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Original Research

The Effects of a 2-hour Surfing Session on the Hydration Status of Male Recreational Surfers

BYRON O'NEILL*[1], ERIC LEON*[1], JAMES FURNESS‡[1,2], BEN SCHRAM‡[1,2], and KEVIN KEMP-SMITH‡[1,2]

[1]Faculty of Health Sciences and Medicine, Bond University, Robina, QLD, AUSTRALIA; [2]Water Based Research Unit, Bond University, Robina, QLD, AUSTRALIA

*Denotes undergraduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 14(6): 1388-1399, 2021. Surfing is a popular sport globally which is performed in varied environmental conditions. With limited research in the field exploring hydration, monitoring the effect of surfing on subject hydration is warranted. The purpose of this study was to determine the relationship between surfing intensity and hydration status. A total of ten recreational male surfers were recruited for this study where hydration status was assessed pre-and post-surf session by measures of body mass (BM) and urine specific gravity (USG). Intensity of the surf session was quantified by Global Positioning Systems and Heart Rate monitoring. Subjects surfed for two hours and covered an average distance of 4974.18 ± 542.62 m, with an average speed of 2.48 ± 0.27 km/h and peak speed of 31.86 ± 3.51 km/h. A statistically significant decrease in absolute and relative BM was observed (0.70 ± 0.4 kg, $p < 0.05$ & 0.86 ± 0.54%, $p < 0.001$, respectively). No statistically significant correlation was found between variables (total distance paddled and relative BM, $r = 0.432$, $p = 0.245$; average HR and relative BM change, $r = -.246$, $p = 0.595$). Total distance paddled combined with average HR significantly predicted relative body mass change ($F(2,3) = 29.362$, $p = 0.011$, adjusted $R^2 = 95.1\%$). The results demonstrate that a 2-hour recreational surfing session, in temperate environmental conditions, without neoprene garments resulted in minimal BM changes and no changes in USG. Surfers who paddle a greater distance at a higher average HR sustained greater BM changes.

KEY WORDS: Exercise physiology, urine specific gravity, hydration, water sports

INTRODUCTION

Dehydration can be described as a body water deficiency that can be elicited by physical activity often resulting in hyperosmotic hypovolemia (4). Proper hydration has been shown to be necessary for optimal sport performance, and dehydration can be detrimental to physiological functioning (4, 18). This is supported by a body of evidence that shows dehydration can affect aerobic and anaerobic energy systems and may contribute to an increased risk of injury (8, 17, 18). Inadequate hydration is also linked with increased core temperature (18). In response to an increased core temperature, blood flow to the skin is increased to maximize heat loss through convection and sweating occurs to allow for heat loss through evaporation (18). When dehydration is present these two cooling systems cannot function adequately, and a rise in core temperature is seen (18).

Dehydration is the progressive loss of body fluid and is a consequence of heat stress typically in a sporting context. A hotter climate, higher humidity, poor moisture wicking clothing and increasing physical work rate require increased dependence on the effects of evaporative cooling through sweat loss. Evaporative cooling and convective heat loss occur when surrounding air contacts skin covered in sweat, the moving air causes sweat to evaporate forming a vapor resulting in heat transfer. Dehydration can reduce sweat production and the sudomotor responses of vasodilation of surface blood vessels, this in turn may reduce the bodies evaporative and convective heat loss capabilities (15).

Previous research has suggested that the land-based athlete is exposed to less imposing convective and conductive heat loss from the skin compared to the water-based athlete (5). This may be responsible for maintenance of a cooler core temperature in water-based sports versus land-based sports (5). In water-based sports in particular, there are several unique circumstances that influence core temperature and fluid balance. Firstly, skin temperature becomes congruent with water temperature during immersion, and heat loss by convection depends on both the water temperature and water flow over the skin. Thus, the water temperature and water characteristics influence core temperature, independent of the effect of ambient temperature and relative humidity (5). Secondly, while sweat loss still occurs in the water-based athlete, the sweat is unable to evaporate and provide its cooling effect like it would on land (12). Thirdly, the water exerts hydrostatic pressure upon the water-based athlete, which increases plasma blood volume and decreases peripheral blood pooling; this leads to inhibition of antidiuretic hormone (ADH), and consequently increases the excretion of dilute urine (2, 19). Given the paucity of research specific to surfing, it remains unclear how these dynamic environmental factors affect hydration status.

