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Efectos de la bebida nutricional de proteína de leche en la ingesta de energía y antifatiga después del ejercicio

Effects of Milk Protein Nutritional Beverage on Energy Intake and Anti-fatigue after Exercise

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Resumen
La leche es un alimento con alto valor nutricional. La investigación muestra que el consumo de lácteos tiene un buen efecto en el cuerpo. Cada litro de leche contiene aproximadamente 32 g de proteína, incluida la caseína (aproximadamente el 80%) y la proteína de suero (aproximadamente el 20%). Son proteínas de alta calidad que contienen todos los aminoácidos esenciales. Este artículo analizó los efectos de la bebida nutricional de proteína de leche en el consumo de energía y antifatiga después del ejercicio. No se encontraron diferencias en el apetito y la ingesta de energía entre MPB y CB en los sujetos. Sin embargo, después del ejercicio, algunos sujetos bebieron MPB y su consumo de energía fue significativamente menor que el de CB. Los estudios han demostrado que las bebidas ricas en proteínas de la leche pueden cambiar los hábitos alimenticios al aumentar la conciencia del comportamiento de la dieta y controlar la saciedad, reduciendo la ingesta de energía, en comparación con las bebidas con carbohidratos. Los datos existentes solo pueden revelar en parte los efectos de las bebidas de proteína de leche sobre la ingesta de energía y la saciedad después del ejercicio, pero no hay vías fisiológicas claras y relevantes.

Palabras clave: proteína de leche; Consumo de energía; Cognición dietética; Efecto antifatiga

Abstract
Milk is a food with high nutritional value. Research shows that dairy consumption has a good effect on the body. Each liter of milk contains about 32 g of protein, including casein (about 80%) and whey protein (about 20%). They are high quality proteins containing all essential amino acids. This paper analyzed the effects of milk protein nutritional beverage on energy intake and anti-fatigue after exercise. No differences in appetite and energy intake between MPB and CB were found in the subjects. However, after exercise, some subjects drank MPB and their energy intake was significantly lower than that of CB. Studies have shown that milk protein-rich beverages can change dietary habits by increasing awareness of dietary behavior and controlling satiety, reducing energy intake, compared with carbohydrate beverages. Existing data can only partly reveal the effects of milk protein drinks on energy intake and satiety after exercise, but there are no clear and relevant physiological pathways.

Key words: Milk protein; Energy intake; Dietary cognition; Anti-fatigue effect

1. Introduction

Milk is a food with high nutritional value. Research shows that dairy consumption has a good effect on the body. The key role of this effect is mainly attributed to protein content (Abargoueietal., 2012). Each liter of milk contains about 32 g of protein, including casein (about 80%) and whey protein (about 20%). They are high quality proteins containing all essential amino acids, but they have different digestion and absorption behavior. Both protein types can delay gastric emptying[1]. In addition, long-term induction of casein can induce the secretion of anorexia-related hormones such as cholecystokinin (CCK) and glucagon-like peptide (GLP-1).

From the physiological point of view, appetite can be controlled and changed to a certain extent. Existing studies have pointed out that part of milk protein intake can increase satiety and reduce appetite. At present, the satiety effect of milk protein and the way of protein consumption (food or beverage) are not clear. Some studies tested the satiety effect of milk proteins in yogurt or beverages[2-3]. In those studies, the amount of protein ranged from 5 to 51 g, with different sizes and energy values. The satiety effect showed that appetite, energy intake and subsequent delays in eating varied in foods with different protein contents, compared with similar isothermal foods that provided lower amounts of protein or carbohydrates as complete substitutes for protein.

The difference between these studies is due to the different experimental methods and the lack of uniform control food. Interestingly, most literatures generally believe that women are more sensitive to protein-rich foods than men[4].

