Body-Mass Management of Australian Lightweight Rowers prior to and during Competition

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ABSTRACT

SLATER, G. J., A. J. RICE, K. SHARPE, I. MUJIKA, D. JENKINS, and A. G. HAHN. Body-Mass Management of Australian Lightweight Rowers prior to and during Competition. *Med. Sci. Sports Exerc.*, Vol. 37, No. 5, pp. 860–866, 2005. **Purpose:** Although the body-mass management strategies of athletes in high-participation weight-category sports such as wrestling have been thoroughly investigated, little is known about such practices among lightweight rowers. This study examined the body-mass management practices of lightweight rowers before competition and compared these with current guidelines of the International Federation of Rowing Association (FISA). Quantification of nutrient intake in the 1–2 h between weigh-in and racing was also sought. **Methods:** Lightweight rowers ($N = 100$) competing in a national regatta completed a questionnaire that assessed body-mass management practices during the 4 wk before and throughout a regatta plus recovery strategies after weigh-in. Biochemical data were collected immediately after weigh-in to validate questionnaire responses. Responses were categorized according to gender and age category (Senior B or younger than 23 yr old, i.e., U23, Senior A or OPEN, i.e., open age limit) for competition. **Results:** Most athletes (male U23 76.5%, OPEN 92.3%; female U23 84.0%, OPEN 94.1%) decreased their body mass in the weeks before the regatta at rates compliant with FISA guidelines. Gradual dieting, fluid restriction, and increased training load were the most popular methods of body-mass management. Although the importance of recovery after weigh-in was recognized by athletes, nutrient intake and especially sodium (male U23 5.3 ± 4.9, OPEN 7.7 ± 5.9; female U23 5.7 ± 6.8, OPEN 10.2 ± 5.4 mg·kg^{-1}) and fluid intake (male U23 12.1 ± 7.1, OPEN 13.5 ± 8.1; female U23 9.4 ± 7.4, OPEN 14.8 ± 6.9 mL·kg^{-1}) were below current sports nutrition recommendations. **Conclusion:** Few rowers were natural lightweights; the majority reduced their body mass in the weeks before a regatta. Nutritional recovery strategies implemented by lightweight rowers after weigh-in were not consistent with current guidelines. **Key Words:** MAKING WEIGHT, HYPOHYDRATION, RECOVERY, ROWING

In competitive rowing, two distinct weight categories exist: lightweight and heavyweight. The lightweight category is defined by maximal weights of 59 kg (boat average 57 kg) and 72.5 kg (boat average 70 kg) for females and males, respectively (22). Although the weight-making strategies of athletes such as wrestlers have received significant attention, little is known about the weight-making practices of lightweight rowers. From the limited data available, lightweight rowers appear to rely on acute methods of weight loss before competition. Practices include an increase in training volume, food restriction, promotion of active and/or passive sweat production, and fluid restriction (5,17,26). Unfortunately, these data come from questionnaires in which response rates were low (<50%) and/or without validation. Thus, a response bias and/or a reluctance of athletes to honestly reveal their weight-making strategies may have rendered the results invalid (5). Furthermore, little is known about the body-mass management practices of lightweight rowers throughout a multiday regatta during which they have to weigh in before each race.

Lightweight rowers are required to weigh in not less than 1 h and no more than 2 h before the start of each race during a regatta (29). Major international regattas such as those conducted during the Olympic Games or World Championships can run for upward of 1–2 wk. Athletes typically race every 24 to 48 h, depending on race results, as they progress from heats and repechages through to semifinals and finals.

Full restoration of muscle glycogen and total body water is likely to require more than the 1- to 2-h recovery period available to rowers after weigh-in. As a result, the recovery strategies implemented between weigh-in and racing are likely to influence subsequent performance among athletes who undertake acute weight-loss strategies. This was well documented by Burge et al. (1) who, after inducing a 5.2%

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decrease in body mass over a 24-h period, observed a 22-s increase in time to complete a 2000-m rowing ergometer time trial. Although similar decrements in performance associated with hypohydration have been observed in other high-intensity aerobic activities (30), the recovery strategy used by Burge and associates was less than optimal; volunteers consumed only 1.5 L of tap water after weigh-in despite previous food and fluid restriction. Current sports nutrition guidelines encourage the replacement of electrolytes and carbohydrates in addition to fluid during recovery after weigh-in (29). The self-selected recovery strategies used by lightweight rowers after weigh-in remains to be investigated in detail.

