Effects of acute postexercise chocolate milk consumption during intensive judo training on the recovery of salivary hormones, salivary SIgA, mood state, muscle soreness, and judo-related performance

Title:

Effects of acute post-exercise chocolate milk consumption during intensive judo training on the recovery of salivary hormones, salivary IgA, mood state, muscle soreness and judo-related performance.

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Abstract

This study examined the effects of post-exercise chocolate milk (CM) or water (W) consumption during 5 days of intensive judo training with concomitant weight loss on salivary cortisol and testosterone, salivary secretory immunoglobulin A (SIgA), delayed-onset muscle soreness (DOMS) and judo-related performance. Twelve trained male judo athletes engaged in 5 days of intensive judo training followed by a simulated judo competition, on two separate training weeks interspersed by 14 days. Immediately post-training, the athletes consumed 1000 ml of W on week 1 and the equivalent volume of CM on week 2. During both weeks, athletes were instructed to "make weight" for the upcoming competition. Judo-related performance in the timed-push-ups and the Special Judo Fitness Test improved by 14.6% and 6.8%, respectively, at the end of the training week with CM consumption (both $p<0.001$). Decreased salivary cortisol ($p<0.01$) and a trend for increased salivary testosterone/cortisol ratio ($p=0.07$) were also observed mid-week in the CM condition. Saliva flow rate was higher during the week with CM intake compared with W ($p<0.001$). DOMS ($p<0.001$) and mood disturbance ($p<0.0001$) increased after the first day of training in the W but not in the CM condition. Responses of salivary testosterone and SIgA were similar between drinks ($p>0.05$). Body mass decreased by 1.9% in the W condition and by 1.1% in the CM condition, with no significant differences between drinks. This study indicates that post-exercise CM consumption during short-term intensive judo training is beneficial for enhancing aspects of recovery, without affecting intentional weight loss.

Keywords: carbohydrate-protein beverage, making weight, salivary cortisol, salivary testosterone, mucosal immunity, special judo fitness test

Introduction

Chocolate milk contains carbohydrates (CHO) and protein, in addition to fluid and electrolytes and could potentially serve as a post-exercise recovery drink. Studies show that chocolate milk (CM) consumption after exercise can enhance subsequent endurance performance during repeated bouts of exercise (Karp et al. 2006; Thomas et al. 2009; Ferguson-Stegall et al. 2011; Spaccarotella and Andzel 2011; Lunn et al. 2012) and speed up recovery during intensive soccer training (Gilson et al. 2010; Spaccarotella and Andzel 2011). In addition, post-exercise consumption of whole milk has been shown to be beneficial in restoring sweat losses in dehydrated subjects (Shirreffs et al. 2007; Watson et al. 2008). Dairy proteins found in fluid milk have been reported to elicit acute rises in muscle protein synthesis following endurance (Ferguson-Stegall et al. 2011) and resistance exercise (Wilkinson et al. 2007) and could potentially be effective in attenuating markers of exercise-induced muscle damage (Cockburn et al. 2008; Pritchett et al. 2009; Gilson et al. 2010) and delayed onset muscle soreness (DOMS) (Cockburn et al. 2010). Attenuated ratings of DOMS and serum creatine kinase (CK) responses were reported when CM was consumed immediately after muscle-damaging exercise (Cockburn et al. 2010); however, other studies report no change in DOMS despite attenuated increases in circulating CK responses during recovery (Cockburn et al. 2008; Pritchett et al. 2009; Gilson et al. 2010). During a brief period of intensified soccer training period, Gilson et al. (2010) reported that post-exercise CM consumption compared with a CHO-replacement beverage attenuated serum CK responses, despite similar changes between drinks on exercise performance, serum myoglobin concentrations, DOMS and muscle function. Mucosal immunity appears to deteriorate during periods of intensive training (Walsh et al. 2011); however, the effects of post-exercise CM consumption during intensive training on saliva secretory immunoglobulin A (SIgA) responses have not been investigated.

Judo is a sport with weight categories, where athletes often engage in periods of weight loss in the days preceding a competition. Most usual practices involve rapid weight loss (>5 days) procedures, mainly by food and fluid restriction. Several unorthodox and aggressive rapid weight loss methods are followed by judo athletes, such as intensive exercising, skipping meals and limiting CHO intake, restricting fluid intake and positively promoting sweat losses which can have detrimental effects on their competition performance and health (Artioli et al. 2010). The combination of rapid weight loss practices and intense exercise training in the week preceding the competition could have adverse effects on athletes' competition performance.

The majority of investigations that have assessed the effects of CM included endurance-type sports and examined aspects of laboratory-based endurance performance and muscle function tests. Therefore, the purpose of this study was to examine whether post-exercise CM consumption during 5 days of intense judo training can enhance aspects of recovery, by limiting the disturbances in salivary hormones, mucosal immunity and mood state, attenuating muscle soreness and improving subsequent judo-specific performance, without affecting intentional weight loss.

Materials and Methods

Participants

Twelve trained, male, national level judo athletes volunteered to participate in the study (mean ± SD: age 19 ± 4 years; height 175 ± 7 cm; body mass 77.4 ± 7.9 kg; body fat 11.1 ± 4.2 %; maximal oxygen uptake 56.8 ± 3.2 $ml \cdot kg^{-1} \cdot min^{-1}$; training experience 7 ± 3 years.). All athletes had competed in judo for at least five years and trained a minimum of 4 times per week. Subjects were lactose tolerant, non-smokers, not taking any form of medication, refrained from alcohol consumption and remained free from illness for the total duration of the study. No overt signs of overreaching (as described by Meeusen et al. 2013) were observed in the subjects before commencing the study; thus subjects in the weeks preceding the study did not present any deterioration in performance, disturbances in mood, reported no recent illness (upper respiratory symptoms) and were generally in good form physically and psychologically. Prior to the study, all subjects completed an informed consent and a health screening questionnaire. The national ethics committee approved all procedures undertaken. For the athletes under 18 years old (17 years at the time of study) informed consent was given by their guardians (Cyprus National Bioethics Committee).