Milk whey is a rich source of branched chain amino acids, which play a key role in muscle metabolism and protein synthesis. The composition of whey amino acids and electrolytes makes milk a good substitute for traditional sports drinks. Compared with sports and electrolyte drinks, milk can more effectively replenish water and effectively alleviate the phenomenon of post-exercise dehydration. Therefore, the purpose of this study was to clarify the satiety effect of 9% milk protein added to beverages compared with calorie beverages containing carbohydrates[5-6]. To this end, this study developed two kinds of drinks, and conducted a randomized cross-over study among women who exercised regularly in order to reveal the effect of milk protein-rich drinks on women's energy intake after exercise.

2. Results and analysis

2.1 Drinks

Two kinds of milk beverages with different protein/carbohydrate ratios were developed. Both beverages were prepared from water-diluted UHT skim milk. Milk protein (Arla Foods Ingredients) and low calorie sweeteners were added to milk protein-rich beverages (MPB), while carbohydrates (25% maltodextrin, 25% corn starch, Cargill) were added to carbohydrate-rich beverages (CB). The maximum amount of milk protein added to MPB did not affect the consistency of beverages. Starch and sugar added to CB are used to balance the heat and consistency provided by milk protein in MPB. Stevioside was used to regulate the sweetness of MPB. In this study, the formulation of beverages was optimized so that they could have similar taste, aroma, texture and color as much as possible[7-8]. All drinks were processed by UHT and placed in 250 mLPET (polyethylene terephthalate) bottles. Alphanumeric numbers were given to all drinks bottles.

Figure 1: Milk protein nutrition

2.2 Amino acid composition of the beverage

The large nutrient content of MPB and CB was evaluated by the method of the Analytical Chemists Association, and the amino acid composition of the beverage was determined by liquid chromatography-high resolution mass spectrometry (LC/HRMS) as described in previous studies. The 2 mL beverage was centrifuged at 16000 x g for 10 min, and the supernatant was separated and diluted with H_2O/CH_3CN (50/50) 1% formic acid solution (1:10).

2.3 Research objects

Subjects consisted of students and staff of the unit. All eligible subjects were female, with a body mass index ranging from 18 to 24.5 kg/m^2, and a moderately active lifestyle with a physical activity level of 600 to 1500 metabolism. Equivalent (MET)-min/week. The following subjects were excluded from the study: BMI ≥ 24.6 kg/m^2 or ≤17.9 kg/m^2, lack of physical activity (<600 MET-min/week), overweight, chronic disease, taking prescription drugs or supplements, The level of physical activity is too high (>1500 MET-min/week), the weight has been significantly reduced in the past 3 months (change ≥ 2 kg), pregnant women or lactating women. A total of 30 subjects were included in the study. The subject's physical activity was assessed by the International Physical Activity Questionnaire (IPAQ) (Hagstr A kind of mer et al., 2006) and the overall physical activity (3 h per week) was expressed as MET. A three-factor diet questionnaire (TFEQ) survey was conducted on all subjects, which tested three different aspects of dietary behavior, including restrictive diet, inhibition of eating and hunger. The study protocol was approved by the ethics committee of the unit, and all subjects signed informed consent.

2.4 Research Design

This study was a cross-randomized, double-blind study that lasted for 3 weeks and consisted of two fixed experimental days per week. The experimental day was fixed at the same week for the same week. The drink consumption of the subjects within 3 weeks was randomly assigned. Within each experimental day, the subjects drank the corresponding beverages immediately after exercise and tested. Subjects exercised between 5 pm and 7 pm and maintained the same duration, type, intensity and amount of exercise. To rule out the effects of the menstrual cycle on individual appetite, each woman started the program within 1 week of menstruation. Subjects were asked to arrive at the lab 1 week prior to the start of the experiment to obtain a personalized calendar of drinks and beverages[9-10]. To assess compliance with the protocol, at the end of each week, the subject came to the lab and returned the beverage bottle to weigh the remainder of the bottle. In addition, subjects were asked to complete an IPAQ to monitor the level of physical activity over the past week. Subjects' dietary intake, appetite, thirst and beverage preferences were recorded on all experimental days. The diet and time of each meal is recorded in the food diary and is used to calculate the energy intake and macronutrient composition of each meal as well as the time of eating. Appetite was assessed on a 100mm visual analogue scale (VAS) with “nothing at the left” and “special” on the right. Five specific times on the experimental day were: after breakfast, morning (11:00 am); after lunch, exercise Before and after drinking the drink. At a later point in time, the subject underwent a specific VAS questionnaire for the beverage that was just consumed. The main evaluation range included the subject's hunger and thirst (sweetness, acidity, fat taste, consistency, pleasure and Overall palatability). In addition, the subject's degree of thirst was assessed by the VAS questionnaire[11].