The primary aim of the present study was to closely examine the self-reported body-mass management and recovery strategies used by lightweight rowers before and throughout a multiday regatta. It was hypothesized that acute weight-loss strategies common to other weight-category sports would also be prevalent among lightweight rowers, and that the recovery practices employed by lightweight rowers after weigh-in and before competition would be less than ideal.

METHODS

The self-reported body-mass management practices and recovery strategies of lightweight rowers before and during competition were sought via questionnaire during the Australian Rowing Championships. As a method of validating questionnaire responses, a blood sample was collected and specific biomarkers compared between athletes who were retrospectively grouped according to questionnaire responses. Specific biomarkers were selected that offered an insight into hydration status and energy balance/nutritional status of volunteers.

Subjects. Of the 132 lightweight rowers competing in either the U23 (younger than 23 yr old) or OPEN (open age limit) age categories at the regatta, 107 volunteered (81%) to participate in this investigation. Volunteers were fully informed of the nature and possible risks of the investigation before giving their written informed consent. The investigation was approved by the Human Research Ethics Committee of the Australian Institute of Sport.

Biochemistry. Immediately after official weigh-in for each athlete's first race of the regatta, 8 mL of venous blood was sampled via venepuncture from a superficial forearm vein into a serum separation tube using standard phlebotomy procedures and centrifuged at 4500 rpm for 5 min. The resultant serum was stored at −20°C and later analyzed for prealbumin, insulin-like growth factor-I (IGF-I), β-hydroxybutyrate (β-HB), cortisol, osmolality (OSM), and total triiodothyronine (T_3); the typical error (TE) of samples collected within 72 h of each other were 12.3%, 19.0%, 68.1%, 4.4%, 4.6%, and 14.8%, respectively. Cortisol, T_3, and IGF-I were measured on an Immulite® 1000 analyzer (DPC, Los Angeles, CA) using solid-phase, competitive chemiluminescent enzyme immunoassays for cortisol and T_3, and a solid-phase enzyme-labeled chemiluminescent immunometric assay for IGF-I. A Hitachi 911 clinical chemistry analyzer (Roche Diagnostics, Mannheim, Germany) was used to quantify prealbumin via an immunoturbidimetric assay. β-HB was also analyzed on the Hitachi 911 using a kinetic enzymatic method. OSM was calculated via the freezing-point depression method using an Osmomat 030-D cryogenic osmometer (Gonotec, Berlin, Germany). The mean of duplicate measures was used in analysis.

Questionnaire. After blood sampling, athletes were asked to complete a four-page questionnaire (20 questions) that sought responses to body-mass management beliefs and practices used by the athletes in the 4 wk before and during a regatta. Information on the recovery strategies employed by the rowers after weigh-in was also gathered. The questionnaire was based on those used in previous surveys of athletic populations required to make weight (5,11,17,25); only one of these investigations sought to validate questionnaire responses (25). The majority of questions were closed ended to facilitate the administration of the questionnaire and subsequent data analysis. Questions were clustered by content area to facilitate memory.

A draft of the questionnaire had been piloted with lightweight rowers ($N = 10$) in the Canberra region, with feedback specifically sought on the length, language, and content of the questionnaire. After modifying the questionnaire in accordance with recommendations, a final draft was critiqued by all researchers. Athletes were requested to return completed questionnaires to designated boxes located within the weigh-in area at any stage throughout the regatta. Detailed instructions were provided for the recording of dietary information; dimension grids were provided to assist in quantifying dietary intake. Self-reported nutrient intake was evaluated and analyzed by a qualified dietitian using the Foodworks dietary analysis program (version 2.10, Xyris Software, Brisbane, Australia).

Statistical analysis. Differences between age-group and gender categories for descriptive data and self-reported nutrient intake after weigh-in were assessed by ANOVA. Questionnaire responses were analyzed using logistic regression models. Associations between acknowledged weight-loss strategies and blood biochemistry were assessed by ANOVA with specified biochemical parameters as the dependent variable and gender plus weight-loss strategy as categorical predictors. All statistical analyses were undertaken using Statistica software for Windows (version 6.0, Statsoft, Tulsa, OK). Significance was accepted at $P < 0.05$. All data are presented as the mean ± SD unless otherwise specified.

RESULTS

One hundred two blood samples and 100 completed questionnaires were collected from the rowers who volunteered to participate in the study. Descriptive data for volunteers are presented in Table 1.

Questionnaire. Fifty-eight questionnaires were completed by male participants ($N = 34$ U23, $N = 24$ OPEN),

TABLE 1. Descriptive data and average weekly training load of lightweight rowers (completing the questionnaire) in the 3 months preceding the Australian Rowing Championships (N = 100).