Procedures

Design

This was a field study that took place in January during pre-season preparations. In week 1, athletes initially engaged in 5 days of intensive judo training (days 1-5, Mon-Fri) followed by a simulated competition (day 6, Sat), whereas the athletes consumed 1000 ml of W immediately post-exercise. Following a period of 14 days, the same procedures were repeated; in week 2, the same athletes engaged in 5 days of intensive judo training (days 1-5, Mon-Fri) followed by a simulated competition (day 6, Sat), whereas the athletes consumed 1000 ml of CM immediately post-exercise (Figure 1). During both weeks, athletes were instructed to "make weight" as to reach the body mass required to compete within their weight category during the simulated competition at the end of each week. The first week served as the observation week to obtain baseline measurements and the second week as the intervention. The simulated competition was organised by the National Judo Federation and, to try to be as close to real-time sporting scenarios, it was organised as to motivate athletes' weight loss and assess any effect of the drink on the changes in body mass. Athletes' body mass ranged 55-90 kg, therefore the amount of CM provided at least 1 g CHO per kg body mass (for ingredients see Table 1). Training was performed indoors (*dojo*) in the evening and consisted of judo-specific skills and drills and mat work. Athletes trained together in the same *dojo*, under the supervision of the same coach. The training program followed in this study was based on previous weeks, whilst increasing the training load. Athletes engaged in their usual, previous volume of training during the 14-day washout period. Performance tests, questionnaires to assess DOMS and mood state and morning resting saliva samples to assess salivary hormones, salivary SIgA and saliva flow rate were collected frequently throughout the study. Subjects have had their last meals at least 3 h prior to testing and were instructed to avoid beverages with caffeine and high-CHO content at least 3 h before testing. Subjects were also instructed to avoid milk-based beverages during the duration of the study. Subjects did not train or exercise for 2 days before and after each training week.

<< Figure 1 about here>>

<<Table 1 about here>>

Training quantification

On both training weeks the judo training sessions lasted 2.0 - 2.5 h (18:00-20:30 hrs). The training consisted of a warm-up (~20 min), judo-specific skills and drills and mat work (~50 min), several sets of ground *Randori* (~40 min) and standing *Randori* (~40 min) and cool-down (~10 min). Specific judo exercises were identical on both training weeks. To quantify exercise intensity, each subject wore a Polar heart rate (HR) monitor (Polar Electro Oy, Kempele, Finland) during all training sessions. Records of HR for both training sessions were then downloaded to a computer using Polar Team System and %HRmax, average HR and time spent in each training zone were then individually calculated based on each subject's HRmax. Furthermore, RPE using Borg's 6-20 scale (Borg, 1982) were recorded 30 min following each training session. The training volume was calculated by multiplying the time spent in each training zone by heart rate as a percentage of HRmax (time x % HRmax). Training load was calculated as suggested by Foster et al. (2001) by multiplying session RPE by session duration.

Dietary control

In week 1, the athletes consumed 1000 ml of W, whereas in week 2 they consumed 1000 ml of CM during post-exercise recovery. Both drinks were given within 10 min post-training and were consumed within 1 h of recovery. Subjects were instructed not to consume any other drinks or foods other than their prescribed beverage for 1.5 h post-training. For the needs of simulated competition, subjects were asked to "make weight" for the upcoming simulated competition following their usual nutritional practices during the first week; they were instructed to replicate the same weight loss practices on the following week. On week 1, the athletes completed a personalised food diary with the type, amount and timing of foods and drinks they consumed. Food diaries were given back to the athletes on week 2 and they were instructed to replicate the same dietary habits. Subjects were instructed to stay as close to the first treatment period regarding the amount, type and timing of food and drinks they consumed. Athletes would decrease their body mass until they reached the body weight required for their weight category; this would suggest decreasing their body weight by 1.5 - 2.0 % on both weeks. Days 1, 3 and 5 had been chosen for body mass assessments as to examine the differences of CM or W on changes in body mass and fat at mid-week (day 3) and at the end of the training week (day 5) compared to baseline (day 1; before CM or W was ingested). Dietary records for each treatment period were analysed using Comp-Eat Pro (version 5.7).

Body mass and fat measurements

Measurements of body mass (Seca 703, Vogel & Halke, Germany) and body fat were made 4 times in total each week, before training (~17:30) at days 1, 3 and 5 and in the morning (~8:30) of day 6. Body fat was assessed via 4-site skinfold measurements (Harpenden, Baty Intl, West Sussex, UK) and percentage of body fat was calculated using the equation of Jackson and Pollock (1978).

Performance testing

Following a familiarization session, all subjects performed three judo-related performance tests each time; before training on day 1 to obtain baseline measurements and again on the same time on day 5. The tests were performed at the dojo after warming-up and following body mass measurements. On this order on all occasions, the athletes performed a counterbalanced horizontal jump test, a timed push-ups test and a Special Judo Fitness Test (SJFT).

For the measurement of the horizontal jump distance, subjects performed a jump forwards two times using a free countermovement jump protocol. The best of the two jumps was recorded. Reliability of this test was previously assessed at ICC=0.85 (Papacosta et al., 2013).

Push-ups were performed in a prone position, by lowering and raising the body using the arms. The athletes performed their maximal number of push-ups in a timed 30-s period. The number of completed push-ups in 30 s was recorded as the score of the test. Reliability of this test in these athletes was calculated as described previously (Papacosta et al., 2013) reaching a value of ICC=0.79.

The SJFT was conducted as described by Sterkowitz (1995). The test was conducted in series of 3 bouts lasting 15 s, 30 s and 30 s interspersed by 10-s intervals. During the test, the judoka throws the two opponents as many times as possible using the ippon-seoi-nage technique. HR was measured immediately at the end of the test and after 1 min using a HR monitor to calculate the performance index as:

SJFT index = (HR immediately post + HR one minute post) / total number of throws

A low SJFT index indicates better performance. Reliability of this test was previously assessed at ICC=0.67 (Papacosta et al., 2013).

DOMS and mood state measurement

DOMS was recorded on a visual analogue scale by rating the level of soreness on a scale of 1 (not sore) to 10 (extremely sore) for overall body soreness, soreness on front thigh muscles and soreness of upper body muscles (arms, chest, trapezoids). Subjects rated their subjective feeling of soreness while lightly palpating their muscles in a standing position. Mood state was assessed by the profile of mood state (POMS) questionnaire (McNair et al. 1971).

