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CONSUMPTION OF LOW-FAT MILK BEFORE MUAYTHAI EXERCISE DID NOT AFFECT GUT COMFORT AND COUNTERMOVEMENT JUMP

Jirasin JINDAMORAKOD and Alisa NANA*

College of Sports Science and Technology, Mahidol University, Nakhon Pathom, Thailand

ABSTRACT

Introduction: Previous studies have mainly examined the benefits of milk consumption during or as a recovery drink. However, there is minimal research examining the effects of milk intake before an exercise session. The aim of this study was to examine the effects of low-fat (LF) milk consumption before a MuayThai exercise on gut comfort and countermovement jump (CMJ) . Twenty active Thai males (mean ± SD; age 21.5 ± 3.5 years; BMI 22.9 ± 1.6 kg/m^2; $\dot{V}O_{2max}$ 45.4 ± 6.6 mL/kg/min) completed 3 trials (randomized cross-over design) in which they consumed 500 mL of either LF milk (~220 kcal), sports drink (~220 kcal), or water (0 kcal) 2 hours before undertaking a MuayThai exercise session (5 rounds of 3 minutes, with 2 minutes rest between each round). Gut comfort questionnaire was measured throughout the experiment and palatability questionnaire was measured immediately after the consumption of a drink intervention. CMJs were measured as an index for explosive strength of the lower extremity muscles by comparison between before as baseline data and after the simulation of MuayThai exercise. **Results:** There were no significant differences in gut comfort between drinks at any time point. Sports drink scored the highest in terms of palatability, while there were no differences between LF milk and water. There were no changes in pre- to post-exercise CMJ in any of the drink conditions. **Conclusions:** Consumption of moderate amount of LF milk 2 hours before a MuayThai exercise did not affect gut comfort and CMJ performance.

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*Corresponding author: Alisa NANA, PhD

College of Sports Science and Technology, Mahidol University,

Salaya campus, 999 Phuttamonton Sai 4 Rd, Salaya, Nakhon Pathom, Thailand, 73170

Tel: +66 83 132 0007; Fax: +66 2 889 3693; E-mail: alisa.nan@mahidol.ac.th

INTRODUCTION

Milk is a considered a nutritious drink as it contains carbohydrate, protein, fat, electrolytes and calcium. The macro- and micronutrients presented in milk are considered optimum fuel sources for the body to use during an exercise session. While the consumption of milk post-exercise has been shown to be beneficial to muscle protein synthesis[1]. However, milk is not a typical beverage to consume before an exercise session, particularly in the Thais, as they may feel nauseous if they are not accustomed to having protein before exercise[2]. Furthermore, many athletes avoid consuming dairy products, particularly milk, before and/or during an exercise session due to fears concerning gastrointestinal discomfort because it could impair their exercise session[3,4]. Avoiding dairy foods from meals may lead to a reduction in total calcium intake and compromise bone health, as well as the unnecessary reduction in the intake of high quality proteins typically found in dairy products[5-7]. Thais, in particular, do not consume adequate amount of dietary calcium through everyday food and this is reflected in dietary surveys where consumption of milk was below the recommended amount. According to the recent survey, Thai people consumed lower amount of milk when compared with other countries. Specifically, Thai adults only drank 2 glasses of milk per week, which is equivalent to only 500-600 mg calcium/week. This was well below the recommended dietary intake of calcium of 800-1000 mg/day[8]. One of the reasons contributing to low milk intake in Thais could be from the fear of lactose intolerance which was thought to be high among Thais. However, lactose intolerance is relatively uncommon and the symptoms are typically not severe[9].

