and weak swimmers. Good swimmers were more likely to choose front crawl when completing the 5-min swim in swimwear, the weak swimmers more likely to choose a combination of resting strokes (such as breaststroke, backstroke, or sidestroke to complete the time requirement). Since all participants were required to repeat the same stroke sequence in the clothed swim, it is possible that the front crawl out-of water recovery may have increased the workload over a 5-min period for the good swimmers, irrespective of their proficiency. Choi and colleagues (2000) found similar increased maximal oxygen uptake (VO_2max) when comparing front crawl with breaststroke and elementary backstroke. This suggests that wise decisions about stroke selection where survival requires prolonged swimming may be paramount in survival situations. Further work on the energy costs of different swimming strokes when clothed will help resolve this issue.

Of the three water competencies measured in this pilot study, the floating test produced the only nonsignificant difference between performance in swimwear and clothing. This observation was important for several reasons. First, it further reinforces previous evidence (Barwood et al., 2011) that clothing, rather than weighing a victim down, may not only provide initial buoyancy in sudden immersion but also insulation and continued buoyancy in subsequent survival. While this appeared to be the case in the current study where the participants wore lightweight clothing other evidence suggests that heavier external attire (such as work boots, work overalls) had a deleterious effect on treading water (Amtmann et al., 2012). Second, it suggests that in the event of a sudden immersion, lightweight clothing need not be removed since it does not appear to add to flotation difficulties and removing it may require additional energy expenditure and possible loss of trapped air. Third, it appears that, in case of competent swimmers at least, differences in overall proficiency did not affect the capacity to float when wearing clothes. This needs to be tested with less able swimmers and with differing forms of clothing before any firm conclusions can be reached.

Limitations

While the results of this pilot study are encouraging and provide a research instrument capable of further application, several limitations should be considered when applying the findings to other studies. First, the nonrandomized order of trials may have caused an order effect. In future studies, it is recommended that the study group be halved and the order of testing be reversed for one half of participants. Second, the trials were individualized and this limited the number of participants that could be assessed. It is recommended that in future use, the tests could be done with multiples of 6–8 participants (one per lane) for each 20-min testing session, approximately 36 participants per 2-hr session. Third, the protocols were developed and tested using young adult participants with known water competencies—further testing with more diverse populations is required before the effects of clothing on survival are fully understood. Fourth, the floating assessment scale was not tested for interobserver reliability even though they were based on similar scales where this was tested (Kjendlie et al., 2013). Fifth, the clothing used was lightweight, did not include external clothing layers, or footwear. Further studies are required before the effects of clothing on the water competencies of swimming and floating can be generalized to other situations (such as sudden immersion in winter season clothing). Sixth, all testing took place in a closed water situation, further testing in open water where more hostile environmental conditions might prevail (such as rough water, cold, waves) is recommended. These limitations notwithstanding, the findings from the application of the measurement protocols developed in this first phase of the *Can You Swim in Clothes?* project provide valuable insight into the issue of survival with/without clothing and warrant further use.

Conclusion

Water safety advice on what to do in the event of unintentional immersion when wearing clothes is largely based on anecdotal evidence and expert opinion. The aim of the *Can You Swim in Clothes?* project is to provide empirical evidence on the impact of clothing on survival in water so as to inform water safety advice and refute/support current thinking. This initial phase of the study has successfully explored suitable test protocols that readily identified how clothing affects physical performance in the water. The results of this initial exploration suggest that clothing does impact detrimentally on swimming-related water competencies especially with regard to stroke selection but does not similarly effect floating competency to the same degree. Further research using the research instruments and replicating the assessment protocols reported in this study is advised. Follow-up studies with participants more representative of a normal population, as well as clothing studies on high risk groups such as males and rock-based fishers, is also recommended.

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