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Title: Skimmed, Lactose-free Milk Ingestion Post Exercise: Rehydration Effectiveness and GI Disturbances versus Water and a Sports Drink in physically active people

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Running Head: Post-Exercise Hydration: Milk vs. Others

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ABSTRACT

Post-exercise hydration is fundamental to replace fluid loss from sweat. This study evaluated rehydration and gastrointestinal (GI) symptoms for each of three beverages: water (W), sports drink (SD) and skimmed, lactose-free milk (SLM) after moderate-intensity cycling in the heat. Sixteen college students completed three exercise sessions each to lose ≈2% of their body mass (BM). They drank 150% of BM loss of the drink assigned in randomized order; net fluid balance (NFB), diuresis and GI symptoms were measured and followed up for three hours after completion of fluid intake. SLM showed higher fluid retention (~69%) versus W (~40%) ($p < .001$); SD (~56%) was not different from SLM or W ($p > .05$). NFB was higher for SLM (-0.26 kg) and SD (-0.42 kg) than water (-0.67 kg) after three hours ($p < .001$), resulting from a significantly lower diuresis with SLM. Reported GI disturbances were mild and showed no difference among drinks ($p > 0.05$) despite ingestion of W (1992 ± 425 ml), SD (1999 ± 429 ml) and SLM (1993 ± 426 ml) in 90 minutes. In conclusion, SLM was more effective than water for post-exercise rehydration, showing greater fluid retention for the three-hour follow-up and presenting with low intensity GI symptoms similar to those with W and SD. These results confirm that SLM is an effective option for hydration after exercise in the heat.

Keywords: hydration, milk, acute GI problems, fluid balance.

INTRODUCTION

Dehydration during prolonged exercise in the heat is a common occurrence requiring fluid and electrolyte ingestion to maintain homeostasis and prevent muscle fatigue, cramping, and heat exhaustion (Sawka et al., 2007). Post-exercise rehydration involves ingesting solutions with water, carbohydrates (~60-80 g/L), sodium (~10-35 mmol/L), chloride (~10-12 mmol/L), potassium (~3-5 mmol/L) and an osmolality of ~280-380 mOsm/kg (Baker & Jeukendrup, 2011).

Gastric emptying of ingested beverages plays a key role in rehydration effectiveness (Leiper et al., 2001), representing a first barrier to the absorption process. Fluid volume, energy content, osmolality, and pH, all have a direct impact on the speed of emptying of stomach contents. For instance, high-calorie beverages are emptied considerably slower in comparison to those with low- or null energy content (Jeukendrup & Moseley, 2010). Intestinal absorption of fluids also influences rehydration speed; hydration beverages should aim to be emptied and absorbed quickly, together with having positive palatability, fluid retention and GI tolerance qualities (Baker & Jeukendrup, 2011; Pérez-Castillo et al., 2023).

Skimmed milk has been shown to be effective for hydration in a euhydrated state. Maughan et al. (2016) evaluated hydration effectiveness of 13 beverages by calculating a hydration index (BHI), using a reference value for water = 1.00. After correction for the water content of each beverage, oral rehydration solutions obtained a mean BHI of 1.50 ($p = .01$), while skimmed milk obtained 1.44 ($p < .01$), and whole milk 1.32 ($p = .02$), compared with water. This suggests that skimmed milk could be almost as effective as the solutions formulated specifically for hydration. Whole milk has resulted in better post-exercise fluid retention than a sports drink (Desbrow et al., 2014). Furthermore, skimmed milk has been shown to provide good rehydration after exercising in the heat, resulting in higher fluid retention than water and a sports drink (Shirreffs, Watson, et al. 2007).

Milk offers valuable nutrients for exercise recovery and/or hydration, like protein, sodium, potassium, calcium, and vitamins, but there is a concern with its lactose content due to GI issues. Lactose is a disaccharide that may facilitate the absorption of sodium and water, but it may cause severe problems in intolerant individuals (Misselwitz et al., 2019; del Carmen Tocaa et al., 2022). Even lactose-free skimmed milk may cause mild digestive issues like belching and bloating during exercise when 900 mL are ingested in 90 minutes (Aragón-Vargas et al., 2023). On the other hand, recent studies show that post-exercise ingestion of dairy drinks is associated with effective rehydration and low severity of GI symptoms (Russo et al., 2021), although the ingested volumes have been moderate (≈ 1700 mL over 4 hours). Other studies using higher volumes have not assessed GI symptoms (Volterman et al., 2014). These results warrant confirmation and the comparison of a large volume of lactose-free milk with water and conventional sports drinks. If a sufficiently large volume of milk causes greater GI distress than the latter two beverages, it will be difficult to recommend it as a rehydration beverage.

Therefore, the purpose of this study was to compare the rehydration effectiveness and GI responses of three widely available beverages: water (W), sports drink (SD), and skimmed, lactose-free milk (SLM), ingested in a large volume after moderate-to-high-intensity cycle ergometer exercise in the heat.