Saliva collection and analysis

Saliva samples were collected daily in the morning after an overnight fast at 07:00 within 10 min after waking up during all occasions (Figure 1). Subjects were instructed to swallow to empty their mouth before an unstimulated saliva sample was collected. Saliva collections were made with the subject seated, head leaning slightly forward with eyes open, and making minimal orofacial movement while passively dribbling into a sterile vial (Sterilin, Caerphily, UK). The collection time was 2 min at least or until an adequate volume of saliva (~1.5 ml) had been collected. Saliva was then stored in the same vials at −30ºC and were transported frozen to the Loughborough University laboratories for analysis. Concentrations of sC, sT and SIgA were determined in duplicate using commercially available ELISA kits (Salimetrics, PA, USA). Mean intra-assay coefficients of variation were 2.8%, 2.4% and 2.5% for sC, sT and SIgA, respectively. Saliva volume was estimated by weighing the vial immediately after collection and assuming that saliva density was 1.00 $g \cdot ml^{-1}$ (Cole and Eastoe, 1988). Saliva flow rate was then calculated by dividing the total saliva volume collected in each sample (in ml) by the time taken to produce the sample (in min). The SIgA secretion rate ($\mu g \cdot min^{-1}$) was calculated by multiplying the absolute SIgA concentration ($\mu g \cdot ml^{-1}$) by the saliva flow rate ($ml \cdot min^{-1}$).

Statistical analysis

Data was checked for normality, homogeneity of variance and sphericity before statistical analysis. If Mauchly's test indicated that assumption of sphericity was violated the degrees of freedom were corrected using Greenhouse-Geisser estimates. For statistical analysis a two-way ANOVA for repeated measures (drink x time) with Bonferroni adjustments was used. The 95% confidence intervals (CI) for relative differences and size effects using Cohen's *r* from simple planned contrasts (Rosenthal et al., 2000) were calculated to confirm meaningful significant differences. Mean nutrient intake and training volume in arbitrary units (AU) of each training week were compared using dependent paired t-tests. Statistical significance was set at $p \leq 0.05$. All data are presented as mean ± SD. Data was analysed using SPSS (SPSS v. 19.0; SPSS Inc, Chicago, IL, USA).

Results

Training load, ratings of perceived exertion and dietary intake

Mean training load, RPE, training volume and time spend in each training zone did not present significant differences between the two weeks ($p>0.05$). Mean training load was 2805 ± 190 AU and 2769 ± 196 AU during the week with the CM and W treatment, respectively. Mean RPE for each training week was 16 ± 1. No significant differences ($p>0.05$) were found for dietary intake between treatments. The mean 5-day energy intake was 2387 ± 255 kcal (CHO 49.2 ± 8.5 %, protein 25.8 ± 5.5 %, fat 25.0 ± 6.3 %) during the W treatment, and 2575 ± 315 kcal (CHO 51.7 ± 8.9 %, protein 23.0 ± 3.2 %, fat 25.3 ± 7.4 %) during the CM treatment.

Body mass and fat

Body mass decreased from baseline (p<0.001, *r*=0.55) on days 5 and 6 in W treatment and on day 6 in CM treatment. Main effect for drink approached significance (p=0.08) with the decrease in body weight by day 6 reaching 1.9% in the W treatment (CI -82 to -191%) and 1.1% in the CM treatment (CI -48 to -152%). Body fat increased by the end of each training week (p<0.001, *r*=0.64) by ~1% in both the W (CI 30 to 197%) and CM conditions (CI 61 to 206%) with slighty higher values during the CM week (p=0.003, *r*=0.75). (Table 2).

Performance tests

Performance in the horizontal jump did not change with the consumption of either beverage (p>0.05), even though mean jump performance was generally better during the CM condition (p=0.05). Significant main effects of drink (p<0.001, *r*=0.71), time (p<0.001, *r*=0.64) and interaction (p<0.001, *r*=0.74) showed that number of push-ups performed in 30-s increased significantly by the end of the training week in the CM but not in the W condition; performance enhanced in all subjects by a mean of 14.6% in the CM condition (CI 63 to 136%) and in 4 out of 12 subjects by a mean of 2.2% in the W condition (CI -100 to 224%). Mean number of throws in the SJFT was generally higher during the CM condition (p<0.001), with no significant effects of CM. Significant effects of drink (p=0.04, *r*=0.58), time (p=0.04, *r*=0.57) and interaction (p=0.05, *r*=0.50) showed that SJFT performance index improved significantly by 6.8% after CM consumption (CI 90 to 530%) but not after W consumption (CI -67 to 265%); performance enhanced in 10 out of 12 subjects in the CM condition and in 5 out of 12 subjects in the W condition (Table 3).

DOMS

Significant effects of drink ($p<0.001$, $r=0.79$), time ($p<0.01$, $r=0.70$) and interaction ($p<0.001$, $r=0.77$) showed that general DOMS was lower throughout the week in the CM condition compared with W (CI -45 to -155%); muscle soreness rose from day 1 in both treatments but kept increasing from mid-week to the end of the week in the W (CI 46 to 153%) but not the CM condition (CI -377 to 398). DOMS was mainly located on upper body muscles ($p=0.002$) with a similar pattern of increase to general DOMS. DOMS of lower body increased from day 1 to the end of the training week in the W condition but not in the CM condition ($p=0.04$) (Table 4).

Mood state

Significant effects of drink ($p<0.0001$, $r=0.85$), time ($p=0.007$, $r=0.72$) and interaction ($p<0.001$, $r=0.79$) showed that total mood disturbance scores were lower during the CM condition compared with W (CI -33 to -165%). By day 5, mood disturbance increased progressively from day 1 during the W week (CI 54 to 146%), whereas no significant changes were observed during the CM week (CI -88 to 288%). Subscale of tension ($p<0.01$) was lower during the CM compared with W, without differences in subscales of vigour, aggression, confusion, fatigue and depression between drinks ($p>0.05$) (Table 4).

<<Table 2 about here>>

<<Table 3 about here>>

<<Table 4 about here>>

Salivary hormones

Data for sC, sT and sT/C ratio is shown on Figures 2 A, B and C, respectively. A significant effect of drink ($p=0.02$, $r=0.68$) and interaction ($p<0.001$, $r=0.59$) showed that mean sC concentrations were significantly lower during the week with the CM condition (CI -18 to -182%) without significant differences across time ($p>0.05$). Concentrations of sT were similar across time and between the two treatments ($p>0.05$). Significant main effects of time ($p=0.03$, $r=0.44$) and interaction ($p=0.02$, $r=0.67$) showed that mean sT/C ratio increased significantly from baseline in the CM treatment (day 2: CI 5 to 195%; day 4: CI 1 to 249%) with a tendency for higher values during the CM condition compared with W ($p=0.07$, $r=0.48$; CI -9 to 209%).

