

# Lactose-Free Skim Milk as a Sports Drink for Female Collegiate Basketball Athletes: A Comparison of Two Drinking Strategies

Original Research

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## Abstract

**Introduction:** Hypohydration is known to affect strength, power, intermittent high intensity activity as well as physiologic and perceptible responses which in turn may affect subsequent training bouts. A simple hydration strategy to prevent hypohydration (e.g. drinking *ad libitum*) and intake of beverages with higher nutrient content compared to water (e.g. low-fat milk) may prove to be relevant for athletes.

**Methods:** Female collegiate basketball athletes volunteered to participate in this randomized crossover study. Participants drank lactose-free skim milk during training and were assigned to one of two drinking strategies: Programmed fluid intake (PFI) or *Ad libitum* (AdL). The running anaerobic sprint test (RAST) was used to measure performance indices. Perceived exertion, perceived recovery, hydration status, thirst, gastrointestinal comfort, and palatability were determined throughout the protocol.

**Results:** Intake of lactose free skim milk by either strategy during training was found to have no significant effect on subsequent anaerobic performance after training (for maximum power  $p=0.095$ , for fatigue index  $p=0.20$ ). No significant differences were found between the groups in subjective measures of exercise intensity ( $p=0.53$ ), perceived recovery ( $p=0.48$ ) and subjective measures of thirst ( $p>0.05$ ), gastrointestinal comfort ( $p>0.05$ ), and palatability ( $p>0.05$ ).

**Conclusions:** Lactose-free skim milk was well tolerated and may therefore be ingested as a beverage during intermittent exercise. Drinking strategy had no significant effect on subsequent performance in this study.

**Key Words:** ad libitum fluid intake, programmed fluid intake, anaerobic performance, collegiate athletes, basketball

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## Introduction

Minimizing dehydration is of primary importance in sports and exercise that are anaerobic in nature. Strength, power, intermittent high intensity activity has been found to be affected by hypohydration and negative effects on performance, physiologic and perceptible responses prevalent in subsequent bouts as well.<sup>1</sup>

Looking into the drinking behavior of collegiate athletes, studies have shown that most do not drink enough to replenish water lost during training as evidenced by arriving for training in a hypohydrated state.<sup>2,3</sup> Most collegiate

athletes have limited knowledge on nutrition and hydration strategies and do not follow any drinking plan<sup>4</sup> which puts them at a greater risk of being in a chronic dehydrated state. Recommending a simple hydration strategy (e.g. drinking *ad libitum*) and beverages with higher nutrient content compared to water (e.g. low-fat milk) may prove to be relevant to collegiate athletes. A systematic review that investigated the effect of *ad libitum drinking* vs programmed drinking on endurance performance reported significant differences in drink volumes, however no difference in exercise performance was found.<sup>5</sup> In another study, drink amounts were similar with *ad libitum* consumption of either water, Gatorade or milk permeate solution and no difference in fluid balance, hydration status and performance found as well.<sup>6</sup>

Cow's milk ingestion, particularly low-fat milk for rehydration was found to be as good as carbohydrate-electrolyte drinks in terms of its effects on hydration and performance.<sup>7,8</sup> Milk has been found to have positive effects on muscle protein synthesis (therefore muscle recovery) and has shown positive results in strength gains and muscle hypertrophy.<sup>9</sup> Intake of milk in the sports context has also been associated with recovery instead of a "before or during" activity beverage probably because of preconceptions on its fat content and potential stomach discomfort. Recommendations for its use need to be prudent as well, since certain nationalities, Asians, are known to have higher incidence of lactose intolerance.<sup>10</sup> Especially in the sport setting, it would therefore be sensible to recommend the ingestion of low fat or lactose-free milk due to the benefits from its natural components without delays in absorption and stomach discomfort.<sup>11</sup> A study on the use of low-fat lactose free milk has shown positive effects in terms of hydration and subsequent performance of endurance cyclists,<sup>10</sup> however, research still needs to be done on its effect on subsequent anaerobic exercise when consumed during exercise or training. This study therefore investigated the effects of ingestion of lactose-free skim milk during training using two different hydration strategies (programmed fluid intake vs *ad libitum* intake) on hydration status, performance, physiologic and subjective measures after training.

