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Gary Slater [a]; Benedict Tan [b]
[a] High Performance Group, Singapore Sports Council, Singapore
[b] Changi Sports Medicine Centre, Changi General Hospital, Singapore

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Body mass changes and nutrient intake of dinghy sailors while racing

GARY SLATER[1] & BENEDICT TAN[2]

[1]*High Performance Group, Singapore Sports Council, Singapore and* [2]*Changi Sports Medicine Centre, Changi General Hospital, Singapore*

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Abstract

Dinghy sailing is a physically challenging sport with competitors on water for several hours. Regulations and space in the boat limit the amount of food and fluid competitors can carry. Consequently, it is possible that the hydration and nutritional status of dinghy sailors may be compromised while racing. Despite this, the food and fluid intake of sailors while racing are unknown. The aim of this study was to assess the dietary intake of a group of club sailors while racing and compare this with current sports nutrition guidelines. Thirty-five sailors (9 females, 26 males) were monitored during a club regatta. Body mass changes were measured before and after racing, as were food and fluid intake. Results showed that most participants were in negative fluid balance after racing (males: mean −2.1% [95% confidence limits −1.7 to −2.5%]; females: −0.9% [0 to −1.8%]), most likely due to low voluntary fluid intake (males: 1215 ml [734 to 1695 ml]; females: 792 ml [468 to 1117 m]). Carbohydrate intake (males: 59 g [21 to 97 g]; females: 30 g [0 to 61 g]) was below recommendations for normal sports activity. Results revealed that the nutritional practices of club sailors do not comply with current sports nutrition guidelines. However, the performance implications of a compromise in nutrient intake remain to be investigated. Practical advice on methods of overcoming space limitations for the carriage of adequate fluid and food is offered.

Keywords: *Nutrition, sailing, hydration status*

Introduction

During the past decade, a significant body of literature has been built on dinghy sailing, including assessments of the physiological demands (Felici, Rodio, Madaffari, Ercolani, & Marchetti, 1999; Legg, Mackie, & Smith, 1999b), biomechanical aspects (Mackie, Sanders, & Legg, 1999), and medical implications (Allen, 1999) of the sport. Publication of a recent textbook (Tan, 2000) and a review of literature (Shephard, 1997) have further added to our understanding of dinghy racing. While existing literature makes mention of nutritional needs, little is known about the dietary practices of dinghy sailors.

The nutritional challenges faced by sailors competing in trans-oceanic races have been shown to be substantial (Branth *et al.*, 1996), but little is known of the nutrient intake of dinghy sailors during competition. While the metabolic and cardiorespiratory demands of dinghy sailing depend predominantly on the wind conditions (Vogiatzis, Spurway, Wilson, & Boreham, 1995), aerobic and anaerobic metabolism are not heavily stressed (Blackburn, 1994). Despite this, dinghy sailors face other challenges that may influence total sweat loss and their ability to match this with fluid intake.

Regulations and boat space limit the amount of food and fluid competitors can carry. Furthermore, regattas may be run for several hours at a time, over a number of days, and are typically undertaken during the hottest part of the day in the summer months. Consequently, the hydration and nutritional status of competitive sailors could be compromised during a regatta. Despite this, the food and fluid intake of dinghy sailors while racing is unknown. In contrast, body mass changes and voluntary nutrient intake practices of athletes in other sports have been well documented, including participants of aquatic sports such as swimming and water-polo (Cox, Broad, Riley, & Burke, 2002), team sports (Broad, Burke, Cox, Heeley, & Riley, 1996), cycling (Robinson *et al.*, 1995), running (Pugh, Corbett, & Johnson, 1967), and ultra-endurance events (Eden & Abernethy, 1994).

The aim of this study was to assess the body mass changes and nutrient intakes of a group of club

Correspondence: G. Slater, Singapore Sports Council, 15 Stadium Rd, National Stadium, Singapore 397718. E-mail: gary.slater@ausport.gov.au

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sailors during competition and compare these with current sports nutrition guidelines.

