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The effect of a carbohydrate-electrolyte solution on fluid balance and performance at a thermoneutral environment in international level fencers

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Running Head: Fluid Balance and performance in fencing

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Abstract

The purpose of the study was to examine a possible effect of a carbohydrate-electrolyte (CHO-E) solution on fluid balance and performance in fencing at a thermoneutral environment. Sixteen fencers, performed two 120-min training sessions separated by 7-14 days under similar environmental conditions (Temperature: 20.3 °C, Humidity: 45-47%). Each session consisted of 60-min conditioning exercises followed by 10 bouts of 3 min against the same opponent with 3 min interval between each bout. Participants ingested at regular intervals either a 6% CHO-E solution or an artificially sweetened water (PL) in a counter-balanced order. No difference was observed between conditions in the heart rate responses, perceived exertion, changes in plasma volume, urine specific gravity, number of bouts won, or lost, or points for and against. Considerable variability was observed in body weight changes which revealed significant differences at Time level (i.e. Pre vs. Post Exercise) ($F_{1,15}$=9.31, p=0.008, η^2=0.38), whereas no difference was found between conditions (i.e. CHO-E vs. PL) ($F_{1,15}$=0.43, p=0.52, η^2=0.03) and Conditions X Time interaction ($F_{1,15}$=3.57, p=0.078, η^2=0.19). Fluid loss was not significantly different between conditions (p=0.08, d=0.47). Blood glucose was higher (p< 0.01) post-exercise in CHO-E, whereas blood lactate was similar between conditions. In conclusion, the CHO-E solution was as effective as the artificially sweetened water in terms of fluid balance and fencing performance at a thermoneutral environment. Due to large individual variability fencers should monitor their fluid intake and body fluid loss in training and competition.

KEY WORDS: Sports drink; fencing training; fluid loss

INTRODUCTION

Fencing is one of the oldest contact sports in the world. It is interesting to note that fencing has evolved from centuries of dueling, swordsmanship and self-defense, turning into an extremely safe sport during mid-18th century. Fencing is part of the Modern Olympic Games program since 1896 in Athens, while women's fencing was only introduced in 1924. Today, International Fencing Federation (FIE) is composed of 152 recognized and affiliated National Federations with more than 300,000 fencers practicing in local clubs and participating in organized competitions (18).

At international level, competition lasts a day and usually consists of two main parts, the preliminary part-phase and the elimination part-phase. In the first part each fencer competes in approximately 6 bouts-matches of maximum 3 min each against different opponents. In the elimination part each fencer plays against an opponent for 3 continuous bouts of 3 min with 1 min rest period between the bouts or until the first fencer reaches 15 touches. The athlete who wins continues to the next elimination round. The activity pattern during fencing is characterized by non-cycling type of intermittent activities that require agility and concentration and consists of short and intense (less than a second) actions or longer (more than a minute) submaximal changes of direction while the effective overall competition time ranges from 17 to 48 min depending on the weapon and the level of the two opponents (3, 42, 50).

Due to the nature of the sport, fencers have to wear specific sporting gear during competition that covers the entire body surface in order to protect themselves from the opponent's hits with the sword. This specific sporting gear is also worn during training when fencers practice/play one against the other. During simulated competition the cardiovascular system of the athlete is recruited moderately, with energy expenditure over 10 $kcal.min^{-1}$ corresponding to approximately 8.5-9.3 METs, oxygen uptake (VO_2) and heart rate (HR) remain below the anaerobic threshold (AT) (11, 36), while maximum lactate values reach 6.9 $mmol.l^{-1}$ in the final minute during the recovery period between rounds (36). However, fencers wearing the specific protective equipment (jacket, sleeve, glove, and mask) increase rectal, esophageal and chest temperature, sweat rate, fluid loss, lactate concentration at submaximal exercise intensities and HR compared to wearing normal sportswear and also achieve lower performance levels during graded exercise when this is performed in fencing gear (45, 51).

Bearing in mind all the above, it is easily understood that fencers during competition as well as training may face challenges with their fluid balance. A degree of dehydration over 2% of body weight (BW) is considered detrimental in terms of endurance performance (49) and upper and lower body anaerobic muscular power (28). Furthermore, dehydration has detrimental effects in attention and decision-making speed (1, 14) and results in poorer cognitive function and motor skill that contribute to poor skill-based performance (22), factors which are important in fencing. Consuming beverages containing carbohydrates and electrolytes during prolonged exercise maintain carbohydrate oxidation rates, blood glucose levels and reduce the rate of muscle and liver glycogen stores leading to improvements in performance compared to placebo or artificially sweetened fluids (13). Also, a carbohydrate-electrolyte solution (CHO-E) provides thermoregulatory benefits during exercise performed in warm conditions by maintaining blood flow to the periphery and reducing cardiovascular drift and core temperature (37). Therefore, the use of a CHO-E solution is recommended **during extended bouts of exercise** since such beverages maintain fluid balance by replacing sweat losses and electrolytes and also provide energy during exercise (44). Furthermore, during shorter exercise periods lasting about one hour, mouth rinsing with carbohydrate solutions may stimulate central nervous system through oral receptors leading to performance improvement as reported in several investigations (2).

It is interesting to note, however, that although several investigations on fluid balance have been conducted in a large variety of sports (4, 5, 12, 15, 21, 26, 30-32, 34, 35, 38-41, 46, 48), to the best of the authors' knowledge no study has examined fluid balance in fencing. Furthermore, a possible effect of ingesting a CHO-E compared to water in fencing performance has not been investigated.

Therefore, it was the purpose of the present study to examine whether a CHO-E during fencing training would be better in terms of performance and fluid balance compared to a flavored water solution.

METHODS

Experimental Approach to the Problem

The study consisted of two identical in content training sessions of approximately 120-min duration, designed to simulate fencing training and competition intensities. The sessions were separated by 7-14 days and performed at 16:00 hours in week days. In the training sessions, the participants randomly ingested at regular intervals either a commercially available 6% CHO-E (Gatorade) (CHO-E) or the same volume of an artificially sweetened water solution (PL). The volume provided was approximately 1.5 times the amount of fluid loss recorded in the Preliminary Study described below. Participants were divided into pairs according to their sex and fencing ability as judged by each fencer's coach. Six male and two female pairs were formed that were the same for both CHO-E and PL trials. Each pair was asked to compete against each other in 10 bouts of 3 min with 3 min interval, aiming the maximum possible hits during every bout. Urine and blood samples were collected pre and post each training session. In addition, the participants visited the laboratory for preliminary testing (anthropometric measurements, determination of VO_2 max, and HRmax) five days before the main trials.