	Male U23	Male OPEN	Female U23	Female OPEN
Age (yr)*	20.2 ± 1.1	26.7 ± 5.2	19.1 ± 1.6	27.3 ± 3.0
Body mass (kg)†	70.6 ± 1.9	71.2 ± 1.1	57.4 ± 1.6	57.9 ± 1.1
Stretch stature (cm)†	181.6 ± 5.2	180.7 ± 3.9	170.0 ± 5.3	170.3 ± 3.5
Competitive rowing history (yr)*	2.0 ± 0.1	4.6 ± 3.5	1.4 ± 0.8	3.9 ± 2.9
Personal best 2000 m ergo (s)*†	395.8 ± 12.1	386.3 ± 11.1	459.4 ± 10.1	444.1 ± 15.4
Training load				
On water (h·wk^{-1})	10.5 ± 2.8	12.1 ± 3.7	10.5 ± 2.6	10.5 ± 3.9
Weights (h·wk^{-1})	2.7 ± 2.1	2.9 ± 2.0	2.1 ± 1.8	2.7 ± 1.6
X-training (h·wk^{-1})	4.2 ± 2.5	4.4 ± 2.3	3.8 ± 2.6	6.7 ± 3.0‡

Values are means ± SD.
* Main effect of age category ($P < 0.05$).
† Main effect of gender ($P < 0.01$).
‡ Significantly greater than other groups ($P < 0.05$).
X-training; cross training (i.e., participation in an alternative training mode exclusive to those normally used).

and 42 were completed by females (N = 25 U23, N = 17 OPEN), representing a 75.8% response rate among all lightweight rowers (male 80.6%, female 70.0%) competing in the regatta.

Body-mass management. Peak offseason body mass was 75.1 ± 3.4 kg and 76.2 ± 2.0 kg for male athletes in U23 and OPEN, respectively. Oarswomen averaged 61.6 ± 4.1 kg and 62.4 ± 2.0 kg, respectively, for athletes in U23 and OPEN. The majority of males (U23 76.5%, OPEN 92.3%) and females (U23 84.0%, OPEN 94.1%) reduced their body mass in the final 4 wk before a regatta (Fig. 1). Maximal weight loss in the week before a regatta was as high as 6 kg for males and 4.5 kg for females. The most common methods of body-mass management in the 4 wk before a regatta for males and females are shown in Table 2. No athlete acknowledged the use of vomiting or diuretics to assist in achieving the specified body mass. However, one athlete disclosed the use of diet pills in the 4 wk before a regatta.

Of athletes acknowledging some form of weight loss before a regatta, the majority (91%) made use of two or more weight-loss practices. Over half (60%) of these respondents (i.e., those acknowledging at least two weight-loss practices) undertook four or more weight-loss practices. Among athletes acknowledging some form of dietary restriction, the majority (83%) also noted use of fluid restriction. Only one athlete reported the use of fluid restriction without simultaneous dietary restrictions.

Female rowers were more likely than male rowers to restrict carbohydrate (P = 0.005) and sodium/fiber ($P < 0.001$) intake at some time in the 4 wk before a regatta. Athletes competing in the OPEN division tended to use acute weight loss (P = 0.08) more than younger athletes. Aside from this, weight-loss practices varied little according to age or gender.

Among athletes who restricted food/fluid intake to "make weight," the majority believed nutrient intake in the period between weigh-in and racing partially (male U23 73.1%, OPEN 73.9%; female U23 57.1%, OPEN 81.3%) or fully (male U23 19.2%, OPEN 17.4%; female U23 38.1%, OPEN 18.7%) restored energy reserves and performance. Response to this question did not vary between gender (P = 0.99) or age groups (P = 0.99). For athletes reducing body mass before competition, the majority had no (male U23 73.5%, OPEN 66.7%; female U23 64.0%, OPEN 29.4%) difficulty or occasionally (male U23 17.6%, OPEN 29.2%; female U23 32.0%, OPEN 58.8%) had difficulty remaining at weight during a multiday regatta. A small percentage of respondents (male U23 8.8%, OPEN 4.2%; female U23 4.0%, OPEN 11.8%) did find it difficult remaining at weight, the proportion not varying between gender (P = 0.83) or age groups (P = 0.87). Self-reported daily body-mass variation throughout a regatta was approximately 0.5–1 kg (male U23 1.2 ± 0.9 kg, OPEN 1.1 ± 0.7 kg; female U23 0.5 ± 0.5 kg, OPEN 0.8 ± 0.5 kg). However, daily variations of up to 4 kg and 2 kg were reported among some oarsmen and oarswomen, respectively.

