A subjective evaluation of a drinking system for saturation divers

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Key words

Saturation diving, fluid balance, thermal problems (hypothermia and hyperthermia)

Abstract

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Studies have shown that divers may lose large volumes of body fluids in hot-water-suit (HWS) dives lasting for four hours or longer, and that this dehydration is mainly caused by sweating. Body fluid balance may be impaired and the diver's alertness and power of judgement could be influenced by such imbalance. The main objective of the present study was to obtain a subjective judgement of a drinking system for divers (DSFD) and to obtain information related to body fluid loss during long saturation lock-out dives. Via a suction pipe imbedded in the microphone unit in the oronasal mask, the DSFD makes it possible for the diver to drink while in the water. Ten divers tested the drinking system during 12 saturation lock-out dives lasting an average of 5.5 h. A questionnaire was answered after each dive. The divers drank 21 times (range 5–30 times) during the dives, and the average drinking volume was 1.4 litre (range 1.0–1.5 litre), but drank only 0.04 litre (range 0–0.3 litre) in the bell after diving. The system was easy to operate and preparation and clothing did not cause any delay. The suction pipe did not intrude and the microphone performed excellently. The work in water was not hindered by DSFD and all divers were very satisfied with the drinking system. It was obvious that the need for fluid intake after a dive with DSFD was markedly reduced – another good indication of maintained body fluid balance.

Introduction

Occupational diving is an activity that may influence body fluid balance and induce non-homeostatic conditions. With the open hot-water-suit (HWS) technique, cooling of the diver is avoided by the surface-heated seawater delivered via an umbilical to perforated hoses sewn into the suit material. Warm seawater with a temperature of about 38ºC will thereby continuously flood the skin's surface. The hot water enters the suit through an on/off valve at the diver's waist making it possible for the diver to control the supply. However, it is a fact that most (or all) divers regulate the hot water flow in order to be warm and comfortable rather than thermoneutral or cold (personal communications). Since the diver's skin is at 100% humidity the normal evaporative heat loss does not occur and hyperthermia may develop. If the diver loses body fluids equivalent to more than 3% of his body weight, both his physical and mental performance may be impaired by the end of the dive.[1,2] Thus, if a critical situation should occur at the end of a dive, a dehydrated and hyperthermic diver might not react adequately and thereby might endanger his safety.

The effect of water immersion and weightlessness on the circulatory system and urine production (immersion diuresis) is well established.[3] In addition to this fluid loss, we have previously shown that divers may lose large volumes of body fluids in HWS dives lasting for four hours or longer, and that this dehydration is mainly caused by sweating.[4,5] In support for this view, body core temperature increased by 0.6ºC, from a predive value of 37.4ºC, during operational saturation diving.[6] Also, fluid intakes of more than 1.5–2 litres have been reported shortly after diving (information from a diving company). It should be emphasised that during a normal working dive lasting for 4–6 hours the diver does not drink any fluid. To maintain body fluid balance, a drinking system for divers (DSFD) has been developed.[7] The DSFD may, therefore, add to both comfort and safety during long-lasting HWS dives.

The main objective of the present study was to obtain a subjective assessment of DSFD and to obtain information related to body fluid loss during long-lasting, saturation lock-out dives.

Methods

A bag containing the drinking fluid is located on the diver's back. The fluid flows via a supply hose, a manually operated valve penetrator on the side of the helmet, and a suction pipe with a mouthpiece imbedded in the microphone unit in the oronasal mask (Figures 1 and 2). When the diver requires a drink he opens the valve and sucks on the mouthpiece.

Ten divers tested the drinking system during 12 saturation lock-out dives with an average lock-out duration of 5.5 hours (range 3–6 h 50 min). A questionnaire (Table 1) was answered after each dive.

Results

The detailed results from the subjective evaluation are presented in Table 1 (one diver did not answer questions 3 and 8, and two divers did not answer questions 12 and 13).

Figure 1
The drinking system dismantled into its constituent parts: a fluid bag (A), supply hose (B), valve (C) and microphone with cable and suction pipe (D)

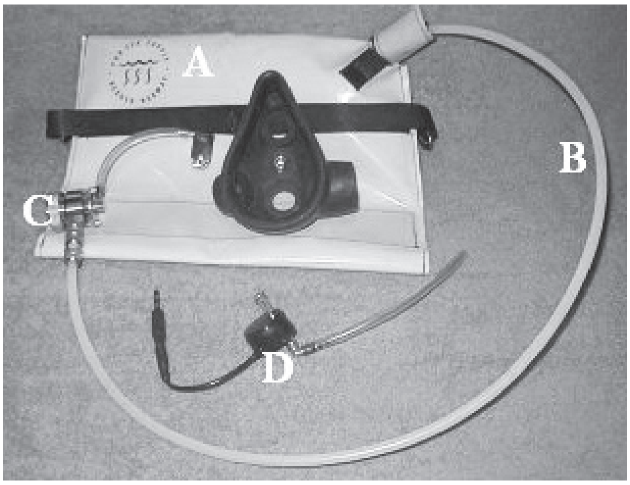

Figure 2
A diving helmet showing the supply hose (B) and the valve (C) in position