Subjects

Sixteen fencers, 12 men and 4 women, members of the Greek National team in epee, [age: 21.4 ± 0.2 years (range: 17-27), body weight (BW): 74.6 ± 3.3 kg, height: 178 ± 2, body mass index: 23.4 ± 0.8 $kg.m^{-2}$, % body fat: 15.1 ± 1.4%, maximal heart rate (HRmax): 196 ± 2 $b.min^{-1}$, and maximal oxygen consumption (VO_2max): 49.3 ± 1.4 $ml.Kg^{-1}.min^{-1}$] participated in the study. From these volunteers 8 men and 2 women had also participated in the Preliminary Study described below. All fencers had adequate experience participating in at least six international competitions every year. Prior to data collection, all volunteers completed a detailed medical questionnaire and gave informed consent, after a thorough description of the risks being involved. Parental written informed consent was signed for 2 of the volunteers who were under 18 years of age. The study had the approval of the Ethical Committee of the University and all procedures were in accordance with the Helsinki declaration of 1975, as revised in 1996.

Laboratory Testing

Five days before the 1st training session participants were tested for VO_2max, HRmax and estimation of body composition. Percent body fat was estimated using a skinfold caliper (Harpenden, RH15 9LB, England) and sex-specific equations (24, 25). Following this, all fencers performed a maximal exercise test on a motorized treadmill (Runrace Technogym, Gambettola, Italy) to determine HRmax (Polar FS2c, Kempele, Finland) and VO_2 max. The treadmill test consisted of a graded exercise protocol with 0% inclination and four 4-min stages to establish a VO_2 versus HR relationship (VO_2-HR). After completion of the four 4-min stages the treadmill was set to 4% inclination and speed was increased every min by 1 $km.h^{-1}$ to volitional fatigue. Expired air samples were collected for 60 s during the last min of each 4-min stage as well as in the last min of the test using the Douglas bag method. Also, HR was recorded throughout the treadmill test. The mean HR during the last minute of the treadmill exercise test was considered as the HRmax. The gas samples were analyzed using a dry gas meter (Harvard, UK), an infrared carbon dioxide (Vacumed 17630, Ventura CA, USA), and a cold dry fuel cell O_2 (Vacumed 17620, Ventura CA, USA) analyzers which had been calibrated with known gas mixtures. From the gas analysis VO_2max was determined in STPD conditions. From the VO_2-HR equation created for each individual the percentages of HR_{max} (%HRmax) and the percentages VO_2max (%VO_2max) during the training sessions were estimated.

Preliminary Study

The purpose of the Preliminary Study was to examine the voluntary fluid intake and fluid balance during a typical training session in fencing. A typical training session was conducted that included a warm-up period, specific fencing physical condition exercises (PCE), and 8 bouts of fencing of 3 min duration interrupted by 3 min rest aiming for the maximum possible hits. Before and after the training session which lasted 105 min, BW was measured and fluid intake during exercise was recorded. Twelve fencers, 8 men and 4 women, members of the Greek National team in epee, (age: 22.3 ± 2.1 years and BW: 69.8 ± 2.5 kg) participated.

Voluntary fluid intake throughout the training session was 945 ± 57 ml (range: 680-1140 ml). Without accounting for fluid intake, body weight decreased by 0.15 ± 0.1 kg, whereas when fluid intake was accounted for BW changes it was observed that BW decreased by 1.09 ± 0.09 kg (range: 0.48 – 1.60 kg). These BW losses corresponded to 1.6 ± 0.1 % of BW (range: 0.8 – 2.2 %). Ambient temperature and humidity during the training session were 17.7 ^{o}C and 40.1 % respectively.

Procedures

The experimental protocol of the study is presented in Figure 1. Participants arrived at the National Fencing Centre at 16:00, emptied their bladder and a baseline urine sample was collected. Also, within the next 5 minutes duplicate 20-μl and 10-μl, and triplicate microhematocrit (about 70 μl each) capillary blood samples for the determination of blood glucose, lactate, hemoglobin and hematocrit were obtained from the thumb using a finger prick needle after having the participants place their hand in warm water. The capillary blood samples were collected while participants were in a seated position for 5 min. Following this, in an appropriate area that provided privacy, volunteers' nude BW was recorded using a portable digital scale that had accuracy to 0.02kg (Delmac Instruments PS 400LBAT, Athens, Greece). Then, each participant dressed into his/her warming-up clothes and warmed-up for 10 min by running at a low intensity self selected pace (jogging). It should be mentioned that the warming-up clothes were the same in both CHO-E and PL trials. Afterwards fencers performed a combination of 5 min static and dynamic stretching for the lower limbs. Then, fencers performed PCE for 40 min. The PCE were adapted for elite fencers aiming to improve both aerobic and anaerobic fitness including alternating circuit training, sprint running, jumping and plyometric exercises, simulated fencing drills such as different kind and duration of fencing steps and lunges in order to improve general fitness and agility (7). Within 5 min after finishing the PCE, fencers dressed in their fencing gear used in official competitions. Afterwards, participants were divided in pairs (6 male and 2 female pairs) and competed in the 10 bouts of 3 min duration with 3 min interval, aiming for the maximum possible hits. This competition phase lasted 60 min (Fig. 1). During the 3-min interval times between the fencing bouts fencers were seated and got ready for the next bout 10-15 s before completion of the 3-min rest period. All bouts took place on the official competitive piste used in international competitions (Sword Hellas, Athens, Greece). The given and received hits by the two opponents were recorded automatically by a fencing apparatus used in official competitions (Favero, model FA-07, Italy). After completing the 10-bout period, the same capillary blood samples with the ones taken before exercise were also collected after participants had adopted a seated position for 5 min. Following blood collection, participants recorded their nude BW after carefully drying their bodies with a towel. Throughout the exercise period participants' urine output was weighted using an appropriate scale (Philips Essence HR 2394 Philips, Budapest, Hungary) and assuming water specific gravity equal to 1 (i.e.: 1 ml = 1 g). The urine output was also used to estimate sweat loss according to the formula: Sweat Loss= [($BW_{before\ exercise}$ – $BW_{after\ exercise}$) – Urine Output] + Fluid Intake. This calculation, however, does not consider losses due to fuel oxidation and respiration. However, these factors are small in magnitude and are unlikely to be different between trials (17, 40).

