Isotonic sports drink promotes rehydration and decreases proteinuria following karate training

Suplemento hidroeletrolítico favorece reidratação e diminui proteinúria pós-treino em atletas karate

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Abstract

Introduction: Adequate hydration status in the sport is essential for good health, yet the relationship between hydration, proteinuria and sports is little studied. **Objective:** To analyze the influence of an isotonic sports drink as rehydration strategy on the hydration status and proteinuria after karate training. **Methods:** Ten athletes participated in this study. In the first session of standard training, called observation training session (STO), the athletes hydrated themselves according to their habits, and in the second session of standard training, called nutritional intervention training session (STIN), an ideal practice of hydration protocol was followed, using an isotonic sports drink as a rehydration liquid during the training. The hydration status was verified by monitoring the body weight before and after training, the urine specific gravity pre-and post-training and the urine volume post-training. To observe the influence of practice of hydration on the renal function post exercise proteinuria was measured. **Results:** We observed a statistically significant difference in urine density between the samples pre- and post-exercise only on STIN (p = 0.047). When we compare the sessions, there was a lower variation in body weight (p = 0.011) and higher urinary volume (p < 0.001), on nutritional intervention training. In STO, there was a higher percentage of athletes who showed proteinuria (70%) compared to the STIN (50%) in the urine sample after training. **Conclusion:** The use of isotonic sports drink as practice of hydration by karate athletes promoted rehydration during one session of training and reduce post-training proteinuria.

Keywords: dehydration; dietary supplements; martial arts; proteinuria.

Resumo

Introdução: Um adequado estado de hidratação durante a atividade esportiva é essencial para a manutenção da boa saúde, porém a relação entre hidratação, proteinúria e esportes é pouco estudada. **Objetivo:** analisar a influência de suplemento hidroeletrolítico (bebida esportiva isotônica) como estratégia de reidratação sobre o estado de hidratação e proteinúria após treino de Karate. **Métodos:** Dez atletas participaram deste estudo. Na primeira sessão de treino padronizado, denominada sessão de treino de observação (STO), os atletas se reidrataram segundo seus hábitos; na segunda sessão de treino padronizado, denominada sessão de treino de intervenção nutricional (STIN), foi seguido um protocolo ideal de prática de hidratação, utilizando-se de suplemento hidroeletrolítico como líquido reidratante durante o treino. O estado de hidratação foi verificado pelo monitoramento do peso corporal antes e após o treino, pela gravidade específica da urina pré e pós-treino e pelo volume urinário pós-treino. De forma a observar a influência da prática de hidratação sobre a função renal, a proteinúria pós-exercício foi medida. **Resultados:** Observou-se uma diferença estatisticamente significativa na densidade urinária entre as amostras coletadas pré e pós-exercício apenas na STIN (p = 0,047). Quando comparados entre sessões, houve menor variação ponderal (p = 0,011) e maior volume urinário (p < 0,001) no treino com intervenção nutricional. Na STO, houve um percentual mais elevado de atletas que apresentaram proteinúria (70%) em comparação a STIN (50%) na amostra de urina coletada após o treino. Conclusão: O uso de suplemento hidroeletrolitico como prática de hidratação por atletas de karate favoreceu a reidratação durante uma sessão de treino e reduziu a proteinúria pós-treino.

Palavras-chave: desidratação, suplementos nutricionais; artes marciais; proteinúria.

Introduction

Modern karate has its roots in the Okinawa islands in Japan. As a martial art, it is known for its educational and pedagogical possibilities.[1]

Karate, an internationally disseminated sport, is characterized by intermittent exercise.[2] In general terms, karate is divided into three sections: *Kihon* (basic defense and attack techniques), *Kata* (sequence of motions simulating a fight with several imaginary opponents), and *Kumite* (actual combat between two opponents).[3]

Karate's growing popularity is, however, faced with lack of information on practitioner and athlete nutrition and hydration in particular.[2,3]

As in other sports in which athletes are categorized based on their body weight, methods designed to produce quick weight loss, principally through dehydration, are often used.[4]

