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Physiological, Performance, and Nutritional Profile of the Brazilian Olympic Wushu (Kung-Fu) Team

Guilherme Giannini Artioli,[1,2] Bruno Gualano,[1] Emerson Franchini,[2]
Rafael Novaes Batista,[1] Viviane Ozores Polacow,[1] and Antonio Herbert Lancha Jr[1]

[1]*Laboratory of Applied Nutrition and Metabolism and* [2]*Combat Sports and Martial Arts Research Group, School of Physical Education and Sport, Sao Paulo University, Sao Paulo, Brazil*

Abstract

Artioli, GG, Gualano, B, Franchini, E, Batista, RN, Polacow, VO, and Lancha, AH Jr. Physiological, performance, and nutritional profile of the Brazilian Olympic Wushu (kung-fu) team. *J Strength Cond Res* 23(X): xxx–xxx, 2008—The purpose of the present study was to determine physiological, nutritional, and performance profiles of elite Olympic Wushu (kung-fu) athletes. Ten men and four women elite athletes took part in the study. They completed the following tests: body composition, nutritional assessment, upper-body Wingate Test, vertical jump, lumbar isometric strength, and flexibility. Blood lactate was determined at rest and after the Wingate Test. Blood lactate was also determined during a training session (combat and Taolu training). We found low body fat (men: 9.5 ± 6.3%; women: 18.0 ± 4.8%), high flexibility (sit-and-reach–men: 45.5 ± 6.1 cm; women: 44.0 ± 6.3 cm), high leg power (vertical jump–men: 37.7 ± 8.4 cm; women: 32.3 ± 1.1 cm), high lumbar isometric strength (men: 159 ± 13 cm; women: 94 ± 6 cm), moderate arm mean and peak power (Wingate Test–men: 4.1 ± 0.4 and 5.8 ± 0.5 $W \cdot kg^{-1}$, respectively; women: 2.5 ± 0.3 and 3.4 ± 0.3 $W \cdot kg^{-1}$, respectively), and elevated blood lactate after the Wingate Test (men: 10.8 ± 2.0 $mmol \cdot L^{-1}$; women: 10.2 ± 2.0 $mmol \cdot L^{-1}$) and during training (combat: 12.0 ± 1.8 $mmol \cdot L^{-1}$; Taolu: 7.7 ± 3.3 $mmol \cdot L^{-1}$). Men athletes consume a high-fat, low-carbohydrate diet, whereas women consume a moderate, high-carbohydrate diet. Energy consumption was markedly variable. In conclusion, Olympic Wushu seems to be a highly anaerobic-dependent combat sport. Low body fat, high flexibility, leg anaerobic power, isometric strength, and moderately high arm anaerobic power seem to be important for successful competitive performance.

Key Words nutrition assessment, evaluation, martial arts

Address correspondence to Guilherme Giannini Artioli, artioli@usp.br.

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Introduction

Wushu, also known as kung-fu, is a millenary martial art originating from China. At present, there are hundreds of different Wushu styles. Despite this great diversity, an Olympic Wushu style was recently created to standardize the rules, techniques, and competition patterns. The main purpose of these standardizations was the inclusion in the Olympic Games. Even though Olympic Wushu is not 1 of the 28 official Olympic sports yet, it was included as a demonstration sport in the 2008 Beijing Olympic Games.

Olympic Wushu includes Taolu and fighting competitions. Taolu competitions are characterized by formal and standardized barehanded, long weapons, and short weapon routines. Movements are evaluated by precision, agility, velocity, and strength. Fighting competitions, in turn, have different weight categories for men and women. Wushu combats consists in three 2-minute rounds with a 1-minute rest and are characterized by full-contact punches, kicks, and throw techniques. Although there are some studies characterizing physiological profiles of kickboxers (33), wrestlers (23,27), judo (5,9,10,20,26), karate (2,12,22), and taekwon-do competitors (15,29), to our knowledge there is no research addressing this issue in elite Olympic Wushu athletes.

The literature on combat sports reports that athletes who grapple with opponents (i.e., wrestlers and judo athletes) have markedly high anaerobic capacity and strength, high or above-average aerobic power, and low body fat (5,9,16,20,23,26,28), whereas athletes who strike opponents (i.e., karate and taekwon-do players) have marked high aerobic capacity, flexibility, and above-average anaerobic power and capacity (15,29,33). Olympic Wushu contests combine both grappling and striking techniques, but there is no information regarding the physical attributes of Wushu athletes available at scientific literature. Determining the physiological profile of elite athletes in a given sport is important for defining aspects of physical performance that are important to competitive performance. In addition, few studies have evaluated combat sports women athletes.