In light from the previous study by Haakonsen and group in 2014, they have shown that cyclists could consume dairy-based meals 90 min before starting exercise without any significant effects to gut comfort or performance[10]. Furthermore, to our knowledge, no previous study has been undertaken to examine the effect of milk intake before exercise in the Thai population, especially in a high-intensity exercise session such as MuayThai that is gaining popularity as a form of physical activity and is also a well-known national sport of Thailand. Therefore, the primary aim of this study was to investigate the effects of consumption of low-fat (LF) milk on gut comfort, in comparison with sports drink, and water. The secondary aim of the study was to investigate whether these drinks have an effect on countermovement jump (CMJ) following a MuayThai exercise session. It was hypothesized that LF milk would have no negative effects on gut comfort and would have positive effects on countermovement jump (CMJ).

METHODS

Subjects

Twenty healthy males (mean ± SD; age 21.5 ± 3.5 yrs; weight 67.0 ± 8.7 kg; height 170.7 ± 7.2 cm; BMI 22.9 ± 1.6 kg/m^2; HR_{max} 187.4 ± 6.5 beats/min; $\dot{V}O_{2\ max}$ 45.4 ± 6.6 mL/kg/min) with previous MuayThai exercise experience of more than 12 weeks were recruited for this study. Each subject

received information regarding the risk and benefits of the investigation and the subject provided their consent before the experiment began. Screening questionnaires and interview were used to exclude subjects with any underlying diseases or those who were lactose intolerant. Ethical approval of this study was granted by the Mahidol University Central Institutional Review Board (MU-CIRB 2018/116.1106).

Preliminary Test

On the first visit, each subject underwent a preliminary incremental exercise test to determine the individual's intensity of exercise that is the MuayThai exercise session. This consisted of the measurement of anaerobic threshold (AT) and maximum oxygen consumption ($\dot{V}O_{2\,max}$), which were determined by the telemetry gas analyzer (Oxycon Mobile, USA) on a treadmill. After a short self-selected warm-up, subjects started the running test according to the Bruce treadmill protocol[11]. In brief, the protocol consisted of 5 minutes of warming up and followed by a linearly increase in speed every 3 minutes until exhaustion. Exhaustion was considered when the subject reached the level of exercise at which the subject was unable to maintain the running speed. A familiarization session of the exercise session was performed on the same day, including MuayThai exercise movements such as attacking and defending patterns. On visits 2-4, subjects underwent the experimental trials in a randomized cross-over design.

Pre-trial diet and physical activity standardisation

During the 24 h before the experimental days, subjects were requested to abstain from vigorous exercise, caffeine and alcohol intake and ensure adequate sleep duration of 6-8 h. Subject were also asked to record their food and drink intake during the 24 h before Visit 1. In the morning of each trial, subjects were asked to consume a breakfast meal at 07:00 a.m. at home. Subjects received the same standard diet provided by the researcher the night before the trial with pre-packaged meals. The standardized breakfast meal (i.e. rice with curry, egg, tuna, and orange juice) provided each subject approximately 11 kcal/kg body mass, 2.0 g carbohydrate/kg body mass, 0.5 g protein/kg body mass, and 0.5 g fat/kg body mass.

Pre-exercise drink intervention

The drink interventions were provided in a randomized, counterbalanced crossover design. Subjects received 500 mL of either plain low-fat cow's milk (Foremost Low Fat, Samut Prakan, Thailand), sports drink (Red-flavoured Sponsor Befresh, Prachin Buri, Thailand) or water (Aquafina, Pathum Thani, Thailand), 2 hours before the MuayThai exercise. The energy content of LF milk and sports drink were almost analogous. The nutritional composition of the drink interventions is shown in Table 1. Each drink intervention was given to subjects along with the breakfast meal the night before each trial for practical reason so subjects can consume them at home. It was not possible to blind the drink interventions to the subjects as each drink was distinctly

different and has a unique color, flavor, or smell. Subjects were asked to refrigerate their drink and to consume it cold 2 hours before commencing the exercise session. Compliance with both the drink and breakfast meal was rechecked with a telephone call and/or a picture taken with a mobile phone.