A recent study by Brito *et al.*[2] indicated that Karate practitioners have very little knowledge of what constitutes adequate hydration. Additionally, karate suits (karategi) often do not allow for proper circulation of air or evaporation of sweat, thus increasing the risk of dehydration.[3]

Good performance in training sessions and competitions, thermoregulation, and maintenance of good overall health require adequate hydration before, during, and after high performance exercise.[5]

A review by Lima, Michels and Amorim[6] suggested that hydration is best achieved during the practice of sports when a combination of water, carbohydrates, and electrolytes is offered in specific volumes and intake frequency, considering local temperatures and type of substrate.

According to the ACSM[5] and the SBME,[7] hydration strategies should be individualized based on exercise intensity and duration, type of sport, the needs of each individual, and the level of dehydration endured by practitioners throughout the sports event.

In the context of maintaining good health, a finding often neglected in the literature and discussed more recently by some authors is a state known as post-exercise proteinuria, a manifestation observed after intense exercise possibly associated with dehydration, muscle injury, and/or kidney disorders related to physical activity.[8-10]

Few intervention studies have been carried out to analyze hydration practices, and information and recommendations on hydration protocols for intermittent exercise programs are scarce. The evidence cited above further stresses the relevance of this study, a pioneering intervention on nutritional and hydration practices adopted by karate athletes in Brazil.

The overall goal of this study was to investigate the impact of a sports drink on the hydration status and kidney function of karate athletes.

Methods

This field intervention study utilized a time series, i.e., the analyses were based on data collected before and after the intervention and each individual enrolled was his/her own control.[11]

The ten athletes included in the study had to meet the following enrollment criteria: 1) male or female aged between 14 and 29 years; 2) at least two training sessions a week; 3) regular participation in tournaments from 2011 to the time the study was carried out.

The athletes joining the study practiced *Goju-Ryu-style karate*, and were training for a local open tournament. The study was carried out during pre-competition practice, which occurs before competition season, in the months of June and July of 2012.

All participants signed informed consent terms. Minors had their terms signed by their parents or guardians. Participant personal information was kept confidential.

None of the participants had a history of disease or health conditions involving their kidneys or urinary tract, *diabetes mellitus* or hypertension; none took ergogenic substances, caffeine, alcohol or drugs that might have altered study results.

A convenience sample was setup based on the willingness and availability of athletes to join the study.

The Research Ethics Committee of the Institution (CEPEC-FEFISA) approved the study design, protocol number 335/11.

The athletes were interviewed in the first stage of the study for information on their practice routine. Participants had their body weight, height, and skinfold thickness measured.

The second and third stages took place during a training micro-cycle, in which the athletes were observed during pre-competition training carried out in the evening, from 6 to 10 pm.

Anthropometric measurements were performed according to the body density protocol described by Costa,[12] with the aid of a Toledo® model 2096PP/2 scale with a resolution of 0.05 Kg, a Sanny® wall stadiometer with a resolution of 1 mm, and a Lange® skinfold caliper with a scale from 0 to 60 mm.

Body weight measurements were made with participants standing with feet hip distance apart, facing the examiner. Participants wore only trunks (men) or shorts and tops (women); karate suits were not allowed, since they absorb a significant amount of sweat.

Body density calculations were performed based on the measurements of skinfold thickness in seven sites (chest, mid-axillary, triceps, subscapular, abdominal, suprailiac, thigh) in males and four (triceps, suprailiac, abdominal, thigh) in females. Two or three measurements were made on the right hemibody, and the mean values were recorded for purposes of the study.

The 7-site skinfold body fat equation described by Jackson and Pollock[13] was used for male participants and the 4-site skinfold formula proposed by Jackson *et al* [14] was applied to female participants, followed by the Siri equation[15] to convert the values into percent body fat.