Considering that Wushu training programs are typically based on intuition, tradition, and personal experience, as is the case in many martial arts, research-based information regarding physiological, nutritional, and performance characteristics of elite men and women athletes are needed to improve training programs.

Thus, the purpose of the present study was to determine physiological, nutritional, and performance profiles of elite men and women Olympic Wushu athletes submitted to laboratory tests and training conditions.

METHODS

Experimental Approach to the Problem

The tests were performed on three separate days. On the first day, athletes' diets were assessed. Thereafter, anthropometric and body composition measurements were taken. On the following morning, all performance tests were conducted. Initially, blood samples were collected to determine resting lactate. The physical tests were applied according to the following sequence: resting blood sampling, warm-up, upper-body (UB) Wingate test, vertical jump, isometric lumbar strength, and flexibility. In addition, blood samples for lactate analysis were collected on the third day at rest and during the training session (Taolu and combat training sessions).

Considering the lack of a specific Olympic Wushu performance test in the literature, we required athletes to perform a nonspecific battery of physical performance tests. The tests were chosen to provide a profile of the athletes and sport requirements for a high-level performance. In spite of little information regarding Olympic Wushu physiological requirements, we based our choice on other studies evaluating combat sports athletes (5,8,9,15,16,23,26,29,33). Validity and feasibility of the tests were also considered.

Subjects

Fourteen Olympic Wushu athletes took part in this study (men: $n = 10$; age = 26 ± 4 years, range: 21–32; weight = 76.9 ± 11.3 kg, range: 60.5–100.7; height = 178 ± 6.9 cm, range: 164.7–188; women: $n = 4$, age = 25 ± 4 years, range: 21–28; weight = 60.1 ± 5.0 kg, range: 54–66.2; height = 164.5 ± 4.6 cm, range: 158–168.5). They were members of the Brazilian National Team, preparing for the 2005 South America Championship. All measurements were taken in a week preceding the 2005 South America Championship. The athletes were training at least 10 $h \cdot wk^{-1}$, including both technical and physical conditioning. Ten athletes were available for blood lactate analysis during Wushu training (seven Taolu athletes and three combat athletes). Before the beginning of the data collection, subjects were informed about the objectives and risks involving their participation in the study and were required to provide informed written consent. The experimental procedure was approved by the institutional ethics committee.

Dietary Assessment

A semiquantitative food frequency questionnaire validated for the Brazilian population (24) was used to assess food consumption. This questionnaire contains 73 food items, and subjects had to report the frequency of consumption for each, on a daily, weekly, or monthly basis. For each item, three choices of portion size were given, in household measurements. With the aid of a Microsoft Excel program, the data were converted into daily consumption categories. Then, the data were analyzed by computer software (Virtual Nutri, Brazil). The variables analyzed were the energy and macronutrient content of the diet of each subject. The macronutrient data are described as a percentage of energy intake and in grams per kilogram of body weight.

Anthropometric Measurements and Body Composition Assessment

Body weight was recorded on a digital scale to the nearest 50 g. Skinfold thickness was measured with a Harpenden caliper from four body sites (i.e., triceps, suprailiac, abdominal, and thigh) according to the *Anthropometric Standardization Reference Manual* (14).

Body composition was determined through hydrostatic weighing. Athletes were weighed at least eight times with the body completely underwater after maximal expiration. The higher value was considered the underwater weight. Residual lung volume was predicted according to Goldman and Becklake (13). Body density was calculated according to Wilmore and Behnke (32), and body fat according to Siri (25).

Anaerobic Arm Power

The Wingate anaerobic test was used to measure UB mean power and peak power. A UB 30-second Wingate test was performed in a mechanically braked device especially developed for this purpose 0.7 $Kp \cdot kg^{-1}$) (Cefise, Brazil). In both tests, computer software recorded the velocity and calculated the power output for each second. Relative mean power ($W \cdot kg^{-1}$) was considered as the mean of each subject's 30-second power output. Relative peak power ($W \cdot kg^{-1}$) was considered as the greatest power output during the test.

Vertical Jump

The squat jump was performed on a platform specifically designed for this test. A computer software (Ergo-jump, Campinas, Brazil) calculated the height jumped from flight time. The vertical jump score was the highest jump of three consecutive trials (intraclass coefficient correlation: 0.985; $p < 0.001$). A short recovery time (30 seconds) was allowed for each jump.