Table 1 Nutritional composition of pre-exercise drinks (per 500 mL)

	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Sodium (mg)
Low-fat milk	229	26.7	15.6	6.7	222
Sports drink	216	54	0	0	240
Water	0	0	0	0	0

Experimental procedures

Subjects arrived at the laboratory at the same time each trial (10:00 am) to prepare for the experiment. Two hours after the consumption of drinks, subjects were given 15 minutes to undertake self-selected warm-up (active stretching), which was then followed by a jump practice for familiarization with the testing protocol. In the CMJ test, retroreflective marker was attached at the area of sacrum bone and subjects were asked to perform a downward movement and conduct a vertical jump with maximal effort. In the landing phase, subjects were set up in an upright position and made sure to bend the knees following landing by holding both hands on the hip throughout the jump. The highest distance among the three trials was used for statistical analysis as baseline data[12,13]. Two cameras motion capture (BTS DX 5000, BTS Bioengineering, Italy) were used to capture movement for calculation of the difference in centimeters during countermovement jump. Following the CMJ, subjects were asked to briefly (approximately 15 min) rest and sit on a chair during the set-up of the telemetry gas analyser before the MuayThai exercise started. The MuayThai simulation exercise consisted of 5 rounds, 3 minutes per round with 2 minutes rest periods between each round and rested for 3 minutes following the final round as a recovery period. All trials were undertaken in an air-conditioned laboratory (mean ± SD; 24.9 ± 1.1 °C and 43.0 ± 4.0 % relative humidity). This exercise simulation session was undertaken in an allocated space with dimensions comparative to a standard-sized MuayThai ring (5 x 5 meters). During each round, subjects perform knees, elbows, fists, and kick to pad arm shields sparring attached on a skilled boxing instructor. All Subjects were verbally encouraged to perform maximum effort by ensuring that their performance was as close to the anaerobic threshold as possible. Furthermore, they were continuously asked to perform with their maximal ability throughout the experiment. After the simulation of MuayThai exercise test, subjects performed the CMJ test as post-exercise data to compare with the baseline data. An overview of this study procedure is presented in Figure 1.

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Journal of Sports Science and Technology Volume 21, No. 1, 2021

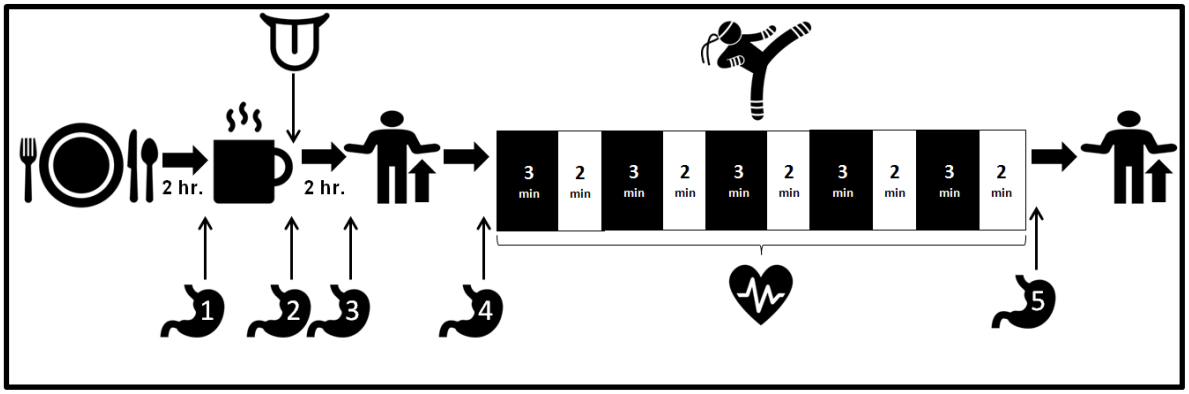

Figure 1 Schematic representation of the study procedure

: Standardised breakfast; = Gut comfort questionnaire; = Pre-exercise drink intervention; = Palatibility questionnaire; = Countermovement jump; = MuayThai exercise simulation; = heart rate