Training protocol

Fieldwork was carried out in two one-day sessions six days apart from each other. On the first session - Observation Training Session (STO) - the athletes were asked to do what they normally did to hydrate, whereas on the second session - Nutritional Intervention Training Session (STIN) - they were prescribed individualized hydration protocols developed based on the recommendations of the ACSM[5] and the SBME.[7]

In both sessions the athletes were advised 1) not to perform intense physical exercises in the 24 hours preceding the sessions; 2) not to drink alcohol in the 48 hours preceding the sessions; 3) have a meal about 90 minutes before the sessions while sticking to their eating habits; 4) wear sports clothes. The athletes were asked to adopt specific hydration practices only in the nutritional intervention session.

The athletes were asked to perform identical training sessions based on Shiai Kumite (competitive full contact sparring) for 90 minutes in the two days of the study. The level of physical effort was gradually increased until minute 78, and progressively decreased to relaxation in the last 12 minutes of practice.

The following data were collected in the two sessions: 1) volume and type of fluids ingested before and during the session; 2) urine samples before and after training; 3) urination volume immediately after training; 4) body weight before and after training; 5) room temperature and relative air humidity in 30-minute intervals.

The volumes and types of fluid ingested before the training sessions were reported by the participants; the types of fluid ingested during the training sessions were recorded by the examiners; and the volumes ingested during training were calculated with the aid of graded bottles labeled with the names of each of the athletes, used by them to drink fluids. The number of times the athletes filled their bottles minus the fluid remaining at the end of the training session measured with a 250-ml graded beaker was used to calculate the ingested fluid volume, as follows:

Ingested volume = [(Bottle volume x # of times the bottle was filled) - (remaining volume)][16]

The athletes were given 80-ml containers and containers with 10 ml of preservative solution. They were instructed to use the 80-ml containers to collect midstream urine and to pour 10 ml of the urine collected into the container with preservative solution. The procedure was performed before and after the training sessions. The 80-ml containers were discarded after each use.

In the urine collection procedure after training, the athletes were asked to void their bladders and count the number of 80-ml containers they were able to fill. The participants reported the volumes.

The urine samples were first stored in a cooler and then transferred to a refrigerator. They were handed for processing no more than 14 hours after collection. Reagent test strips (urine type 1) were used to gather the following information, among others: urine density, color, and proteinuria.

Soon after collecting urine samples before and after the training sessions, the athletes were weighed wearing only trunks (males) or shorts and tops (females) on a Toledo® model 2096PP/2 scale with a resolution of 50 grams.

The pre- and post-training body weights were used to calculate the level of dehydration (body weight variation) of each athlete after training, based on the following equation designed by the author of this study:

% DH = [(iBW -fBW) x 100/iBW]

Where: % DH = percent dehydration; iBW = body weight before training (kilograms); and fBW = body weight after training (kilograms).

The athletes' sweat rate (SR) was also calculated based on their body weights in grams before (iBW) and after (fBW) training, end urination volume (uV) in mL, volume of fluids ingested during training in mL, and training time in minutes, through the following equation:

SR = [(iBW + ingested hydrating fluids) - (fBW + uV)]/training time [16]

Temperature and relative air humidity were captured at the start and 30, 60, and 90 minutes into the training session with an Instrutemp® model ITHT 2200 digital thermo-hygrometer.

Hydration practice protocols

In the observation session, the athletes adopted their usual hydration protocols before, during, and after training.

In the nutritional intervention session, the athletes were asked to drink 500 mL of water two hours before training so that they were hydrated at the start of the training session.[5,7]

During the training session the athletes were offered a commercially available sports drink of the flavor of their preference, kept at 17-21°C. Chart 1 shows the composition of the sports drink used in the study.

Chart 1 Composition of the sports drink used in the rehydration protocol

Element	Content in 200 mL
Energy content	44 Kcal
Carbohydrates	11 g
Protein	-
Fat	-
Na^+	83 mg
K^+	44 mg
Cl^-	43 mg

(Source: nutritional information published by the supplier).

The volume of sports drink prescribed to each athlete was calculated from the data collected during the observation training session with the aid of the equation described below, proposed by the author of this study based on the recommendations of the ACSM[5] and the SBME[7]:

[Hydration need = (iBW - fBW) + ingested hydrating fluid].