2.5 Statistical analysis

Statistical analysis of the data was performed using SPSS 18.0 software to assess differences in subjective appetite scores and EI assessments by one-way analysis of variance. Data were compared between the two groups using the t test. Statistical significance was set to $p < 0.05$.

3.Results

3.1 Beverage composition

The results show the composition of each 100 mL of MPB and CB. These beverages were isothermal (47.0 kcal) with MPB = 3.75 and CB = 0.03 for protein/carbohydrate ratios (Table 1). The amino acid content of the two beverages was analyzed, and the total amino acid amount of MPB was about 8.75 times that of CB (p=0.001).

Table 1: Nutritional composition of milk protein beverage and carbohydrate beverage per 100 mL

Nutrient content	Milk Protein Beverage (MPB)		Carbohydrate beverage (CB)	
	Content (g)	Energy (%)	Content (g)	Energy (%)
Fat	0.04±0.01	0.7	0.03±0.001	0.7
Carbohydrate	2.49±0.02	21.5	11.2±0.43	93.5
Starch	-		5.61±0.31	
Sugar	2.51±0.02		5.39±0.12	
Protein	9.33±0.31	78.8	0.31±0.02	2.8
Milk protein	9.04±0.27		-	
Sodium	0.07±0.01		0.07±0.01	
Calcium	0.06±0.01		0.02±0.01	

3.2 Subject characteristics

Statistical results showed the characteristics of 30 participants (age, weight, body mass index, F1 restricted diet, F2 depressed diet, F3 starvation and metabolic equivalent) (Table 2). The subjects drank all the drinks provided after exercise, and the exercise process was carried out at the same time (5:00-19:00), and the same intensity was maintained during the study week.

Table 2: Basic characteristics of subjects ($\bar{x} \pm S$)

Parameter	Average value	Range
Age (year)	24.6±7.2	20~41
Weight (kg)	58.3±6	45~68

Body mass index (kg/m2)	22.1±1.8	18.3~24.6
F1 (restrictive diet)	12.1±3.6	6~17
F2 (to suppress eating)	6.1±3.2	3~14
F3 (hunger)	3.9±2.6	0~14
Metabolic equivalent (MET, min/week)	1175.4±113.5	1070~450

3.3 Energy Intake and Nutrition Consumption before and after Exercise

The energy intake and nutrient consumption statistics before and after exercise showed the average energy intake and nutrient composition of diet consumed before and after exercise in the experimental day, as well as the consumption of each beverage (Table 3). The data showed that there was no significant difference in energy intake and dietary nutrient composition between drinks and beverages in the same time period (before and after drinking).