## Scientific Methods

### Participants

10 female collegiate basketball athletes volunteered to participate in this randomized crossover study (Mean  $\pm$  SD values for Age 19.4  $\pm$  1.7 yrs, Body Mass 59.24  $\pm$  7.52 kg, Height 157.9  $\pm$  8.1 cm, first morning USG 1.018  $\pm$  .008) with  $\geq$ 7-day washout between experimental trials.<sup>7,10</sup> The participants gave consent to participate in the experimental trials during a briefing session set before starting the screening process. The research was reviewed and approved by the Mahidol University Central Institutional Review Board COA No. MU-CIRB 2017/012.0102.

### Protocol

The participants were randomly assigned to either *ad libitum* or programmed fluid intake of Lactose-free skim milk LFM to determine the effects on hydration status (by changes in body mass BM), performance (running-based anaerobic sprint test RAST), perception of recovery using the Perceived Recovery Scale PRS,<sup>12</sup> perceived exertion using Borg Rating for Perceived Exertion 6-20 RPE scale,<sup>13</sup> gastrointestinal comfort (Visual Analog Scale VAS), palatability and thirst ratings (VAS) after a training session. Store bought LFM (Harvey Fresh Lactose Free Skim Milk brand, Australia) was used and the drinks during trials were maintained at 10°C.<sup>7</sup> During experimental days, participants were assigned to one of two drinking strategies: Programmed fluid intake PFI or *Ad libitum AdL*. *Ad libitum* drinking was defined as drinking fluids anytime and in whatever volume desired<sup>14</sup> while programmed fluid intake or individualized fluid plan is consuming fluids at set amounts and intervals such to replace fluids lost during exercise (1-2% body mass loss).<sup>15</sup>

They were instructed to rate their feelings of recovery during and after exercise by indicating a score of 1 to 10 in the PRS scale. Very poorly recovered/extremely tired (0) means that declined performance may be expected, while very well recovered/highly energetic (10) means improved performance may be expected.<sup>12</sup> The visual analog scales were scored as follows: thirst rating was from "not at all thirsty" (0) to "very very thirsty" (10); gastrointestinal comfort from "no discomfort" (0) to "extreme discomfort" (10); palatability ratings from "dislike very much" (0) to "like very much" (10).

### Preliminary day

The participants were asked to arrive at the lab at 0700 hours, well rested and well hydrated. They were requested to empty their bladder, urine sample collected for measurement of urine specific gravity using a urine refractometer (Atago 300CL/URC-NM, Japan) after which near nude body mass (Tanita RD-901 IRONMAN body composition monitor, Tanita, Japan) was also determined to establish euhydrated weight. Recommendation regarding fluid intake on the day before the trials was ~2.2 L/day for adult females (~58 kg) and 2.5 L/day for adult males (~70 kg) under

average conditions.<sup>16</sup> Other baseline data were measured, such as height (standard wall stadiometer), resting heart rate and blood pressure (Omron SEM-1, Kyoto Japan). A physical activity readiness questionnaire (PAR-Q) was administered, as well as a brief interview for medical history and medications taken recently and at the time of data collection. The participants were also asked to produce a 24-hour diet and physical activity recall. Conditions listed here were replicated on the day before the experiment to ensure similar metabolic conditions for the participants.<sup>7</sup>

The table below lists the participants characteristics on preliminary day.

**Table 1.** Participant's demographic information (N=10)

Participant Information (N=10, females)		
	Mean	S.D.
Age (yrs)	19.4	1.7
Weight (kg)	59.24	7.52
Height (cm)	157.92	8.08
RHR (bpm)	68.6	9.3
USG	1.018	0.008
Sweat rate (ml/hr)	442.08	157.32

*RHR – resting heart rate*

#### *Running-based Anaerobic Sprint test (RAST)*

The athletes then commenced with the Running-based Anaerobic Sprint test (RAST) which was found to be a reproducible and valid procedure for assessing anaerobic power.<sup>17</sup> It also determines output (i.e., peak power, mean power, fatigue index, maximal speed, and mean speed) similar to those determined in Wingate anaerobic test (WAnT), showing high correlations with the same variables.<sup>18</sup> A stopwatch was used to time the six sprints. Analysis of the results was done by comparing the results with data from their other RAST results. Body mass and subjective variables were measured after the Running-based Anaerobic Sprint Test.