Questionnaires

A previously developed Likert scale gut comfort questionnaire[10] was used to assess gut comfort during the experiment. Subjects were asked to score at five time points (before drink intervention, 30 min post-consumption, 60 min post-consumption, immediately pre-exercise, and immediately post-exercise). The question is *how comfortable does your stomach feel at the moment?*, according to a five point scale (1 = *very comfortable*; 2 = *comfortable*; 3 = *average comfort*; 4 = *uncomfortable*; 5 = *very uncomfortable*). Subjects were explained that discomfort on this scale included symptoms such as nausea, bloating and gut pain. The palatability questionnaire[14] was used to monitor how subjects felt about the drink. Subjects were asked to provide a score once after immediately consuming the pre-exercise drink. This score indicated how strongly they felt about five criteria related to the drink interventions in terms of visual appeal, smell, taste, after taste, and palatability using a 100 mm visual analog scales (VAS).

STATISTICAL ANALYSIS

Results are reported using descriptive as mean (±), standard deviation (SD). The Kolmogorov-Smirnov test was used to assess the normal distribution of all data sets. Changes in CMJ between the drink interventions were assessed using one-way repeated-measure ANOVA. A two-way repeated-measure ANOVA was used to compare the physiological responses of HR during the simulation of MuayThai exercise. When significant, Bonferroni post-hoc test was used to analyze pairwise comparison and identify the significance. The palatability scores of pre-exercise drink interventions were assessed using a minimal clinically significant difference which was set at 20 mm (Fischer and Singer, 1999)[15]. Friedman test was used to compare the main effect of gut comfort on pre-exercise drink interventions during MuayThai exercise. When the significant effect was found, the Wilcoxon Signed Rank test was used for the pairwise comparison. Statistical significance was set at $p<0.05$.

RESULTS

Countermovement jump (CMJ)

CMJ in the sports drink group was the highest after the MuayThai exercise, however, this was not statistically significant. One-way repeated-measure ANOVA showed no significant difference in changes in CMJ among the 3 drink interventions (p=0.55) (F=0.604, p=0.55) as shown in Table 2.

Table 2 Height in countermovement jump (CMJ) before and after MuayThai exercise for low-fat milk, sports drink, and water conditions (mean ± SD).

	Pre (cm)	Post (cm)	Change (cm)	%Change	*p*-value (Pre-Post)
Low-fat milk	47.13 ± 4.61	47.75 ± 4.37	0.62 ± 1.91	1.47 ± 4.14	0.16
Sports drink	47.10 ± 3.93	47.88 ± 4.05	0.78 ± 2.39	1.76 ± 4.99	0.16
Water	47.44 ± 4.06	47.60 ± 4.40	0.16 ± 1.76	0.33 ± 3.86	0.70
***p*-value**	0.96	0.98	0.60	0.55	

Gut comfort

Freidman test showed no evidence of a statistically significant association between pre-exercise gut comfort (Table 3) and drink type (p=0.84). Furthermore, there was also no evidence of a statistically significant association between gut comfort delta scores and beverage type at 30 min (p=0.49) or 60 min post-drink (p=0.83) also immediately pre-exercise (p=0.26) and immediately post-exercise (p=0.47) as shown in Table 3.

วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 21 ฉบับที่ 1, กรกฎาคม 2564

Journal of Sports Science and Technology Volume 21, No. 1, 2021

Table 3 Frequency distribution of gut comfort scores across time points for low-fat milk, sports drink, and water conditions.