Of the research published on water-based activity, hydration status is most commonly performed via body mass change or urine specific gravity (USG), both of which have been deemed to be valid and practiced in field-based research. Surfing is one such water-based sport which may expose the subejct to the deleterious effects of dehydration due to the addition of several other environmental factors including variable surface water turbulence, wave conditions, water temperature, ambient air temperature, relative humidity, and solar irradiance. Despite these factors, only two studies to date have reported on the effects of hydration (3, 13). Both cognitive function and muscular endurance have been shown to be negatively affected by dehydration (3), and surfers who paddle greater amounts appear to be affected more by body mass (BM) changes (13). Both cognitive function and musculoskeletal endurance are important for surfing as surfers are required to execute split second decisions in navigating their environment while paddling, transferring from prone to standing and riding waves.

Given the unique environment in which surfing is performed and the paucity of literature identified in water-based sports such as surfing, further research is warranted. The purpose of this study was to pilot a methodology to assess the effects of a two-hour surfing session on hydration status of recreational surfers through BM changes and USG, both of which are the most commonly reported measures in water-based sports. A secondary purpose was to determine the relationship between surfing intensity and hydration status. The authors hypothesised that a two-hour surfing session would result in significant BM and USG changes; with these changes associated with surfing intensity. An observational cohort study was employed in which subjects' hydration status was analysed in surf conditions reflective of the normative magnitude for a typical recreational surfing exercise.

METHODS

Participants

Ten male recreational surfers volunteered to take part in this investigation. Mean and standard deviations were calculated for age, height, and body mass (33.20 ± 5.9 years, 179.21 ± 5.07cm, 81.91 ± 10.08 kg, respectively) encapsulating subjects demographics. A body mass index of 25.52 ± 3.21 kg/m^2 placed subjects collectively within a healthy-weight category. Inclusion criteria consisted of subjects being male, between the ages of 18 - 45 years old, to have had a minimum of five years surfing experience and were free from physical or psychological health conditions that would be exacerbated by participating within this study. For familiarisation and further risk mitigation, subjects utilised their own surfing equipment, in line with previous surf specific research (7). Flyers outlining the research opportunity and above inclusion criteria were utilised for the recruitment process and distributed at a local Gold Coast beach in Queensland, Australia. Subjects were informed of the experimental methodology, associated risks and personal information required via an explanatory statement before written informed consent was obtained. This study was approved by the Bond University Human Ethics Research Committee (#0000016050).

Protocol

Subjects were advised to arrive on the data collection day as they would on any normal morning of surfing, and to surf and act as they normally would in the conditions presented to them. All 10 subjects surfed on the same day and at the exact time.

Due to the thermal effects of wetsuits and wetsuit garments, subjects were asked to only wear board shorts and either a t-shirt or neoprene rash vest. No hydration controls were implemented as subjects were advised to arrive at the testing location as per their normal nutritional and hydration habits. Subjects arrived at a local beach where measurements of BM, height and USG were taken prior to and immediately post subjects undertaking two hours of surfing. Global Positioning Systems (GPS) coupled with heart rate (HR) monitoring were measured over the 2-hour surfing timeframe. Environmental measurements including air and water temperature, relative humidity, wind speed and direction as well as surf characteristics (swell direction and size) were all recorded in correlation to the location and times in which the data collection was undertaken.

Measurements of subject BM in kilograms (kg) were taken after urination both pre and post surfing intervention using a Seca 803 electronic portable scale (Seca, GMBH & CO. Hamburg, Germany) at the beach on a levelled concrete surface, measuring BM to the nearest 0.1 kg. Subjects were asked to completely void their bladder for purpose of USG analysis prior to both the pre and post measurements of BM. Subjects were weighed in their same lower body garments (underwear or board short) both pre and post surf with subjects thoroughly towel dried prior to post surf measures. Due to the field-based nature of this study, measuring the influence of urination and respiratory loss on BM changes was not possible. Height, measured in centimetres (cm) was taken following pre surf BM utilising a Seca 213 portable stadiometer (Seca GMBH & CO. Hamburg, Germany) at the beach on a levelled concrete surface measuring to the closest 1 mm.