METHODS

16 college students, males and females aged 18-40 years old, were assessed as apparently healthy according to the Revised Physical Activity Readiness Questionnaire (Adams, 1999) and classified as physically active according to the ACSM criteria (Garber et al., 2011). Specific questions targeted possible cardiovascular, renal, or hepatic problems, as well as any

pharmacological treatment which could influence the study results. Participants were requested to abstain from caffeine, alcohol, diuretics, stimulants, and strenuous exercise 24 hours before each visit to the laboratory. Each participant provided his or her informed consent in writing; the protocol was approved by [IRB name and institution to be revealed for publication], according to the form CEC-127-2022 and in compliance with the Declaration of Helsinki.

For each experimental session, participants arrived in the laboratory after fasting for ten hours or more, on three different occasions separated by at least 48 hours. They recorded their dietary intake before the first session with the intention of replicating it for the remaining visits. They also followed specific fluid intake instructions the preceding 24 hours. A urine sample was obtained upon arrival to test for urine specific gravity (USG) with an ATAGO® URC-Ne refractometer (d 1.000-1.050), accepting values ≤1.020 as euhydration. Each participant consumed a standard breakfast providing 1573 kJ (376 kcal): 11% fat, 14.5% protein, 74% carbohydrate, including 200 mL of fluid and approximately 876 mg sodium. After 30 min they were weighed nude and dry (pre-exercise body mass, BM_{pre}) on an e-Accura® DSB291 scale to the nearest 10 g. At this point, all baseline GI symptoms were evaluated with the questionnaire used by Aragón-Vargas et al. (2023) on a Likert scale going from 0 (no problem) to 9 (the worst it has ever been).

Exercise sessions consisted of intermittent (20 min) pedaling on a stationary bicycle (Schwinn AC Performance Plus, Vancouver, WA, USA) in a heat chamber (32°C, 70% relative humidity) at a moderate-to high intensity (80-85 % maximum heart rate); these 20-min exercise bouts were repeated until body mass loss reached ~2%BM_{pre}. Exercise intensity was controlled via heart rate monitoring with a Polar® (Model FT7, Kempele, Finland). Upon exercise completion, participants were weighed nude and dry again ($BM_{postexer}$) and the GI problems questionnaire was applied again. Conditions were assigned in random order: bottled water (W), sports drink (Gatorade®, 60 g carbohydrate/L, 18 mEq Na+/L, 3 mEq K+/L, 1000 kJ/L, SG=1.028) (SD), or skimmed, lactose-free milk (Delactomy®, 48 g carbohydrate/L, 2 g fat/L, 32 g protein / L, 17 mEq Na+/L, 40 mEq K+/L 1415 kJ/L, SG=1.036) (SLM). Fluid volume for ingestion was calculated as 150% BM loss and divided into 3 aliquots to be ingested every 30 minutes, weighed with an OHAUS® compact digital balance with 1 gram accuracy (model CS2000, Parsippany, NJ, USA). At the end of this 90 min rehydration period a third nude and dry body mass was obtained ($BM_{postingestion}$). All participants were evaluated under all conditions, with a minimum of 48 hours between tests for the same participant.

After rehydration, urine was collected for 3 hours at 0, 30, 60, 90, 120, 150 and 180 minutes. Each sample was kept in a pre-weighed container, with gross weight recorded using the OHAUS® precision scale mentioned above. Net weight was obtained by subtracting the container, and volume was calculated in mL assuming 1g = 1mL (Kurdak et al., 2010). At 3 hours, nude body mass was recorded (BM_{3hPI}) using an e-Accura® scale (Model DSB921, 250 kg, 10 g resolution). Total urine volume (TUV) was calculated by summing the 7 samples. From TUV and ingested volume, percent fluid elimination (%FE) and conservation (%FC) were calculated, according to:

- % FE: (TUV X 100)/Fluid ingestion volume
- % FC: 100% - %FE

Net fluid balance (NFB) was calculated for each of four moments in time: pre-exercise, post-exercise, post-ingestion and three hours post-ingestion, using body mass immediately prior to exercise, as follows:

$$NFB_{time} = BM_{time} - BM_{pre}$$

Finally, at times 60, 120, and 180 min post exercise, the GI symptoms questionnaire was applied, for a total of 5 GI symptoms evaluations. Drawing on Aragón-Vargas et al. (2023) and Pfeiffer et al. (2012), this questionnaire assesses GI symptoms across three categories: upper tract (reflux, bloating, nausea, etc.), lower tract (cramps, flatulence, etc.), and systemic (dizziness, headache, etc.). In addition, a combined score (CS) adding up all the values for each symptom under each of the three categories (maximum potential score of 63 for upper GI, 54 for lower GI, and 36 for systemic symptoms) was calculated. These were standardized using the formula:

$$Standardized\ (z)\ score\colon\ zCS = \frac{CS - Mean\ CS\ category}{Standard\ Deviation\ CS\ category}$$