<<***Figure 2 about here***>>

Saliva SIgA

Data for SIgA absolute concentrations and secretion rate is shown in Figures 3 A and B, respectively. Although mean SIgA absolute concentrations increased in the morning of the competition day from the first days of the week in the W condition ($p=0.004$, $r=0.26$), no significant effect of drink or interaction was found ($p>0.05$).

A significant effect of time showed that mean SIgA secretion rate increased towards the end of the week ($p=0.02$, $r=0.81$), in a similar manner in both conditions ($p>0.05$).

Saliva flow rate

A significant main effect of drink ($p=0.008$, $r=0.70$) and interaction ($p<0.001$, $r=0.72$) showed that mean saliva flow rate was significantly higher during the week of the CM condition compared with W (CI 86 – 111%), without significant changes across time ($p>0.05$). Data is shown in Figure 3 C.

<<Figure 3 about here>>

Discussion

This study showed that post-exercise chocolate milk consumption during 5 days of intensive judo training was favourable for enhancing several aspects of recovery from intensive judo training, without affecting intentional weight loss. Post-exercise CM consumption was associated with lower sC responses and higher saliva flow, attenuated muscle soreness ratings, ameliorated mood disturbance and enhanced judo-specific performance.

In this study, post-exercise CM consumption improved timed push-ups and judo-specific performance by the end of the week, without changes in countermovement jump. The findings of our study agree with some (Karp et al. 2006; Cockburn et al. 2008; Thomas et al. 2009; Ferguson-Stegall et al. 2011; Lunn et al. 2012) but not all studies (Pritchett et al., 2009; Gilson et al. 2010; Spaccarotella and Andzel 2011). The majority of previous investigations assessed the effects of CM during laboratory-based standardized tests, whereas the present study assessed the effects of CM in an applied sport setting. Our previous study in these athletes showed that responses of sC, SIgA, saliva flow rate, muscle soreness, mood state and judo-related performance can serve as markers of training and recovery in judo (Papacosta et al. 2013); therefore the present study assessed the effects of CM during recovery on judo-related, field performance.

Morning sC concentrations were lower in the week of the CM treatment compared with W, which may indicate that accumulated stress of the consecutive intense training sessions was lower when CM was consumed. Similarly, mood was not disturbed when CM was consumed after training. Deterioration of physical performance, elevated cortisol responses and disturbance of mood state are all considered as markers of overreaching and recovery (Meeusen et al. 2013).

CHO supplementation during intensified exercise/training has been shown to maintain physical performance and mood (Achten et al. 2004; Halson et al. 2004). Therefore we suggest that the post-exercise CM consumption aided the recovery from exercise and attenuated the symptoms of overreaching during a short-term period of intense judo training, possibly due to enhanced energy and CHO availability. SIgA did not exhibit differences between conditions; however, the duration of the intensive training period may have been too short for any changes in SIgA levels.

Attenuation of muscle soreness ratings during the week with CM consumption was observed in this study. These results agree with the findings of Cockburn et al. (2010) who reported that CM consumption after muscle-damaging exercise attenuated the increases in DOMS, enhanced muscle-related performance and attenuated the rise in CK responses. Similar investigations showed attenuated rises in CK after the consumption of CM during recovery (Wojcik et al. 2001; Cockburn et al. 2008; Pritchett et al. 2009; Gilson et al. 2010). It has been previously suggested that the protein content in the CM was associated with higher muscle amino-acid uptake and increased muscle protein synthesis (Wilkinson et al. 2007) as well as increased activation status of signalling proteins associated with protein synthesis and attenuation of markers of muscle protein degradation (Ferguson-Stegall et al. 2011; Lunn et al. 2012). In our study, the combination of lower sensation of muscle soreness and enhancement in functional tests with post-exercise CM consumption could be attributed to a lower degree of muscle tissue disruption with the CM.

One of the aims of this study was to observe whether consuming a milk-based CHO-protein recovery beverage could affect pre-competition weight loss in judo. Typically, judo athletes do not tend to consume CHO in the week preceding a competition, as it could possibly interfere with their weight loss practices. In our study, body mass decreased by the morning of the competition day in both conditions, thus by 1.9% in the W condition and 1.1% in the CM condition. Although not reaching statistical significance, body weight was relatively maintained throughout the CM week, whereas it was reduced progressively in the W condition, which could be in accordance with the enhanced mood state that was evident in the week with CM consumption. This fact could indicate two things: (a) that the higher energy content in the CM affected the usual weight loss practice of the judo athletes, as seen on W week (observation week), and making it more difficult to "make weight" or (b) the reduction in body weight of these athletes was actually the effect of mild dehydration. Although no urine osmolality measurements were made, saliva flow rate was higher during the CM week compared with the W week. This could indicate that CM may have been associated with enhanced hydration in these athletes, as decreased rates of saliva flow were reported in dehydrated subjects (Fortes et al. 2012). Previous studies have shown that fluid milk consumption post-exercise was more effective in restoring sweat losses compared with W after exercise-induced mild dehydration (Shirreffs et al. 2007), whereas in already exercise/heat-induced dehydrated subjects milk was effective for maintaining positive net fluid balance during recovery (Watson et al. 2008). This could explain the difference in weight loss between the two beverages, indicating that athletes possibly had higher fluid retention during recovery and were in positive net fluid balance with the CM. Therefore, it appears more probable that the decrease in weight loss in these athletes was actually a result of mild dehydration. The findings indicate that CM consumption post-exercise probably has no meaningful effect on the athletes' weight loss practices; on the contrary the beneficial effects of the CM for enhancing recovery may be more important for effective competition performance than any possible consequence on weight loss.

Limitations of this study were the lack of a randomised, double-blind, crossover design with equicaloric placebo. Due to the nature of the beverages, it was impossible to blind the treatment to the researchers and participants. The lack of equicaloric placebo in this study was chosen as to comply with the usual nutritional practices of judo athletes preceding competition; however, future investigations may assess the effects of CM versus a same equicaloric, flavoured and coloured beverage. The reason for not choosing a crossover design was to eliminate the bias of subjects regarding practices for weight loss. Athletes were requested to follow their usual practices for "making weight" in the first week, and follow these practices during the CM week. Should CM had been given to some athletes on the first week and observe that it interfered with their required weight loss it is possible that on the second week these athletes would try harder to lose weight by further reducing energy consumption. Even though the athletes were instructed to follow the same diet on both weeks and while care was taken as to try to control for all food and drink intake via food diaries, athletes had all their meals at their own space without supervision. However, it should be noted that this was a field study involving national elite athletes during "real-life" training situations; therefore the main objective of athletes and coaches was to enhance performance and perform better at the upcoming competition. Hence, a crossover design was not a safe choice for this cohort of athletes because of the risk that energy consumption would not have been the same between conditions and consequently the effects of CM on weight loss would not have been reliable.