USG was taken prior to BM recordings both pre and post surf procedure. USG analysis was later undertaken in laboratory conditions utilising an Atago PAL-10S handheld digital refractometer (ATAGO Co.,LTD. Tokyo, Japan) measuring USG to ± 0.001. Subjects were asked to excrete a midstream flow of urine into a disposable Livingstone Urine Jar 70ml (Livingstone International Pty Ltd. Sydney, Australia). Samples were analysed via calibration of the refractometer with 1mL of distilled water. Following calibration, 1mL of urine was manually pipetted onto the refractometer and a reading taken. The refractometer was wiped down with an alcohol swab and recalibration was undertaken again following the next sample analysis. Following USG analysis, all pre and post samples along with utilised consumables were placed in a biohazard bag and disposed at Bond University via their medical waste management protocol. Criteria for hydration status based on pre, post and change USG values were developed on recommended thresholds (4, 9, 10). Values ≤ 1.020 classified subjects as euhydrated. USG values > 1.020 deemed subjects to be in a dehydrated state.

GPS & HR equipment were fitted to subjects following recording of previous measurements and removed prior to all post surfing measurements. Firstly, subjects were fitted with HR monitoring straps (T34 transmitter, 5kHz, Polar, Finland). The sensors on the strap were wiped with an alcohol swab to increase surface moisture and conduction with skin before being placed over the subject's xyphoid process. Sensors were taped down with Leuko 50mm rigid tape before a GPS sports vest was fitted over the top. Subjects were familiarised with GPS units (GPSports HPISPU, 15Hz), and after the units were turned on, they were placed in a waterproof zip tight bag worn in the supplied vest. Upon completion of the data collection period, data from all units was downloaded to specialised software (GPSports: Team AMS Release R1) with time periods pre and post subjects undertaking two hours of surfing removed from final data analysis.

To quantify time spent over the two-hour period, six zones were created for both the speeds and heart rates subjects were exposed to. The six speed zones were adapted from Farley, Abbiss and Sheppard (6) who utilised time motion analysis and GPS to decipher time spent undertaking particular tasks whilst surfing. Zone 1 reflects subjects sitting and captures speeds of 0 - 1 km/h. Zone 2 represents slow to moderate paddling and incorporates speeds of 1 - 4 km/h. Zone 3 shows moderate-fast paddling reflected by 4 - 8 km/h. Zone 4 is slow wave riding as captured within 8 - 12 km/h. Zone 5 is moderate wave riding encapsulated by 12 - 16 km/h. The final speed Zone 6 represents high-extremely high-speed wave riding as shown by 16 - 40 km/h.

Heart rate (HR) zones were established utilising an equation based on predicted HR max (220-subject age). The mean age of the subjects was calculated and subtracted from 220, representing a predicted 100% HR max within zoning as follows: Zone 1 (30 - 40%), Zone 2 (40 - 50%), Zone 3 (50 - 60%), Zone 4 (60 - 70%), Zone 5 (70 - 80%), and Zone 6 (80 - 100%). As an index of work undertaken by subjects, intensity was represented by distance, measured in meters (m) coupled with average HR (bpm) (Intensity = distance x average HR).

Environmental Conditions: Surf conditions including swell size, direction and period were collected from willyweather.com.au. Water temperature, ambient temperature, relative humidity, wind direction and speed were all collected from the Bureau of Meteorology website (http://www.bom.gov.au/). These conditions were recorded on the morning of the data collection day and reflect real time conditions.

Statistical Analysis
Data were transferred to a spreadsheet from where descriptive statistics including means, standard deviations, ranges, and confidence intervals were determined (Statistical Package for the Social Sciences, v23.0). Paired t-tests were then used to assess USG changes pre and post activity. Finally, a multiple linear regression analysis was undertaken to assess the influence of distance and average heart rate on body mass changes and effect size was represented utilising the adjusted R^2 value. Significance was set at 0.05 *a priori*.

RESULTS

All subjects (n = 10) completed the two-hour surf session. Table 1 reflects the environmental conditions that surfers were exposed to during the two-hour surf session.

Table 1. Environmental conditions experienced over the two-hour surf session.

	Swell	Wind	Temperature
Direction	South-East	North-North-East	
Size (ft)	3.9		
Period (s)	8.9		
Speed (km)		13.5	
Water (°C)			26
Ambient (°C)			27.4
Humidity (%)			69

Body mass was found to decrease significantly in both absolute and relative terms as seen in Table 2. The mean USG score prior to entering the water classified 60% of the subjects to be euhydrated, with 40% of subjects presenting in a dehydrated state (> 1.020). USG change values revealed conflicting results (three increased, three stayed the same, and four decreased), with a non-significant mean decrease over the duration of the surfing activity.

