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A Pilot Study: Does Oxygenated Water Support Lactate Clearance Kinetics After Simulated Games in Elite Taekwondo Athletes?

Original Research

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Abstract

Introduction: To further understand the effects of ingesting oxygenated water supplementation (OS) on heart rate (HR), rating of perceived exertion (RPE), and blood lactate (BL) during two simulated combats in elite Taekwondo athletes.

Methods: Eight Taekwondo athletes from National Chung Cheng University participated in the study. In the counterbalanced and double-blind design, all participants have randomly given OS or placebo (PL). Participants ingested a series of 4 × 15mL volumes of either OS or PL before and during the combats. HR, RPE, and BL were measured before and after the combats. Data were analyzed by repeated-measures two-way ANOVA.

Results: There was no interaction effect in HR and BL between the two groups during the simulated combats (p = 0.982). There was a significant time effect (p = 0.002) in BL between two combats (Combat-1-pre: 2.0 ± 0.9, Post-1: 11.7 ± 4.8, Post-5: 8.7 ± 3.1, Post-10: 7.0 ± 3.0, Post-90: 2.7 ± 0.9; Combat-2-pre: 2.7 ± 0.9, Post-1: 14.7 ± 3.9, Post-5: 9.3 ± 3.0, Post-10: 7.8 ± 2.9, Post-90: 4.6 ± 2.2 mmol/L).

Conclusions: In two simulated Taekwondo competitions, uptake of OS appeared to have no effects on HR and BL. Furthermore, the study showed that repeated exposures to Taekwondo combat were associated with increased BL response.

Key Words: sports nutrition, repeated competition, recovery, combat sports, supplementation

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Introduction

The blood circulatory system (cardiovascular system) delivers nutrients and oxygen gas to all cells in the body. In general, the human body in motion needs a lot of oxygen gas to metabolize carbon dioxide, to maintain a high level of athletic performance. In the past several years, the studies have shown that high concentrations of oxygen gas could deliver higher power output with a fixed heart rate (HR) response and a more relaxed feeling when doing the same power output[1], and inhibit the increase in malondialdehyde (MDA) and enhance recovery after exercise[2].

Limited research has investigated the effects of OS in exercise protocols[3,4,5,6,8,16,17]. The majority of these studies have used VO_2max, HR, rating of perceived exertion (RPE), and blood lactate (BL) as an assessment of exercise capacity, but these results of studies did not support the claims that ingesting OS enhances performance, recovery, aerobic performance[3,4,5,6,8,16,17]. Oxygen uptake through the gastrointestinal tract after oral administration of OS in humans is

not well studied and is debated in the literature. Forth and Adam measured the changes of oxygen partial pressure in the abdominal cavity and the portal vein of rabbits using direct measurements from probes following OS administration by gastric tubes. The study demonstrated that rabbits could absorb dissolved oxygen from the stomach to the portal vein[8]. However, the transferability of their findings to humans was limited. Recently, a study using magnetic resonance imaging (MRI) to assess the effects of OS intake in humans has shown that intake of OS leads to a measurable increase in the relaxation time of the hepatic portal vein[9]. It's suggested that intake of OS affects the human body, which could be the possibility that oxygen reached the hepatic portal vein. Previous studies have estimated that the ingestion of OS containing O_2 dissolved oxygen in athletes could enhance athletic performance[7]. Despite there are some benefit reports of OS on athletes[7,10], few controlled trials have been conducted. Therefore, the ergogenic effects of these drinks remain questionable. Recently, it has been demonstrated that ingestion of OS could improve recovery on endurance exercise, especially ingesting OS[10]. The study revealed that OS ingestion resulted in enhanced post-exercise BL clearance for endurance athletes and the post-exercise recovery was enhanced via increased lactate clearance.