During a regatta, body-mass management goals between races differed between groups; female athletes (P

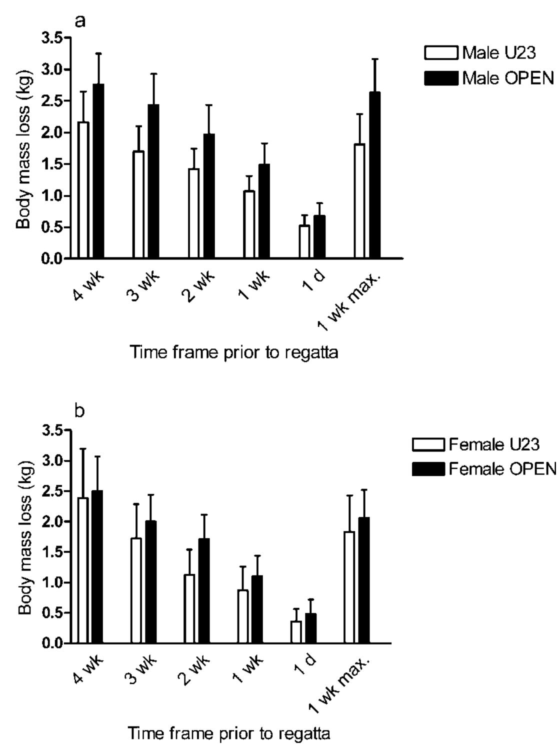

FIGURE 1—Self-reported body-mass loss in the 4 wk before a regatta among lightweight oarsmen (a) and oarswomen (b). Values are means ± 95% confidence intervals.

TABLE 2. Body-mass management strategies among lightweight oarsmen and oarswomen in the 4 wk before a regatta.

	Dieting		Skipping meals		Restricting carbohydrate		Fasting		Increased training		Restricting fluid		Sweat suits		Sauna		Low salt		Low residue		Laxatives	
	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN
Male																						
No	25.7	22.2	68.6	55.6	60.0	63.0	88.6	92.6	51.0	67.0	40.0	37.0	63.0	59.0	69.0	67.0	77.0	85.0	77.0	74.0	83.0	89.0
Yes	74.3	77.7	31.4	44.4	40.0	37.0	11.4	7.4	49.0	33.0	60.0	63.0	37.0	41.0	31.0	33.0	23.0	15.0	23.0	26.0	17.0	11.0
≤1 d	—	3.7	5.7	—	2.9	—	11.4	7.4	—	—	51.0	52.0	37.0	37.0	26.0	33.0	—	3.7	2.9	3.7	2.9	7.4
≤2 d	2.9	—	5.7	3.7	2.9	3.7	—	—	—	—	8.6	7.4	—	3.7	5.7	—	8.6	7.4	8.6	3.7		
≤3 d	—	—	5.7	18.5	—	3.7	—	—	—	—	—	3.7	—	—	—	—	2.9	3.7	2.9	3.7	2.9	—
≤4 d	2.9	—	—	3.7	—	—	—	—	—	—	—	—	—	—	—	—	5.7	—	5.7	—	—	—
≤1 wk	2.9	14.8	8.6	—	8.6	14.8	—	—	2.9	3.7	—	—	—	—	—	—	5.7	7.4	2.9	7.4	2.9	—
≤2 wk	14.3	7.4	5.7	7.4	8.6	3.7	—	—	8.6	—	—	—	—	—	—	—	—	—	—	3.7		—
≤3 wk	14.3	11.1	—	7.4	8.6	—	—	—	8.6	7.4	—	—	—	—	—	—	—	—	—	—		—
≤4 wk	37.0	40.7	—	3.7	8.6	11.1	—	—	29.0	22.0	—	—	—	—	—	—	—	—	—	—		—
Female																						
No	32.1	5.9	75.0	41.2	53.6	11.8	85.7	88.2	64.3	47.1	50.0	11.8	82.1	70.6	67.9	41.2	71.4	17.6	71.4	29.4	85.7	32.1
Yes	67.9	94.1	25.0	58.8	46.4	88.2	14.3	11.8	35.7	52.9	50.0	88.2	17.9	29.4	32.1	58.8	28.6	82.4	28.6	70.6	14.3	67.9
≤1 d	—	—	—	11.8	—	—	7.1	5.9	—	—	35.7	52.9	14.3	29.4	28.6	41.2	—	—	—	—	—	—
≤2 d	—	—	3.6	5.9	3.6	5.9	3.6	—	3.6	—	10.7	11.8	—	—	—	11.8	3.6	—	7.1	—	3.6	—
≤3 d	3.6	—	—	11.8	—	5.9	—	—	—	—	3.6	17.6	3.6	—	—	—	3.6	5.9	7.1	17.6	3.6	3.6
≤4 d	—	—	7.1	5.9	—	17.6	3.6	—	—	—	—	—	—	—	—	—	7.1	11.8	3.6	41.2	3.6	—
≤1 wk	—	—	7.1	5.9	—	11.8	—	—	—	11.8	—	5.9	—	—	—	—	10.7	47.1	10.7	5.9	—	—
≤2 wk	3.6	17.6	—	—	21.4	11.8	—	5.9	7.4	—	—	—	—	—	—	—	—	11.8	—	5.9	—	3.6
≤3 wk	10.7	—	3.6	17.6	3.6	17.6	—	—	7.1	17.6	—	—	—	—	3.6	5.9	3.6	—	—	—	3.6	10.7
≤4 wk	50.0	76.5	3.6	—	17.9	17.6	—	—	17.9	23.5	—	—	—	—	—	—	—	5.9	—	—	—	50.0