Table 2. Parameters of subject hydration pre and post.

Subject	Δ Absolute BM (kg)	Δ Relative BM (%)	Pre USG	Post USG	Δ USG
1	-0.7	0.82	1.02	1.02§	0.005↑
2	-0.5	0.69	1.03§	1.01	0.023↓
3	-0.5	0.56	1.03§	1.03§	0.004↓
4	-0.5	0.55	1.02§	1.02§	0
5	-1.6	2.20	1.01	1.00	0.003↓
6	-0.8	0.80	1.02	1.02§	0
7	-0.4	0.57	1.02§	1.02§	0
8	-0.3	0.39	1.01	1.02§	0.008↑
9	-0.5	0.67	1.01	1.01	0.001↑
10	-1.2	1.40	1.01	1.00	0.006↓
Mean	0.70±0.41*	0.86±0.54†	1.0174±0.0095	1.0152±0.0094	0.0022±0.0084

Δ = Change, * = $p < 0.05$, † = $p < 0.001$, § = State of dehydration (USG ≥ 1.020), ↑ = Increase in USG value, ↓ = Decrease in USG value.

The average distance covered by all subjects was 4974.18 ± 542.62 m, with an average speed of 2.48 ± 0.27 km/h and peak speed of 31.86 ± 3.51 km/h. Peak heart rates were 164 ± 8 bpm with the average heart rate of 110 ± 9 bpm. The information pertaining to distance covered in speed zones along with time spent within both speed and heart rate zones can be found in Table 3 below. Of the total two-hour session, subjects spent 53.45% of the time paddling, equating to a distance of 3766.79 m (Zones 2 and 3). Wave riding accounted for only 4.01% of total time (Zones 4-6 1199.45m) with 42.57% of the total time spent sitting (Zone 1). Subjects spent approximately half (52.90%) of the total time at an intensity of 50-70% of their HR peak (Zone 3 & 4).

Table 3. Distance covered and time spent (% total time) in speed and heart rate zones over two-hour surf session.

Zone	Speed (km/hr)	Distance (m)	Time (%)	% HR Peak	Time (%)
1	0 - 1	7.98 ± 2.41	42.57 ± 4.45	30 - 40%	10.40 ± 17.73
2	1 - 4	2131.21 ± 266.36	38.48 ± 3.16	40 - 50%	17.69 ± 10.20
3	4 - 8	1635.58 ± 337.37	14.97 ± 3.23	50 - 60%	31.63 ± 11.52
4	8 - 12	255.52 ± 57.13	1.33 ± 0.31	60 - 70%	21.27 ± 11.98
5	12 - 16	224.21 ± 82.51	0.84 ± 0.35	70 - 80%	13.57 ± 10.16
6	16 - 40	719.72 ± 169.13	1.84 ± 0.72	80 - 100%	5.47 ± 6.23

Values presented as mean ± SD.

No statistically significant correlation was found between all variables (total distance paddled and relative BM, $r = 0.432$, $p = 0.245$; average HR and relative BM change, $r = -0.246$, $p = 0.595$). For the regression analysis, a sample size of six was used due to data errors which were primarily associated with heart rate data drop out. The multiple regression model was found to significantly predict relative body mass change, $F(2,3) = 29.362$, $p = 0.011$, adjusted $R^2 = 95.1\%$. A summary of the regression model and the associated equation can be seen below in Table 4.

Table 4: Regression model summary for predicted relative body mass change.

Factor		Constant	Average HR	Total Distance Paddled
R	0.975			
R-Square	0.951			
Adjusted R-value	0.919			
Standard Error of Estimate	0.040			
Beta-Coefficient		0.743	0.010	-0.00033
95% CI		(-0.197, 1.684)	(0.003, 0.016)	(-.000500, -.000161)
p-value		0.087	0.017	0.008

Regression equation: Relative Body Mass Change = 0.743 + (0.010 x Average HR) – (0.00033 x Total Distance Paddled).