Table 3: Energy intake and nutrient consumption before and after exercise

Energy and nutrients	Milk Protein Beverage (MPB)			Carbohydrate beverage (CB)		
	Before exercise	After exercise	Total	Before exercise	After exercise	Total
Energy intake (kcal)	893.16±44.66	464.19±23.21	1357.35±67.81	906.21±45.31	473.42±23.67	1379.63±68.93
Protein (g)	32.97±1.65	30.22±1.51	63.19±3.10	36.66±1.83	27.52±1.38	64.18±3.15
Energy(%)	13	26	19	17	23	19
Lipid (g)	33.61±1.68	22.27±1.11	55.88±2.74	34.97±1.75	22.67±1.13	57.64±2.83
Energy(%)	34	42	37	35	40	35
Saturated fat (g)	11.92±0.60	7.14±0.36	19.06±0.90	11.33±0.57	7.30±0.37	18.63±0.88
Monounsaturated fat (g)	14.33±0.72	11.32±0.57	25.65±1.23	14.38±0.72	11.84±0.59	26.22±1.26
Polyunsaturated fat (g)	5.53±0.28	4.10±0.21	9.63±0.43	5.55±0.28	4.30±0.22	9.85±0.44
Carbohydrate (g)	119.08±5.95	39.11±1.96	158.19±7.85	117.09±5.85	43.48±2.17	160.57±7.97
Energy(%)	54	35	45	52	35	46
Starch (g)	58.26±2.91	26.22±1.31	84.48±4.17	89.22±4.46	29.36±1.47	118.58±4.46
Energy(%)	28	24	25	18	24	29
Sugar (g)	47.77±2.39	11.10±0.56	58.87±2.89	40.08±2.00	10.96±0.55	51.04±2.50
Energy(%)	21	10	16	17	9	16
Dietary fiber (g)	9.43±0.47	4.94±0.25	14.37±0.66	10.07±0.50	4.66±0.23	14.73±0.68

3.4 The appetite and thirst of subjects

The average appetite (hunger, satisfaction, satiety and willingness to eat) and thirst of subjects (n = 30) recorded on the experimental day during MPB or CB drinking were analyzed. No significant difference in appetite or thirst was found at any time before and after consumption of each drink.

The data showed that the daily energy intake before exercise/drinking was different from that after exercise/drinking. The energy intake of MPB after exercise was significantly less than that of CB (-11% vs+9%, p=0.02) in 12 out of 30 people. Compared with CB, the same subjects who took MP B after exercise had significantly lower hunger (-8% vs + 16%, P = 0.01) and longer eating time (211 min vs 132 min, P = 0.01). On the contrary, they showed no difference in satisfaction, satiety and desire to eat. The 12 subjects were named responders (R), while the other 18 subjects were non-responders (NR).

3.5 Responsor and Non-responder Characteristics

The data showed that only their dietary behaviors were different between the two subgroups, but there was no significant difference in other aspects. The restricted diet score of respondents was significantly higher than that of non-responders (p = 0.033) (Table 4).

Table 4: Responsor and non-responder characteristics

Feature	Responsor (CR)	Non-responder (NR)	P
Number of cases	12	18	——

Age (year)	26.6±6.9	23.3±5.2	0.113
Weight ((kg)	58.3±6.1	57.3±6.6	0.435
Body mass index (kg/m^2)	22.3±2.4	20.4±1.8	0.322
F1 (restrictive diet)	15.2±2.6	10.1±3.8	0.033
F2 (to suppress eating)	5.012	7.3±3.6	0.097
F3 (hunger)	2.8±2	4.8±3.2	0.102
Metabolic equivalent (MET, min/week)	1237.5±144.9	1147.6±104.5	0.313

4.Discussion

Fatigue, also known as fatigue, is a subjective feeling of discomfort. But objectively, under the same conditions, they will lose their ability to complete the normal activities or work they were engaged in. Every disease develops to a certain stage, fatigue can occur, so there are many diseases that can cause fatigue. Modern Chinese medicine holds that fatigue is a disease name with its etiology and pathogenesis. It is a common and frequently-occurring disease in clinic. It belongs to sub-health category, involving five viscera and six organs, mainly spleen, liver and kidney[12-13]. It can be regulated by TCM differentiation of symptoms and signs in order to achieve the purpose of prevention, treatment and control. Fatigue is caused by deficiency of vital energy and mental change (or unobstruction). In the treatment, we should not only invigorate deficiency and correct the deficiency, but also dispel fatigue and calm the mind. On the one hand, it nourishes the body and nourishes the deficiency[14]. On the other hand, it can relax the mind, relax the mind, keep the mind at ease, keep the mind at peace, and eliminate fatigue.