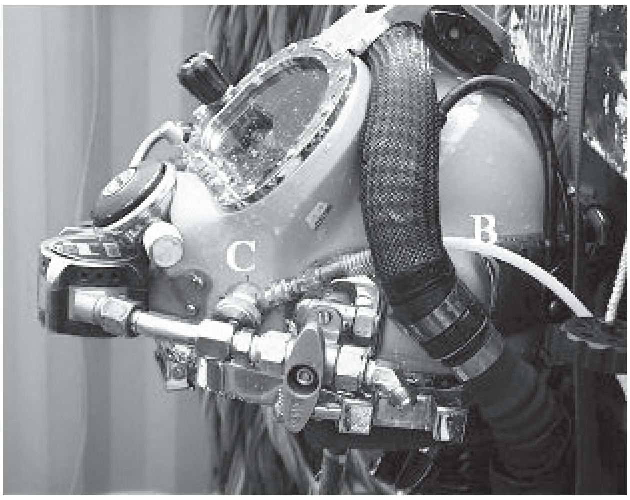

Table 1
Subjective evaluation of a drinking system for divers from 12 trials with ten divers; average lock-out duration was 5.5 hours

Questions	Responses	
Physiological aspects		
1. What did you drink?	9 dives: Juice and water (50/50) 2 dives: Water 1 dive: Orange juice	
2. How often did you drink during the dive?	Average: 21 times (range 5–30)	
3. Did you drink every time you felt the urge?	Yes: 11	No: 0
4. How much did you drink in the bell after the dive?	Average: 0.04 L (range 0–0.3)	
5. Would you consider using the drinking system if offered on subsequent occasions?	Yes: 12	No: 0
6. On a scale from 1 to 5, how would you characterise the use of DSFD? (1 = unuseable, 5 = very useful)	Average: 4.5 (range 4–5)	
7. Do you believe the need for a break during a long lock-out would diminish with DSFD?	Yes: 10	No: 2
Technical aspects		
8. Was the dressing delayed due to the DSFD?	Yes: 1	No: 10
9. If yes, indicate approximately the time delay	5 min	
10. Was it difficult to operate the DSFD valve?	Yes: 0	No: 12
11. Did the mouthpiece cause any problems with:		
Communication?	Yes: 0	No: 12
Breathing?	Yes: 0	No: 12
Comfort?	Yes: 0	No: 12
12. Are you satisfied with the shape of the microphone?	Yes: 10	No: 0
13. Are you satisfied with the position of the microphone hole in the oral nasal mask?	Yes: 10	No: 0
To be answered by the Diving Supervisor (*n* = 5)		
14. How would you characterise the sound quality of the microphone compared to other microphones?	Excellent: 1	Good: 4

On average, the divers drank 21 times (range 5–30 times) during a dive. The drinking volume using the DSFD was 1.4 L (range 1.0–1.5 L). Fluid intake in the bell after the dive was only 0.04 L (range 0–0.3 L) when using the DSFD.

Discussion

The drinking system was easy to operate and preparation and clothing did not cause any delay. The suction pipe did not intrude and the microphone performed well (Table 1). Thus, the work in water was not hindered by DSFD. All divers were very satisfied with the drinking system and indicated that they would use the system if available in future diving operations. By using the DSFD it was obvious that the need for fluid intake after a dive was markedly reduced – a good indication of maintained body fluid balance. Under normal operational conditions, divers drink about 1–1.5 L in the bell after finishing the dive. Possible negative effects of dehydration on the diver's physical performance, alertness and power of judgment will thereby be avoided.[1,2]

It is also well established that body temperature regulation is impaired by dehydration.[8] The observed core temperature increase in saturation divers may partly be caused by the sweat fluid loss and dehydration previously described.[4–6] Furthermore, dehydration may increase the risk for decompression sickness (DCS). In a review of 68 recreational divers with spinal cord decompression sickness, risk factors were fatigue, circumstances suggesting dehydration, and extreme physical effort.[9] A study on pigs dived on similar tables showed that dehydration significantly increased the risk of severe decompression sickness.[10] These findings are relevant to saturation diving and the in-water decompression during excursions. The importance of maintained fluid balance is further indicated by the recommendation of the International Marine Contractors Association that a diver spending over two hours out of a closed bell should be offered the opportunity to return to the bell for a drink or other refreshments.[11] Thus, we maintain that the DSFD described here will add to the safety of divers during long HWS dives.

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