DISCUSSION

The primary aim of this study was to assess the effects of a two-hour surfing session on hydration status of recreational surfers. Subjects in the current study had a statistically significant BM change of 0.86% ± 0.54. This finding is consistent with Meir, Duncan, Crowley-McHattan, Gorrie and Sheppard (13) and Reaburn, Pearce and Starr-Thomas (16) who reported a BM change of 1.2% ± 1.6 in recreational surfers and 0.90% ± 0.1 in male competitive swimmers, respectively. However, Carrasco (3) found BM changes in elite surfers over a two-hour surf session to be significantly higher than our study's findings, at 3.9 ± 0.7%. This greater difference in body mass loss in the Carrasco (3) study may be attributed to increased fluid loss and energy expenditure due to the use of neoprene wetsuits, rather than differences in surfer's ability. Fluid loss is increased as heat is trapped between the body and inner layer of neoprene negating the physiological effects of thermoregulation via evaporative cooling. These wetsuits are so warm that they exacerbate sweat rate in order to regulate core temperature.

Regarding post-surf testing USG values, results were conflicting as no trend was witnessed and the majority of BM changes did not correlate with our USG values. Changes from pre-surf values indicated that 30% of USG values increased, 30% stayed the same, and 40% decreased. Current literature on hydration status changes by Macaluso et al. (11) and Walker et al. (22) found similar inconsistencies with USG data when compared to BM data results.

Our secondary aim was to analyze the effects that surfing intensity has on hydration status. Using average HR and paddle distance as a measure of intensity of the surf session a linear regression model showed that 95% of relative BM changes could be explained by intensity. To our knowledge this is the first study to show a significant relationship between intensity of a surfing session and BM changes. However, given the small sample size used to generate the regression model (n = 6) caution needs to be applied when interpreting these results.

Our study used GPS with six speed zones to profile surfing activity. The speed zones were set to be consistent with paddling speeds outlined by Farley, Abbiss, and Sheppard (6) The proportion of time surfers spent in each speed zone was consistent with what has been found in previous studies using GPS to profile surfing activity. Additionally, these findings were consistent with studies using time motion analysis to profile activity in surfing. These findings suggest that GPS speed zone parameters could be used alone without time motion analysis to capture activity profiling data in a surf session (1, 13, 14, 20). (Appendix Table 1). This could have future application for professional surf coaching and research, as using GPS for activity profiling is more time efficient than time motion analysis.

Limitations: Within this study we achieved the stated aims, however there are several limitations that need to be noted. Firstly, the small sample size limits the generalizability of the findings, the sample only included recreational surfers who were all males and provides hydration information from one unique surf session. The small sample size was dictated by several factors beyond the studies control. The researchers had a small timeframe in which to collect data being dictated by optimal surf conditions and the time commitment required by the surfers to undertake the two-hour surfing session. Further it was felt that having women undertake a urine sample in the open-air setting may have deterred females from being involved. Furthermore, nutrition and hydration parameters were not controlled to prior to this study, increasing the variability between subjects. Although this may be problematic, findings related to hydration status were important showing that 40% of subjects were already in a dehydrated state before pre-testing.

Finally, although USG is a convenient hydration measure for field based research, USG is susceptible to lag behind the bodies true hydration status due to the protective role of the kidneys and their ability to process acutely ingested fluids (15). For this reason, we suggest future research use USG for pre-testing and AM (morning) first void hydration status only.
Given these limitations, caution should be applied when generalizing these findings beyond this study. The authors recommend larger observational studies that assess the effects of surfing on hydration across a range of different expertise levels, gender, garment utilization environmental conditions.

Conclusion: Based on findings of this study, it appears that a 2-hr recreational surfing session, in temperate environmental conditions, without neoprene garments results in BM changes. However, it does not result in dehydration. Furthermore, those surfers who paddle a greater distance at a higher average heart rate will sustain greater body mass changes. This study supports previous findings in the literature that pre- to post-surf BM is a simple and reliable measure of hydration status of surfers for field research and performance training.

Current literature suggests urine specific gravity is only reliable for chronic dehydration and should only be used for pre-testing (11, 15, 22) Our findings varied to the above findings due to the subjects showing limited changes in USG after surfing compared to pre-surfing. With 40% of the subjects already in a moderately dehydrated state (USG > 1.020) prior to the 2-hour surfing session, and the variability in the post-surfing USG being sizable possibly attributable to the large proportion of subjects already in a dehydrated state.

The current findings are consistent with results reported from other studies that used time motion analysis. Additionally, the findings from this study indicate that GPS speed zone parameters could be a viable option to capture activity profiling data in a surf session. Therefore, GPS may be practical for future surf training and overall athlete monitoring. Overall, this study adds to the knowledge base in surfing research. Future research needs to be undertaken in varying environmental conditions, with longer surf session times, and with the use of different neoprene garments.