The volume of sports drink was divided into seven equal parts distributed throughout the training session. The athletes were asked to hydrate at the start and 25, 38, 48, 61, 73, and 90 minutes into the training session.

Statistical Analysis

Quantitative variables were reported through measurements of central tendency and scatter, while qualitative variables were reported as proportions.

The *Kolmogorov-Smirnov* test was used to assess the compliance of quantitative variables to a normal distribution. The results of the Kolmogorov-Smirnov test indicated that the variables had to be assessed by means of a non-parametric test, the Wilcoxon signed-rank test.

In the analyses at hand, $p < 0.05$ was considered statistically significant. Statistical analyses were conducted on the *Statistical Package for the Social Sciences* (SPSS, 2000), version 13.0.

Results

Table 1 shows the characteristics of the karate athletes included in the study.

Table 1 Characterization of karate athletes and experience in the sport, 2012

	Females (N = 2)	Males (N = 8)
Age (years) *	18.5 ± 2.12	18.88 ± 4.16
Ranking	1st Dan	6th Kyu to 1st Dan
Degree of experience	Local Games, Open Games, Pan-American Games	Local Games, Open Games, Pan-American Games
Training Frequency	3-5 hours a week	3-12 hours a week
Time practicing karate (years) *	10.5 ± 3.54	8.63 ± 3.78

* Values reported as means and standard deviations.

The results showed that both male and female athletes, although young, had significant experience as karate practitioners.

Table 2 presents the mean values and standard deviations concerning the height, body weight, body mass index (BMI), and percent body fat (% BF) of the studied population.

Table 2 Anthropometric characterization of karate athletes, 2012

	Females (N = 2)	Males (N = 8)
Height (m) *	1.65 ± 0.06	1.73 ± 0.07
Body weight (Kg) *	60.83 ± 10.36	68.89 ± 10.94
BMI (kg/m²) *	22.25 ± 2.09	22.84 ± 3.12
% BF *	28.72 ± 2.93	12.12 ± 5.05

* Values reported as means and standard deviations.

The temperature and relative air humidity data and variations captured in intervals of 30 minutes during both training sessions are shown in Table 3.

The participants had a mean sweat rate of 10.31 ± 3.41 mL/min in the observation training session (STO), *versus* 9.88 ± 3.36 mL/min in the nutritional intervention session (STIN), a non-significant difference ($p = 0.386$). Thus, the environmental conditions and training intensity were believed to have been similar in the two training sessions.

A significant difference was found when the two sessions were compared for body weight variation (%DH STO=-0.72% ± 0.43 *vs*. %DH STIN =-0.10% ± 0.43; $p = 0.011$).

However, it should be noted that during the observation training session the athletes were allowed to ingest fluid ad libitum; nine athletes drank water and one had no fluids. In the nutritional intervention session the athletes were prescribed individualized quantities of a sports drink.

Table 4 shows the mean values and standard deviations for urine density (UD) measured in the two training sessions.

No significant differences were found for urine density (UD) measured before and after training in the observation session ($p = 0.438$); a significant difference was identified in the nutritional intervention session ($p = 0.047$). This finding indicates that the athletes were more dehydrated in STIN than in STO.

Although drinking fluids 30 minutes before practice was not habitual to some athletes, they had to do it in STO in order to be able to collect urine before training.

One of the athletes started STO in a significant state of dehydration (UD = 1.025 mg/L), and at the end of the training session she was minimally dehydrated (UD = 1.010 mg/L); another athlete started the training session minimally dehydrated (UD = 1.010 mg/L) and ended it well hydrated (UD = 1.005 mg/L). These findings suggest that drinking water some 30 minutes before practice helped mitigate increases in urine density in the observation training session.

The color of the urine samples in the pre- and post-training tests were categorized as citrine yellow, suggesting that all athletes were normally hydrated based on the reference standards of the lab in charge of urinalysis.

A statistically significant difference was found in post-training urination volume when the values for the observation and nutritional intervention sessions were compared ($p < 0.001$). In STO, the mean urination volume after training was 116.5 ± 54.27 mL, whereas in STIN the volume was 261 ± 254.49 mL.