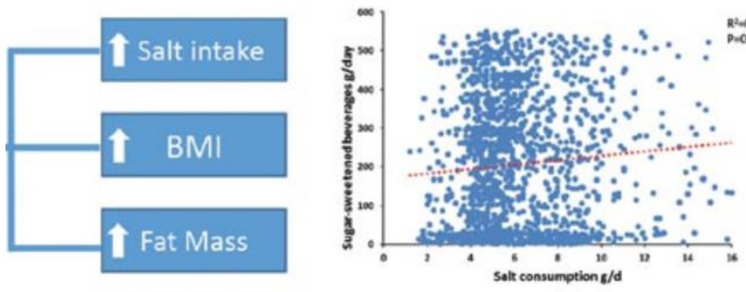

Figure 2: Milk anti-fatigue

This study developed a new milk protein-rich beverage and tested its effect on women's satiety after exercise. Data showed that 12 out of 30 women had significantly fewer hunger sensations after exercising and drinking milk protein drinks. These subjects were called responders and scored higher in the three-factor diet questionnaire than other subjects (non-responders). Previous studies have shown that subjects who drink milk protein beverages have an Energy-Compensating effect. In this study, the two drinks were of equal calorie, and the amount of drinks was fixed (250 mL). Only women at the same stage of menstrual cycle participated in the study. Another advantage of the study was that drinks were repeated three times over a three-week period, whereas in previous studies drinks only passed a single acute consumption test. Based on previous literature, this study hypothesizes that MPB can increase satiety, because milk contains high levels of protein, including casein and whey protein. The satiety effect of casein may be a hormonal reaction caused by circulating amino acids produced by digestion. On the other hand, whey protein was found to be more effective for satiety than carbohydrates[15]. This effect is related to whey content of amino acids and glycogenous peptide and alpha-whey protein, which can enhance serum tryptophan. The data of this study showed that the consumption of milk protein beverage reduced the individual energy intake of respondents. In addition, data show that restrictive diet is a key factor in the satiety effect induced by milk protein beverages and carbohydrate beverages. Psychometric characterization showed that respondents were more restrained than carbohydrates, that is, they had better control over their dietary behavior and were more susceptible to the satiety effect of lactoprotein. This may explain the differences in satiety effects of milk protein in literature studies and the differences between men and women in the same study (Marmonieretal., 2000). In this study, women were in the menstrual cycle (the study lasted for three weeks and began one week after menstruation), and the difference in restrictive diet was a clear cut-in factor to determine the satiety effect of milk protein beverage and carbohydrate beverage. Evidence has shown that cognitive control plays a key role in the physiological reduction of appetite caused by enhanced high protein intake through the reward system. This is the key concept of implementing personalized nutrition strategy and consumer-centered new food design.

5. Conclusion

People who eat more restrictively tend to have higher body mass index (BMI) than those who eat less restrictively, because they limit food consumption by limiting time, during which they try to monitor and regulate food intake through their own rules. Milk protein-rich beverages were more effective for energy control in these subjects, with stronger anti-fatigue abilities and might be an effective functional food for weight management. The main limitation of this study is the lack of measurement of single hormone and nerve signals and hydration status during the experiment. At the same time, the available data can only partly reveal the effect of milk protein beverage on women's ability to eat and satiety after exercise, but there is no clear and relevant physiological pathway. In addition, the sample size of this study is small, so it is necessary to expand the sample size in future studies and explore its physiological mechanism.