Taekwondo is a very popular combat sport in Olympic Games that was introduced in 1988. Taekwondo athletes are required to compete in several combats during a single day. Such repeated exposures to combat significantly altered the physiological requirements. Furthermore, the post-exercise recovery between combats has become more important since the modification of the Taekwondo rules in 2017. If the athletes are in a state of fatigue for competition, the performance of the athletes will be affected. The fatigue may cause the fall of athletes during combats, which will lose scores. The previous study performed multiple exercises on a single day that caused changes in metabolic function and muscle tissue damage, which resulted in poor athletic performance[12]. On the other hand, repeated combats in wrestling, Brazilian Jiu-Jitsu, and other martial arts competitions caused a significant decrease in plasma catecholamines and increased BL levels, which could affect the performance of athletes[12,13]. The competition of combat sports, such as taekwondo, requires several combats in a single day till the finals. Repeated high-pressure and high-intensity combats in a single day will cause considerable physiological loads in athletes. Thus, athletes often use the strategy of dynamic stretch or diet interventions to help recovery between combats in the competition. However, which nutritional supplement that can help athletes recover after combats as soon as possible and improve their performance for the next combat is still unclear and needed more research to clarify.

The effect of OS ingestion for high-intensity exercise is still unknown. Therefore, the study aimed to investigate the effects of ingesting OS on HR and BL during two simulated combats in elite Taekwondo athletes. It was hypothesized that the HR, BL, and RPE in the OS group would be lower than PL during two simulated combats and OS ingestion would increase the clearance rate of BL during competition in Taekwondo athletes.

Scientific Methods

Participants

The subjects were composed of eight Taekwondo elite athletes from National Chung Cheng University (4 males and 4 females Taekwondo athletes) in this study. All of the participants have been ranked top 8 in National Intercollegiate Athletic Games in Taiwan. The subjects consisted of 4 males (age: 20.3 ± 1.4, height: 173.5 ± 2.8, weight: 65.5 ± 4.7) and 4 females (age: 20.8 ± 0.9, height: 163.3 ± 2.2, weight: 53.3 ± 2.4). The participants had 8.1 ± 2.1 of Taekwondo training experience. The weight category of collegiate participants was classified in accordance with the Olympic weight class rules of Taekwondo discipline as follow, male: ≤ 58 kg (n = 2), > 68 to ≤ 80 kg (n = 2), female: > 47 to ≤ 57kg (n = 4).

Prior to the participant recruitment, the study had been approved by the Institute Review Board of National Chung Cheng University (CCUREC107020602). The purpose and experimental procedures were carefully explained to the participants by the researcher, and all participants completed an informed consent form before participating.

Protocol

According to the Taekwondo competition arrangements, the HR, BL and, RPE were measured at 5 minutes before the competition, Round1 (R1), Round 2 (R2), Round3 (R3) and 1 minute (Post-1), 5 minutes (Post-5), and 10 minutes (Post-10) after the R3. A wireless heart rate monitor (Polar v800; Polar Electro Inc., USA) was used to periodically record the HR during rest and simulated combats. The fingertip blood samples were also collected immediately post-matches for determination of BL levels by lactate meter (Lactate Pro™2 LT-1730, Arkray, Japan). RPE was collected immediately at the end of each combat and was recalled for each round (Borg's 6–20 scale)[14]. Borg's 6–20 scale

demonstrates proven reliability and validity across a range of intermittent sports and exercise intensities, and it may be sensitive to changes in the physiological responses in Taekwondo combat[15].