The participants were then allowed to rest and recover for one hour after which they were weighed, and other subjective measures recorded prior to measurement of their sweat rate during training. The regular training session (2 hours, repeated as closely as possible in the experimental trials) then resumed with the athletes consuming their regular amount of fluids. The amount of fluid ingested and voided was monitored during the training period.

#### *Sweat rate measurement*

Sweat rate (SR) was determined and individual values used as the fluid volume to be replaced in the individual programmed fluid intake PFI strategy. Each athlete's sweat rate was computed (sweating rate = pre-exercise body weight – post-exercise body weight + fluid intake - urine volume/exercise time in hours).<sup>19</sup> This computed sweat rate was used to determine the amount of PFI (hydration status maintained at 1% body mass loss) ingested by the participants. This amount was divided into equal boluses such that the player drank each amount at set intervals (e.g. every 10 minutes) during the experimental trials.

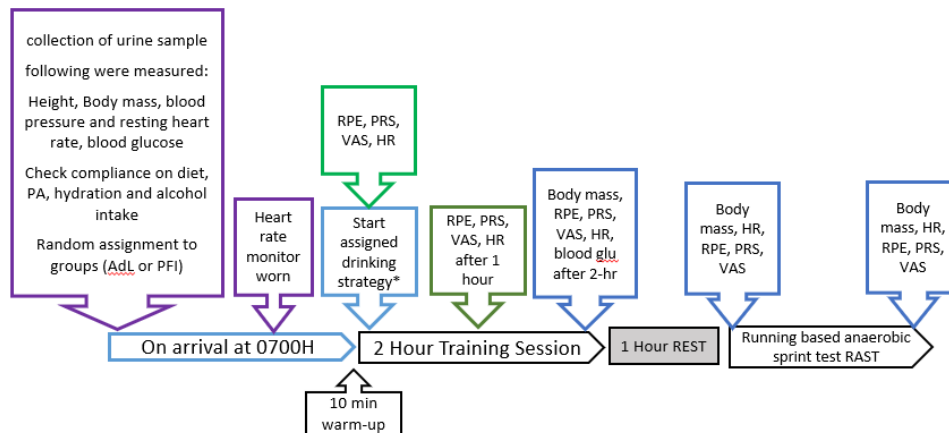
Amount of fluid required to maintain BW loss at 1% = Sweat production during the familiarization trial (L) – (PFI pre-exercise BW (kg)(post-void) × 0.01).<sup>15</sup>

#### *Experimental day protocol*

Similar procedures for the preliminary day were followed upon arrival of participants. Blood glucose was determined by pin-prick (Glucosure AutoCode blood glucose monitoring system, ApexBio, Taiwan). Body mass was determined to check if they were at euhydrated weight. Baseline measurements for resting heart rate and blood pressure and blood glucose were recorded. Compliance to the instructions given on diet, physical activity and hydration was checked. The FT1 Polar heart rate monitor (Polar Electro Oy, Finland) was then worn by the participants. The participants then were randomly assigned to one of the two drinking strategies/groups (PFI or AdL).

*Ad libitum* fluid intake and PFI of the LFM was in effect for a total of 3 hours: from the start of the warm-up, throughout the 2-hour training session, and until the end of the 1-hour rest period (post training). Individually labeled containers were kept in a cooler filled with ice to maintain the drink temperature. For the PFI group, the previously determined amount was divided into equal boluses such that the player drank each amount at 10-minute intervals

during the training session. The first bolus was given just prior to the warmup. The AdL group was given their beverage in 1 L containers and were instructed to consume as much (or as little) as they wanted, at any time they wanted to drink.<sup>14</sup> The protocol is found in Figure 1 below.



\*PFI group drank the bolus of beverage every 10 minutes

**Figure 1.** Experimental day protocol.

*Statistical Analysis*

Results were reported as Mean ± SD and significance level set at  $p < 0.05$  a priori. Normality was assessed using the Shapiro Wilk test and analysis of results done using paired t-test or Wilcoxon signed rank test (SPSS, IBM Statistical package v.20) when appropriate.