Statistical analysis

This was an experimental, repeated-measures, randomized (conditions), crossover study. Descriptive statistics (mean, s.d., range) were calculated for age, height, initial body mass and GI symptoms to characterize the sample; variables were evaluated for normality (Shapiro-Wilk test). One-way ANOVAs on urine gravity, initial mass, fluid volume, exercise time, environmental conditions (temperature, humidity) and GI symptoms (pre, post-exercise) verified baseline similarity among conditions; Levene's test verified homoscedasticity. Dependent variables: TUV, % dehydration and %FC were each analyzed with one ANOVA (three conditions). For the following variables that had to be analyzed for more than one independent variable, least squares was applied: NFB was compared with double interaction (condition X time of measurement) and with participants as a random effect. Both partial and accumulated urine volumes were examined by weighted least squares with a double interaction (condition X time of measurement) and participants as a random effect; for the purpose of analysis, urine samples were collected every 30 min for 3 hours, resulting in 7 collection time points. For statistical analysis and to avoid too many zero values, these points were grouped into 4 periods: post-ingestion; 1, 2, and 3 hours post ingestion. Lastly, GI symptoms were evaluated with the standardized combined scores (zPC) for each category, using least squares, a triple interaction (condition X time of measurement X symptom) and the participants as a random effect. Analyses were performed with RStudio 2023.06.0+421 (figures) and JMP® Pro 17 (SAS Institute, Inc., Cary, NC, USA).

RESULTS

16 participants (4 females, 12 males) completed all three conditions in this study. Their basic characteristics were (mean ± S.D.; min-max): age = 22.9 ± 2.5; 19-28 y.o. Height = 168.9 ± 8.9; 150.2-182.6 cm. Weight = 66.6 ± 13.9; 49.9-107.1 kg. A post-hoc statistical power (sp) analysis confirmed that a sample of 16 participants, with sp > .85 to be considered adequate under $\alpha < .05$, resulted in the following sp values considering specific meaningful mean differences (mmd) for each variable: total urine volume, mmd = 300 mL, sp = .994; fluid conservation, mmd = 10%, sp = .87; NFB, mmd = 0.2 kg, sp = .94; GI symptoms (upper, lower, systemic), mmd = 0.6 arbitrary units (AU), sp > .90.

One-way analyses of variance showed that W, SD, and SLM trials were performed under similar hydration status (Table 1): baseline urine specific gravity (p = .581) and body mass (p = .998) were the same. During exercise, both ambient heat (p = .529) and relative humidity (p = .708) were similar among conditions; resulting percent dehydration (p = .715) and exercise time (p = .999) were not different among conditions. Gastrointestinal symptoms (upper, lower and systemic) showed no significant differences, either pre or post exercise, among the experimental conditions. Levene's test confirmed homoscedasticity within variables (p > .05).

Hydration effectiveness

Figure 1 shows the changes in net fluid balance. The exercise protocol resulted in similar losses of approximately 2%BM: $NFB_{postexer}$ =-1.29, -1.29, and -1.31 kg prior to conditions W, SD and SLM, respectively (p = .996). After drinking 150% of BM loss, NFB was also similar among conditions (p = .685). At the end of monitoring, however, significant differences were detected (p < 0.001): least squares means contrasts showed NFB estimated differences for W-SD = -

0.25 kg (95% CI: -0.45 to -0.06 kg, $p < 0.001$); W-SLM = -0.40 kg (95% CI: -0.60 to -0.21 kg, $p < 0.001$); and SD-SLM = -0.15 kg (95% CI: -0.34 to 0.04 kg, $p = .126$).

Fluid retention values for each condition were (mean, 95% CI): W (39.6 %, 28.4 to 50.6 %), SD (55.6 %, 43.7 to 67.5%), and SLM (69.8 %, 61.5 to 78.0 %). Contrasts showed a significant difference between the water and milk conditions ($p < .001$): SLM-W = 30.2% (95% CI: 13.3 to 47.2%). The other contrasts were not significant: SD-W = 16.1% (95% CI: -0.1 to 33.0%, $p = .066$), SLM-SD = 14.2% (95% CI: -0.2 to 31.1%, $p = 0.118$).

Figure 2 compares diuresis over time for the three conditions. There was a significant interaction between time of measurement and condition ($p < .001$) for partial collection of urine. Specific contrast means are as follows (mean difference; 95%CI): immediately upon completing rehydration, W-SD = 74.2 mL; -32.5 to 180.9 mL ($p = .172$), W-SLM = 100.4 mL; 11.1 to 189.7 mL ($p = .028$), SD-SLM = 26.2 mL; -48.8 to 101.1 mL ($p = .491$). After one hour, W-SD = 183.1 mL; 76.4 to 289.7 mL ($p < .001$), W-SLM = 347.9 mL; 258.6 to 437.2 mL ($p < .001$), SD-SLM = 164.8 mL; 89.9 to 239.8 mL ($p < .001$). After two hours, W-SD = 46.2 mL; -60.5 to 152.9 mL ($p = .393$), W-SLM = 144.0 mL; 54.7 to 233.3 mL ($p = .002$), SD-SLM = 97.8 mL; 22.9 to 172.8 mL ($p = .010$). Finally, after three hours, W-SD = 17.9 mL; -88.7 to 124.6 mL ($p = .740$), W-SLM = 32.2 mL; -57.1 to 121.5 mL ($p = .477$), SD-SLM = 14.3 mL; -60.7 to 89.2 mL ($p = .707$).