Fluid Intake and Fluid Solutions

The CHO-E solution was a commercially available sports drink (Gatorade, orange flavour, non-carbonated). The PL solution was made up of 35 ml of the CHO-E solution and 1.5 g of a sweetener (Sweat'N Low, Cumberland Packing Corporation, Brooklyn, New York, USA) per 1 litre of water. This provided about 14 kcal/litre and had a carbohydrate concentration of 0.3 %. The addition of the sweetener gave PL a sweeter taste than the CHO-E and volunteers were told that the purpose of the investigation was to compare different concentrations of drinks on fencing performance and fluid balance.

The Preliminary Study was conducted in February when, as reported earlier, indoor temperature was < 18 ^{o}C since the indoor training area was not air-conditioned. The experimental training sessions (CHO-E and PL) took place early May when ambient temperatures usually were > 20 ^{o}C, while the whole protocol was extended by 15 min compared to the Preliminary Study. **<u>Additionally, in the</u>**

experimental training sessions 6 out of the 16 athletes had not taken part in the Preliminary Study and therefore no data on fluid loss and fluid intake were available for them. Therefore, and also considering the high variability in fluid intake and loss observed in the Preliminary Study, it was decided that the total amount of fluid provided during the two experimental trials would be adjusted to approximately 1.5 times the fluid lost in the Preliminary Study (15.6 ml.kg.BW^{-1}), so that to ensure euhydration during exercise. Each participant was required to consume 6 ml.kg BW^{-1} of the assigned fluid after the end of the warming up period (10 min) and then 2.5 ml.kg BW^{-1} at 20, 30, and 40 min during the PCE program, as well as before the 1st, 3rd, 6th and 9th bout of fencing (Fig. 1). So, the total fluid provided was 23.5 ml.kg BW^{-1}. Fluid balance was estimated as the difference between pre- and post-exercise BW.

HR, Rate of Perceived Exertion, and Ambient Temperature and Humidity

The HR responses were recorded (Polar, FS2c, Kempele, Finland) every10 min during the warm-up and the PCE periods as well as at the beginning and at the end of each fencing bout (Fig. 1). Rate of perceived exertion (RPE) (8) was also employed at the same time points (Fig. 1). Also, humidity and ambient temperature were recorded (Brannan, Cumbria, England) and found to be similar between CHO-E and PL trials (Relative Humidity: CHO-E: 47 ± 2 % vs. PL: 45 ± 2 %, p=0.55; Temperature: 20.3 ± 0.5 ^{o}C in both conditions).

Blood and Urine Samples

The duplicate 20 μl capillary blood samples were dispensed into Eppendorf vials containing 200 μl of 2% perchloric acid, mixed well, centrifuged at 1500 g for 4 min, and stored at -40^{o}C for subsequent analysis. The two deproteinized samples obtained at each time point (i.e.: pre and post exercise) from each participant were analyzed in duplicate through photometric methods (Jenway 7315, Staffordshire, UK) for glucose using a commercially available kit (Randox, Crumlin, UK) and for lactate using chemicals (nicotinamide adenine dinucleotide, lactate dehydrogenase, and glycerin buffer) from Sigma Diagnostics

(St.Louis, MO, USA) and lactate standards from Trinity Biotech (Wicklom, Ireland) according to the manufacturer's instructions provided in the past by Sigma Diagnostics (no. 826-UV).

The triplicate microhematocrit blood samples were used for measuring hematocrit (Micro-Haematocrit Reader, Hawkley, England), whereas the duplicate 10-μl samples were used for measuring hemoglobin (Dr. Langue Mini-Kuvette LKM 143, Berlin, Germany) photometrically (Miniphotometer 8, Dr Lange GmbH, Berlin, Germany). From hematocrit and hemoglobin values changes of plasma volume were calculated as previously described (16).

Urine samples were stored at 6-8 °C **and analyzed within 2 hours after collection** for specific gravity, using specific urine reagent strips (TECO Diagnostics, Anaheim, CA USA).

Dietary and Training Control

Participants weighed (Kenwood chef/major kitchen scale, UK) and recorded their normal food intake for 2 days before the 1st trial and were asked to replicate this diet for the same period of time before the 2nd trial. The same procedure was followed on the day of the 1st trial until participants arrived at the area where the study took place. Furthermore, the athletes were asked to consume the last meal or snack on the day of the main trials at least 6 hours before exercise and to drink 6 ml.Kg BW^{-1} water 2 hours before exercise to facilitate euhydration (49). Dietary records were analyzed in Microsoft Access by the use of a food database developed in our laboratory based on published data (19) and food labels.

Statistical Analyses

Data were analyzed using SPSS (SPSS inc., Chicago, IL, USA version 16.0). A repeated measures 2-way [(Treatment: CHO-E vs. PL) x Time (Time Points)] ANOVA was used to compare urine specific gravity, BW changes, blood lactate and glucose responses, HR, %HRmax, %VO_2max, and RPE. Dietary intake (average of 2 days before and on the experimental day), fluid loss, estimated sweat loss, urine volume, changes in plasma volume, average values for selected time periods in HR, %HRmax, %VO_2 max, RPE, as well as performance variables (draws, games and points won) and average HR throughout the experimental protocol were analyzed using two-tailed paired t-test. To identify differences between means in the event of a significant interaction, in the two-way ANOVA, simple main effects were used with Bonferroni adjustment for multiple comparisons. It should be noted that performance data were analysed not only by treatment (CHO-E vs. PL), but by order (Trial 1 vs. Trial 2) as well. All assumptions associated with repeated measures designs were tested and the degrees of freedom for significant main effects, interaction and error term were adjusted according to Greenhouse-Geisser epsilon when the assumption of sphericity was violated (29). Effect size for main effects and interaction was estimated by calculating partial eta squared (η^2) in ANOVA and Cohen's *d* (*d*) in the t-tests. Also, 95% confidence intervals (95%CI) of the difference between means in the two conditions are reported. Data are presented as means ± SE. The level of significance was set at $p<0.05$.