The study was conducted using a double-blind, cross-over design, the subject pool was randomly separated into two groups with 4 subjects in each group. OS n=4 or PL n=4. Participants ingested a series of 4 × 15mL volumes of either OS or PL before and during the combats, but all participants were blinded to group allocation. The intake of OS was according to Fleming's study[10]. The composition of 15mL of OS was ASO® solution (Activate Stabilized Oxygen), a registered dietary oxygen supplement for human consumption. The ingredients to ASO® are the following: Distilled water: (62.04%), Dissolved O_2 (in molecular O_4 form): (35.00%), Salt and traced elements: (2.96%) (OXIGEN Beverages USA Inc.) The taste-matched PL comprised of 0.6mg of NaCl added to 15mL of distilled water. The HR and BL concentration was measured before and after the combats. Two days of repeated competitions were performed during the two weeks in a counterbalanced order, and two groups were exchanged to drink OS or PL next week (see Figure 1). Participants were maintaining normal daily routine and instructed to avoid alcohol and caffeine during the 24-h period prior to experiment. Also, it was instructed to avoid vigorous exercise during the 48-h period prior to experiment. On the day of the experiment, meal (composition of the lunch: Protein: 4.69g, Carbohydrates: 19.43g, Fat: 6.43g), and water (350 mL of each combat) were given by the investigator. The other drink and food should not be ingested.

Simulated combat was performed according to the World Taekwondo official rules and followed the Olympic weight categories[11]. Briefly, each combat was carried out in an official competition area (8 × 8 m) and consisted of three 2 min rounds of 1 min intervals. All participants competed with an opponent within their corresponding Olympic weight categories and matched experience levels to ensure the intensity of simulated competitions. The Taekwondo simulated competition was performed within an 8 x 8 m competition area that was according to Taekwondo 2017 rules by the World Taekwondo. Each match consisted of 3 rounds of Taekwondo competition (2 min per round separated by a 1 min break), and all participants were required to compete for 2 competitions on a single day, the interval between the two combats during a single day was 90 minutes (see Figure 1).

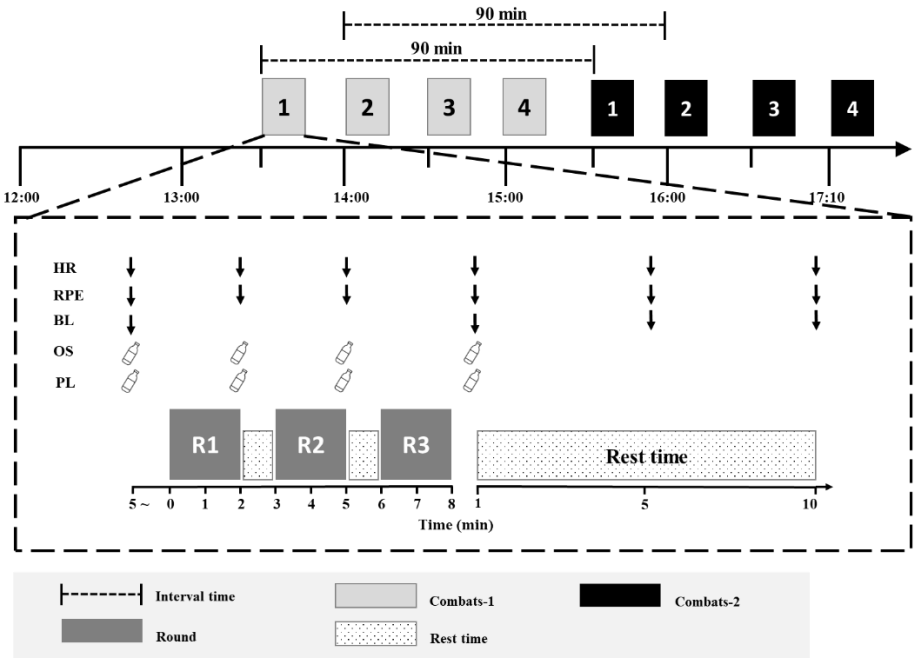

Figure 1. Schematic representation of the competition day. Eight participants were enrolled in this double-blind, randomized, placebo-controlled, crossover study. HR=heart rate, RPE = rating of perceived exertion, BL= blood lactate, OS= oxygenated water, PL= placebo, R= the round of combat, Recovery= rest time in minutes between and after the combat.