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REFERENCES

1. Barlow MJ, Gresty K, Findlay M, Cooke CB, Davidson MA. The effect of wave conditions and surfer ability on performance and the physiological response of recreational surfers. J Strength Cond Res 28(10): 2946-2953, 2014.

2. Boning D, Mrugalla M, Maassen N, Busse M, Wagner TO. Exercise versus immersion: Antagonistic effects on water and electrolyte metabolism during swimming. Eur J Appl Physiol Occup Physiol 57(2): 248-253, 1988.

3. Carrasco AJ. Effects of exercise-induced dehydration on cognitive ability, muscular endurance and surfing performance. [Master of Science thesis]. Auckland, New Zealand: Massey University; 2008.

4. Casa DJ, Clarkson PM, Roberts WO. American College of Sports Medicine roundtable on hydration and physical activity: Consensus statements. Curr Sports Med Rep 4(3): 115-127, 2005.

5. Cox GR, Broad EM, Riley MD, Burke LM. Body mass changes and voluntary fluid intakes of elite level water polo players and swimmers. J Sci Med Sport 5(3): 183-193, 2002.

6. Farley O, Abbiss CR, Sheppard J. Performance analysis of surfing: A review. J Strength Cond Res 31: 260-271, 2017.

7. Farley O, Coyne JO, Secomb J, Lundgren L, Tran TT, Sheppard JM, Abbiss C. Comparison of the 400 metre time endurance surf paddle between elite competitive surfers, competitive surfers, and recreational surfers. J Aust Strength Cond 21(2): 125-127, 2013.

8. Gigou P-Y, Lamontagne-Lacasse M, Goulet ED. Meta-analysis of the effects of pre-exercise hypohydration on endurance performance, lactate threshold and VO2max: 1679. Med Sci Sports Exerc 42(5): 361-362, 2010.

9. Higham DG, Naughton GA, Burt LA, Shi X. Comparison of fluid balance between competitive swimmers and less active adolescents. Int J Sport Nutr Exerc Metab 19(3): 259-274, 2009.

10. Joiner JT. NOAA diving manual: Diving for science and technology. Flagstaff, AZ: Best; 2001.

11. Macaluso F, Di Felice V, Boscaino G, Bonsignore G, Stampone T, Farina F, Morici G. Effects of three different water temperatures on dehydration in competitive swimmers. Sci Sports 26(5): 265-271, 2011.

12. McMurray R, Horvath S. Thermoregulation in swimmers and runners. J Appl Physiol 46(6): 1086-1092, 1979.

13. Meir R, Duncan B, Crowley-McHattan Z, Gorrie C, Sheppard J. Water, water, everywhere, nor any drop to drink: Fluid loss in australian recreational surfers. J Aust Strength Cond 23(6): 16-20, 2015.

14. Meir RA, Lowdon BJ, Davie AJ, Geebng DU, Victoia A. Heart rates and estimated energy expenditure during recreational surfing. Aust J Sci Med Sport 23(3): 70-74, 1991.

15. Périard JD, Racinais S, Sawka MN. Adaptations and mechanisms of human heat acclimation: Applications for competitive athletes and sports. Scand J Med Sci Sports 25: 20-38, 2015

16. Popowski LA, Oppliger RA, Patrick GL, Johnson RF, Kim AJ, Gisolf C. Blood and urinary measures of hydration status during progressive acute dehydration. Med Sci Sports Exerc 33(5): 747-753, 2001.

17. Reaburn P, Pearce S, Starr-Thomas G. Fluid loss in swimmers. J Swim Res 11: 36-39, 1996.

18. Savoie F-A, Kenefick RW, Ely BR, Cheuvront SN, Goulet ED. Effect of hypohydration on muscle endurance, strength, anaerobic power and capacity and vertical jumping ability: A meta-analysis. Sports Med 45(8): 1207-1227, 2015.

19. Sawka M, Latzka W, Matott R, Montain S. Hydration effects on temperature regulation. Int J Sports Med 19(2): S108, 1998.

20. Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc 39(2): 377-390, 2007.

21. Secomb JL, Sheppard JM, Dascombe BJ. Time-motion analysis of a 2-hour surfing training session. Int J Sports Physiol Perform 10(1): 17-22, 2015.