**Results**

The results of the study showed no difference between the two drinking strategies in terms of hydration status (body mass changes), performance (pre-post RAST) and the physiological (heart rate and blood glucose) and perceived exertion, recovery and subjective ratings of thirst, gastrointestinal comfort, and palatability. The amount of lactose-free milk ingested was also similar for the two groups despite the different strategies employed, which suggests that the beverage was well liked and well tolerated. They were able to replace sweat losses during the 2-hr training period which resulted in adequate hydration for the participants.

Groups were found to be similar in terms of body mass (Mean ± SD PFI group  $58.9 \pm 7.6$  kg and AdL group  $59.3 \pm 7.5$  kg,  $p = .055$ ), resting heart rate ( $p = .538$ ) and urine specific gravity ( $p = .194$ ) at the start of each experimental day. Blood glucose levels were not different between groups during the pre-test ( $p = .844$ ), to posttest ( $p = 0.776$ ) and similar within each group from pre-post for PFI group ( $p = .482$ ) and AdL group ( $p = .482$ ) (Table 2). Heart rate HR was found to be similar for both groups at the different time points they were measured. This means that exercise intensity was similar for the two groups which is also supported by the results on Ratings for Perceived Exertion RPE. The mean temperature was  $31.81 \pm 1.89^\circ$  C., and relative humidity was  $58.12 \pm 8.37\%$ .

**Table 2.** PFI vs AdL groups base measurements (N=10, sig level  $p < .05$ ).

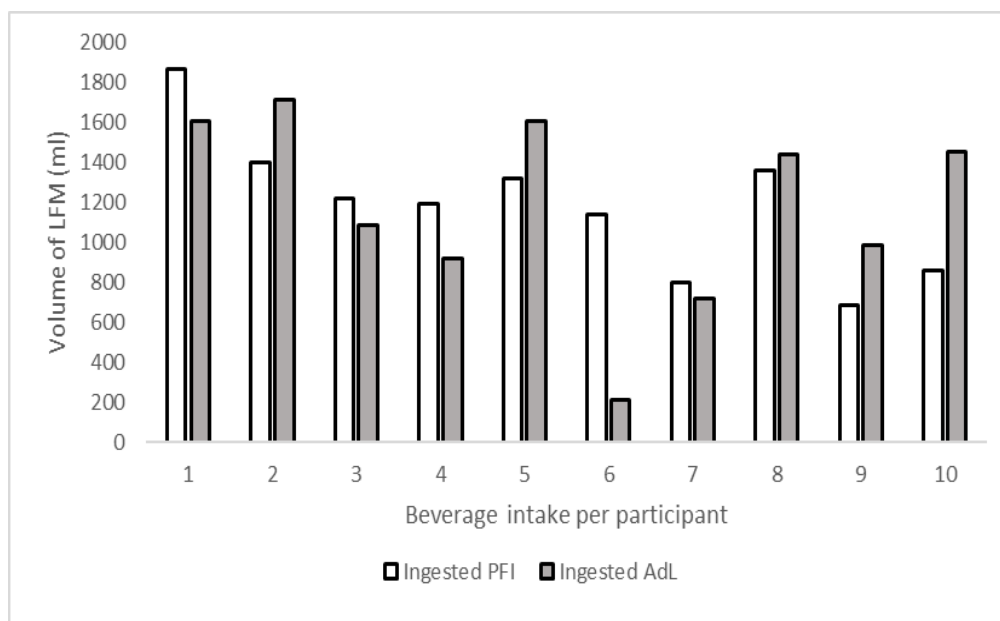
	PFI Mean±SD	AdL Mean±SD	p value
Body mass (kg)	$58.9 \pm 7.6$	$59.3 \pm 7.5$	0.055
RHR (bpm)	$70.9 \pm 10.1$	$69.1 \pm 9.2$	0.538
Urine specific gravity USG	$1.0197 \pm .0066$	$1.0164 \pm .0079$	0.194
Bglu_pre (mg/dL)	$111.9 \pm 19.01$	$110.9 \pm 12.88$	0.844
Bglu_post (mg/dL)	$116.8 \pm 9.32$	$115.6 \pm 15.03$	0.776

No significant difference was found between the groups for the Running anaerobic sprint test RAST for Maximum power, Average Power and Fatigue Index as can be seen in Table 3. No significant difference was found between groups in terms of hydration status (body mass) from start to end of the protocol. Drink volume was also found to not to be significantly different between the groups.