In conclusion, this study suggests that CM can successfully serve as a recovery beverage during periods of intensive judo training as it can have beneficial effects on several aspects of recovery, without meaningful effects on pre-competition intentional weight loss. This study identified that the consumption of CM compared with W during 5 days of intensive judo training was associated with lower sC responses, limited the disturbances in mood, attenuated ratings of muscle soreness and enhanced judo-related performance, possibly attributed to the higher caloric content.

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References

Achten, J., Halson, S. L., Moseley, L., Rayson, M. P., Casey, A. and Jeukendrup, A. E. 2004. Higher dietary carbohydrate content during intensified running training results in better maintenance of performance and mood state. J. Appl. Physiol. (1985), 96, 1331-1340.

Artioli, G. G., Gualano, B., Franchini, E., Scagliusi, F. B., Takesian, M., Fuchs, M. and Lancha, A. H., Jr. 2010. Prevalence, magnitude, and methods of rapid weight loss among judo competitors. Med. Sci. Sports. Exerc. 42, 436-442.

Borg, G. A. 1982. Psychophysical bases of perceived exertion. Med. Sci. Sports. Exerc. 14, 377-381.

Cockburn, E., Hayes, P. R., French, D. N., Stevenson, E. and St Clair Gibson, A. 2008. Acute milk-based protein-CHO supplementation attenuates exercise-induced muscle damage. Appl. Physiol. Nutr. Metab. 33, 775-783.

Cockburn, E., Stevenson, E., Hayes, P. R., Robson-Ansley, P. and Howatson, G. 2010. Effect of milk-based carbohydrate-protein supplement timing on the attenuation of exercise-induced muscle damage. Appl. Physiol. Nutr. Metab. 35, 270-277.

Cole, A. S. and Eastoe, J. E. 1988. Biochemistry and Oral Biology, London, Wright.

Cooke, C. B. 2009. Maximal oxygen uptake, economy and efficiency. In: Eston, R. a. R., T. (ed.) Kinanthropometry and Exercise Physiology laboratory manual: Tests, procedures and data. 3rd ed. London: Routledge.

Ferguson-Stegall, L., McCleave, E. L., Ding, Z., Doerner, P. G., 3rd, Wang, B., Liao, Y. H., Kammer, L., Liu, Y., Hwang, J., Dessard, B. M. and Ivy, J. L. 2011. Postexercise carbohydrate-protein supplementation improves subsequent exercise performance and intracellular signaling for protein synthesis. J. Strength. Cond. Res. 25, 1210-1224.

Fortes, M. B., Diment, B. C., Di Felice, U. and Walsh, N. P. 2012. Dehydration decreases saliva antimicrobial proteins important for mucosal immunity. Appl. Physiol. Nutr. Metab. 37, 850-859.

Foster, C., Florhaug, J. A., Franklin, J., Gottschall, L., Hrovatin, L. A., Parker, S., Doleshal, P. and Dodge, C. 2001. A new approach to monitoring exercise training. J. Strength. Cond. Res. 15, 109-115.

Gilson, F. S., Saunders, M. J., Moran, C. W., Moore, R. W., Womack, C. J. and Kent, M. K. 2010. Effects of chocolate milk consumption on markers of muscle recovery following soccer training: a randomized cross-over study. J. Int. Soc. Sports. Nutr. 7, 19.

Halson, S. L., Lancaster, G. I., Achten, J., Gleeson, M. and Jeukendrup, A. E. 2004. Effects of carbohydrate supplementation on performance and carbohydrate oxidation after intensified cycling training. J. Appl. Physiol. (1985), 97, 1245-1253.

Jackson, A. S. and Pollock, M. L. 1978. Generalized equations for predicting body density of men. Br. J. Nutr. 40, 497-504.

Karp, J. R., Johnston, J. D., Tecklenburg, S., Mickleborough, T. D., Fly, A. D. and Stager, J. M. 2006. Chocolate milk as a post-exercise recovery aid. Int. J. Sport. Nutr. Exerc. Metab. 16, 78-91.

Lunn, W. R., Pasiakos, S. M., Colletto, M. R., Karfonta, K. E., Carbone, J. W., Anderson, J. M. and Rodriguez, N. R. 2012. Chocolate milk and endurance exercise recovery: protein balance, glycogen, and performance. Med. Sci. Sports. Exerc. 44, 682-691.

McNair, D. M., Lorr, M. and Droppleman, L. F. 1971. Manual for the Profile of Mood States. , San Diego, CA.

Meeusen, R., Duclos, M., Foster, C., Fry, A., Gleeson, M., Nieman, D., Raglin, J., Rietjens, G., Steinacker, J. and Urhausen, A. 2013. Prevention, diagnosis, and treatment of the overtraining syndrome: joint consensus statement of the European College of Sport Science and the American College of Sports Medicine. Med. Sci. Sports. Exerc. 45, 186-205.

Papacosta, E., Gleeson, M., and Nassis, G.P. 2013. Salivary hormones, IgA, and performance during intense training and tapering in judo athletes. J. Strength. Cond. Res. 27, 2569–2580,

Pritchett, K., Bishop, P., Pritchett, R., Green, M. and Katica, C. 2009. Acute effects of chocolate milk and a commercial recovery beverage on postexercise recovery indices and endurance cycling performance. Appl. Physiol. Nutr. Metab. 34, 1017-1022.

Rosenthal, R., Rosnow R.L. and Rubin, D.B. 2000. Contrasts and effect sizes in behavioural research: a correlational approach. Cambridge: Cambridge University Press

Shirreffs, S. M., Watson, P. and Maughan, R. J. 2007. Milk as an effective post-exercise rehydration drink. Br. J. Nutr. 98, 173-180.

Spaccarotella, K. J. and Andzel, W. D. 2011. The effects of low fat chocolate milk on postexercise recovery in collegiate athletes. J. Strength. Cond. Res. 25, 3456-3460.

Sterkowitz, S. 1995. Special Judo Fitness Test. Antropomotoryka, 12/13, 29-44.

