Influence of wet suit wear on anxiety responses to underwater exercise

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Koltyn KF, Morgan WP. Influence of west suit wear on anxiety responses to underwater exercise. Undersea Hyperbaric Med 1997; 24(1):23–28.–The purpose of this investigation was to evaluate the effect of wearing a wet suit on selected psychological and physiologic variables. Certified divers (n = 13) finned underwater at 0.52 m/s for 20 min with and without a wet suit. Order was randomly assigned and performed on separate days. Heart rate, respiration rate, use of compressed air, ratings of perceived exertion, and breathing ratings increased significantly ($P < 0.05$) for both conditions, and increases in heart rate, use of compressed air, and breathing ratings were significantly greater for the wet-suit condition. Rectal temperature increased significantly ($P < 0.001$) for the wet-suit but not the bathing-suit condition. State anxiety and body awareness increased ($P < 0.001$) following the wet-suit condition. Furthermore, state anxiety decreased significantly ($P < 0.001$) by 15 min after exercise in the bathing-suit condition. It is concluded that wet suit wear can result in elevated anxiety when performed at a water temperature and exercise intensity sufficient to produce increased core temperature.

anxiety, scuba, core temperature, body awareness, wet suits

Many scuba divers dive in water that is lower than neutral temperature (29°–33°C) (1). Water conducts heat from the body approximately 25 times faster than air (1), so direct loss of body heat in water can be a potential thermal problem for divers. Many divers wear protective suits when diving to minimize heat loss. Divers also wear thermal protection to increase exposure time in cold water. In addition, a wet suit might be worn for protection against marine life, coral, and other stressors. Wearing protective apparel (i.e., wet suits) could represent an important factor in terms of psychological responses during underwater exercise. If a diver is too warm or too cold, for example, it is possible that elevations in state anxiety might occur, and this in turn could provoke panic behavior. Panic or near-panic behavior is a potentially serious problem for a significant portion of individuals who take part in scuba diving (2). It has been reported by Sweeney (3) that over the past 20 yr the primary cause of death in scuba diving is panic. The second cause of death is air embolism, which is usually due to uncontrolled ascents resulting from panic (3). Panic behavior occurs in inexperienced divers as well as experienced ones. In a survey of 300 experienced divers, it was reported that 54% had experienced panic or near-panic behavior on one or more occasions (4).

Aerobic exercise performed on land has been consistently associated with reductions in anxiety. However, the nature of the relationship between underwater exercise and anxiety has received much less attention. Preliminary research investigating the interaction of exercise, water temperature, and protective apparel on anxiety responses in scuba divers revealed different anxiety responses for different temperature conditions (5). Ten certified scuba divers completed 30 min of underwater finning at 35% of $\dot{V}O_{2max}$ in warm (29°C) and cold (18°C) water with and without a wet suit. In the cold water condition, anxiety decreased significantly when divers wore a wet suit, whereas anxiety increased significantly when divers did not wear a wet suit. In the warm-water condition, anxiety increased significantly when divers wore a wet suit compared to no significant change in anxiety when divers did not wear a wet suit. The interaction of water temperature and protective apparel seems to represent an important factor in anxiety responses during underwater exercise.

Furthermore, the mechanism responsible for changes in anxiety associated with exercise still needs to be determined. The present study was designed to investigate the temperature hypothesis which is one of the mechanisms believed to be responsible for the anxiolytic effect of exercise. This hypothesis states that the anxiolytic effect of exercise is caused by elevations in deep body temperature, and it has been shown that different conditions which elevate core temperature are associated with reduced anxiety. For example, Kuusinen and Heinonen (6) have reported reductions in tension after a sauna and hot shower, and Raglin and Morgan (7) have also reported reduced anxiety after a hot shower. Research using a cat model has also demonstrated that heating of the hypothalamus to 41 °C produces electrophysiologic changes characteristic of a deeply relaxed state (8). Exercise increases core temperature in direct proportion to the intensity of the exercise stimulus, and this has led deVries (9) to propose that the tranquilizer effect of exercise may be caused by elevations in body temperature. The approach taken in our research has involved several related strategies based on efforts to minimize or to eliminate the customary rise in body temperature associated with exercise. If anxiety were observed to decrease in the absence of a rise in body temperature, this finding would serve to refute the temperature hypothesis. On the other hand, if anxiety failed to decrease after exercise where body temperature did not rise, this would offer evidence in support of the temperature hypothesis.