**Table 3.** PFI vs AdL anaerobic performance results (RAST), body mass measurements and drink amount (N=10, sig level  $p < .05$ ).

	PFI Mean $\pm$ SD	AdL Mean $\pm$ SD	p value
Max Power (Watts W)	280.25 $\pm$ 68	309.93 $\pm$ 70.46	0.095
Ave Power (W)	232.3 $\pm$ 54.3	252.0 $\pm$ 59.8	0.176
Fatigue index (W/s)	2.2 $\pm$ .9	2.7 $\pm$ 1.1	0.201
BM start (kg)	58.9 $\pm$ 7.6	59.2 $\pm$ 7.5	0.272
BM end (kg)	58.95 $\pm$ 7.54	59.26 $\pm$ 7.47	0.11
BM change (kg)	.048 $\pm$ .462	.085 $\pm$ .703	0.875
Drink amt (ml)	1186 $\pm$ 345	1175 $\pm$ 479	0.936

It is relevant to show the beverage intake per participant noting that one participant drank very little during AdL strategy (Figure 2).



**Figure 2.** Amount ingested by individual participants in PFI and AdL strategies.

Subjective measures for perceived exertion (RPE scale) were similar from pre-performance test (Mean  $\pm$  SD for in PFI group = 6.4  $\pm$  0.97, AdL group = 6.4  $\pm$  0.52,  $p=1.0$ ; no exertion) and post-performance test (Mean  $\pm$  SD for in PFI group = 15  $\pm$  2.5, AdL group = 14.5  $\pm$  2.1,  $p=0.53$ ; hard/heavy). Perceived recovery (PRS scale) was found to be similar as well, where pre-performance Mean  $\pm$  SD for in PFI group = 8.7  $\pm$  1.2, AdL group = 8.3  $\pm$  2.0,  $p=0.581$ ; well recovered/somewhat energetic) and post-performance test (Mean  $\pm$  SD for in PFI group = 5.2  $\pm$  1.6, AdL group = 5.4  $\pm$  1.6,  $p=0.48$ ; adequately recovered).

Subjective ratings of the participants for thirst, gastrointestinal comfort and palatability using visual analog scales (VAS) measured at different time points revealed similar ratings for the two drinking strategies.

## Discussion

### Hydration status and subsequent performance

In determining if drinking strategy had any effect on hydration status of the participants, no difference was found between the PFI and AdL groups. The participants were euhydrated at the start of the protocol, which was important

because otherwise, the pre-established PFI might not be able to restore fluid lost during their activity. Body mass was also similar from pre- to post-performance test. This means that lactose-free milk ingestion using the two drinking strategies was able to replace fluid losses similarly. This finding is consistent with a study by Evans et al.<sup>20</sup> where drinking strategy had no effect on volume ingested hence no significant body mass changes were observed throughout the protocol.

No significant differences were found for the subsequent performance variables using the RAST. It appears that body weight and time are the main determinants for scoring well in this test. Greater weight and less time usually translate to increased power. Maximum power refers to the highest power output during the sprints, indicative of anaerobic capacity (strength and speed), minimum power is the lowest power output, while average power is the participant's ability to maintain power (anaerobic endurance). Fatigue index is the rate at which power declines during the sprints (reflective of anaerobic endurance) hence higher values means there was a greater decline in power over the 6 sprints done. A study by Dion et al.<sup>15</sup> also showed that both PFI and *ad libitum* strategies did not affect aerobic performance. The results also show us that the drinking strategies (PFI and AdL) had a similar effect on subsequent anaerobic performance.

Effects of fatigue on performance may be accurately measured by the PRS scale despite the measurement being subjective in nature.<sup>12</sup> Both drinking strategies resulted in similar perceptions of recovery in this study. This result is expected since the volumes of drink ingested were similar for both groups.