Frequencies are presented as percentages of all male (U23 N = 34, OPEN N = 24) and female (U23 N = 25, OPEN N = 17) athletes.

< 0.001) were more likely to remain at weight than males (Fig. 2). The majority of respondents who acknowledged the use of acute weight loss found making weight during a multiday regatta easier (male U23 50.0%, OPEN 63.6%; female U23 65.0%, OPEN 81.3%) or the same (male U23 36.7%, OPEN 18.2%; female U23 25.0%, OPEN 12.5%), with only a minority (male U23 13.3%, OPEN 18.2%; female U23 10.0%, OPEN 6.3%) acknowledging that achieving the specified weight limit became harder as the regatta progressed. Responses to this question did not differ between age (P = 0.56) or gender categories (P = 0.38). Although the weight-loss strategies of the majority of athletes did not change throughout a regatta (male U23 66.7%, OPEN 68.2%; female U23 47.4%, OPEN 64.7%), a third or more did change their strategies (male U23 33.3%, OPEN 31.8%; female U23 52.6%, OPEN 35.3%); responses were similar between age (P = 0.37) and gender categories (P = 0.28).

Rowers were asked to rate the influence that the media and significant others had on their body-mass management practices (Table 3). Younger athletes (i.e., U23) placed a higher priority on information from parents (P = 0.01), whereas females perceived information from the dietitian to be more important (P = 0.008). The influence of the media and other significant people did not vary by gender or age group (P > 0.05).

Nutrient intake during recovery. Nutrient intakes of athletes in the recovery period between weigh-in and racing are compared with current recommendations (29) in Figure 3. Only a minority of athletes achieved fluid recommendations (male U23 2.9%, OPEN 4.2%; female U23 4.0%, OPEN 0.0%). None of the athletes ingested sufficient sodium in recovery. Associated protein (male U23 mean 0.15 (95% CI 0.11–0.19), OPEN 0.22 (95% CI 0.13–0.31); female U23 mean 0.15 (95% CI 0.09–0.21), OPEN 0.33 (95% CI 0.23–0.43) $g \cdot kg^{-1}$) and fat (male U23 mean 0.07 (95% CI 0.05–0.10), OPEN mean 0.06 (95% CI 0.04–0.08); female U23 mean 0.07 (95% CI 0.04–0.10), OPEN mean 0.13 (95% CI 0.08–0.17) $g \cdot kg^{-1}$) intakes were low during this period. Dietary protein intake was higher among OPEN class athletes (P = 0.001). No other main effects were evident for these nutrients.