In regards to the presence of protein traces or protein in urine, proteinuria was increased by 70% after STO, since 60% of the athletes with proteinuria after training did not present the condition before training; one athlete (10% of the sample) had traces of protein in urine before training and 100 mg/dL of urine protein after training.

Proteinuria increased by 50% after STIN, since 40% of the athletes with proteinuria after training did not have protein in their urine samples before training; 10% of the participants had traces of protein in urine before training and 30mg/dL of urine protein after training.

Discussion

Maintaining proper hydration might be a decisive factor in obtaining the expected physical performance from competitive athletes, in addition to improving their overall health.[2,7]

Our results revealed that proteinuria increased after pre-competition karate training sessions, a finding in agreement with other previously published studies.[8-10]

Table 3 Variation of room temperature and relative air humidity, 2012

	STO		STIN	
Time	Humidity (%)	Temperature (° C)	Humidity (%)	Temperature (° C)
7:30 pm	85	17.8	74	21.2
8 pm	86	17.5	78	20.8
8:30 pm	88	17.5	82	20.6
9 pm	90	17.1	85	20.3
Media	87.25	17.48	79.75	20.73
SD	2.22	0.29	4.79	0.38

Note: STO (observation training session); STIN (nutritional intervention training session). * Data collected with a digital thermo-hygrometer. ** SD = standard deviation

Table 4 Urine density of karate athletes before and after training, 2012

	Pre-training UD (mg/L) *	Post-training UD (mg/L) *	*p*
STO	1.019 ± 6.58	1.020.5 ± 8.32	0.438
STIN	1.019.5 ± 5.50	1.024 ± 6.58	0.047

Note: STO (observation training session); STIN (nutritional intervention training session). UD = urine density. * Values reported as means and standard deviations.

It is important to realize that the elevated levels of relative air humidity recorded in the two training sessions might have increased the athletes' sweat rate while impairing the evaporation of sweat, thus increasing the risk of dehydration during physical activity.[5]

Although a significant difference was found in body weight variation between STO and STIN, dehydration/body weight loss associated with training was less than 1%.

Brito *et al.*[17] studied 15 judo athletes undergoing 120-minute training sessions and found statistically significant body weight variation and mean dehydration of 2.25 ± 0.47% in the group taking sports drink and 2.22% ± 0.49% dehydration in the group offered a placebo fluid. However, the protocol followed by the judo athletes was different from the protocol used in this study, with judo athletes in the two groups being offered 3 mL per kilogram of body weight of fluids every 20 minutes.

In 2014, Nery *et al.*[18] reported 0.69% dehydration in a group of cyclists training indoors for 50 minutes allowed to drink water ad libitum, a percentage close to the results reported for STO in this study (-0.72% ± 0.43).

According to recent recommendations from the ASCM,[19] pre- and post-training body weight, urination volume, and urine density are useful parameters to monitor one's hydration status.

A significant difference in urine density before and after training was observed only in STIN, suggesting the athletes were more dehydrated when taking sports drink. However, reliable hydration status estimation cannot be based on one single parameter in isolation, but rather on the combination of at least two assessment parameters.[16,20]

Additionally, as reported in the results, some athletes ingested fluids 30 minutes before STO, so that they would be able to collect urine samples before training. The unusual consumption of water before training might have led to a lesser increase in urine density.

Interestingly, in 2012 Kalman *et al.*[21] compared the rehydration effect of four fluids (water, pure coconut water, concentrated coconut water, and a sports drink) and were unable to find changes in urine density in the pre- and post-exercise periods for any of the fluids. The individuals participating in the study were asked to walk on a treadmill for 60 minutes, a substantially different type of exercise when compared to karate and other intermittent exercise sports.

According to Strasinger,[22] the volume of urine excreted is generally determined by the body's hydration status, i.e., the more hydrated an individual is, the more urine he/she will excrete. Therefore, the results reported in our study for post-training urination volume indicate that the protocol using sports drink as a rehydration agent produced better hydration during training.