Figure 3 shows accumulated urine volumes for all conditions. There is a significant interaction between time of measurement and condition ($p < .001$). Mean contrasts analysis showed (mean difference; 95%CI): immediately upon completing rehydration, W-SD = 74.1 mL; -114.9 to 263.1 mL, ($p = .440$), W-SLM = 100.3 mL; -59.5 to 260.1 mL ($p = .217$), SD-SLM = 26.2 mL; -111.0 to 163.4 mL ($p = .707$). After one hour, W-SD = 208.9 mL; 75.3 to 342.6 mL ($p = .002$), W-SLM = 378.7 mL; 265.7 to 491.7 mL ($p < .001$), SD-SLM = 169.8 mL; 72.8 to 266.8 mL

($p = .001$). After two hours, W-SD = 298.7 mL; 165.1 to 432.4 mL ($p < .001$), W-SLM = 576.8 mL; 463.9 to 689.8 mL ($p < .001$), SD-SLM = 278.1 mL; 181.1 to 375.1 mL ($p < .001$). Finally, after three hours, W-SD = 297.9 mL; 164.3 to 431.6 mL ($p < .001$), W-SLM = 611.0 mL; 498.0 to 724.0 mL ($p < .001$), SD-SLM = 313.1 mL; 216.1 to 410.1 mL ($p < .001$).

GI symptoms

Gastrointestinal symptoms were measured at pre-exercise, post-exercise, and 60, 120, and 180 min, but beverages were ingested post-exercise; only results of 60, 120 and 180 minutes post-exercise are shown. Most reported scores were low (0) or light to moderate (1-4) on the 0 to 9 scale. Accumulated scores were low: upper GI tract CS = 7 out of 63; lower tract CS = 5 out of 54; systemic CS = 8 out of 36. Table 2 shows combined scores for GI symptoms in each category (upper GI, lower GI, systemic) and individual symptoms within each category. Data is from 60, 120 and 180 minutes post-exercise for w, SD, and SLM. Median and range of scores are reported for each beverage and symptom/category. Overall, most symptoms had low median scores of 0-3, indicating mild or no GI issues across beverages at the times measured.

Combined Scores (CS) were standardized for analysis. The triple interaction among condition, time of measurement, and symptom category was not significant ($p = .904$) (Figure 4). No significant double interactions between condition and time of measurement ($p = .458$) or condition and symptom category ($p = .058$); likewise for time of measurement and symptom ($p = .927$). Simple effects were significant: symptom ($p = .045$), condition ($p = .025$) and time of measurement ($p = .017$).

DISCUSSION

This study compared rehydration effectiveness of water, sports drink, and skimmed, lactose-free milk by measuring net fluid balance, diuresis, fluid retention, and GI symptoms after ingesting ~2 L. Specifically, skimmed, lactose-free milk showed higher net fluid balance 3 hours post-ingestion, from greater fluid retention (~69%) versus water (~40%) although not different from sports drink (~56%); this supports SLM as an effective rehydration drink.

Volterman et al. (2014) reported greater retention for milk versus sports drink and water at 1 and 2 hours post-exercise. James et al. (2011) found higher retention for milk (~55%) versus carbohydrate-electrolyte drink (~43%) at 4 hours ($p < .05$). Presently, SLM showed a higher NFB three hours post ingestion (-0.26 kg) vs. water (-0.67 kg) but not vs. sports drink (-0.42 kg). Except for the latter non-significant difference, these results agree with previous studies (Shirreffs, Watson, et al., 2007; James et al., 2011; Berry et al., 2020) using different types of milk for post-exercise rehydration. Nevertheless, in our study SLM had lower total urine volume vs. both W and SD.

SLM intake post-exercise resulted in a lower diuresis versus W and SD. This aligns with Seery & Jakeman (2016) reporting lower diuresis 2, 3, 4, and 5 hours after milk intake versus water and sports drink post-exercise in the heat (30°C, 58% humidity). The effect could stem from milk's nutritional composition. Several studies (Desbrow et al., 2014; Baguley et al., 2016; Maughan et al., 2016; Campagnolo et al., 2017; Mallari et al., 2019) observed this with milk versus sports drinks, possibly due to slower gastric emptying from milk's higher energy content (≈1415 kJ/L) versus the sports drink (≈1000 kJ/L). Overall, the lower diuresis and higher retention with SLM suggest it has greater hydrating capacity versus sports drink or water post-exercise.