Nutritional recovery strategies did not change before a final compared with a heat for most athletes (male U23 91.2%, OPEN 87.5%; female U23 83.3%, OPEN 87.5%). For approximately half of the respondents, the time frame between races did influence nutrient intake in recovery (i.e., 24 h (male U23 47.1%, OPEN 54.2%; female U23 41.7%, OPEN 43.8%) or 48 h (male U23 35.3%, OPEN 45.8%; female U23 37.5%, OPEN 37.5%)). If racing every 24 h, food intake was more likely to decrease (male U23 62.5%, OPEN 76.9%; female U23 60.0%, OPEN 57.1%) or remain stable (male U23 25.0%, OPEN 23.1%; female U23 30.0%, OPEN 42.9%) after weigh-in for the first race. A similar response was observed for fluid intake in recovery. When racing every 48 h, food intake was more likely to increase (male U23 58.3%, OPEN 27.3%; female U23 44.4%, OPEN 66.7%) than to remain

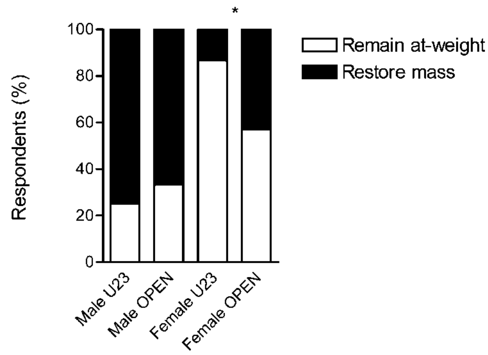

FIGURE 2—Body-mass management goals between races during a multiday regatta. *Main effect of gender ($P < 0.01$).

stable (male U23 25.0%, OPEN 27.3%; female U23 22.2%, OPEN 16.7%) or to decrease (male U23 16.7%, OPEN 45.5%; female U23 33.3%, OPEN 16.7%) after weigh-in for the first race. Fluid intake in recovery followed a similar pattern. The influence of time between races on nutrient intake in recovery did not differ by gender or age at 24 h ($P > 0.05$) or 48 h ($P > 0.05$).

Biochemistry. Sixty blood samples were collected from oarsmen ($N = 34$ U23, $N = 26$ OPEN), and 42 were collected from oarswomen ($N = 25$ U23, $N = 17$ OPEN) before racing (i.e., single scull or coxless pair). The effects of self-reported acute weight-loss strategies on biochemical variables are presented in Table 4. IGF-I and T_3 were lower among athletes reporting the use of dietary restriction to achieve specified body-mass limits. β-HB tended to be higher among these athletes.

Using a serum OSM $\geq$300 mOsm$\cdot$kg^{-1} water to define hypohydration (16), the majority of athletes (male U23 82%, OPEN 77%; female U23 92%, OPEN 94%) presented at weigh-in in a hypohydrated state. Athletes participating in the U23 category were more likely to present in a hypohydrated state ($P = 0.03$). No gender differences were evident ($P = 0.89$).

DISCUSSION

The primary finding of this investigation is that the majority of lightweight rowers competing at the 2003 Australian Rowing Championships used both acute and chronic weight-loss strategies, often in combination, to achieve specified body-mass limits in the weeks before a regatta. Moreover, the nutritional recovery practices employed between weigh-in and competition were not consistent with current guidelines, raising concerns about the performance implications of making weight.

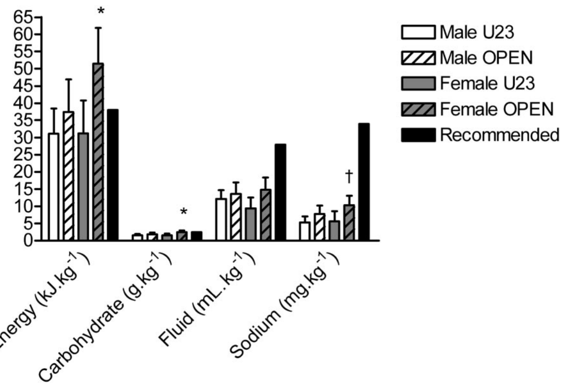

FIGURE 3—Self-reported nutrient intake in the recovery period between weigh-in and racing compared with current recommendations. Values are means ± 95% confidence intervals for 98 athletes. *Significantly greater than male U23 and female U23 ($P < 0.05$). †Significantly greater than male U23 ($P = 0.02$).

Approximately one fourth of those athletes who completed the present questionnaire reported body-mass losses in excess of 3 kg in the 4 wk before a regatta. International Federation of Rowing Association (FISA) guidelines specify that "athletes should be no more than 5 kg above weight 5 to 6 months before competition, and no more than 3 kg above requirements 2 to 3 months before racing." Additionally, "weight loss in the 24 h before racing is encouraged to not exceed 1 kg." In the present investigation, only nine athletes indicated a body-mass loss in excess of 1 kg in the day before racing, confirming that the majority of respondents were in compliance with FISA body-mass management guidelines.