Lumbar Isometric Strength

Lumbar extension isometric strength was measured with a lumbar extension dynamometer (Kratos, Sao Paulo, Brazil). The isometric strength score was the best score of three consecutive trials (intraclass coefficient correlation: 0.980;

$p < 0.001$). A short recovery time (30 seconds) was allowed for each effort.

Flexibility

Flexibility was evaluated by the sit-and-reach trunk forward flexion test. After three consecutive trials, the best score was recorded (intraclass coefficient correlation: 0.970; $p < 0.001$).

Blood Sampling and Lactate Analysis

Twenty-five-microliter blood samples were collected from subjects' earlobes and immediately stored in a 2% NaF solution at approximately 2° C. Samples were subjected to electrochemical analysis in an automated device (YSI 1500, Yellow Springs, Ohio) within, at most, 5 hours. Samples were obtained at rest and at 3 minutes after the UB Wingate Test. Blood samples were also obtained at rest and during the Taolu and combat training sessions.

Statistical Analyses

Descriptive statistics were determined for each variable recorded. Data are shown as mean ± *SD* (range). Considering the discrepancy in numbers of subjects between groups, a general linear model analysis of variance was performed to verify significant differences between men and women athletes. Pearson linear correlation analysis among variables was also conducted. The alpha level was previously set at 5%.

Results

Body composition, performance scores, and blood lactate at rest and in response to the UB anaerobic Wingate Test are
T1 shown in Table 1. As expected, men athletes have lower body fat and higher isometric strength, UB mean, and peak power than the women athletes. No significant gender differences were observed in flexibility, vertical jump, or blood lactate concentration.

Moderate and significant correlations were observed between body fat and some performance parameters. Moreover, a high significant correlation was found between body fat and the sum of four skinfold thicknesses (Figure 1). F1

Blood lactate concentration during combat training was found to be high, as well as blood lactate concentration during Taolu training, although to a lesser extent (Figure 2). F2

Nutritional data are shown in Table 2. Athletes, especially T2 men, ingested high-fat, low-carbohydrate diets. Energy intake was markedly variable (range: 1009–5282 kcal).

Discussion

To our knowledge, this is the first study that investigated the physical and physiological profile of highly trained elite Olympic Wushu competitors. The athletes who took part in this study were preparing for the 2005 South America Championship. The study was conducted in a week preceding the 2005 South America Championship, and the athletes were very close to their peak. All the participants won medals in this competition, and some qualified to participate in the 2005 World Championship. Therefore, they were some of the best of South America in their categories at the time of data collection, and they could be considered elite athletes. Knowledge of the physiological and fitness profile of elite athletes in a given sport is important to determine the capacities associated with competitive success. Although the literature presents a variety of martial arts athlete profiles, Wushu athlete data have been lacking.

The present study shows that Olympic Wushu athletes have low body fat, high flexibility, high leg power, and moderate arm anaerobic power. Olympic Wushu, which can be characterized by a mixture of grappling, throwing, and striking techniques, seems to require the same capacities as other combat sports.

Compared with athletes in combat sports that are grappling- and striking based, Wushu fighters have similar fat content, but less fat, than noncompetitive martial arts practitioners (8). Body fat content observed in our athletes

Table 1. Physiological and performance profile of the participants.

	Men	Women
Body fat (%)*	9.5 ± 6.3 (1.45–19.6)	18.0 ± 4.8 (11–21.4)
Sum SKF (30)*	36.3 ± 17.9 (19–71.7)	63.1 ± 12.8 (51.7–79.2)
Flexibility (21)	45.5 ± 6.1 (37–55)	44.0 ± 6.3 (37.5–52.5)
Vertical jump (21)	37.7 ± 8.4 (24.4–48.8)	32.3 ± 1.1 (30.7–33)
Lumbar isometric strength (kgf)*	159 ± 13 (134–170)	94 ± 6 (88–100)
Lumbar isometric strength ($kgf \cdot kg^{-1}$)*	21 ± 0.2 (1.66–2.38)	16 ± 0.2 (1.36–1.81)
UB mean power ($W \cdot kg^{-1}$)*	4.1 ± 0.4 (3.66–4.71)	2.5 ± 0.3 (2.31–2.9)
UB peak power ($W \cdot kg^{-1}$)*	5.8 ± 0.5 (4.9–6.96)	3.4 ± 0.3 (3.11–3.84)
Resting blood lactate ($mmol \cdot L^{-1}$)	2.4 ± 0.8 (0.85–3.08)	1.7 ± 0.4 (1.11–1.99)
Postexercise blood lactate ($mmol \cdot L^{-1}$)	10.8 ± 2.0 (8.18–14.45)	10.2 ± 1.5 (8.76–12.25)

*Significant difference between men and women ($p < 0.01$).
SKF = skinfold thicknesses; UB = upper body.