Methods

An investigation was undertaken to assess the body mass changes and dietary practices of dinghy sailors (Laser and Laser Radial) during club competition in Singapore. Thirty-five athletes (9 females, 26 males) volunteered for the investigation. Volunteers were fully informed of the nature of the investigation before providing written consent. The investigation was approved by the Singapore Sports Council Research Ethics Committee.

Bladder-voided body mass was measured just before departing the shore for racing. Athletes were towel-dried and weighed in minimal clothing on a calibrated digital scale (UC 300, A&D Company, Ltd., Milpitas, CA, USA) with a precision of ± 0.05 kg. At the same time, a weighted inventory of all food and fluid to be carried in either the athlete's boat or that of a support crew was measured using a portable food scale with a precision of ± 2 g (Salter Microtronic Electric Kitchen Scale, Salter Housewares Ltd., Kent, UK). This process was repeated upon the completion of racing (including body mass measurement before and after voiding the bladder), ensuring special care was taken to remove any surface water/sweat before the weigh-in after racing. Volunteers were requested to keep all food and fluid packaging for reweighing. Total fluid intake, including that contained in ingested food, was calculated using the Foodworks dietary analysis program (Xyris Software, Brisbane, QLD, Australia). Care was taken to ensure the participants maintained their usual dietary practices while sailing. The participants were informed that the objective of this study was to investigate body mass changes in response to a day of racing.

Change in body mass over the session and weight of food and fluid consumed were used to calculate sweat loss (g) for each athlete using the following formula, as described elsewhere (Cox *et al.*, 2002):

$$(\text{pre-exercise body mass(g)} - \text{post-exercise body mass(g)}) + \text{food (g)} + \text{fluid intake (g)}$$

No correction was made for respiratory or metabolic water losses (Mitchell, Nadel, & Stolwijk, 1972; Snellen, 1966). The duration of races was also noted, and expressed as the time taken by the winner to complete the course. Without facilities for measuring body mass after each race, rates of sweat loss and fluid intake were expressed per hour of total sailing time, inclusive of the time taken to sail to and from the course and "recovery" time between races. Hence, sweat rates while racing are likely to be underestimated.

Without an index of hydration status before racing, it was not possible to estimate the extent of hypohydration experienced while racing. Thus percentage change in fluid balance was calculated using the following formula, as described elsewhere (Cox *et al.*, 2002):

$$[(\text{post-exercise body mass(g)} - \text{pre-exercise body mass(g)}) / \text{pre-exercise body mass(g)}] \times 100$$

The environmental conditions (temperature, humidity, and wind speed) were monitored from a support boat in close proximity to the sailing course using an environmental probe (Kestrel 4000, Nielsen-Kellerman Co., Chester, PA).

After the post-exercise weigh-in, the participants were provided with a short questionnaire using closed-ended questions that sought information on sources of nutrition information and perceived impact of nutrition on sailing performance. The participants were also asked if they evacuated their bladder or bowel while sailing; data from individuals confirming bladder/bowel evacuation were removed from the analysis of changes in fluid balance and sweat rates only.

Statistical analysis

Data were analysed using independent *t*-tests. All statistical analyses were undertaken using Statistica software for Windows (version 6.0, Statsoft, Tulsa, OK). Statistical significance was set at $P < 0.05$. All data are reported as means with 95% confidence limits (95%CL), unless otherwise specified.

Results

The characteristics of all 36 individuals who volunteered for the investigation are presented in Table I. Athletes were on water for approximately 5 h, inclusive of a total of 93 min of racing over three races. Environmental conditions were characteristic of those experienced in Singapore: hot (mean 31°C,

Table I. Characteristics of participants (means and 95% confidence limits).