Thomas, K., Morris, P. and Stevenson, E. 2009. Improved endurance capacity following chocolate milk consumption compared with 2 commercially available sport drinks. Appl. Physiol. Nutr. Metab. 34, 78-82.

Watson, P., Love, T. D., Maughan, R. J. and Shirreffs, S. M. 2008. A comparison of the effects of milk and a carbohydrate-electrolyte drink on the restoration of fluid balance and exercise capacity in a hot, humid environment. Eur. J. Appl. Physiol. 104, 633-642.

Wilkinson, S. B., Tarnopolsky, M. A., Macdonald, M. J., Macdonald, J. R., Armstrong, D. and Phillips, S. M. 2007. Consumption of fluid skim milk promotes greater muscle protein accretion after resistance exercise than does consumption of an isonitrogenous and isoenergetic soy-protein beverage. Am. J. Clin. Nutr. 85, 1031-1040.

Walsh, N. P., Gleeson, M., Shephard, R. J., Woods, J. A., Bishop, N. C., Fleshner, M., Green, C., Pedersen, B. K., Hoffman-Goetz, L., Rogers, C. J., Northoff, H., Abbasi, A. and Simon, P. 2011. Position statement. Part one: Immune function and exercise. Exerc. Immunol. Rev. 17**,** 6-63.

Wojcik, J. R., Walber-Rankin, J., Smith, L. L. and Gwazdauskas, F. C. 2001. Comparison of carbohydrate and milk-based beverages on muscle damage and glycogen following exercise. Int. J. Sport. Nutr. Exerc. Metab. 11, 406-419.

TABLES AND FIGURE LEGENDS

Table 1. Ingredients of the chocolate milk beverage

Energy (kcal·L^{-1})	870.0
Carbohydrates (g·L^{-1})	107.0
of which sugars	105.0
Protein (g·L^{-1})	35.0
Fat (g·L^{-1})	33.0
of which saturates	19.0
Sodium (g·L^{-1})	0.7
Calcium (g·L^{-1})	0.9
Phosphorus (g·L^{-1})	1.3
Vitamin B2 (mg·L^{-1})	1.5
Cocoa (g·L^{-1})	13.5

values supplied by manufacturer

Table 2. Changes in body mass and body fat during the water (W) and chocolate milk (CM) treatment (Mean ± SD).

		DAY 1	DAY 3	DAY 5	DAY 6
Body mass (kg)	W	78.2 ± 7.4	77.8 ± 7.5	77.4 ± 7.5*	76.7 ± 7.3*§
	CM	78.3 ± 8.0	78.3 ± 8.0	78.4 ± 8.1	77.5 ± 8.0*§
Body fat (%)	W	12.4 ± 3.8	12.6 ± 3.5	13.6 ± 4.5*§	13.0 ± 4.1
	CM	13.3 ± 4.8	13.3 ± 3.4	14.1 ± 3.1*§	13.7 ± 3.8

Data are mean ± SD; * indicates significantly different ($p<0.05$) from day 1; § indicates significantly different ($p<0.05$) from day 3.

Table 3. Performance tests at the beginning (DAY 1) and end (DAY 5) of training weeks during the water (W) and chocolate milk (CM) treatment (Mean ± SD).

Performance test		**DAY 1**			**DAY 5**		
Horizontal jump (m)	W	2.32	±	0.16	2.36	±	0.21
	CM	2.41	±	0.17#	2.43	±	0.17 #
Push-ups in 30 s (no.)	W	45	±	7	46	±	6
	CM	48	±	7	55	±	6 *#
Special Judo Fitness Test (throws)	W	25	±	3	25	±	3
	CM	27	±	2 #	28	±	2 #
Special Judo Fitness Test (index)	W	14.2	±	1.6	13.7	±	1.2
	CM	13.3	±	2.1	12.4	±	1.1*#

Data are mean ± SD; * indicates significantly different ($p<0.05$) from Pre; # indicates significantly different ($p<0.05$) than W.

Table 4. Changes in muscle soreness and mood disturbance during the weeks with water (W) and chocolate milk (CM) treatment (Mean ± SD).

		DAY 1	DAY 3	DAY 5
General muscle soreness	W	1.5 ± 0.7	3.2 ± 1.6 *	4.5 ± 1.8 *§
	CM	1.6 ± 0.8	2.4 ± 1.0 *#	2.5 ± 1.0 *#
Front thigh soreness	W	1.4 ± 0.7	2.2 ± 1.6	3.4 ± 1.6 *
	CM	1.3 ± 0.6	2.2 ± 0.8	2.4 ± 1.1 #
Upper body soreness	W	1.2 ± 0.4	2.8 ± 1.6 *	3.8 ± 1.6 *§
	CM	1.5 ± 0.8	2.2 ± 0.8 *#	2.3 ± 1.1 *#
Total mood disturbance	W	-6.0 ± 5.1	1.4 ± 7.3 *	4.8 ± 6.1 *§
	CM	-4.3 ± 5.2	-1.6 ± 5.3	-3.4 ± 6.0 #
Vigour	W	13.9 ± 3.7	11.1 ± 4.1	9.6 ± 3.8
	CM	10.7 ± 3	11.1 ± 3.7	11.1 ± 2.9
Tension	W	2.2 ± 2	3.6 ± 2.8	4.7 ± 3.7
	CM	2.0 ± 1.8	2.6 ± 2.9	2.6 ± 2.6 #
Depression	W	0.2 ± 0.4	1.0 ± 1.2	0.7 ± 1.2
	CM	0.3 ± 0.7	0.1 ± 0.3	0.1 ± 0.3
Aggression	W	1.6 ± 1	2.3 ± 2.4	2.3 ± 1.6
	CM	2.0 ± 1.2	1.8 ± 2.2	1.9 ± 1.9
Fatigue	W	3.7 ± 2.2	5.2 ± 1.9	6.3 ± 3.8
	CM	4.0 ± 3	5.1 ± 2.1	3.8 ± 3.2
Confusion	W	0.3 ± 0.5	0.4 ± 0.7	0.4 ± 0.5
	CM	0.6 ± 1.1	0.3 ± 0.7	0.2 ± 0.4

* indicates significantly different ($p<0.05$) from day 1; § indicates significantly different ($p<0.05$) from day 3; # indicates significantly different ($p<0.05$) than W

Figure 1. Schematic representation of experimental study design. BM indicates body mass and fat measurements; Q indicates questionnaire assessments; s indicates saliva collection.