Milk protein content could be an important mechanism for lower SLM diuresis. Milk proteins may stimulate antidiuretic hormone, and milk electrolytes could also increase plasma osmolality to activate ADH (Watson et al., 2008). Studies show dairy proteins' role in post-exercise fluid retention and rehydration: Evans et al. (2018) found whey protein did not improve or inhibit retention versus maltodextrin. Hobson & James (2015) noted dairy proteins in drinks do not interfere with rehydration, James et al. (2013) suggested dairy proteins increase fluid retention, James et al. (2012) linked casein to greater retention from gastric coagulation, Seifert et al. (2006) found higher retention with a protein and carbohydrate drink versus drinks with carbohydrate or plain water. Overall these previous studies, along with the results of the present one, support a link between dairy protein and greater milk fluid retention.

From the present study it is not possible, however, to reach conclusions regarding the specific ingredients responsible for the fluid retention qualities of skimmed, lactose-free milk. The systematic, rigorous comparison of specific, commercially available drinks is useful to make practical recommendations to physically active people, but it is not compatible with determining the role of each component in fluid retention, as acknowledged by Shirreffs, et al. (2007). In the present study SLM and SD differed in protein, carbohydrates, fat, and potassium; new studies controlling one beverage ingredient at a time, particularly protein, are warranted.

Several studies (Maughan et al., 2004; Roy, 2008; Aragón-Vargas, 2016; Zhang et al., 2023) suggest skimmed milk may have slower gastric emptying versus water and sports drinks because of its higher energy and fat content. Our participants ingested ≈ 2L of SLM, approximately 2828 kJ. Participants in Clayton et al. (2014) drank ≈ 2.1L, ≈ 3696kJ (a 10%CHO solution); 40% of the fluid was still in the stomach after 2h. Possibly, some SLM may still be in the stomach after 3h in our case. Further research with methods like appearance of D2O (deuterium) in the blood (Williams et al., 2023) is warranted, to determine where the extra fluid from skimmed, lactose-free milk resides in the body.

Regarding GI disturbances, the present study found no significant differences in their appearance or severity among conditions (W, SD, and SLM). GI symptom scores were low regardless of category, suggesting absent or mild problems on the 0-to-9 scale. This agrees with da Silva et al. (2021) who showed no severe symptoms after rehydration with a low-fat, lactose-free beverage with protein. Odell & Wallis (2021) pointed out even regular lactose-containing dairy beverages do not provoke GI disturbances in most lactose resistant people, after ingesting large volumes before, during, or after exercise.

In the present study, significant differences in GI symptoms were observed at pre-exercise time of measurement. These were higher in upper and lower GI tract, versus systemic symptoms, probably from the standardized breakfast consumed upon arrival. However, for all post exercise and post fluid ingestion time of measurements, no differences were identified among categories or time of measurement. The report of very mild symptoms after milk ingestion post-exercise, and no significant differences among beverages, agrees with Karp et al. (2006), da Silva et al. (2021) and Russo et al. (2021), which show very low severity in reported GI symptoms.

Because of the nature of this study, it was not possible to blind the participants from the conditions, as the beverages were clearly distinguishable by taste. This may be considered a limitation, but given the fact that participants were not used to drinking milk after exercising, they would have been expected to rate their GI symptoms higher in that condition. This was not the case.

CONCLUSION

Together, the results from this study confirm that skimmed, lactose-free milk is more effective than water and similar to a conventional sports drink for post-exercise rehydration: resulting diuresis is lower and therefore both fluid retention and net fluid balance are higher than water, without causing greater GI tract disturbance.

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Tables:

Table 1. Environmental and physiological variables by condition.

Variable	Water Mean (95% CI)	Sports Drink Mean (95% CI)	Milk Mean (95% CI)	Sig. (p < .05)
USG (arrival)	1.012 (1.010 to 1.015)	1.014 (1.012 to 1.017)	1.014 (1.011 to 1.017)	.581
Pre-exercise BM (kg)	66.5 (59.3 to 73.6)	66.7 (59.5 to 73.9)	66.5 (59.3 to 73.7)	.998
Ingested volume (mL)	1991.8 (1765.2 to 2218.4)	1998.8 (1769.7 to 2227.8)	1993.1 (1765.8 to 2220.4)	.998
Dehydration (%)	-1.9 (-2.0 to -1.9)	-2.0 (-2.0 to -1.9)	-2.0 (-2.0 to -1.9)	.715
Exercise time (min.)	56.56 (52.03 to 61.10)	56.56 (51.35 to 61.78)	56.43 (50.79 to 62.09)	.999
Temperature (°C)	32.14 (32.04 to 32.23)	32.16 (32.05 to 32.27)	32.21 (32.12 to 32.31)	.529
Relative humidity (%)	71.29 (70.65 to 71.94)	70.93 (70.32 to 71.55)	70.98(70.24 to 71.72)	.708
Pre-exercise zPC GI.S.				
Upper	-0.30 (-0.41 to -0.19)	-0.19 (-0.30 to -0.08)	-0.34 (-0.45 to -0.23)	.140
Lower	-0.13 (-0.35 to -0.08)	-0.13 (-0.35 to -0.08)	-0.26 (-0.48 to -0.04)	.609
Systemic	-0.95 (-1.05 to -0.86)	-0.90 (-1.00 to -0.80)	-0.98 (-1.08 to -0.88)	.501
Post-exercise zPC GI.S.				