Variable	Males ($n = 26$)	Females ($n = 9$)
Age (years)	21.4 (18.4 to 24.5)	18.3 (16.6 to 20.0)
Body mass (kg)	65.3 (61.8 to 68.7)	53.1 (49.3 to 56.8)
Training load ($h \cdot week^{-1}$)	9.7 (5.0 to 14.4)	8.9 (5.9 to 12.0)
Sailing experience (years)	3.9 (2.5 to 5.4)	2.7 (0.6 to 4.9)

range 29 – 33°C) and humid (mean 74%, range 62 – 81% relative humidity) with only light breezes (mean 8.2 knots, range 4 – 13 knots). Athletes dressed accordingly; light, unrestrictive attire was worn underneath lifejackets. No wet or dry suits were used.

During post-race interviews, 14 males and five females acknowledged evacuating their bladders while sailing, so their data were omitted from estimates of sweat loss and change in hydration status only. Results from the remaining athletes are summarized in Table II. Fluid balance was negative, ranging from −0.57 to −2.78% for males and from −0.18 to −1.50% for females (Figure 1). Sweat rates ranged from 240 to 712 ml · h^{-1} for males and from 142 to 394 ml · h^{-1} for females (Figure 2).

Data for nutrient intake while sailing are summarized in Table III. Fluid intake ranged from 0 to 1211 ml · h^{-1} for males and from 73 to 295 ml · h^{-1} for females. As a consequence, males replaced 37.2% (95%CL 23.0 to 51.4%) of sweat losses and females 62.1% (95%CL 34.6 to 89.7%). Fluid replacement tended to be greater among females ($P = 0.06$). Carbohydrate intake varied between 0 and 87 g · h^{-1} for males and between 0 and 18 g · h^{-1} for females (Figure 3). There were no differences in fluid intake between those athletes who voided their bladders while racing and those who did not for either males ($P = 0.32$) or females ($P = 0.51$).

Altogether, 65.4% of males and 44.4% of females believed food and fluid intake on water had a "high" or "very high" impact on performance. Three athletes thought nutrient intake on water had a "very limited" or "limited" effect on performance. In total, 61.5% of males and 55.6% of females had previously sought nutritional advice. The most popular sources of such advice included "other athletes/friends" (37.1% of respondents), "coach" (28.6%), "television/magazines/newspapers" (25.7%), and "family members" (22.9%). Only "television/magazines/newspapers" ($P = 0.03$) and "dietitian" ($P = 0.001$) had a favourable influence on fluid intake among males while racing. A similar trend was evident for females, although this was not statistically significant for either "television/magazines/newspapers" ($P = 0.07$) or "dietitian" ($P = 0.18$). Carbohydrate intake while sailing was influenced by the same sources of information and in a similar manner.

Table II. Change in fluid balance and sweat loss while on water for 5 h under hot (mean 31°C, range 29 – 33°C) and humid conditions (mean 74%, range 62 – 81% relative humidity) and relatively light breezes (mean 8.2, range 4 – 13 knots) (means and 95% confidence limits).

Variable	Males ($n = 12$)	Females ($n = 4$)
Change in fluid balance (%)	−2.1* (−1.7 to −2.5)	−0.8 (0.1 to −1.8)
Sweat loss		
Total (ml)	2325* (1870 to 2780)	1140 (213 to 2067)
Per hour (ml · h^{-1})	465* (374 to 556)	228 (43 to 413)

*Significant difference between the sexes ($P < 0.05$).

Discussion

The main finding of this investigation is that the nutrient intake practices of Singaporean club sailors

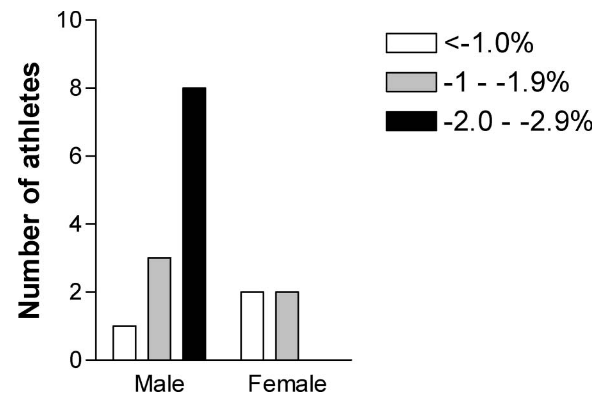

Figure 1. Distribution of changes in fluid balance among dinghy sailors (12 males, 4 females) during a day of racing.