Figure 2. Mean (± SD) concentrations of [A] salivary cortisol, [B] salivary testosterone and [C] salivary T/C ratio during the weeks with water (grey columns) and chocolate milk (black columns) conditions. ¤ indicates significantly different ($p<0.05$) from day 1; # indicates significantly different ($p<0.05$) than water.

Figure 3. Mean (± SD) concentrations of [A] SIgA absolute concentrations, [B] SIgA secretion rate and [C] saliva flow rate during the weeks with water (grey columns) and chocolate milk (black columns) conditions. ¤ indicates significantly different ($p<0.05$) from day 1; † indicates significantly different ($p<0.05$) from day 2; # indicates significantly different ($p<0.05$) than water.

Figure 1

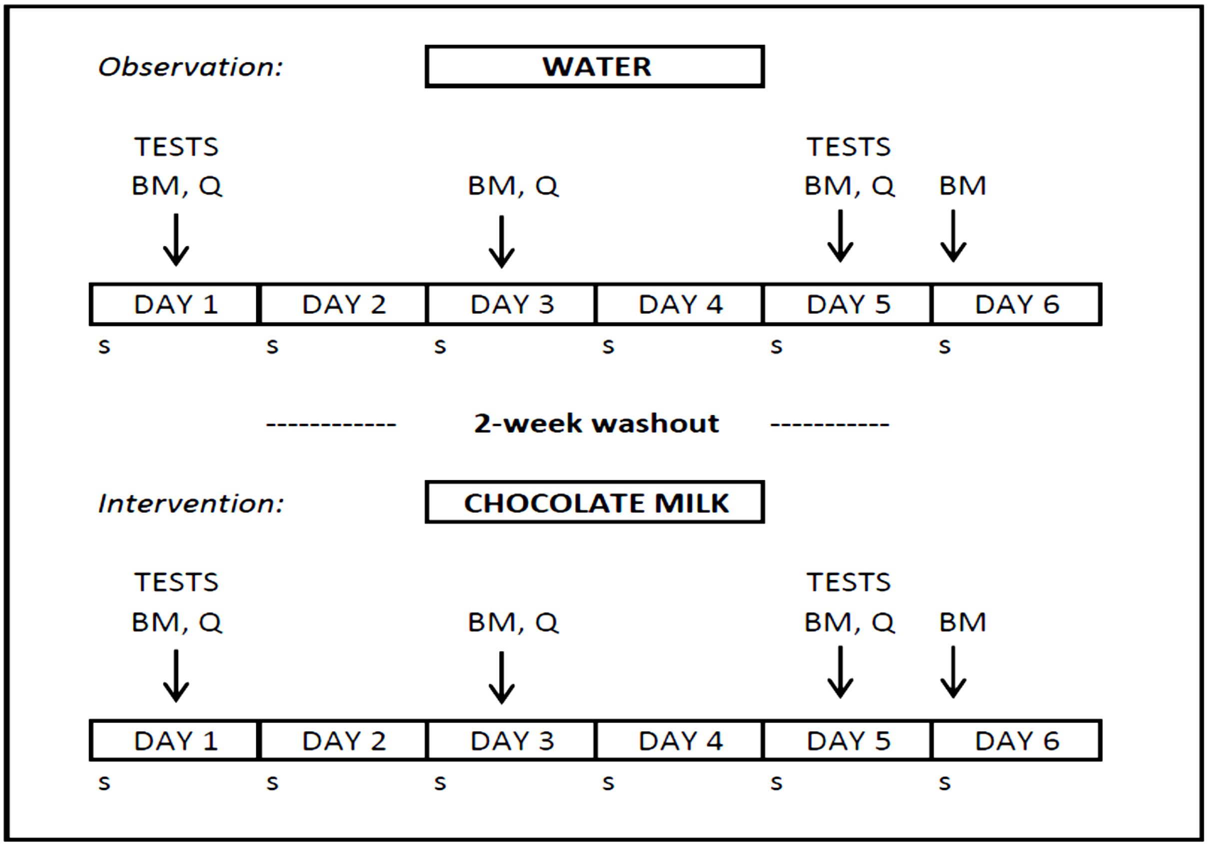

Observation:
WATER
TESTS
BM, Q
BM, Q
TESTS
BM, Q
BM
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
s
s
s
s
s
s
------------ 2-week washout -----------
Intervention:
CHOCOLATE MILK
TESTS
BM, Q
BM, Q
TESTS
BM, Q
BM
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
s
s
s
s
s
s