In two earlier studies, temperature was manipulated with whole-body cooling (10) and with underwater exercise (11). It was found that underwater exercise was most effective in blocking the customary rise in temperature associated with exercise. Despite the observation that core temperature did not change following the underwater scuba protocol, a significant reduction in state anxiety occurred 15 min after exercise. Although this finding offers evidence to refute the temperature hypothesis, it would be more compelling to demonstrate an anxiolytic effect with and without increased core temperature. Thus, the primary purpose of this investigation was to examine how wearing a wet suit influenced temperature and anxiety responses during underwater exercise. A secondary purpose was to quantify the effect of wearing a wet suit on selected variables that are used routinely in underwater exercise (e.g., amount of compressed air consumed, respiration rate, breathing distress, heart rate, perception of effort), as well as the interaction of these independent and dependent variables with anxiety responses.

METHODS

Fifteen male certified divers with a mean age of 25 yr (SD = 6.5) volunteered to be in this study. Two of the divers were unable to complete all phases of the test protocol. In one case it was necessary to discontinue the test because it was apparent that the diver would not have adequate air to complete the exercise protocol. This was viewed as an unusual response because 50 divers had been tested and all had completed the protocol with a minimum post-exercise reserve of 500 psi in a tank containing 3,000 psi at the outset. The second diver aborted at 10 min complaining of difficulty breathing, but subsequent testing of the equipment revealed that it was functional. These two cases indicated that this protocol was safe yet effective in producing variable stress responses in divers. The 13 individuals who completed all phases of the testing had been diving for 7 yr (SD = 5). The minimal sample size was computed on the basis of: a) an alpha of 0.05; b) a power of 0.70; and c) a meaningful difference to be 0.50 SD (12). The research protocol was approved in accordance with the ethical standards of the Committee on Human Experimentation at the University of Wisconsin-Madison, and each participant signed an informed consent statement before involvement in the study. Participants were reimbursed for their participation at the rate of $10.00 per hour. All participants were provided and fitted with standardized scuba equipment. Testing was conducted in an indoor swimming pool at a depth of 1.5 m, and water temperature of 24 °C (±0.5). Core temperature was measured with a rectal thermometer in a subset of five divers to determine the pattern of response before, during, and after underwater exercise. A disposable rectal probe was inserted by the diver at a depth of 10 cm from the external sphincter. The probe was attached to a 2-m extension that in turn was attached to a Yellow Springs thermometer that provided a digital display. Core temperature was assessed: a) before the experiment, b) after the 10-min rest in the water before exercise, c) immediately post-exercise in the water, d) 10 min post-exercise in the water, and e) 15 min post-exercise out of the water.

Test protocol: The test protocol used in this study was previously shown to be safe and reliable (11). The dependent variables consisted of selected physiologic, psychological, and perceptual measures used successfully in our previous scuba research to determine what effect wearing a wet suit might have on these variables (11). Each diver was evaluated on two separate days, and testing was conducted at the same time on both days. One trial was completed while wearing a bathing suit, and the second while wearing a quarter-inch-thick neoprene wet suit. The wet-suit condition did not include a hood or gloves. The order of testing was rotated (i.e., A-B, B-A) and randomly assigned to participants. The testing procedure for the bathing-suit and wet-suit trials consisted of the following.

1. A 24-h history, that included exercise and sleep patterns as well as the individual's perceived sense of well being, was first completed to determine whether an individual should be excluded because of unusual exercise patterns within the previous 24 h, sleep problems the previous night, and medical problems to include minor difficulties such as the common cold, upset stomach, and so on. It was not necessary to exclude any participant, and all individuals rated themselves as having a good sense of well being on the day of testing. The State-Trait Anxiety Inventory (13) and the Body Awareness Scale (14) were also completed at

this time. This testing was done in a room adjacent to the swimming pool where all exercise trials took place. The State-Trait Anxiety Inventory has undergone extensive validation procedures, and it is the most widely employed anxiety measure used in studies dealing with the psychological effects of physical activity. The Body Awareness Scale was developed to quantify body awareness or somatic sensations commonly reported in sport and exercise settings. These sensations are not measured directly with existing anxiety scales such as the State-Trait Anxiety Inventory. The Body Awareness Scale has been shown to possess convergent and discriminant validity (14); further validation efforts are ongoing, and this study was part of the validation process.

2. The divers then reported to the pool and donned scuba equipment. The regulator employed in this study was a Sherwood regulator (model Magnum II). The divers entered the water and completed a neutral buoyancy task. They were asked to submerge and become neutrally buoyant by either inflating or deflating the buoyancy compensator vests they were wearing.