#### *Thirst, GI comfort and palatability*

Thirst, gastrointestinal comfort, and palatability are factors that affect the volume of fluid ingested. With the *ad libitum* drinking strategy, these factors mentioned, as well as electrolyte content of the beverage affect the volume consumed by subjects.<sup>21</sup> Drinking according to a hydration plan such as programmed fluid intake PFI in effect ignores these perceptions<sup>20</sup> and although these strategies aim to replace sweat losses, subjective ratings and volume drank may be affected if the participants dislike the rehydration beverages.<sup>22</sup> In this study, there were no differences in the perceptions of thirst, gastrointestinal comfort, and palatability between the two drinking strategies. This suggests that the beverage was well liked and well tolerated since ingestion volumes were similar for the groups and was adequate to replace sweat losses during the 2-hr training period. It is however considered that one participant drank very little when she was drinking AdL (Figure 2). This result could have possibly affected the mean values for the *AdL* strategy and should be considered in future studies. No significant differences were found for thirst perception throughout the protocol between the two drinking strategies. *Ad libitum* drinking involves drinking “according to the dictates of thirst”.<sup>23,14</sup> During physical activity, drinking is influenced by thirst sensation. But thirst is felt at 2% hypohydration and real fluid requirements are usually underestimated.<sup>24,23,14</sup> Because of this, it is possible that the participants drinking *ad libitum* were drinking more than what their thirst was dictating. At the start of the protocol both groups rated close to “somewhat thirsty” and at the end of the protocol rated “thirsty.” Although differences between groups were not significant, ratings for the PFI group were higher throughout the protocol. Thirst ratings are increased after high intensity intermittent exercise possibly due to an increase in serum osmolality and blood lactate (Mears et al., 2016),<sup>25</sup> which are variables not measured in this study.

In a study done by Haakonssen et al.,<sup>26</sup> dairy foods (milk and yoghurt) were consumed before subsequent cycling performance and were well tolerated (gut comfort and palatability) by the lactose-tolerant participants. In the present study, lactose-free skim milk LFM was ingested during training and recovery and the participants also tolerated the LFM well. Gastrointestinal comfort throughout the protocol was not different between the groups corresponding to a very slight discomfort felt by participants. This finding is relevant because gut tolerance will also influence the volume of drink consumed, especially during exercise. Factors that could have influenced this include the fact that the milk used was lactose-free, covering those who could be lactose-intolerant; and it was skimmed milk, so it had almost no fat content. This facilitates gastric emptying hence less feeling of fullness. This is also evidenced by the participants being able to maintain exercise intensity throughout the 2-hr training period despite drinking the LFM and implementing both PFI and *AdL* strategies.

The amount of lactose-free milk ingested was also similar for the two groups despite the different strategies employed, which suggests that the beverage was well liked and well tolerated overall. This could explain similar results found between groups for the different variables in this study including blood glucose measurements. In similar research on male ice hockey players, *AdL* and individualized fluid plans IFP groups were similar in hydration status even with the IFP group drinking more than adlib group.<sup>3</sup> In this research, either drinking strategy may be recommended since

hydration status was maintained from start to end of the protocol. This was evidenced by non-significant changes in body mass throughout the study. They were able to replace sweat losses during the 2-hr training period which resulted in adequate hydration for the participants.

One study limitation is that only females participated in this research and a concern could be that fluid retention may have been affected by their menstrual cycles. Studies have shown however, that the menstrual cycle has little effect on overall body water, sodium retention and acute fluid retention after postexercise rehydration.<sup>21</sup> Another limitation is that the volunteers were not asked if they liked drinking milk. This could potentially affect this type of research, especially the *ad libitum* group. The author also recommends looking into serum osmolality and blood lactate in the context of thirst sensation during high intensity exercise as these were not measured in this study.

### Conclusions

Lactose-free skim milk consumed *ad libitum* and programmed fluid intake during training had similar effects on hydration status, subjective measures and anaerobic performance largely because the amounts drunk were similar. Lactose-free skim milk was well tolerated and may therefore be ingested as a beverage during intermittent exercise.

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