Figure 2

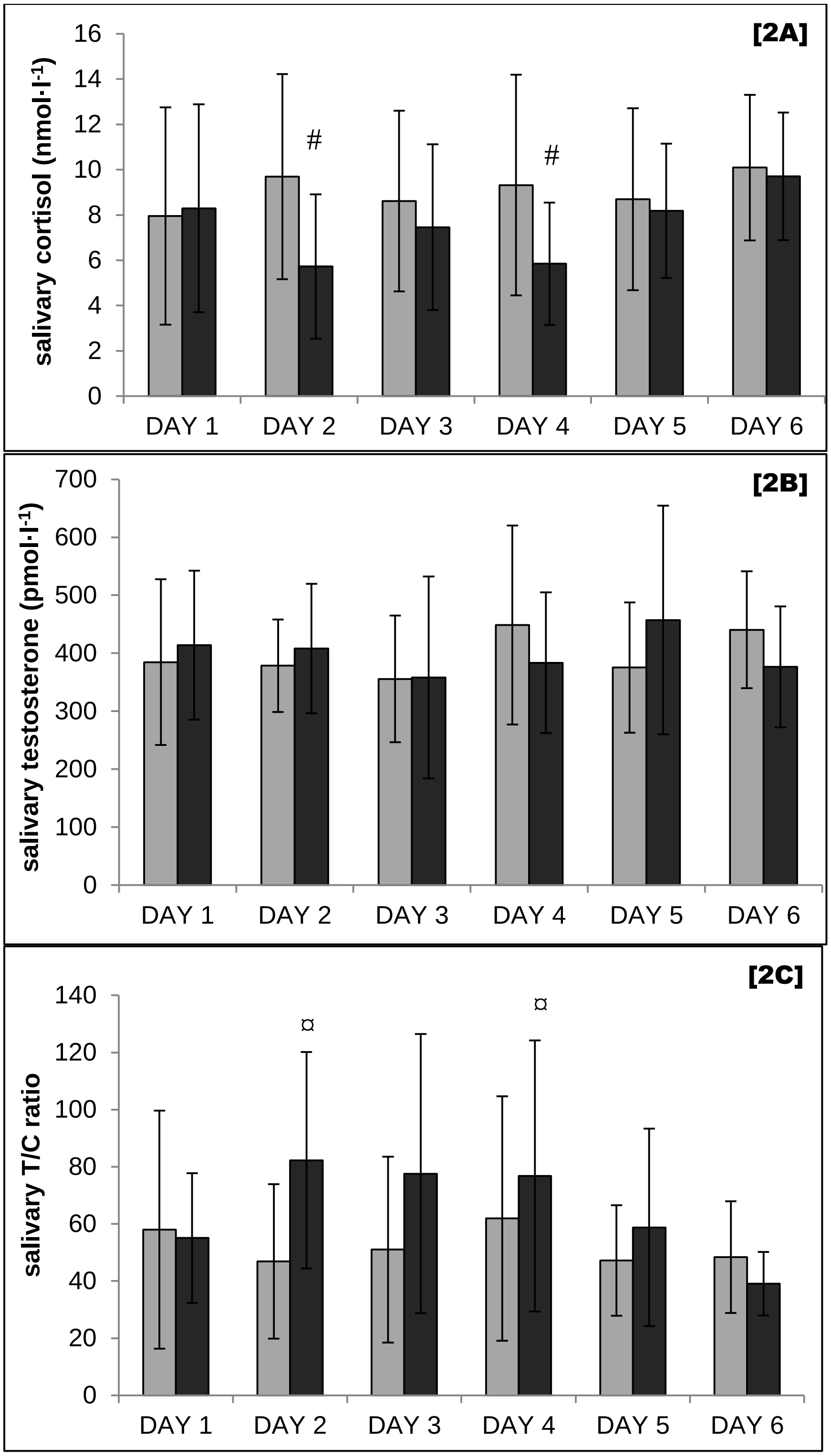
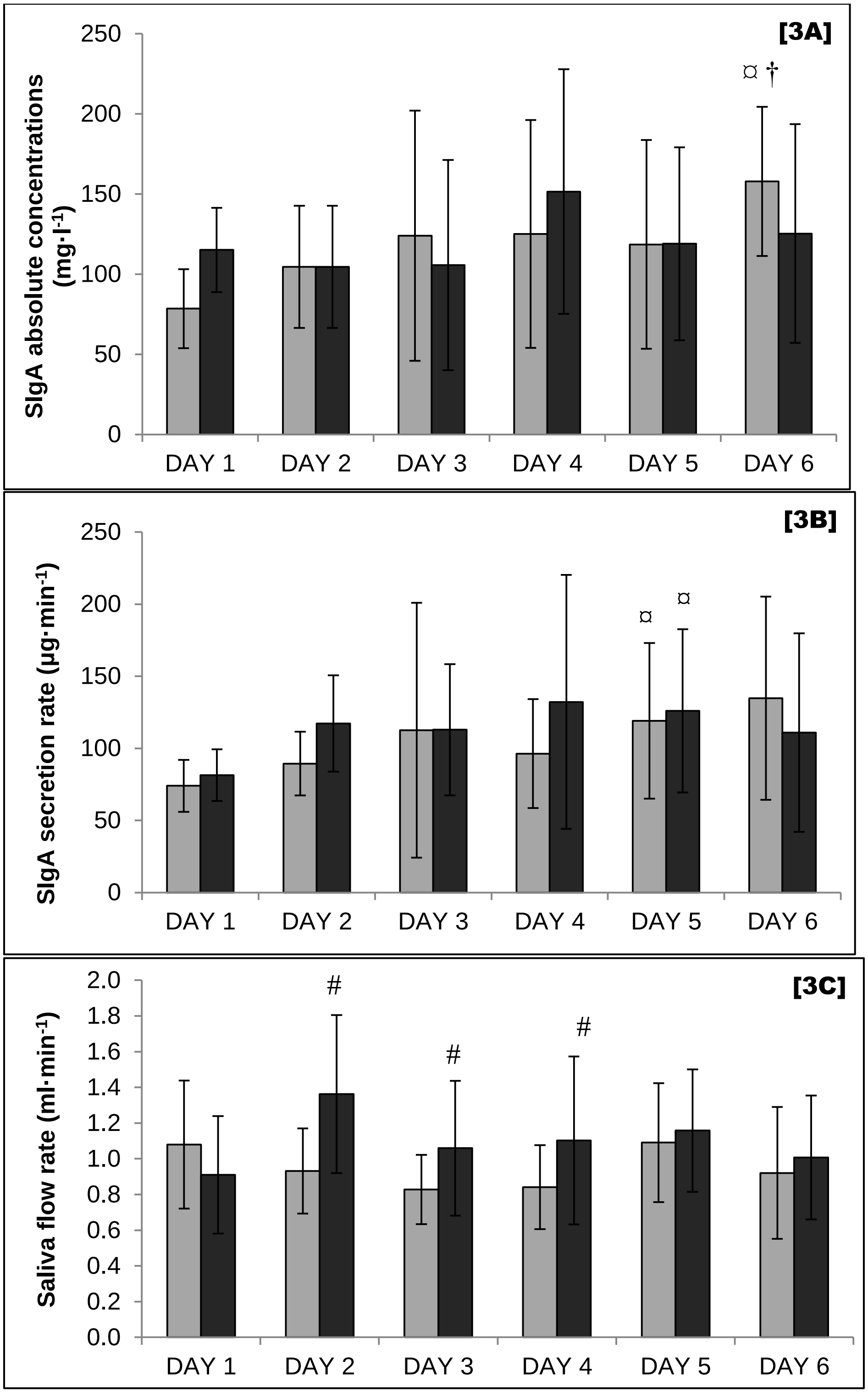

[2A]
salivary cortisol (nmol·l⁻¹)
16
14
12
10
8
6
4
2
0
#
#
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
[2B]
salivary testosterone (pmol·l⁻¹)
700
600
500
400
300
200
100
0
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
[2C]
salivary T/C ratio
140
120
100
80
60
40
20
0
¤
¤
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6

Figure 3


[3A]
SIgA absolute concentrations (mg·l-1)
250
200
150
100
50
0
¤ †
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
[3B]
SIgA secretion rate (µg·min-1)
250
200
150
100
50
0
¤
¤
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6
[3C]
Saliva flow rate (ml·min-1)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
#
#
#
DAY 1
DAY 2
DAY 3
DAY 4
DAY 5
DAY 6