3. Divers next rested quietly underwater for 10 min at a depth of approximately 1.5 m while breathing compressed air. They completed the Body Awareness Scale and the State-Trait Anxiety Inventory using a clipboard and grease pencil after 5 min of the 10-min rest. Heart rate, respiration rate, and use of compressed air were also assessed during the rest period. Heart rate was monitored continuously with a UNIQ Heart Watch (model 8799), which senses the electrical signals generated by the heart through electrodes affixed to the individual's chest. Respiration rate was assessed by videotaping the bubble trail and counting the number of breaths taken per minute. Use of compressed air was measured in pounds per square inch units provided by a digital computer system (Data Scan) attached to the regulator.

4. This rest was followed by a 20-min paced swim at a moderate pace of 0.52 m/s. This pace was determined by pilot testing and examination of the diving literature. It has been reported that a pace of 0.40–0.52 m/s for 20 min of underwater finning was classified as a moderate pace, and 0.52–0.70 m/s for 10 min was considered a fast pace (15,16). Pilot testing determined 0.52 m/s to be the most effective pace for this study. Pace lights were displayed on the bottom of the pool and regulated by a microprocessor-driven system (Pacer Products) to ensure a constant pace. Propulsion was achieved with a finning motion of the legs, and the divers were instructed not to use their arms. The same protocol and pace were employed for both trials. Heart rate was monitored throughout the session, and respiration rate was assessed every 5 min. Subjective ratings were performed using 7-point breathing and perceived exertion (legs) scales that were placed adjacent to the pace lights and visible to the diver. The assessments were performed at 5-min intervals throughout the exercise in accordance with previously described procedures (17,18). The ratings were obtained by asking the divers to perform subjective ratings via an underwater communication system (Sports Communication, model VSC-101).

5. The divers rested quietly after exercise and completed the Body Awareness Scale and the State-Trait Anxiety Inventory using a clipboard and grease pencil. Ratings of perceived exertion (arms, legs, and overall) as well as breathing ratings were obtained at this time. These ratings pertained to the entire 20-min swim as opposed to the ratings obtained at 5-min intervals during the swims. Heart rate and respiration rate were monitored during this 10-min recovery period. Use of compressed air was assessed in pounds per square inch units immediately after exercise and again after the rest period.

6. Divers exited the pool and removed all scuba equipment. Thermal and comfort ratings were then assessed by asking the divers to rate the sensation of comfort and temperature during the 20-min swim according to the procedures described by Gagge et al. (19). The divers then repeated the State-Trait Anxiety Inventory and the Body Awareness Scale.

RESULTS

Data were analyzed with a 2 × 4 repeated measures analysis of variance (ANOVA), and the Geisser-Greenhouse procedure was used to adjust degrees of freedom when the sphericity assumption was not met (20). The Newman-Keuls procedure was used to probe for the location of mean differences when significant main effects were observed with ANOVA (12). Results for selected dependent variables are summarized in Table 1. Significant trial effects were found (i.e., the values increased during exercise) for heart rate ($F = 160.43$; df = 2,18; $P < 0.0001$), respiration rate ($F = 38.54$; df = 2,22; $P < 0.0001$), and use of compressed air ($F = 646.30$; df = 2,20; $P < 0.0001$). Post-hoc analyses revealed that these variables increased significantly, as expected, during exercise in both the bathing-suit and wet-suit conditions. Significant condition effects were also noted (i.e., bathing suit vs. wet suit) for heart rate ($F = 43.50$; df = 1,9; $P < 0.05$) and use of compressed air ($F = 10.33$, df = 1,10; $P < 0.05$). Heart rate and use of compressed air were significantly higher in the wet-suit condition after exercise.

Results for core temperature are summarized in Fig. 1. A significant trials effect was observed for core temperature ($F = 4.31$; df = 1,16; $P < 0.01$), as well as a significant

Table 1: Means and Standard Deviations for Selected Dependent Variables Before, During, and After Exercise While Wearing a Bathing Suit (BST) and a Wet Suit (WST)

Variable	Pre-exercise		Exercise		Recovery	
	BST	WST	BST	WST	BST	WST
Heart rate, beats/min						
Mean	77.9	86.0	122.3[a]	146.8[a,b]	89.0	101.8
SD	14.0	14.7	16.5	20.0	9.8	15.0
Respiration rate, breaths/min						
Mean	12.7	13.6	21.2[a]	23.2[a]	14.3	15.8
SD	4.3	4.9	8.3	7.6	4.9	4.6
Use of compressed air, psi/min						
Mean	21.0	22.0	64.0[a]	72.0[a,b]	22.0	23.0
SD	7.0	5.5	8.0	14.0	5.0	4.0
Use of compressed air, kPa/min						
Mean	144,795	151,690	441,280	496,440	151,690	158,585
SD	48,265	37,923	55,160	96,530	34,475	27,580

[a]Significant ($P < 0.05$) increases from rest; [b]significant ($P < 0.05$) difference between conditions.