Pre-Trial	very comfortable	comfortable	average comfort	uncomfortable	very uncomfortable
Before pre-exercise drink	1	2	3	4	5
Low-fat milk	7	11	2	0	0
Sports drink	6	11	3	0	0
Water	9	4	6	1	0

	Change Scores					
	-3	-2	-1	0	1	2
30 min post- consumption						
Low-fat milk	2	4	4	9	1	0
Sports drink	0	2	4	8	1	0
Water	2	0	7	6	4	0
60 min post-consumption						
Low-fat milk	0	2	7	8	3	0
Sports drink	0	1	4	8	2	0
Water	0	2	5	4	7	1
Pre-exercise						
Low-fat milk	0	2	7	8	3	0
Sports drink	0	1	3	10	1	0
Water	0	3	4	5	6	2
Post-exercise						
Low-fat milk	0	4	6	7	3	0
Sports drink	1	1	3	9	1	0
Water	1	4	3	5	4	3

Palatability

The differences in the mean palatability scores assessed by visual analog scale (VAS) and using the Fischer & Singer 1999 minimal clinically significant difference of 20 mm criteria, suggested that for most criteria (smell, taste, aftertaste, and palatability), sports drink was found to be most palatable (Figure 2). However, except for appeal, there were no differences between the drink interventions. Interestingly, the mean palatability scores were not statistically significant between low-fat milk and water.

วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 21 ฉบับที่ 1, กรกฎาคม 2564
Journal of Sports Science and Technology Volume 21, No. 1, 2021

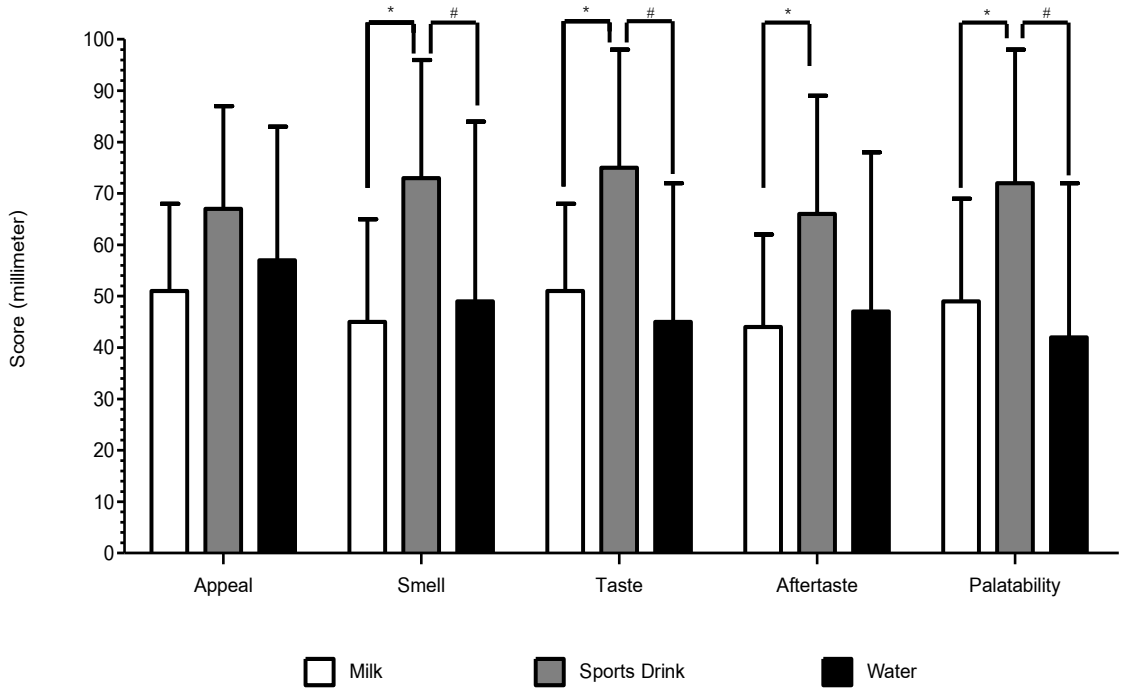

Figure 2 Scores of palatability questionnaire by the visual analog scale (VAS)

*significantly different from Low-fat milk condition (using the minimal clinically significant difference which was set at 20 mm)

#significantly different from Sports drink condition (using the minimal clinically significant difference which was set at 20 mm)

Heart rate (HR)