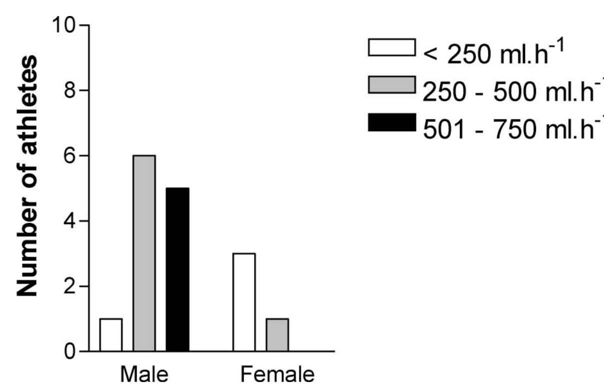

Figure 2. Distribution of rates of fluid loss among dinghy sailors (12 males, 4 females) during a day of racing.

Table III. Nutrient intake of sailors while on water for 5 h under hot (mean 31°C, range 29 – 33°C) and humid conditions (mean 74%, range 62 – 81% relative humidity) and relatively light breezes (mean 8.2, range 4 – 13 knots) (means and 95% confidence limits).

Variable	Males ($n = 26$)	Females ($n = 9$)
Fluid intake		
Total (ml)	1214 (734 to 1695)	792 (468 to 1117)
Per hour (ml · h^{-1})	243 (147 to 339)	159 (94 to 223)
Carbohydrate intake		
Total (g)	59 (21 to 97)	30 (0 to 61)
Per hour (g · h^{-1})	12 (4 to 19)	6 (0 to 12)

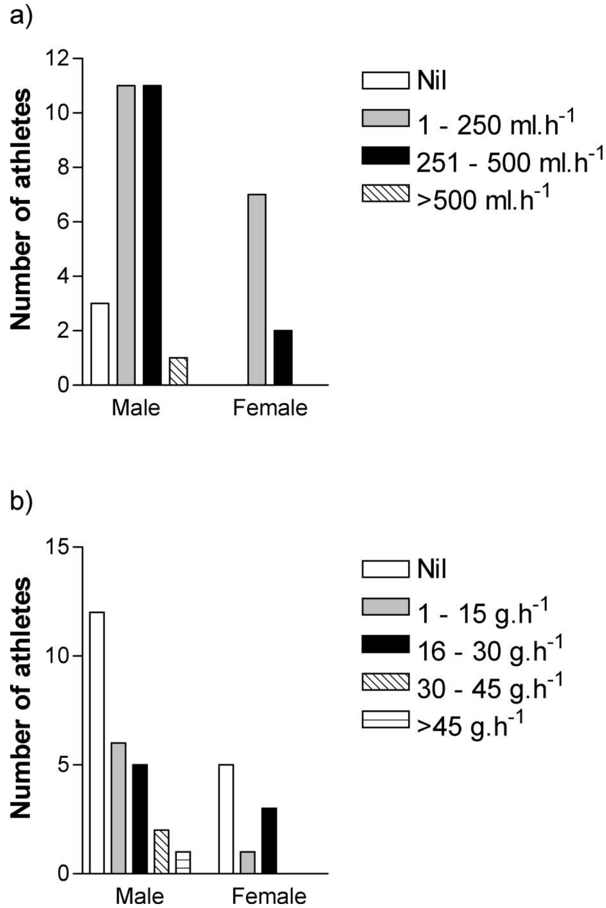

Figure 3. Distributions of mean (a) fluid and (b) carbohydrate intakes per hour among dinghy sailors (12 males, 4 females) during a day of racing.

while racing are not aligned with recommendations. There is a mismatch between sweat rates and fluid intake afloat, resulting in a negative fluid balance in most participants. Similarly, carbohydrate intake while racing is low.