RESULTS

Performance

There was no difference between treatments in the number of games won (CHO-E: 4.4 ± 0.6 vs. PL: 4.1 ± 0.7, 95%CI: -1.0 – 1.8, p=0.58, d=0.14), in the total points won (CHO-E: 58.2 ± 5.7 vs. PL: 58.7 ± 6.8, 95%CI: -10.9 – 9.9, p=0.92, d=0.02), or in the number of draws (CHO-E: 1.6 ± 0.3 vs. PL: 1.4 ± 0.3, 95%CI: -0.9 – 1.1, p=0.79, d=0.06) during the 10x3-min bouts of fencing (Fig. 1). Similarly, there was no difference in the number of games won (Trial 1: 4.3 ± 0.6 vs. Trial 2: 4.3 ± 0.7, 95%CI: 0.7 - -1.4), in the total points won (Trial 1: 58.6 ± 4.8 vs. Trial 2: 58.3 ± 7.4, 95%CI: -10.0 – 10.8, p=0.94, d=0.02), or in the number of draws (1.5 ± 0.3 in both Trial 1 and 2) when data were analyzed by order (i.e. Trial 1 vs. Trial 2).

BW Changes and Fluid Losses

Body weight, and fluid losses after exercise and the corresponding values corrected for fluid intake are presented in Table 1. The 2-way ANOVA for BW revealed significant differences at Time level (i.e. Pre vs. Post Exercise) ($F_{1,15}$=9.31, p=0.008, η^2=0.38), whereas no difference was found at Fluid (i.e. CE vs. P) ($F_{1,15}$=0.43, p=0.52, η^2=0.03) and Fluid x Time interaction levels ($F_{1,15}$=3.57, p=0.078, η^2=0.19). Also, fluid loss (pre-post exercise) and urine volume were not different between conditions, while estimated sweat losses almost reached significance (Table 1). However, considerable variability was observed among fencers as indicated by the range of values.

HR, %HR max, Predicted % VO_2max, and RPE

The 2-way ANOVA analysis for HR revealed significant differences only at Time level ($F_{26,390}$=110.6, p<0.001, η^2=0.88), whereas no differences were found at Fluid ($F_{1,15}$=2.70, p=0.12, η^2=0.15) and Fluid x Time interaction levels ($F_{26,390}$=0.95, p=0.54, η^2=0.06). At Time level the highest HR values were observed at the end of the 5^{th} and 10^{th} 3-min fencing bouts (172 ± 3 $b.min^{-1}$ and 171 ± 3 $b.min^{-1}$ respectively). Similarly, %HRmax responses were different at Time level ($F_{6.3,94.1}$=92.6, p<0.001, η^2=0.86), while no differences were found at Fluid ($F_{1,15}$=2.67, p=0.12, η^2=0.15) and Fluid x Time interaction levels ($F_{5.7,84.8}$=0.94, p=0.54, η^2=0.059). Furthermore, in predicted %VO_2max responses no difference was found at Fluid ($F_{1,15}$=2.06, p=0.17, η^2=0.12) and Fluid x Time interaction ($F_{5.6,83.3}$=1.09, p=0.35, η^2=0.07) and only a difference over Time was observed ($F_{3.3,50.2}$=41.8, p<0.001, η^2=0.74).

Same responses were obtained for RPE where no differences were revealed at Fluid (RPE: $F_{1,15}$=0.02, p=0.90, η^2=0.001) and Fluid x Time levels (RPE: $F_{4.4,66.7}$=0.51, p=0.86, η^2=0.03), and only a difference at Time level was observed (RPE: $F_{3.8,57.5}$=25.3, p<0.001).

Furthermore, average values for HR, %HRmax, predicted %VO_2max, and RPE for selected time periods are also presented in Table 2. There was no difference in any of these responses at these selected time periods between conditions.

Urine Specific Gravity, Blood Lactate, Blood Glucose and Changes in Plasma Volume

Urine and blood variables pre and post exercise are presented in Table 3.The 2-way ANOVA analysis for urine specific gravity showed no difference at Fluid ($F_{1,13}$=2.32, p=0.15, η^2=0.15), Time ($F_{1,13}$=1.47, p=0.28, η^2=0.10), or Fluid x Time interaction levels ($F_{1,1}$=0.03, p=0.88, η^2=0.002). Pre-exercise urine specific gravity levels were > 1.020 in 6 athletes in CHO-E and in 2 athletes in PL, however, only 8 of the 16 fencers of the study experienced urine specific gravity < 1.020 in both trials.

Blood lactate responses were different only at Time level ($F_{1,13}$=113.0, p<0.001, η^2=0.90), whereas at Fluid ($F_{1,13}$=2.44, p=0.14, η^2=0.16), and Fluid x Time interaction levels no differences were found ($F_{1,13}$=1.14, p=0.26, η^2=0.10). On the other hand, the 2-way ANOVA analysis for blood glucose revealed significant differences at Fluid ($F_{1,13}$=16.0, p=0.002, η^2=0.55), Time ($F_{1,13}$=5.1, p=0.04, η^2=0.28) as well as at Fluid x Time interaction levels ($F_{1,13}$=20.1, p=0.001, η^2=0.61). Post-exercise blood glucose levels in CHO-E were higher compared to blood glucose concentrations at the end of exercise in PL condition (Table 3). Finally, changes in plasma volume were not different between CHO-E and PL trials (CHO-E: 3.4 ± 1.3 % vs. PL: 1.4 ± 2.0 %, 95%CI: -3.0 – 7.1, p= 0.40, d=0.23).