Considering the composition of the rehydration fluid, the sports drink used in the study had

5.5% of carbohydrates, a concentration deemed optimal for fluid replacement, since the presence of carbohydrates at this level improves the palatability of the fluid without slowing down gastric emptying.[6,7]

The label of the sports drink used in this study did not mention the type of sugar present in the beverage, although it probably featured a combination of sucrose and glucose as seen in the other competitor brands.

The recommendation over the intake of carbohydrates of the ACSM[19] for endurance sports - lasting between one and 2.5 hours - and intermittent exercise states that athletes should ingest 30-60 grams of carbohydrates at each hour of exercise. The total intake of carbohydrates from the sports drink offered in this study may be categorized as suboptimal. The ACSM also states that more studies are needed to investigate how glycogen storage is optimized when the intake of carbohydrates is suboptimal; the SBME[7] also states that sports drinks usually contain carbohydrates at a concentration of 6%, and that 0.7-1.5 g/kg of simple carbohydrates may be ingested in the period of four hours after physical exercises.

Another important factor to be considered is the presence of sodium in sports drinks, as replacement for this important electrolyte lost through sweat and urine is required.[7,19] Although sodium excretion varies significantly between individuals, replacement is still important. In addition to increasing the palatability of the drink and consequently the voluntary intake of a rehydrating fluid, it also prevents hyponatremia, a condition characterized by serum sodium levels below 130 mmol/L caused by hyperhydration.[6,19]

Sodium is normally added to sports drinks in the form of sodium chloride, thus the chloride ion cited in the formulation of these fluids. In addition to these two electrolytes, 2mmol/L of potassium is also added to improve hydration.[6]

The right proportions of substrate and electrolytes in sports drinks dictate the osmolarity of the fluid and the attainment of optimal intestinal absorption rates. Therefore, the fact that sports drinks provide better intestinal absorption rates than water might explain the improved hydration status.[6,19]

Shavandi *et al.*[9] investigated proteinuria in 10 female karate athletes in three periods: before training, one hour after training, and six hours after training, and found significant increases in proteinuria one hour after training when compared to the levels before training. However, since significant differences were not identified between levels before and six hours after training, the authors concluded that karate training did not produce kidney injury.

Post-exercise proteinuria occurs mainly due to decreases in glomerular filtration rate caused by high intensity short duration exercises or diminished tubular reabsorption secondary to moderate intensity long duration exercises.[9] It should be noted that proteinuria caused by physical exercise is a transient condition. Authors looking into the occurrence of proteinuria in other sports found that it came back to baseline levels after a few hours of rest. Nonetheless, these changes should be monitored to rule out possible diseases and renal overload caused by exercise.[10,23]

Imamura *et al.*[24] studied female karate athletes and reported mild to moderate levels of training intensity; Imamura *et al.*,[25] in a study enrolling male karate athletes, reported moderate levels of training intensity. Doria *et al.*[26] reported that the Kumite portion of the training session was more intense than the Kata component.

The athletes enrolled in this study were training specifically for a Shiai Kumite tournament. The 90-minute sessions may be categorized as medium duration moderate to high intensity exercise, combined with strings of short duration moderate to high intensity physical exercise. However, karate may become a long duration activity in the days preceding a tournament, since many athletes train more than once a day, some in back-to-back sessions.

In general terms, it is common for athletes not to follow nutritionally balanced diets, a factor that may affect their propensity to having post-exercise proteinuria.[27,28] Nevertheless, since the athletes followed a habitual food intake in the two micro training cycles analyzed in this study, the hydration practices appeared to have produced an important effect as seen in the results described.

Conclusion

Our findings indicated that the intake of sports drinks for purposes of hydration, calculated individually based on pre- and post-training body weight, improved the hydration status of competitive karate athletes performing pre-tournament intermittent physical exercises of moderate to high intensity. Therefore, sports drinks may take part in strategies devised to protect renal function by lessening the renal overload caused by physical exercise.

However, given the limited number of studies in the literature investigating the correlations between renal function, exercise, and hydration practices, more studies are required to shed light on this matter.

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