During the MuayThai exercise simulation, the resting HR of LF milk, sports drink and water conditions were 78 ± 12 bpm, 76 ± 10 bpm and 78 ± 11 bpm, respectively and were not significantly different between conditions (p>0.05). During the MuayThai exercise simulation, HR reached the level corresponding to the anaerobic threshold therefore the exercise intensity met the set criteria. HR was significantly different between each time point during the exercise ($F(2.94,49.93) = 304.36$, p<0.001). The overall mean heart rate in all conditions were approximately 175 ± 12 bpm throughout the MuayThai exercise simulation. Specifically, the average heart rate during the exercise in LF milk, sports drink, and water conditions were 176 ± 11, 172 ± 15, and 177 ± 10 bpm. Changes in HR during the fighting rounds and resting period between rounds of the exercise were significantly different from resting (p<0.05). However, patterns of HR changes were similar in all 3 drink interventions and were not significantly different at any time point (p=0.109).

DISCUSSION

To our knowledge, this study was the first study to examine the effects of LF milk consumption before MuayThai exercise on gut comfort and countermovement jumps. The major findings were that consuming LF milk before MuayThai exercise did not negatively affect gut comfort, and also had no impact on CMJ. It was hypothesized that LF milk would have no negative effects on gut comfort and would have positive effects on countermovement jump (CMJ).

Unexpectedly, we found no statistically significant differences in CMJ results in all 3 drink interventions and this finding did not support our hypothesis. Nevertheless, the change scores of CMJ showed a positive improvement with sports drink and LF milk, with the percent changes of sports drink being slightly better than LF milk. Water, on the other hand, showed minimal changes in CMJ. Regardless of the drink type, drinking either LF milk or sports drink before exercise could potentially be beneficial to performance as both drinks contain macronutrients and were almost isocaloric. Although there were no statistically significant differences in CMJ results between the drinks, however, from a practical stand point, it is still better to consume a beverage that contains energy is better rather than not drinking anything or drinking beverages that did not contain any energy. This is in line with the current sports nutrition guideline where it is recommended to consume suitable food and/or drink before an exercise session for their fueling effects on the subsequent exercise performance[16]. Another possible explanation regarding the insignificant changes in CMJ could be potentially caused by the lack of previous experience in CMJ. This was reflected in the wide range of SD values in the changes in CMJ (LF Milk: 1.47 ± 4.14, Sports drink: 1.76 ± 4.99, Water: 0.33 ± 3.86). Moreover, it could also be caused by familiarization or a learning effect of the gestures of the nervous system and neuromuscular adaptations to muscle memory and improved the CMJ. Although CMJ is considered a practical and reliable test to measure the explosive strength of the lower extremity muscles, however, it might not be a typical movement pattern found in MuayThai as boxers generally use many jump techniques to strike the opponent and various movements to evade the opponent. In contrast, CMJ is not considered a common or typical movement seen in MuayThai training and competitions[12,13], and other alternative performance parameters such as sports-specific kicking movements might be more suitable. However, to our knowledge, there is currently no validated MuayThai-specific testing protocol.

In our research, we found that consuming LF milk 2 hours before a MuayThai exercise did not negatively impact gut comfort scores, nor did it impair performance. Our finding was similar to those found in a previous study where they examined the effects of milk consumption along with the pre-exercise meals 2 hours before cycling for 90 minutes. They found no association between gut comfort and meal type[10]. In our study, to minimize gut discomfort, drinks were consumed 2 hours before exercise to ensure that most of the content was emptied from the stomach. Another important consideration relating to gut comfort is the difference in the nutritional composition. Milk and sports drink contain different amounts of protein, fat and the amount and