Dietary Control

Analysis of the dietary data showed that there were no differences between the two trials in average daily energy (CHO-E: 2266 ± 224 kcal vs. PL: 2468 ± 206 kcal, 95%CI: -625 – 221, p=0.32, d=0.26), carbohydrate (CHO-E: 263 ± 33 g vs. PL: 266 ± 26 g, 95%CI: -60 – 54, p=0.90, d=0.03), fat (CHO-E: 50 ± 7 g vs. PL: 59 ± 8 g, 95%CI: -26 – 8, p=0.26, d=0.30), protein (CHO-E: 82 ± 9 g vs. PL: 93 ± 9 g, 95%CI: -32 – 12, p=0.33, d=0.26), or alcohol intake (CHO-E: 3.0 ± 2.3 g vs. PL: 2.5 ± 1.8 g, 95%CI: -5 – 6, p=0.87, d=0.04), consumed during the 2 days prior to each trial. Also, on the day of the main trials no differences between treatments were observed in energy (CHO-E: 488 ± 109 Kcal vs. PL: 685 ± 163 Kcal, 95%CI: -486 – 93, p=0.17, d=0.38), carbohydrate (CHO-E: 74 ± 16 g vs. PL: 79 ± 18 g, 95%CI: -23 – 13, p=0.55, d=0.16), fat (CHO-E: 13 ± 4 g vs. PL: 28 ± 10 g, 95%CI: -36 – 7, p=0.16, d=0.38), or protein intake (CHO-E: 18 ± 5 g vs. PL: 29 ± 9 g, 95%CI: -25 – 3, p=0.11, d=0.44).

DISCUSSION

The main aim of the present study was to examine whether a CHO-E solution during fencing training would improve performance and fluid balance compared to sweetened water (placebo). The main result was that CHO-E had no effect on performance as measured by number of wins and total number of points scored compared to PL. There was also no difference in fluid balance with the CHO-E drink in comparison to the artificially flavored placebo. Furthermore, the Preliminary Study showed that overall fencers naturally ingested sufficient fluid to maintain BW during training since BW was reduced only by 0.15 kg corresponding to 0.2%.

As previously mentioned, fencing has a large thermoregulatory demand due to the nature of the protective clothing. With this in mind, large sweat rates have previously been observed during exercise with fencing clothing (45, 51) and may have a negative impact on performance as a decrease of 2% BW has been shown to deteriorate performance in other sports (49). In the Preliminary Study, despite the fact that considerable variation existed in fluid intake (9.0-19.6 ml.kg BW^{-1}) and BW changes (+0.8% - -0.7%) as a result of training, none of the fencers demonstrated a BW deficit greater than 1%, whereas some fencers actually overhydrated. This result shows that when fencers drink water ad libitum in training performed at an ambient temperature < 20 ^{o}C, they hydrate sufficiently. In the main trials considerable variability in fluid balance was also noticed although fencers ingested the same amount of the assigned fluid (23.5 $ml.kg^{-1}$) relative to body weight. This variability was also mirrored on the sweat loss as well. It is an observation well described in the literature that is due to several factors, some of them controlled in the present study such as exercise intensity, duration and environmental conditions, but also on other parameters concerning subjects' variability like fitness, heat acclimatization, gender and age (43).

The CHO-E solution did not influence fluid loss or urine specific gravity compared to PL. However, a tendency and a relative small effect size were recorded regarding fluid (p=0.08, d=0.47) and estimated sweat losses (p=0.067, d= 0.49) in favor of CHO-E (Table 1). This small non-significant effect may be attributed to the sodium content of the CHO-E solution over PL. Compared to plain water beverages containing sodium maintain plasma osmolality, replace sodium lost through sweat and reduce urine losses maintaining fluid balance (33, 47). Furthermore, in the present study fluid balance was judged on the basis of BW changes before and immediately after exercise. Considering that sweat and urine losses continue during the post-exercise period (44, 49), a limitation of the study was that BW and urine measurements were not made for hours after exercise or even the next morning of the main trials to determine whether sufficient hydration was maintained equally well in both conditions. **This is of particular importance since at international level fencing bouts may be spread over a time period of 6 hours.** In addition, taking into account that exercise took place in thermoneutral conditions (about 20 ^{o}C and 45-47% relative humidity), this small non-significant effect of the CHO-E solution might have reached significance if the study was conducted at a higher ambient temperature.

Previous literature investigating the effect of CHO-E solution on skill based intermittent sports performance have found equivocal results with some demonstrating a positive effect on performance (9, 10) and others demonstrating no effect on performance (20, 23). When investigating the effect of CHO on skill-based sports, the standardization of protocols and skill test reliability always has implications on results, making comparisons between studies difficult (6). In skill-based sports the potential for CHO-E to have a positive effect on performance is likely a result of maintaining performance when fatigued (towards the end of a match) (6). In the present study the overall mean RPE in both trials was about 13 (Table 2) indicating a relatively low fatigue level. The current study found no benefit on fencing performance in terms of number of wins or total points scored. This may be due to the rest periods in fencing being of sufficient duration to prevent fatigue and thus CHO-E had no effect on performance.

It is important to consider the mechanisms of action when looking at the effects of CHO-E on performance. Attempts to elucidate the mechanisms underpinning CHO supplementation effects point to the direct influence of CHO oxidization rates during prolonged exercise (>2 hours) where skeletal muscle and liver glycogen stores are a limiting factor (13). However, given that 5-15g of exogenous CHO is oxidized during the first hour of exercise (27) it becomes questionable whether such mechanisms explain performance benefits during exercise sessions lasting less than 1 hour or during intermittent exercise. In the present study, fencing was undertaken for approximately 1 hour which is often the duration of the first round of a fencing competition. Energy expenditure has been observed to be between 10-12 Kcal.min^{-1} in fencing (11) which if the fights in the present study lasted 3 min, this would be approximately 30-36 kcal utilised per fight. Therefore, there are sufficient CHO stores and any effect on performance is likely to be a central effect. With this in mind, any effect of CHO availability is unlikely to be the result of the proposed mechanisms. In the last decade research has been focused on a central effect due to CHO exposure within the oral cavity during shorter periods of high-intensity exercise (<1 hr.) (2). By exposing oral cavity receptors to glucose maltodextrin, brain regions of reward and motivation are stimulated and work outputs increase (2). Although the specific mouth receptors involved in detecting CHO are yet to be identified, a growing number of studies advocate the role that a CNS pathway plays in moderating a CHO-performance effect (2). This again supports the notion, that any benefit of performance with CHO is likely a result of maintaining performance when fatigued, which as mentioned previously explains the lack of impact on performance in the present study. Rates of perceived exertion were similar between conditions at approximately 14 for both trials during the fencing fights with no obvious difference in workload as HR was similar (approximately 168 bpm).This demonstrates that the sensations of fatigue were comparable between trials when the exercise intensity was the same. However, the use of mouth rinsing a CHO solution instead of ingesting it, as it happened in the present study, produces beneficial results even when RPE are not different compared to placebo rinsing (2). Nevertheless, if the CHO mouth rinsing approach had been adopted in this study, the possible benefit of fluid and electrolyte provided by ingesting the CHO-E solution and maintenance of fluid balance would have been lost.