22. Shaw G, Koivisto A, Gerrard D, Burke LM. Nutrition considerations for open-water swimming. Int J Sport Nutr Exerc Metab 24(4): 373-381, 2014.

23. Walker A, Pope R, Orr RM. The impact of fire suppression tasks on firefighter hydration:A critical review with consideration of the utility of reported hydration measures. Ann Occup Environ Med 28: 63, 2016.

Appendix A

1.0 Practical Applications

Adapted from Sawka, Burke, Eichner, Maughan, Montain and Stachenfeld (19), based on the current evidence in water-based sports.

Before surfing:

- If the surfer has not exercised or been exposed to excessive fluid loss in 8 - 12 hrs prior then no prehydration protocol is merited and normal meals and fluids will be sufficient (3, 13).
- If a prehydration protocol is merited (as above), then the surfer should drink beverages slowly 4 hours prior. An example being ~5 – 7 ml per kg body weight. If the urine is dark in colour, then the surfer should continue to drink two hours before event. (An additional ~3 - 5 ml per kg body weight.)
- Consuming foods or fluids that contain sodium will help promote thirst and fluid retention. (20 – 50 mEq per L of fluid)

- Drinking slowly 4 hours prior to surfing allows urine output to return to ordinary.
- Prehydrating the night before an early morning surfing session may prevent dehydration prior to participation (3).

During a surf session:

- The objective of fluid replacement during a surf session would be to prevent excessive dehydration and electrolyte loss. The current study and prior evidence suggests that a 2-hour recreational surf session in a temperate climate without use of neoprene wetsuits does not result in dehydration and thus no specific fluid replacement strategy is necessary during or after the surf session under these conditions (13).
- The current evidence suggests body mass changes are more drastic when using neoprene wetsuits because of increased sweat rates and increased energy expenditure, thus special care should be taken to ensure dehydration does not occur when surfing in neoprene garments even when water temp and air temp is cool or cold (3, 19).
- It is not currently known how warmer environments (ambient temp, water temp and humidity, and when surfing for > 3 hours) effects hydration status of surfers, therefore special fluid replacement strategies may be warranted. This should be based on replacing body water lost (19).
- Genetic factors, heat acclimation, training status, and body composition are examples of other factors that influence individual sweat rates and electrolyte balance. If dehydration is expected to occur (because of prolonged sessions or use of neoprene), a simple monitoring strategy could possibly be pre and post surf weigh ins, with dietary water and sodium intake adjusted according to these measurements (19).
- Sports beverages containing electrolytes and CHO may be helpful to prevent dehydration and decline ion performance in sessions > 3 hrs or if wearing neoprene garments. The ACSM position stand should be consulted for specific guidelines on recommended electrolyte/CHO concentrations. In general, 500 ml to 1 L of sport drink can be consumed to prevent dehydration, hyponatremia, and decline in performance (19).

After a surf session:

- If a surf session is < 3 hours, in a temperate environment, and neoprene garments have not been used, then a normal meal and fluid intake is sufficient to achieve euhydration (21).
- If > 2% body mass loss has occurred or excessive dehydration is suspected and prompt rehydration is necessary, then the surfer should drink ~1.5 L for every kg of BM lost. This will compensate for the greater urine production incurred due to rapid fluid ingestion (19).
- Consuming sodium will help to promote thirst and retain fluids when rehydrating. This can be achieved in meals, gels, beverages, or salt packs (19).

Table 1. Comparison of activity profiling during a surf session between GPS and time motion analysis.

	Method for activity profiling	Stationary	Paddling	Wave Riding	Misc.
Current study	GPS speed zones	43%	53%	4%	-
Barlow et al. 2013	GPS speed zones	47%	42%	8%	3%
Meir et al. 1991	Time motion analysis	44%	35%	5%	16%
Secomb et al. 2015	Time motion analysis	42%	52%	4%	2%
Meir et al. 2015	Time motion analysis	33%	54%	4%	9%

Table 2: Average heart rates, total distance paddled and relative body mass change for subjects used in the regression equation.

Subject	Average Heart Rate (bpm)	Total Distance Paddled (m)	Relative Body Mass Change (%)
1	111.0	3168.8	0.82
3	107.0	3574.9	0.56
4	112.0	3943.2	0.55
7	113.0	3925.9	0.57
8	99.0	4054.1	0.39
9	126.0	3966.3	0.67