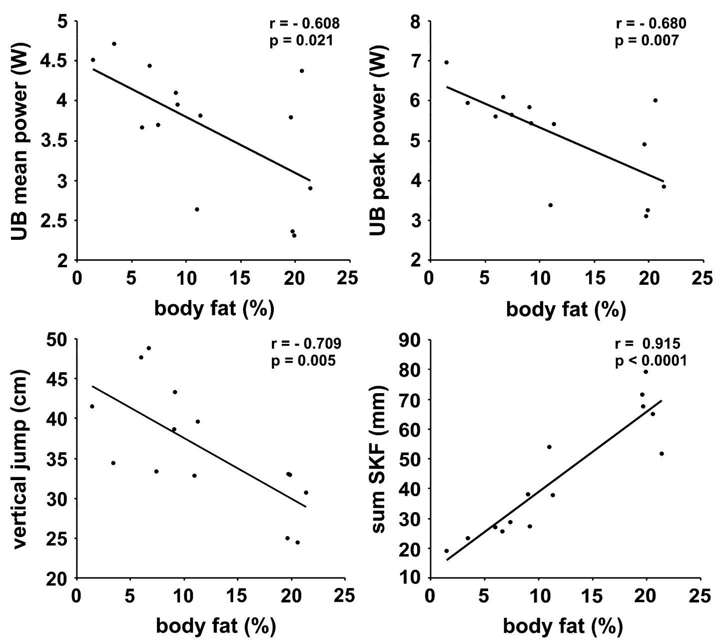

Figure 1. Relationship between body fat and performance variables and between body fat and sum of skinfold thicknesses (SKF).

was similar to those seen in judoists. Taylor and Brassard (26) observed 12.3% body fat on the men's Canadian judo team. This value is somewhat higher than those found in the present study and by Callister et al. (5). Compared with the nonathletic population, these scores roughly represent the 20th and 24th percentiles, respectively. Additionally, these body fat values are lower than those reported by Douris et al. (8) in a novice martial arts population. Significant correlations were observed between body fat and some performance scores. These results suggest that low body fat might be an important factor related to competitive success in Wushu. Moreover, there was a highly significant correlation between body fat and the sum of skinfold thicknesses. Therefore, the sum of skinfold thicknesses could be considered a good predictor of body fat in this athletic population.

Mean anaerobic power in Wushu athletes is lower than in other fighter athletes (5,15,26,33). Zabukovec and Tiidus (33), evaluating four elite kickboxing athletes, as well as Horswill et al. (16), evaluating elite wrestlers, have shown similar values for mean arm power in men, but a higher arm peak power. Vertical jump, whose movement is closer to Wushu movements than cycle ergometry, is more specific to evaluate leg power in these athletes. The vertical jump values obtained by women athletes in this study are in accordance with reports in elite taekwon-do athletes (15,29). On the other hand, our men athletes did not attain the same score reported in the literature for men elite taekwon-do athletes (15,29).

As would be expected, Wushu athletes have high trunk flexibility. The values attained by our athletes are somewhat higher than those found in noncompetitive martial art practitioners (8), elite taekwon-do athletes (15,29), and elite judo athletes (20).

Unfortunately, although we require Wushu athletes to perform lumbar isometric strength, we found no data in the literature to compare with values obtained in this study.

Blood lactate concentration after Wingate in both men and women athletes reached values comparable with other highly

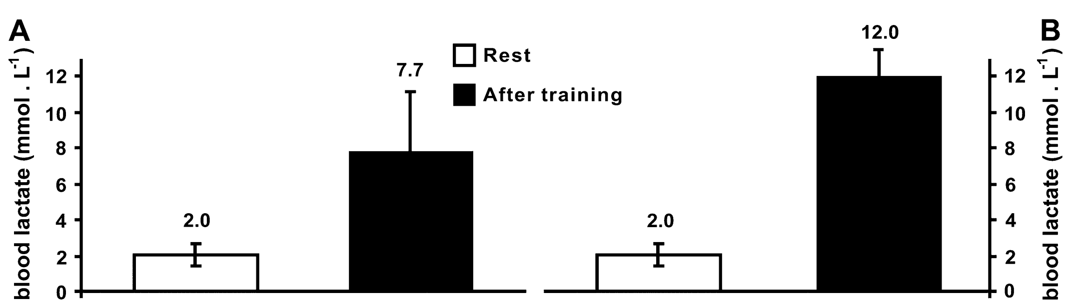

Figure 2. Individual blood lactate response to Taolu (panel A) and combat (panel B) training.