Although fencers were advised to ingest 6 ml.kg·BW^{-1} water 2 hours before exercise to facilitate euhydration (49), 6 participants in CHO-E and 2 in PL had urine specific gravity values higher (> 1.020) than the recommended for euhydration (< 1.020) (49). Furthermore, only 8 fencers before exercise in both trials met the < 1.020 urine specific gravity guideline. Therefore, it is important enough fluid to be consumed throughout the day to maintain hydration levels especially before training sessions.

In conclusion, artificially sweetened water is sufficient to maintain short time hydration in fencers when training, with no detrimental effect on performance when exercise takes place at a thermoneutral environment. Furthermore, when fencers drink water ad libitum in training performed under similar environment conditions, they hydrate sufficiently to maintain euhydration. Further research should be conducted in competitive scenarios to determine whether CHO-E solutions will have an improvement on fencing performance at higher temperatures and also whether euhydration is maintained for hours post-exercise.

PRACTICAL APPLICATIONS

At environmental temperatures up to 20 ^{o}C **it seems that water or a CHO-E both sufficiently maintain short-term fluid balance over a 2-h exercise period in fencing provided an adequate fluid volume is ingested**. However, due to large individual variability fencers should monitor their fluid intake and body fluid loss in training and competition, and adequate fluid should be consumed to ensure euhydration.

REFERENCES

1. Adan, A. Cognitive performance and dehydration. *J Am Coll Nutr* 31(2): 71-78, 2012.

2. Ataide –Silva, T, Di Cavalcanti Alves de Souza, ME, de Amorim, JF, Stathis, CG, Leandro, CG, Lima-Silva, AE. Can carbohydrate mouth rinse improve performance during exercise ? A systematic review. *Nutrients* 6, 1-10, 2014.

3. Aquili, A, Tancredi, V, Triossi, T, De Sanctis, D, Padua, E, D'Arcangelo, G, and Melchiorri, G. Performance analysis in saber. *J Strength Cond Res* 27(3): 624–630, 2013.

4. Arnaoutis, G, Kavouras S A, Angelopoulou, A, Skoulariki, C, Bismpikou, S, Mourkakos, S, and Sidossis, L S. Fluid balance training in elite young athletes of different sports. *J Strength Cond Res* 29(12): 3447-3452, 2015.

5. Baker, LB, Dougherty, KA, Chow, M, and Kenney L. Progressive dehydration causes a progressive decline in basketball skill performance. *Med Sci Sports Exerc* 39(7): 1114-1123, 2007.

6. Baker, LB, Rollo, I, Stein, KW. and Jeukendrup, AE. Acute effects of carbohydrate supplementation on intermittent sports performance. *Nutrients* 7(7): 5733-5763, 2015.

7. Barth, B and Beck, E. The complete guide to fencing. Oxford: Meyer & Meyer Sport (UK) Ltd, 2007.

8. Borg, GAV. Perceived exertion: A note on "history" and methods. *Med Sci Sports Exerc* 5:90-93, 1973.

9. Bottoms, L, Sinclair, J, Taylor, K, Polman, R, and Fewtrell, D. The effects of carbohydrate ingestion on the badminton serve after fatiguing exercise. *J. Sports Sci* 30:285–293, 2012.

10. Bottoms, LM, Hunter, AM, and Galloway, SDR. Effects of carbohyrate ingestion on skill maintenance in squash players. *Eur. J. Sport Sci* 6:187–195, 2006. doi: 10.1080/17461390600804455

11. Bottoms, LM, Sinclair, J, Gabrysz, T, Szmatlan-Gabrysz, U, and Price, MJ. Physiological responses and energy expenditure to simulated epee fencing in elite female fencers. *Serb J Sports Sci* 5(1): 17-20, 2011.

12. Carvalho, P, Oliveira, B, Barros, R, Padrao, P, Moreira, P, and Teixeira, VH. Impact of fluid restriction and ad libitum water intake or a 8 % carbohydrate-electrolyte beverage on skill performance of elite adolescent basketball players. *Int J Sport Nutr Exerc Metabol* 21: 214-221, 2011.

13. Cermak, NM. and van Loon, LJ. The use of Carbohydrates during exercise as an Ergogenic aid. *J Sports Med* 43(11): 1139–1155, 2013.

14. Cian, C, Barraud PT, Melin, B, and Raphel, C. Effects of fluid ingestion on cognitive function after heat stress or exercise-induced dehydration. *Int J Psychophysiol* 42: 243-251, 2001.

15. Cosgrove, SD, Love, TD, Brown, RC, Baker, DF, Howe, AS, and Black, KE. Fluid and electrolyte balance during two different preseason training sessions in elite rugby union players. *J Strength Cond Res* 28(2): 520-527, 2014.

16. Dill, DB, and Costill, DL. (1974) Calculation of percentage changes in volumes of blood, plasma, and red cells in dehydration. *J Appl Physiol*, 37: 247-248.

17. Edwards AM, Mann ME, Marfell-Jones MJ, Rankin DM, Noakes TD, Shillington DP Influence of moderate dehydration on soccer performance: physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests. *Br J Sports Med* 41: 385-391, 2007.

18. FIE (International Fencing Federation) Fencing History. Available at: http://fie.org/fie/about-fencing/fencing-history, 2016.

19. Food Standards Agency. Mc Cance and Widdowson's the Composition of Foods. Cambridge: Royal Society of Chemistry, 2002.