Upper	0.09 (-0.43 to 0.62)	-0.15 (-0.68 to 0.37)	0.28 (-0.24 to 0.81)	.495
Lower	-0.26 (-0.57 to 0.04)	-0.00 (-0.30 to 0.30)	-0.26 (-0.57 to 0.04)	.375
Systemic	-0.32 (-0.81 to 0.16)	-0.11 (-0.60 to 0.37)	0.04 (-0.44 to 0.53)	.560

Note: sig., significance; min., minutes; 95% CI, lower and upper limits of the 95% confidence interval. BM, body mass; mL, milliliters min., minutes;°C, degree Celsius; zPC GI.S., standardized combined scores for gastrointestinal symptoms ; UPPER, upper gastrointestinal tract; LOWER, lower gastrointestinal tract; SYSTEMIC, systemic symptoms.

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Table 2. Combined raw scores for each category (upper GI tract, lower GI tract, systemic) and for individual GI symptoms, by categories. 60, 120 and 180 minutes post-exercise**.**

Sections	Symptom	Water	Sports Drink	SLM
		M (range)	**M (range)**	**M (range)**
Upper GI Tract 63		0 (7)	0 (6)	0 (13)
	Reflux	0 (0)	0 (0)	0 (6)
	Heartburn	0 (0)	0 (3)	0 (3)
	Vomiting	0 (0)	0 (0)	0 (4)
	Nausea	0 (0)	0 (0)	0 (4)
	Thick saliva	0 (7)	0 (6)	0 (4)
	Belching	0 (1)	0 (3)	0 (4)
Lower GI tract 54		0 (8)	0 (3)	0 (5)
	Intestinal cramps	0 (1)	0 (0)	0 (0)
	Abdominal distension	0 (4)	0 (1)	0 (5)
	Abdominal pain	0 (1)	0 (0)	0 (2)
	Flatulence	0 (4)	0 (4)	0 (2)
	Urge to defecate	0 (1)	0 (0)	0 (2)

Systemic 36		3 (10)	3 (8)	3 (7)
	Muscle cramping	0 (7)	0 (1)	0 (3)
	Headache	1 (3)	0 (5)	0 (5)
	Urge to urinate	1 (8)	2 (8)	1 (7)
	Dizziness	0 (3)	0 (3)	0 (4)

Note: GI, gastrointestinal; M, median; SLM, skimmed lactose-free milk; cramping and Loose stools / diarrhea has a value of 0 in both its median and range in all three conditions.