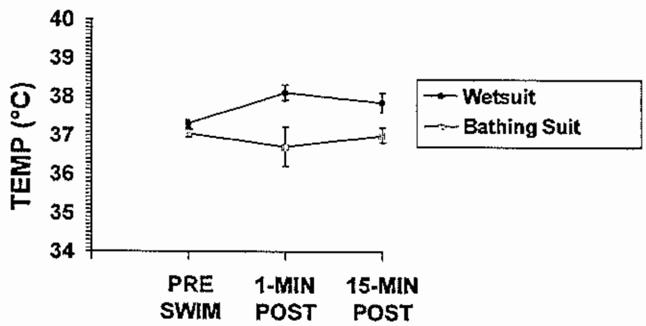

FIG. 1—Means and standard errors for core temperature responses in the wet-suit and bathing-suit conditions.

condition effect for core temperature (F = 7.37; df = 1,4; $P < 0.05$). Post-hoc analyses indicated that core temperature was significantly higher in the wet-suit condition 1, 10, and 15 min post-exercise. Core temperature, however, did not change significantly in the bathing suit condition after exercise, a finding that replicates our earlier report (11).

Results for state anxiety are summarized in Fig. 2. A significant trials effect was seen for state anxiety (F = 6.40; df = 3,36; $P < 0.001$). A significant increase in state anxiety was noted for the wet-suit condition at 1 min after exercise, and state anxiety was found to decrease significantly in the bathing-suit condition at 15 min post-exercise. There was a significant trials effect (F = 11.13; df = 3,36; $P < 0.001$) and condition by trials interaction (F = 6.09; df = 3,36; $P < 0.002$) for body awareness (Fig. 3). This interaction was due to a significant increase in body awareness after exercise in the wet-suit condition along with an insignificant rise for the bathing-suit condition.

Means and standard deviations for perceived exertion and breathing ratings are summarized in Table 2. A significant trials effect was observed (F = 28.65; df = 3,36; $P < 0.0001$) for perceived exertion, which increased significantly during exercise in both conditions. There was also a significant condition effect (F = 7.87; df = 1,12; $P < 0.05$), and perceived exertion was found to be higher in the wet-suit condition compared to the bathing-suit condition at 10 min of exercise. This difference did not persist, and no difference in perception of effort was observed at 15 or 20 min of exercise.

A significant trials effect (F = 6.30; df = 3,36; $P < .002$) and a significant condition effect (F = 8.16; df = 1,12; $P < 0.05$) occurred for breathing ratings. Breathing ratings increased significantly during exercise in both conditions, with ratings in the wet-suit condition being significantly higher ($P < 0.01$) at 20 min.

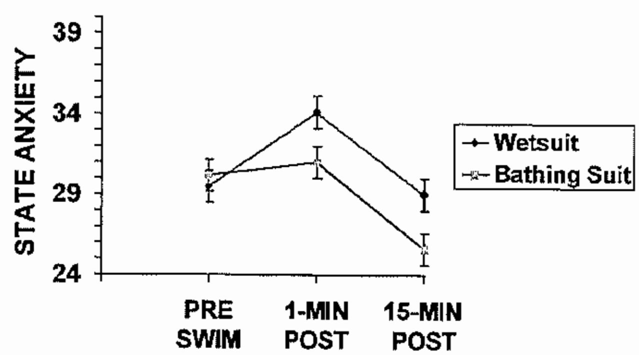

FIG.2—Means and standard errors for state anxiety responses in the wet- suit and bathing-suit conditions.

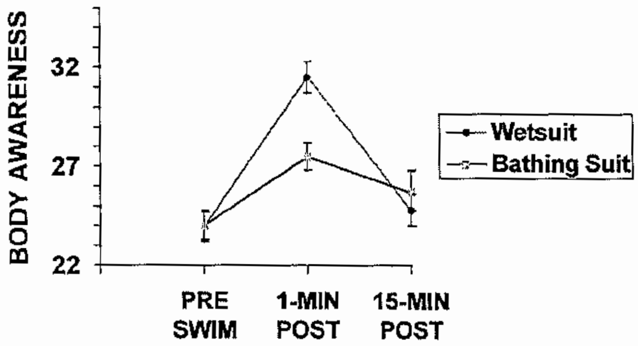

FIG. 3—Means and standad errors for body awareness responses in wet-suit and bathing-suit conditions.