20. Gomes, RG, Capitani, CD, Ugrinowitsch, C, Zourdos, MC, Fernandez-Fernandez, J, Mendez-Villanueva, A. and Aoki, MS. Does carbohydrate supplementation enhance tennis match play performance? *J Int Soc Sports Nutr* 10(1): 46, doi: 10.1186/1550-2783-10-46, 2013.

21. Higham, DG, Naughton, GA, Burt, LA, and Shi, X. Comparison of fluid balance between competitive swimmers and less active adolescents. *Int J Sport Nutr Exerc Metabol*, 19: 259-274, 2009.

22. Hillyer, M, Menon, K, and Singh, R. The effects of dehydration on skill-based performance. *Int J Sports Sci* 5(3): 99-107, 2015.

23. Hornery, DJ, Farrow, D, Mujika, I. and Young, W. 'Fatigue in tennis', *Sports Med* 37(3): 199–212, 2007.

24. Jackson, AS and Pollock, ML. Generalized equations for predicting body density of men. *Br J Nutr* 40: 497–504, 1978.

25. Jackson, AS, Pollock, ML, and Ward, A. Generalized equations for predicting body density of women. *Med Sci Sports Exerc* 12: 175–81, 1980.

26. Jetton, AM, Lawrence, MM, Meucci, M, Haines, TL, Collier, SR, Morris, D. M, Utter, AC. Dehydration and acute weight gain in mixed martial arts fighters before competition. *J Strength Cond Res* 27(5): 1322-1326, 2013.

27. Jeukendrup, A, Brouns, F, Wagenmakers, A. and Saris, W. ‘Carbohydrate-Electrolyte feedings improve 1 h time trial cycling performance’. *Int J Sports Med* 18(02): 125–129, 1997.

28. Jones, LC, Cleary, MA, Lopez, RM, and Lopez, R. Active dehydration impairs upper and lower body anaerobic muscular power. *J Strength Cond Res* 22(2): 455-463, 2008.

29. Keppel, G. *D*esign and Analysis: A Researcher’s Handbook. New York: Prentice-Hall, 1991.

30. Kovacs, MS. A review of fluid and hydration in competitive tennis. *Int J Sports Physiol Performance* 3: 413-423, 2008.

31. Kurdak, SS, Shirreffs, SM, Maughan, RJ, Ozgunen, KT, Ersoz, G, Binnet, MS, and Dvorak J. Hydration and sweating responses to hot weather football competition. *Scand J Med Sci Sports* 20 (Suppl. 3): 133–139, 2010.

32. MacLeod, H. and Sunderland, C. Fluid balance and hydration habits of elite female field hockey players during consecutive international matches. *J Strength Cond Res* 23(4): 1245-1251, 2009.

33. Maughan, RJ, Carbohydrate-electrolyte solutions during prolonged exercise. In: Lamb, DR, and Williams, MH (editors) Ergogenics: The Enhancement of Sport Performance. Perspectives in Exercise Science and Sports Medicine, Vol. 4, pp. 35-85, Carmel, IN: Benchmark Press, 1993.

34. Maughan, RJ, Shirreffs, SM, Merson, S, and Horswill, CA Fluid and electrolyte balance in elite male football (soccer) players training in a cool environment. *J Sport Sci* 23: 73–79, 2005.

35. Meir, RA, and Halliday, AJ. Pre- and Post- body mass changes during an international rugby tournament: a practical perspective. *J Strength Cond Res* 19(3): 713-716, 2005.

36. Milia, R, Roberto, S, Pinna, M, Palazzolo, G, Sanna, I, Concu. A, and Crisafull, A. Physiological responses and energy expenditure during competitive fencing. *Appl. Physiol. Nutr. Metab* 39: 324-328, 2014.

37. Montain, S. J., and Coyle, E. Fluid ingestion during exercise increases skin blood flow independent of increases in blood volume. *J. Appl. Physiol.* 73(3): 903-910, 1992.

38. Nuccio, RP, Barnes, KA, Carter, JM, and Baker LB. Fluid balance in team sport athletes and the effect of hypohydration on cognitive, technical, and physical performance. *Sports Med* 47: 1951-1982, 2017.

39. Palmer, MS, Logan, LM, and Spriet, LL. On-ice rate, voluntary fluid intake, and sodium balance during practice in male junior ice hockey players drinking water or a carbohydrate-electrolyte solution. *Appl. Physiol. Nutr. Metab* 35: 328-335, 2010.

40. Phillips, SM, Turner, AP, Sanderson, MF, Sproule, J. Beverage carbohydrate concentration influences the intermittent endurance capacity of adolescent team games players during prolonged intermittent running. *Eur. J. Appl. Physiol* 112(3): 1107-1116, 2012.

41. Rivera-Brown, AM, and De Felix-Davila, RA. Hydration status in adolescent judo athletes before and after training in the heat. *Int J Sports Physiol Performance* 7: 39-46, 2012.

42. Roi, GS, and Bianchedi, D. The science of fencing. *Sports Medicine* 38(6), 465-481, 2008.

43. Sato, K. The mechanism of eccrine sweat secretion. In: Gisolfi, CV, Lamb, DR, and Nadel, EN. (editors) Exercise, Heat, and Thermoregulation. Perspectives in Exercise Science and Sports Medicine, Vol. 6, pp. 85-117, WCB Brown & Benchmark, 1993.

44. Sawka, MN, Burke, LM, Eichner, RE, Maughan, RJ, Montain, SJ, and Stachenfeld, NS. Exercise and Fluid Replacement. American College of Sports Medicine Position Stand. *Med Sci. Sports Exerc* 39(2): 377-390, 2007.

45. Shin-Ya, H, Yoshida, T, Takahashi, E, Tsuneoka, H, and Nakai, S. Effects of uniform on thermoregulatory responses during exercise in hot environment: Practical field study and laboratory experiment. *Jap J Phys Fitness Sports Med* 52(1): 75-88, 2003.

46. Shirreffs, SM, Aragon-Vargas, LF, Chamorro, M, Maughan, RJ, Serratosa, L, Zachwieja, JJ. The sweating response of elite professional soccer players to training in the heat. *Int J Sports Med* 26: 90-95, 2005.

47. Shirreffs, SM, Taylor, AJ, Leiper, JB, and Maughan, RJ. Post-exercise rehydration in man: effects of volume consumed and drink sodium content. *Med Sci Sports Exerc*, 28(10): 1260-1271, 1996.