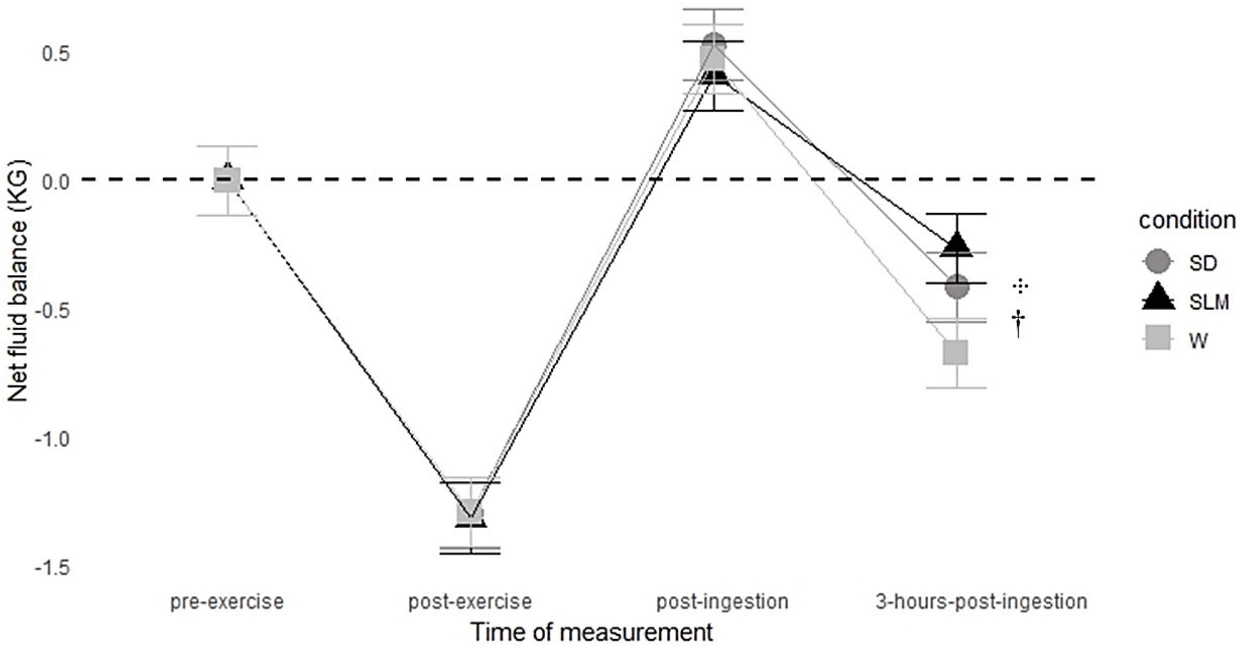

Figure 1: Net fluid balance over time for skimmed lactose-free milk, sports drink and water conditions (n = 48). Values are means (kg) ± 95% CI. SLM, skimmed lactose-free milk; SD, sports drink; W, water; (⁜), significant difference between SLM and W; (†), significant difference between W and SD.

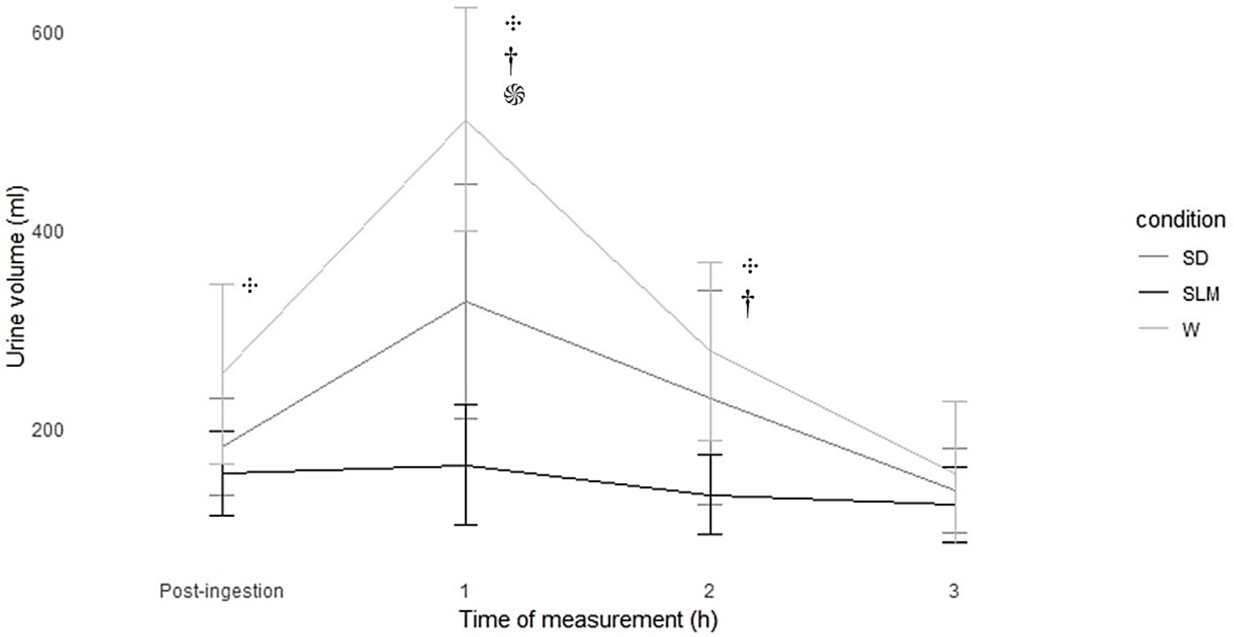

Figure 2: Post-ingestion diuresis, three-hour follow-up for skimmed lactose-free milk, sports drink and water conditions (n = 48). Values are means (mL) ± 95% CI. SLM, skimmed lactose-free milk; SD, sports drink; W, water; (⁜), significant difference ($p < .05$) between SLM and W; (†), significant difference ($p < .05$) between SLM and SD; (֍), significant difference ($p < .05$) between SD and W.