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Table 2. Nutritional assessment data of Wushu athletes.

		Men	Women
Protein	%	16.3 ± 3.2	17.6 ± 3.0
	$g \cdot kg^{-1}$	1.9 ± 1.1	1.6 ± 0.6
Carbohydrate	%*	47.6 ± 9.7	61.1 ± 6.7
	$g \cdot kg^{-1}$*	4.5 ± 1.9	7.2 ± 2.0
Lipid	%*	34.8 ± 7.2	25.4 ± 6.9
	$g \cdot kg^{-1}$	1.7 ± 1.2	1.4 ± 0.7
Energy	kcal	3320 ± 1406	2817 ± 893
	$kcal \cdot kg^{-1}$	41.5 ± 21.2	47.2 ± 15.3

anaerobic-dependent combat sports, such as judo and wrestling (1,6,11). Analyzing blood lactate during training conditions, Wushu seems to be a more anaerobic demanding sport compared with other striking combat sports (17). This is especially true for athletes who engage in combat Wushu rather than Taolu.

It is well established that performance in combat sports is dependent on several aspects, such as physiological characteristics, anthropometric profile, technical capacity, psychological and emotional status, and nutritional requirements. Unfortunately, the importance of the latter has been commonly underestimated by coaches and athletes. To the best of our knowledge, this is the first study that assessed the nutritional profile of highly trained elite Olympic Wushu competitors.

Protein consumption of the athletes was considered adequate, according to the classic recommendations (19). However, only the women met the carbohydrate ingestion requirements ($7.2 \pm 2.0\ g \cdot kg^{-1} \cdot d^{-1}$), which were at the lower end of their recommended range ($7–10\ g \cdot kg^{-1} \cdot d^{-1}$) (4,7). These data are somewhat surprising, because previous studies have demonstrated that men athletes seem to be more frequently within the recommended carbohydrate intake range than women (3). There are two main factors that may explain the suboptimal carbohydrate intake in our study: 1) some athletes, wishing to reduce body weight–a common practice in combat sports (18)–may be unable to meet carbohydrate requirements because of restricted energy intake; and (2) according to our findings, the men athletes consume more fat than their women counterparts. A high-fat diet may be associated with a low carbohydrate intake.

Furthermore, we cannot rule out the possibility that the low carbohydrate intake observed in our study can be associated with other factors, such as poor availability of carbohydrate-rich foods in the immediate eating environment, inadequate practical nutrition skills or food composition knowledge, and/or underreporting of energy intake and then carbohydrate intake (3). Although it is well documented that anaerobic performance can be limited acutely by lower muscle glycogen concentration (for review, see Burke [3] and Burke et al. [4]), we cannot assume only on the basis of our data that the low carbohydrate intake in the Wushu athletes diet would negatively affect their performance in competition. In fact, the recent review by Westman et al. (31) highlights the lack of consistent evidence supporting the hypothesis that "carbohydrate loading" can enhance performance.

In conclusion, Olympic Wushu seems to be a highly anaerobic-dependent combat sport. Elite athletes exhibit low body fat, high flexibility, leg anaerobic power, and isometric strength, and moderately high anaerobic arm power. Therefore, these capacities are important for successful competitive performance. Although these athletes consume adequate protein, carbohydrate ingestion for men was below recommendations, as frequently occurs with weight-classed combat sports.

Practical Applications

The findings of this study suggest that high-level Wushu athletes have low body fat, high flexibility, high leg power, and moderate arm anaerobic power. Thus, coaches should focus on the development of these characteristics in lower-level athletes to attain a better performance. The competition simulations have shown that Wushu activities seem to have a high anaerobic demand. This is especially true for athletes who engage in combat Wushu rather than Taolu. Thus, during physical conditioning training sessions, coaches should place a specific emphasis on the anaerobic training of athletes who compete in combat, although this aspect also needs to be trained in Taolu competitors. One aspect that coaches need to consider is the nutritional consumption of these athletes, because, as with many other weight-classified athletes, their carbohydrate intake was considered suboptimal, which can affect performance negatively.

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