Statistical Analysis

The data were presented as mean ± standard error of the mean (Mean ± S.E.M.). Statistical analyses were conducted using SPSS 19.0 statistical software (IBM Corp., Armonk, NY, USA). Prior to further statistical analysis, all data were examined for normality of distribution. A two-way analysis of variance (ANOVA) with repeated measures on both factors (group × time) was conducted to determine whether there were any statistically significant differences between the OS and PL conditions. For all analyses, $p < .05$ was considered statistically significant.

Results

There was a significant time effect ($p = 0.002$) in BL between two combats (Combat1-pre: 2.0 ± 0.8, Post-1min: 12.1 ± 5.3, Post-5min: 8.7 ± 2.7, Post-10min: 7.0 ± 3.0, Post-90min: 2.8 ± 0.8; Combat2-pre: 2.8 ± 0.8, Post-1min: 14.8 ± 4.0, Post-5min: 9.1 ± 2.7, Post-10min: 7.4 ± 2.5, Post-90min: 4.7 ± 2.1; mmol/L). The BL concentration was significantly elevated in combat 2 compared with combat 1. There was no significant group effect in BL between OS and PL groups ($p = 0.982$) (see Figure 2).

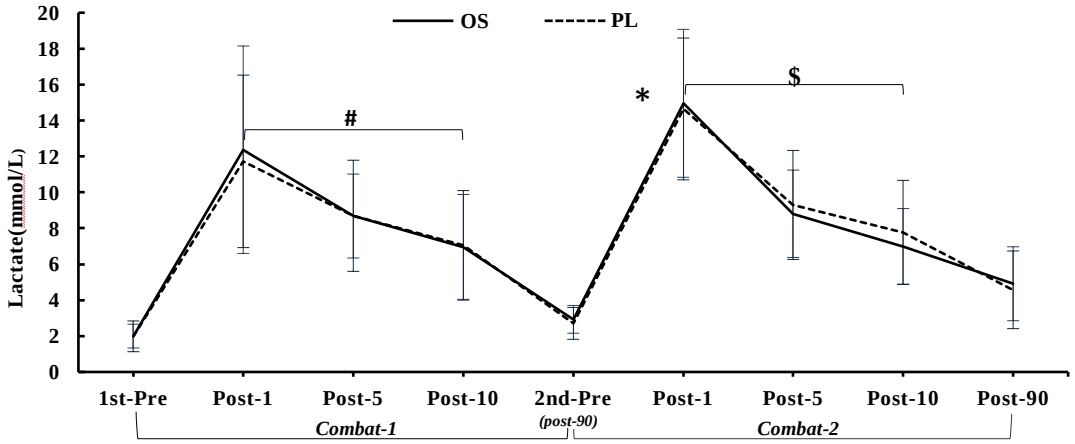

Figure 2. Blood lactate between the rounds and the combats. BL= blood lactate, OS= oxygenated water, PL= placebo, 1st-pre= before the combat-1, 2nd-pre= before the combat-2, Post= after the combat (min). * Significantly different from 1st-post-1 ($p < 0.05$). #Significantly different from 1st-pre, $p < 0.05$). $ Significantly different from 2nd-pre ($p < 0.05$).

There was a significant time effect in HR and RPE between the two combats ($p = 0.001$). Additionally, there was no interaction effect in HR ($p = 0.978$) and RPE ($p = 0.391$) between the OS and PL groups during the simulated combats (see Figure 3 and Figure 4).