Sweat rates

Sweat rates in the present investigation are approximately half those reported during competition among team sport (Broad *et al.*, 1996) and aquatic athletes (Cox *et al.*, 2002), despite the hot and humid environment experienced. However, considering that sweat rates were calculated from the entire time on water (i.e. 5 h), rather than the period of racing alone, sweat rates during competition have most likely been underestimated. Accordingly, when sweat rates are calculated solely from the period of racing (i.e. 93 min), fluid losses (males 1550 ml $\cdot$ h^{-1}, females 760 ml $\cdot$ h^{-1}) are similar to those reported in other sports during competition. Considering that athletes continue to sail actively between races, the true estimate of sweat rates likely falls between these values and the 5-h estimate (males 465 ml $\cdot$ h^{-1}, females 228 ml $\cdot$ h^{-1}).

When sweat rates exceed maximal rates of gastric emptying, some hypohydration is inevitable. However, none of the athletes in the present investigation had sweat rates approaching the reported limits of gastric emptying (Mitchell & Voss, 1991). Thus there is no physiological reason why sailors should not be able to match fluid intake to sweat rates. In the present investigation, the participants replaced approximately 40 – 60% of sweat losses, consistent with other literature suggesting that athletes only replace approximately 50% of their sweat losses when fluid intake is guided by thirst alone (Greenleaf, 1992).

While most assessments of sweat rates are done by measuring changes in body mass, after accounting for food and fluid intake plus urinary and faecal losses, corrections for respiratory fluid loss and the metabolism of endogenous substrates have also been undertaken (Lemon, Deutsch, & Payne, 1989). However, without indices either of resting metabolism in these sailors or of the workload imposed by sailing in light conditions, it was deemed inappropriate to make corrections for metabolic fluid turnover in the present study. Furthermore, the body mass loss attributed to substrate oxidation may be balanced by the associated metabolic water production (Rehrer, 2001). While respiratory losses, which may be in the order of 2 – 5 g $\cdot$ min^{-1} (Mitchell *et al.*, 1972), are not separately accounted for, they contribute to body fluid losses and thus should be replaced during exercise.

Fluid intake

The mean fluid intakes of sailors in the present investigation are similar to those reported by New Zealand Olympic class sailors (Legg & Mackie, 2000). During 4 h of sailing, the mean (combined males and females) fluid intake of this group of elite sailors was 1200 ml. There may be several limitations to fluid intake while competing. In football, fluids are not permitted on the field, limiting opportunities to access them and maintain hydration status (Broad *et al.*, 1996). When runners attempt to match fluid intake to sweat rates, gastrointestinal discomfort increases (Brouns, Saris, & Rehrer, 1987; Daries, Noakes, & Dennis, 2000). Among dinghy sailors, specific rules of the sport do not preclude intake and gastrointestinal distress is unlikely to do so. However, limited space is available for food and fluid carriage, potentially limiting access to nutrients while racing. With this in mind, novel strategies are required if the sailor is to meet general sports nutrition guidelines. Sports supplements such as sports drinks, bars, and gels may be of particular value in achieving both fluid and carbohydrate requirements. Furthermore, with the chance that environmental conditions may become more physically challenging during a regatta, additional supplies should be made available. With planning, it should be possible to store surplus supplies on a coaching/support boat for easy access between races. Recovery periods between races should also be prioritized as opportunities to access nutrients.

Hypohydration

Hypohydration compromises muscular endurance (for a review, see Barr, 1999) and potentially impairs cognitive function (Gopinathan, Pichan, & Sharma, 1988), which in itself may be critical to competitive success in sailing (Legg, Mackie, & Slyfield, 1999a). Although the fluid balance data suggest two-thirds of the male sailors likely experienced hypohydration sufficient to compromise high-intensity exercise performance (Walsh, Noakes, Hawley, & Dennis, 1994), the implications of such hypohydration on dinghy sailing performance remain to be investigated.