Although weight losses of up to 3 kg over 4 wk do not contravene current weight-loss guidelines of 0.5–0.9 kg$\cdot$wk^{-1} (6), higher rates of body-mass loss are associated with reductions in both fat and fat-free masses; the proportional loss of fat-free mass increasing with the rate of body-mass loss (3). Training quality and recovery are

TABLE 3. Influences on body-mass management practices among lightweight oarsmen and oarswomen.

	Other Rowers		Coaches		Parents		Doctor		Dietitian		Physiologist		Mass Media	
	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN	U23	OPEN
Male														
Very low	12.5	16.7	15.6	16.7	36.7	65.2	66.7	56.5	51.2	43.5	58.3	45.5	76.0	78.3
Low	—	—	12.5	20.8	23.3	13.0	7.4	8.7	12.5	8.7	16.7	9.1	4.0	—
Neutral	31.3	25.0	28.1	29.2	13.3	8.7	18.5	21.7	16.7	17.4	16.7	9.1	12.0	13.0
High	34.4	37.5	31.3	29.2	16.7	13.0	3.7	8.7	12.5	21.7	4.2	13.6	8.0	8.7
Very high	21.9	20.8	12.5	4.2	10.0	—	3.7	4.3	4.2	8.7	4.2	22.7	—	—
Female														
Very low	13.0	—	9.5	18.8	26.1	52.9	60.0	52.9	40.0	17.6	57.9	56.3	76.2	82.4
Low	13.0	23.5	19.0	18.8	17.4	23.5	10.0	23.5	5.0	5.9	21.1	6.3	9.5	11.8
Neutral	13.0	—	28.6	37.5	21.7	11.8	25.0	11.8	15.0	17.6	5.3	18.8	9.5	5.9
High	39.1	52.9	33.3	25.0	21.7	11.8	5.0	11.8	25.0	25.3	10.5	18.8	4.8	—
Very high	21.7	23.5	9.5	—	13.0	—	—	—	15.0	23.5	5.3	—	—	—

Frequencies are presented as percentages of all male ($N = 58$) and female ($N = 42$) athletes who completed the questionnaire.

TABLE 4. Differences in various biochemical parameters among athletes based on self-reported body-mass management techniques.

Making weight strategy	Serum	Questionnaire Response		*P*
		Yes	No	
Dietary restriction	Cortisol (nmol·L^{-1})	461.0 ± 145.3	416.3 ± 101.4	0.32
	β-HB (mmol·L^{-1})	0.095 ± 0.014	0.028 ± 0.024	0.09
	IGF-I (ng·mL^{-1})	249.2 ± 87.8	330.1 ± 83.1	0.001
	Prealbumin (g·L^{-1})	0.33 ± 0.07	0.33 ± 0.06	0.73
	T_3 (ng·dL^{-1})	83.5 ± 22.3	106.3 ± 19.7	<0.001
Fluid restriction	Osmolality (mOsm·kg^{-1})	312.6 ± 12.8	312.1 ± 11.0	0.84
	Cortisol (nmol·L^{-1})	466.7 ± 150.3	429.9 ± 108.8	0.25
Sweat promotion	Osmolality (mOsm·kg^{-1})	313.0 ± 12.9	311.8 ± 11.5	0.64
Increased training	Osmolality (mOsm·kg^{-1})	311.5 ± 11.9	313.3 ± 12.6	0.46
	Cortisol (nmol·L^{-1})	462.2 ± 138.6	446.9 ± 141.9	0.64
	β-HB (mmol·L^{-1})	0.084 ± 0.144	0.084 ± 0.120	0.96
	IGF-I (ng·mL^{-1})	253.6 ± 84.2	269.1 ± 97.9	0.37
	Prealbumin (g·L^{-1})	0.32 ± 0.07	0.33 ± 0.06	0.27
	T_3 (ng·dL^{-1})	78.1 ± 20.2	95.0 ± 23.2	<0.001

β-HB, β-hydroxybutyrate; IGF-I, insulin like growth factor I; T_3, triiodothyronine.

also likely to be compromised when larger energy deficits, and thus weight losses, are induced. The performance implications associated with such rates of loss remain to be investigated.

The present group of athletes reported that weight loss was primarily achieved by gradual dieting, fluid restriction, and an increase in training load, practices that contravene precompetition training (18) and dietary (2) guidelines. The findings are nonetheless consistent with those reported for previous groups of lightweight rowers (5,17) and athletes in other weight-category sports (11,25).

The present biochemical data suggest the weight-loss practices reported in the questionnaires were generally truthful. Serum OSM was an exception; the incidence of hypohydration (as inferred from serum OSM) at weigh-in was widespread and far greater than anticipated from questionnaire responses, suggesting athletes were either habitually hypohydrated or did not wish to disclose use of fluid restriction and/or sweat promotion.