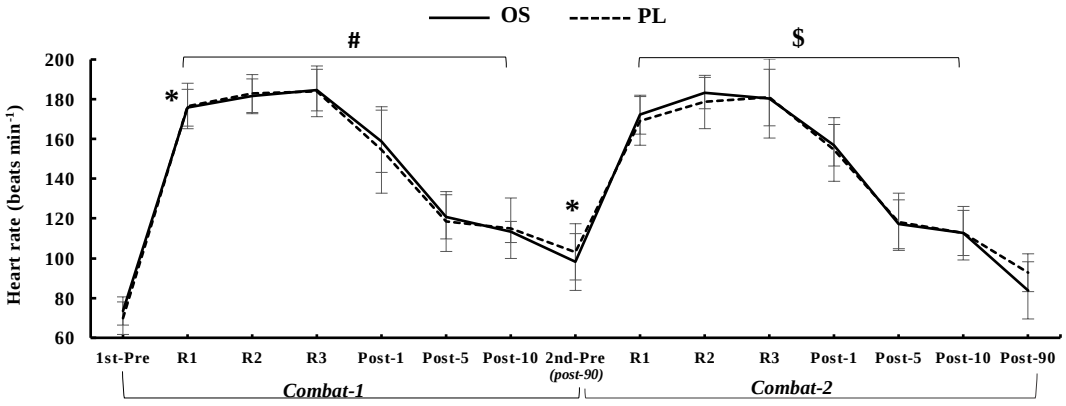

Figure 3. Heart rate between the rounds and the combats. HR= heart rate, OS= oxygenated water, PL= placebo, R= the round of combat, 1st-pre= before the combat-1, 2nd-pre= before the combat-2, Post= after the combat (min). *

Significantly different between two combats at the same time. #Significantly different from 1st-pre, $p < 0.05$). $ Significantly different from 2nd-pre ($p < 0.05$).

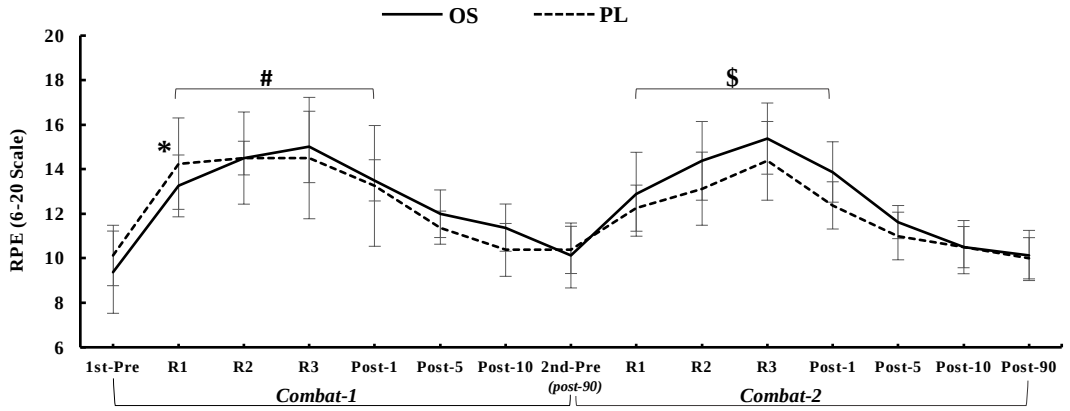

Figure 4. Ratings of perceived exertion ~~(RPE)~~ between the rounds and the combats. RPE= rating of perceived exertion, OS= oxygenated water, PL= placebo, R= the round of combat, 1st-pre= before the combat-1, 2nd-pre=before the combat-2, Post= after the combat (min). * Significantly different between two combats at the same time. #Significantly different from 1st-pre, $p < 0.05$). $ Significantly different from 2nd-pre ($p < 0.05$).

Discussion

From our knowledge, this is the first research to assess changes of BL in the ingestion of OS with elite Taekwondo athletes. Our primary results in the two simulated Taekwondo competitions reported that the HR, BL, and RPE between the OS group and the PL group did not significantly different. The study indicated that physiological recovery capacity is unaffected by the consumption of OS. On the other hand, the BL concentration of Taekwondo athletes in the second competition increased significantly, indicating that repeated exposures to Taekwondo combats may have a physiological impact on Taekwondo athletes.