We found a significant ($P < 0.01$) difference in thermal sensation between the two conditions. The wet-suit condition yielded a mean rating of 6 ± 1 SD (i.e., "warm"), whereas the mean rating for the bathing-suit condition was 4 ± 1 SD (i.e., "neutral") on the 7-point scale. However, comfort ratings (mean = 2; SD = 0.7) as measured by the 4-point scale (19) did not differ in the two conditions.

DISCUSSION

The purpose of this investigation was to evaluate the effect of wearing a wet suit on selected psychological and physiologic variables during and following underwater exercise. Wearing a quarter-inch-thick wet suit during this underwater protocol resulted in a significant increase in core temperature, and thermal ratings corresponded with the core temperature responses. In comparison, core temperature remained unchanged after underwater exercise while wearing a nylon bathing suit.

Examination of results for state anxiety indicated that changes in state anxiety differed significantly for the two conditions. The wet-suit condition resulted in a significant increase in state anxiety immediately following exercise, whereas the bathing-suit condition did not. Also, by 15 min post-exercise, state anxiety was significantly lower in the bathing-suit condition compared with the wet-suit condition. These results not only demonstrate that the anxiolytic effect of underwater exercise occurs in the absence of an increase in core temperature, but the production of an increase in core temperature was actually associated with elevated anxiety.

Body awareness responses were found to differ from state anxiety responses which provides further discriminant evidence for the construct validity of the Body Awareness Scale. Body awareness was not found to decrease significantly after underwater exercise, but a significant increase in body awareness after exercise occurred in the wet-suit condition along with an insignificant rise for the bathing-suit condition. The increase in body awareness in the wet-suit condition was associated with increases in heart rate, respiration rate, and use of compressed air, but these sensations were independent of state anxiety responses. In other words, divers can be aware of their breathing, for example, without experiencing anxiety responses.

For several reasons it is not possible to make a direct comparison of these results with those observed in our earlier work (5) involving underwater finning in cold and warm water. First, the water temperatures were different for the two studies. Second, a relative exercise intensity of 35% $\dot{V}O_{2max}$ was used in our previous study, whereas an absolute work load of 0.52 m/s was used in the present study. Third, the duration of exercise was less in the present study (20 vs. 30 min). Nevertheless, it is possible to make some indirect comparisons since the wet-suit condition resulted in elevated core temperature in all three water temperatures. Furthermore, the increased core temperature observed for scuba exercise performed at 24° and 29°C while wearing a wet suit both resulted in elevated anxiety and body awareness (e.g., dyspnea, palpitations, parathesia). Since elevations in state anxiety would theoretically increase the likelihood of panic behavior, divers should consider not wearing a wet suit unless it is deemed necessary because of environmental concerns (e.g., cold temperature, marine life, abrasive surface).

Table 2: Means and Standard Deviations for Ratings of Perceived Exertion (RPE) and Breathing Ratings Obtained Every 5 min During Underwater Exercise Performed While Wearing a Bathing Suit (BST) and Wet Suit (WST)

	5 min	10 min	15 min	20 min	Mean
RPE, legs					
WST	3.3 (0.7)	4.2 (0.6)	4.5 (0.8)	4.7 (0.9)[a]	4.2 (0.5)
BST	2.8 (0.6)	3.3 (0.5)	3.9 (0.7)	4.0 (0.7)[a]	3.5 (0.5)
Breathing					
WST	2.5 (0.7)	2.9 (0.8)	3.3 (0.6	3.3 (0.5)[a,b]	3.0 (0.3)
BST	2.1 (0.6)	2.4 (0.8)	2.8 (0.6)	2.6 (0.6[a]	2.5 (0.2)

[a]Significant ($P < 0.05$) increase during exercise; [b]significant ($P < 0.05$) difference between conditions.

A secondary purpose of this study was to examine the effect of a wet suit on a number of variables that have been used routinely in underwater studies. Results indicated that wearing a quarter-inch wet suit produced significantly higher heart rates, respiration rates, use of compressed air, and breathing ratings. This finding is in agreement with studies that have been conducted on land employing protective clothing and respiratory equipment. Higher elevations in blood pressure, minute ventilation, and heart rate have been reported (21–23) while wearing protective clothing and respirators. In addition, breathing discomfort is significantly affected by wearing protective clothing and respiratory equipment (22,24), and it has been reported that protective clothing causes body temperature and heart rate to rise at a faster rate (25).

We conclude that: a) wet suit wear can result in elevated anxiety when performed at a water temperature and exercise intensity sufficient to produce increased core temperature; and b) the anxiolytic effect noted after scuba exercise can occur in the absence of elevated core temperature.

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