Due to natural interindividual variability in biochemical parameters, biomarker validation of individual questionnaire responses was not attempted. Rather, athletes were grouped according to questionnaire responses on food/fluid restriction, and these groups were compared using biochemical parameters. Biomarker validation of questionnaire responses has been successfully undertaken previously (28). However, certain questions could not be validated due to the absence of external criteria. The limitations of self-report are acknowledged.

Athletes who acknowledged dietary restriction in the weeks before the regatta tended to have elevations in β-HB and lower concentrations of IGF-I and T_3. Although β-HB was higher among athletes undertaking dietary restriction, confirming a diminished carbohydrate (24) and energy availability (10), concentrations were much lower than those previously reported among females exposed to moderate to severe energy restriction (20–45 kcal·kg^{-1} lean body mass·d^{-1}) (10). Athletes acknowledging gradual dieting also had lower T_3 and IGF-I concentrations, reliable markers of acute energy restriction (4).

Although prealbumin is considered a sensitive marker of marginal protein or energy intake (21) with a half-life of less than 2 d (23), prealbumin concentrations of "dieting" athletes in the present investigation did not differ from those not acknowledging energy restriction. Roemmich and Sinning (20) observed a reduction in prealbumin concentrations, well below the reference range, over the 3–4 months of a competitive wrestling season among adolescent males who effectively halved their energy intake to 24.7 kcal·kg^{-1}·d^{-1}. The discrepancy between this observation and our finding likely reflects differences in the duration and/or degree of energy and/or protein restriction and suggests that for the rowers any dietary restriction was insufficient to compromise visceral protein metabolism. Others have reported that prealbumin is less sensitive than IGF-I to variation in nutrient supply (8).

Although cortisol was elevated among the present athletes who reported using weight-loss techniques, concentrations were not significantly different from those of athletes who did not report weight loss. This is consistent with the data reported by Roemmich and Sinning (20) that showed no appreciable change in serum cortisol throughout a competitive wrestling season. Serum cortisol only appears to increase in response to severe energy restriction, that is, when energy intake is limited to ≤35 kcal·kg^{-1} lean body mass·d^{-1} (9).

Collectively considered, the present biochemical data suggest that dietary restrictions undertaken by the majority of lightweight rowers before competition were moderate. Indeed, compared with the offseason, lightweight oarsmen undertake modest restrictions in energy intake, within the order of 15–25% of unrestricted intake. This increases to 40% among lightweight oarswomen (17).

The majority of the present athletes recognized the importance of nutrient intake in the recovery period after weigh-in, but few undertook nutritional recovery strategies in line with current recommendations, especially for fluid and sodium. Gastric emptying rates within the range of 900–1000 mL·h^{-1} have been observed when aggressive rehydration strategies are employed in the first 2 h after exercise-induced dehydration (14). Given these rates of emptying, it appears that athletes may be able to absorb approximately 2 L of fluid in the recovery period before racing without significantly increasing the risk of gastrointestinal distress (15).

Unless the sodium content of a beverage is sufficiently high, much of the ingested fluid will merely contribute to urinary output and delay restoration of fluid balance (12). Elevation of sodium intake favors maintenance of plasma OSM and sodium concentration, promoting retention of ingested fluid via an increase in plasma renin activity and aldosterone concentrations (19). A sodium intake within the range of 50–60 $mmol \cdot L^{-1}$ is recommended for optimal rehydration (13), substantially greater than the self-selected intake of athletes in the present investigation (~10–20 $mmol \cdot L^{-1}$).

Although a reduction in muscle glycogen stores was likely, considering the dietary restrictions and increase in training load popular among athletes attempting to make weight (1,27), carbohydrate intake in recovery after weigh-in was in line with guidelines. Maximal rates of muscle glycogen restoration are achieved with a carbohydrate intake of approximately 1.2 $g \cdot kg^{-1} \cdot h^{-1}$ (7). Although carbohydrate availability is unlikely to limit a single performance effort in a 6- to 8-min rowing event, the implications of compromised muscle glycogen stores on repeat performances, as occurs during a multiday regatta, remain to be investigated.

In summary, the present investigation has confirmed that the majority of lightweight rowers employ both chronic and acute weight-loss strategies to achieve specified body-mass limits before competition. Given that nutrient intake between weigh-in and racing among athletes undertaking acute weight-loss strategies is less than optimal, the influence of such practices on subsequent performance warrants further investigation.

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