References

[1] Moher D, Liberati A, Tetzlaff J, Altman DG (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 6(7):e1000097
[2] Ioannidis JP, Evans SJ, Gotzsche PC, O'Neill RT, Altman DG, Schulz K, Moher D (2004). Better reporting of harms in randomized trials: an extension of the CONSORT statement. Ann Intern Med 141(10):781–788.
[3] Government B (2004). The Medicines for Human Use (Clinical Trials). Regulations 2004.
[4] Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, Savović J, Schulz KF, Weeks L, Sterne JAC (2011). The Cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ 343:d5928
[5] Pace R, Pluye P, Bartlett G, Macaulay AC, Salsberg J, Jagosh J, Seller R (2012). Testing the reliability and efficiency of the pilot mixed methods appraisal tool (MMAT). for systematic mixed studies review. Int J Nurs Stud 49(1):47–53.
[6] Aquilani R, Opasich C, Gualco A, Verri M, Testa A, Pasini E, Viglio S, Iadarola P, Pastoris O, Dossena M, Boschi F (2008). Adequate energy-protein intake is not enough to improve nutritional and metabolic status in muscle-depleted patients with chronic heart failure. Eur J Heart Fail 10(11):1127–1135.
[7] Rozentryt P, von Haehling S, Lainscak M, Nowak JU, Kalantar-Zadeh K, Polonski L, Anker SD (2010). The effects of a high-caloric protein-rich oral nutritional supplement in patients with chronic heart failure and cachexia on quality of life, body composition, and inflammation markers: a randomized, double-blind pilot study. J Cachexia Sarcopenia Muscle 1(1):35–42.
[8] Pineda-Juarez JA, Sanchez-Ortiz NA, Castillo-Martinez L, Orea-Tejeda A, Cervantes-Gaytan R, Keirns-Davis C, Perez-Ocampo C, Quiroz-Bautista K, Tenorio-Dupont M, Ronquillo-Martinez A (2016). Changes in body composition in heart failure patients after a resistance exercise program and branched chain amino acid supplementation. Clinical Nutr (Edinb, Scotl). 35(1):41–47.
[9] Wu C, Kato TS, Ji R, Zizola C, Brunjes DL, Deng Y, Akashi H, Armstrong HF, Kennel PJ, Thomas T, Forman DE, Hall J, Chokshi A, Bartels MN, Mancini D, Seres D, Schulze PC (2015). Supplementation of l-alanyl-l-glutamine and fish oil improves body composition and quality of life in patients with chronic heart failure. Circ Heart Fail 8(6):1077–1087.
[10] George M, Azhar G, Pangle A, Peeler E, Dawson A, Coker R, Coleman KS, Schrader A, Wei J (2017). Feasibility of conducting a 6-month long home-based exercise program with protein supplementation in elderly community-dwelling individuals with heart failure. J Physiother Phys Rehabilit.
[11] Lombardi C, Carubelli V, Lazzarini V, Vizzardi E, Quinzani F, Guidetti F, Rovetta R, Nodari S, Gheorghiade M, Metra M (2014). Effects of oral amino acid supplements on functional capacity in patients with chronic heart failure. Clin Med Insights Cardiol 8:39–44.
[12] Ryan R, Cochrane Consumers and Communication Review Group (2016). Heterogeneity and subgroup analyses in Cochrane Consumers and Communication Group reviews: planning the analysis at protocol stage.
[13] Frisancho AR (1981). New norms of upper limb fat and muscle areas for assessment of nutritional status. Am J Clin Nutr 34(11):2540–2545.
[14] Rector T (1987). Patient's self-assessment of their congestive heart failure: II. Content, reli-ability and validity of a new measure-the minnesota living with heart failure questionnaire. Heart Fail 3:198
[15] Green CP, Porter CB, Bresnahan DR, Spertus JA (2000). Development and evaluation of the Kansas city cardiomyopathy questionnaire: a new health status measure for heart failure. J Am Coll Cardiol 35(5):1245–1255.