type of sugar[17]. The sports drink used in this study contained ~11% carbohydrates, which consisted of 10% white grape juice made from a concentrate, 5% sucrose and 0.4% glucose. Most white grape juice consists of a combination of glucose and fructose. Fructose is somewhat considered a slower carbohydrate and has a peak oxidation rate of ~0.5 g/min. On the other hand, both sucrose and glucose are considered fast sugars, where sucrose has a peak oxidation rate of ~0.9 g/min, which is similar to the oxidation rate of glucose at 1.0 g/min[18,19]. In comparison with milk which contains lactose as the main source of carbohydrate. Lactose is a disaccharide made up of galactose and glucose and has a typical oxidation rate of 0.5-0.6 g/min[20], which is considered a much slower sugar compared to glucose. In combination with other constituents such as protein and fat, therefore, making milk a much slower drink to be digested and absorbed, and this is reflected in low glycemic index of 37[21]. A previous study found that drinking equal amounts of volume of beverage produce no differences in gastric emptying as long as the beverages had the same amount of calories because it depends mostly on the total calories[22]. Specific brands of LF milk or sports drink chosen in this study had similar energy content, and therefore had similar effects on gastric emptying and gut comfort scores. Noted that LF milk was used in this study and the results from this study therefore may not be applicable to other types of dairy beverages. However, future studies should investigate the effects on gut comfort of pre-exercise consumption of whole milk, which is full-fat milk or flavoured milk, which is useful to drink after exercise in some sports in a previous study. These milk drinks contain more energy (higher fat and/or carbohydrate content) and could be useful for specific types of populations such as children and adolescents, who have higher energy requirements or those trying to gain body mass.

In terms of palatability, sports drink received the highest scores, which was similar with previous research, where the overall satisfaction of commercially available carbohydrate-electrolyte sports beverage has had the highest rating over water[23]. Sports drink is popular among active individuals as it can balance between rehydration and taste[24]. Furthermore, palatability is often driven by the sweetness of sugar, which depend on the presence of mono- and disaccharides in the beverage. Our chosen sports drink contained a combination of fructose, glucose and sucrose. They are all considered to have a relatively high sweet index (sucrose 1, glucose 0.6-0.7 and fructose 1.3). Milk, on the other hand, contains mostly lactose which has the sweetness index of 0.2 - 0.4, which is much lower than those presented in sports drink[25,26]. Another factor contributing to palatability is the temperature of drinks, which was not controlled in this study. Previous studies reported that cold drinks were more preferred than warm drinks and the ideal temperature of a cold drink should be less than 22°C and it can help increase the attractiveness of the drink[27]. While the National Strength and Conditioning Association (NSCA) recommended providing appropriate cold fluid intake at a temperature of 10-15°C[28]. In our study, we recommended that the subjects drink their beverages cold, however, the temperate of the drinks could not be confirmed.

The authors do recognize some of the limitations of this study. First-morning urine specific gravity – an index of hydration status – and sweat rate were not measured on trial days. Each subject was able to drink water ad libitum with a breakfast meal, as well as the 500 mL of fluid intake as part of the drink intervention. During the MuayThai exercise simulation, subjects were also able to drink water ad libitum as well during the rest periods. Water intake was not strictly control in this study because previous research found that dehydration did not occur due to the water intake was guided by thirst[29].

In conclusion, the major finding of the present study was that drinking moderate amount of the LF milk, sports drink or water 2 hours before a MuayThai exercise did not affect gut comfort or CMJ. Our findings might alleviate the worries expressed by many Thai active individuals who avoid consuming milk with the fear of gut discomfort and potential that it might impair the subsequent performance. From a practical stand point, drinking LF milk before exercise may be a good alternative beverage to sports drink. The consumption of milk as part of an exercise session may lead to an increase in the amount of dietary calcium intake to meet the recommended nutritional guidelines. Both exercise and adequate calcium intake are vital aspects to optimizing bone health. Not to mention that milk is readily available from various food outlets, relatively inexpensive and offers a vast variety of flavours. Milk can also be beneficial to muscle protein synthesis. The inclusion of even spread of high-quality protein sources every ~3 hr over the day through drinks such as milk, provides a simple and practical solution to meeting the protein intake guidelines to optimize muscle protein synthesis[30].

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