The results of our study are consistent with previous reports of OS ingestion, which did not improve exercise capacity and recovery[4,6,16,17]. However, since the 2017 OS study in the Fleming's research group, this was the first research that founded the beneficial effects in endurance athletes[10]. The results involving aerobic endurance exercise demonstrated that ingestion of OS could help the BL to be cleared more quickly in the long-distance runner, and suggested that OS can enhance recovery after exercise[10]. Based on the Fleming's inference, OS ingestion may be of greater benefit during and after anaerobic exercise, especially activities that result in a large accumulation of BL. However, it was contrary to our results that OS did not appear to benefit in BL clearance after the simulated Taekwondo combats. Furthermore, our study protocol was similar with high-intensity interval exercise and associated with simulated competition in real combats. A quick energy boost is needed which could maintain athletes to defense and attack. This stress in real combat must take the increased concentrations of catecholamine in the blood into account, thus enhancing pathways in the glycolytic system and BL production[18]. The purpose of this study was to understand the effects of OS in practical application. In our study using the simulated official combats, there were many stochastic variations in the competition. Despite recent results showed that oxygen can reach the hepatic portal vein of the human body[9], the utility of uptake OS in our study is possibly minimal. The significant increase in BL clearance with OS ingestion was not founded in our study during the Taekwondo competitions. The OS absorption and the mechanism of BL clearance with OS in the human body are still needed to be further explored to confirm the effects of OS on different types of movement and performance.

On the other hand, this study found that the second combat of BL of Taekwondo athletes was significantly higher than the first combat in two simulation combats in one day. The BL value increased 10 mmol/L after the two simulated combats in one day. It indicates that the energy demand was increased in the Taekwondo competition. It leads to enhanced anaerobic glycolytic and the concentration of BL would increase significantly. Butios & Tasika found that the BL increased by 2.2 mmol/L on average after the simulated combat[19], which was much lower than our finding. The repeated competition may increase the physiological loads of the competition[26]. However, the results of this study showed that the BL value gradually increased in the second combat with the combat progression. Similar to the

previous study, the wrestlers after finishing the fourth combat in simulated one-day Greco-Roman wrestling tournament have a BL concentration of more than 17 mmol/L. The motor perception fatigue index gradually increased in the combat and peaked in the fourth combat. It indicated that the BL clearance of the athletes would gradually deteriorate after repeated competitions[13]. It was suggested that the BL clearance is an important marker that affects the recovery of athlete ability, and the faster recovery ability is also very important for the performance of athletes[20].

Our results have shown that the RPE and HR did not significantly differ between the groups. In addition, the RPE of the two combats did not reach a significant difference. But the RPE significantly increased with each round and after the competition. Bridge and Chiodo have shown that the RPE results in their studies were similar to our study, indicating that the intensity of the combats was the same perception with the previous study during the combats[15,21,22,23]. The repeated taekwondo competitions did not seem to cause the impact of RPE on the athletes. Previously, there was little physiological research on the Taekwondo simulation competition in Taiwan. It was impossible to compare the difference between the RPE before and after the rule change. The RPE may be affected by physiological and psychological, which were difficult to fully clarify the reasons for the increase or decrease in RPE. In addition, the HR of the two combats did not reach a significant difference, but gradually increased with each round. The results of the study are also similar to the previous studies[15,19,21,22]. The increase in HR indicated that the Taekwondo competition increases the blood supply-demand of the athletes with the combat progression and the increased loads[15]. Taekwondo competition requires multiple competitions on a single day. Thus, it is important to enhance the physiological recovery of Taekwondo athletes for subsequent sports to improve athletic performance[19,24]. Enhancing the recovery of Taekwondo athletes during the rounds and between the combats could help the subsequent performance[25].

Conclusions

To sum up, in two simulated Taekwondo competitions, uptake of OS appeared to have no effects on HR and BL. In order to clarify the effect of OS on performance and different types of exercise, further research is still needed. In addition, the study showed that repeated exposures to Taekwondo combat was associated with increased BL response.

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