High-intensity exercise performance can be compromised at body fluid deficits of less than 2% (Walsh *et al.*, 1994); the magnitude of performance decrement relates to the exercise task and environmental conditions (Sawka & Pandolf, 1990). Exposure to a thermally stressful environment further compromises exercise tolerance. However, during exercise of lower intensity it is possible to maintain work output following even greater hypohydration than was likely in the present study (Dengel, Weyand, Black, & Cureton, 1992). Future studies of the effect of hypohydration on sailing should therefore include wind strength as an independent variable.

It could be argued that a bias may have been introduced in the estimation of sweat rates by removing individuals who voided their bladder from the analysis. Indeed, water turnover does increase in response to a greater fluid intake (Leiper, Pitsiladis, & Maughan, 2001). However, fluid intake was not different between individuals voiding their bladders while sailing and those not doing so and thus it is unlikely that the results have been biased in this way.

Carbohydrate intake

Specific guidelines for carbohydrate intake while sailing have not been devised but requirements are influenced by exercise intensity and thus environmental conditions. Experts recommend a carbohydrate intake of $30-60\ g \cdot h^{-1}$ during exercise (Maughan, 2000). While a carbohydrate intake closer to $30\ g \cdot h^{-1}$ may appear appropriate to athletes in the present investigation due to the light sailing conditions, consideration must also be made for total daily energy requirements as a large proportion of total waking hours may be spent on water. Without sufficient energy intake while sailing, athletes may have difficulty remaining in energy balance, an important issue to consider when competing in multi-day regattas. Thus when specific recommendations are made for carbohydrate intake, both the anticipated intensity and duration of sailing on the day should be considered.

Most participants consumed no or very little carbohydrate throughout the day of racing. The performance implications of this are unknown but such low carbohydrate intakes may increase the risk of hypoglycaemia, which has not only performance but also safety implications in an aquatic sport. The performance implications of such nutritional strategies would likely be compounded during a multi-day regatta. Consequently, an assessment of athletes' blood glucose at the end of a day of racing may be warranted. That said, when carbohydrate stores are maximized before competition and a carbohydrate intake of just $10-20\ g \cdot h^{-1}$ is maintained, the incidence of hypoglycaemia is very low (Noakes *et al.*, 1988). An assessment of dietary intake in the 24–48 h before sailing would have been valuable in the present study.

Factors influencing nutrient intake

After the introduction of a sports science support programme, including that of a dietitian, the fluid intake of elite New Zealand dingy sailors increased by 500 ml, suggesting that a heightened awareness of nutrient requirements while sailing does influence dietary practices (Legg & Mackie, 2000). This is supported in the present investigation. However, despite the favourable influence of sport science professionals on dietary practices, few athletes in the present study had direct contact with a dietitian. Further involvement of sports science/medicine professionals is encouraged.

Consistent with a report on the supplementation practices of Singaporean athletes (Slater, Tan, & Teh, 2003), readily accessible sources of information such as other athletes, coaches, the mass media, and family members are sought for dietary advice. Thus, if dietary practices of all sailors are to be enhanced, the development of high-quality, readily accessible resources should remain a key strategy. The inclusion of significant others in any direct education of athletes is also encouraged.

Future research

An increase in wind speed will increase the physical demands of sailing (Vogiatzis *et al.*, 1995), and thus increase sweat rates and nutrient requirements, assuming other environmental conditions remain unchanged. However, it is unknown if sailors manipulate their nutritional strategies according to environmental conditions. Future investigations should assess the weight loss and voluntary nutrient intake of dinghy sailors while competing in a variety of environmental conditions. The inclusion of an assessment of hydration status before racing is also encouraged. The reader is referred to several recent reviews for markers of hydration status (Kavouras, 2002; Oppliger & Bartok, 2002; Shirreffs, 2000).

In summary, the eating and drink practices of Laser sailors in this study are not aligned with recommendations. A negative fluid balance suggests hypohydration was likely among the majority of male sailors, while carbohydrate intake on water was low in all but three (male) volunteers. The performance implications of such restrictions in nutrient intake while racing warrants further investigation.

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