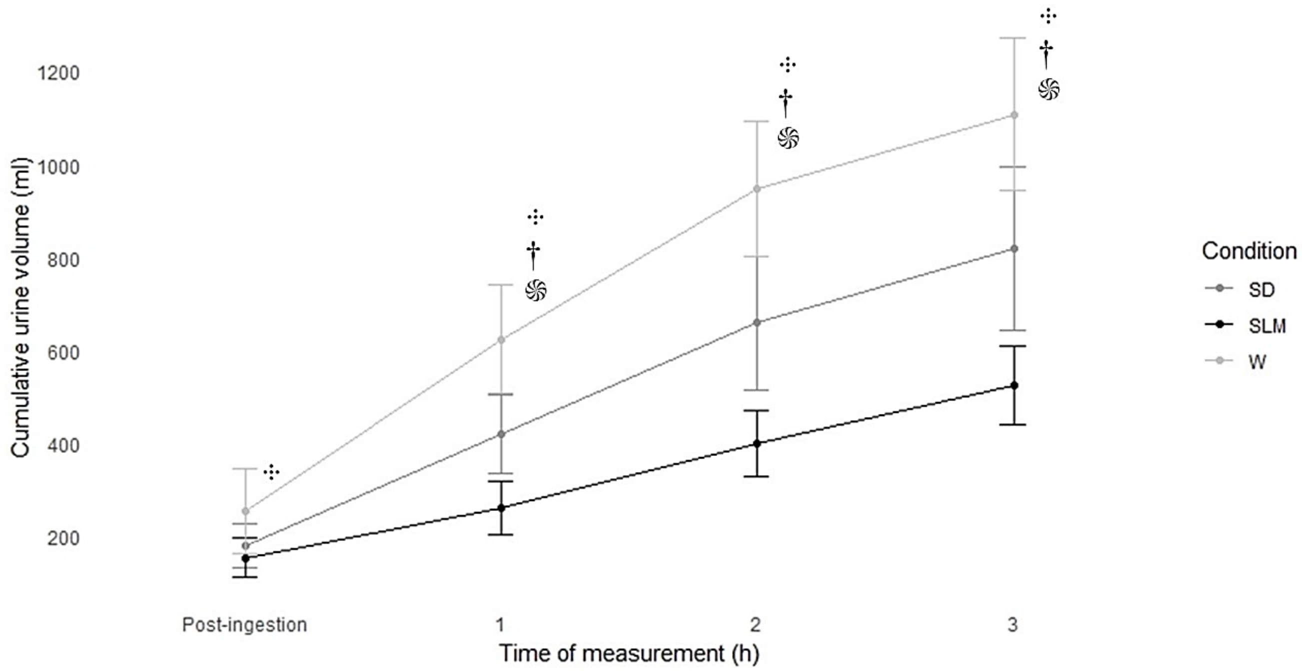

Figure 3: Accumulated urine volume (n = 48) with a three-hour follow-up after fluid ingestion (skimmed lactose-free milk, sports drink and water). Mean (mL) ± 95%CI. SLM, skimmed lactose-free milk; SD, sports drink; W, water; (⁘), significant difference ($p < .05$) between SLM and W; (†), significant difference ($p < .05$) between SLM and SD; (֍), significant difference ($p < .05$) between SD and W.

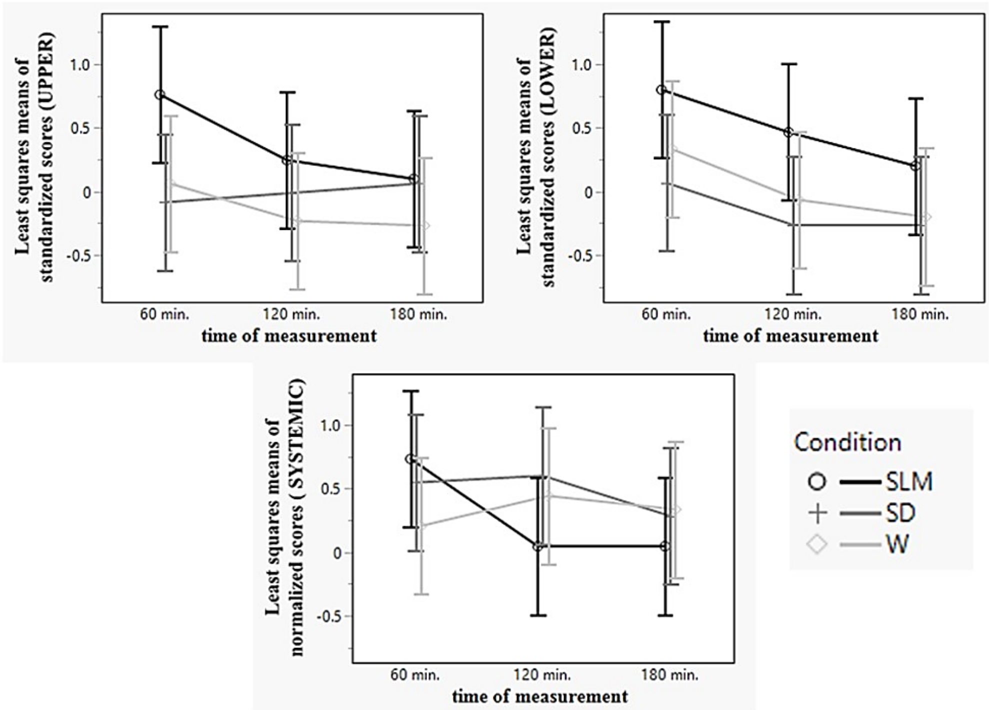

Figure 4: Intestinal sensation least squares means (standardized scores by sections) by condition and time of measurement. Values are means (standardized scores) ± 95%CI. SLM, skimmed lactose-free milk; SD, sports drink; W, water; UPPER, upper gastrointestinal tract; LOWER, lower gastrointestinal tract; SYSTEMIC, systemic symptoms.