48. Smith, MF, Newell, AJ, Baker, MR. Effect of acute mild dehydration on cognitive-motor performance in golf. *J Strength Cond Res* 26(11): 3075-3080, 2012.

49. Thomas, TD, Erdman, KA, Burke, LM, and MacKillop, M. Joint Position Statement of the American College of Sports Medicine, the Academy of Nutrition and Dietetics, and Dietitians of Canada: Nutrition and Athletic Performance. *Med Sci Sports Exerc* 48: 543-568, 2016.

50. Turner, A, James, N, Dimitriou, L, Greenhalgh, A, Moody, J, Fulcher, D, Mias, E, and Kilduff, L. Determinants of Olympic fencing performance and implications for strength and condition in training. *J Strength Cond Res* 28(10): 3001–3011, 2014.

51. Weichenberger, M., Liu, Y, Velders, M, and Steinacker, JM. Influence of Protecting Clothing on Endurance Capacity, Fluid Balance and Thermoregulation in Fencers. *Med Sci Sports Exerc* 44, 895-895 2012.

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Figure Legends

Fig. 1: Experimental protocol

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Table 1: Fluid intake, body weight (BW) changes, urine volume and estimated sweat loss during training (mean ± SE)

Variable	CHO-E	PL	*p*
Fluid Intake (ml)	**1707 ± 73**		-
Fluid Intake Relative to BW (ml.kg^{-1})	**23.5**		-
$BW_{Pre-Exercise}$ (kg)	**73.41 ± 3.22**	**73.42 ± 3.18**	**Fluid: 0.52** **Time: 0.008** **Fluid x Time: 0.078**
$BW_{Post-Exercise}$ (kg)	**73.29 ± 3.20**	**73.01 ± 3.12**	
Fluid Loss (kg)	**0.16 ± 0.1** **(+ 0.88 - -1.32)[1]**	**0.41 ± 0.10** **(+ 0.22 - -1.18)[1]**	**0.08** **(*d*=0.47)** **95%CI: -0.61 – 0.04**
% BW Change$_{(Pre-Post\ Exercise)}$ (%)	**0.2 ± 0.2** **(+1.6 - -1.1)[1]**	**0.5 ± 0.1** **(+0.5 - -1.4)[1]**	**0.07** **(d=0.49)** **95%CI: -0.75 – 0.03**
BW Change$_{(Pre-Post\ Exercise)}$ Corrected for Fluid Intake (kg)	**1.83 ± 0.15** **(0.66 – 2.64)**	**2.12 ± 0.16** **(0.94-3.16)**	**0.08** **(d=0.47)** **95%CI: -0.61 – 0.04**
% BW Change$_{(Pre-Post\ Exercise)}$ Corrected For Fluid Intake (%)	**2.5 ± 0.2** **(0.8 – 3.2)**	**2.8 ± 0.1** **(1.9 – 3.8)**	**0.07** **(*d*=0.50)** **95%CI: -0.74 – 0.02**
Urine Volume (ml)	**108 ± 16** **(35-240)**	**150 ± 43** **(30-710)**	**0.34** **(*d*=0.27)** **95%CI: -135 – 50**
Sweat Loss (L)	**1.73 ± 0.16** **(0.46-2.57)**	**1.97 ± 0.15** **(0.80-2.75)**	**0.067** **(*d*=0.49)** **95%CI: -0.50 – 0.02**

Numbers in parentheses indicate range of values; *d*=Cohen's d

95%CI= 95% Lower and Upper Confidence Interval; 1=Positive signs indicate hyperhydration

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Table 2: Average values for HR, % HRmax, % VO_2max and RPE for selected time periods in CHO-E and PL trials (mean ± SE)

Time Period	CHO-E				PL			
	HR (b/min)	% HRmax	% VO_2max*	RPE	HR (b/min)	% HRmax	% VO_2max*	RPE
10 min – 10th Game (Whole Period)	147 ± 3	75 ± 2	59 ± 3	13 ± 1	144 ± 3	74 ± 1	58 ± 3	12.8 ± 0.5
10 min – 55 min (W.Up & P. C. Period)	154 ± 3	79 ± 2	64 ± 3	12 ± 0	149 ± 3	76 ± 1	60 ± 3	11.9 ± 0.6
1st Game – 10th Game	145 ± 3	74 ± 2	58 ± 3	14 ± 1	143 ± 3	73 ± 1	58 ± 2	13.9 ± 0.6
Pre-Games	122 ± 3	62 ± 2	41 ± 3	-	118 ± 3	60 ± 1	43 ± 3	-
Post-Games	168 ± 3	86 ± 2	72 ± 3	14 ± 1	168 ± 3	86 ± 2	72 ± 3	14.6 ± 0.8

W.Up & P. C. = Warm-up and Physical Conditioning, *Predicted from HR-VO_2 relationship and VO_2max values

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Table 3: Urine specific gravity, blood lactate and blood glucose concentrations in CHO-E and PL conditions (mean ± SE)

Variable	CHO-E		PL	
	Pre-Exercise	Post-Exercise	Pre-Exercise	Post-Exercise
Urine Specific Gravity	1.020 ± 0.002 (1.005-1.030)	1.022 ± 0.002 (1.005-1.030)	1.017 ± 0.002 (1.010-1.030)	1.019 ± 0.003 (1.005-1.030)
Blood Lactate ($mmol·l^{-1}$)	1.3 ± 0.04	2.3 ± 0.1[1]	1.3± 0.04	2.1± 0.1[1]
Blood Glucose ($mmol·l^{-1}$)	4.4 ± 0.2	5.4 ± 0.3[2]	4.5 ± 0.2	4.5 ± 0.2[3]

1: Different at "Time" level (Pre-Exercise: 1.3 ± 0.04 vs. Post-Exercise: 2.2 ± 0.09, 95%CI: -1.1 - -0.7, p< 0.001)

2: Different from Pre-Exercise (95%CI: -1.6 - -0.4, p< 0.01)

3: Different from CHO-E (95%CI: 0.5 – 1.3, p< 0.001)

Numbers in parentheses indicate range of values

Figure

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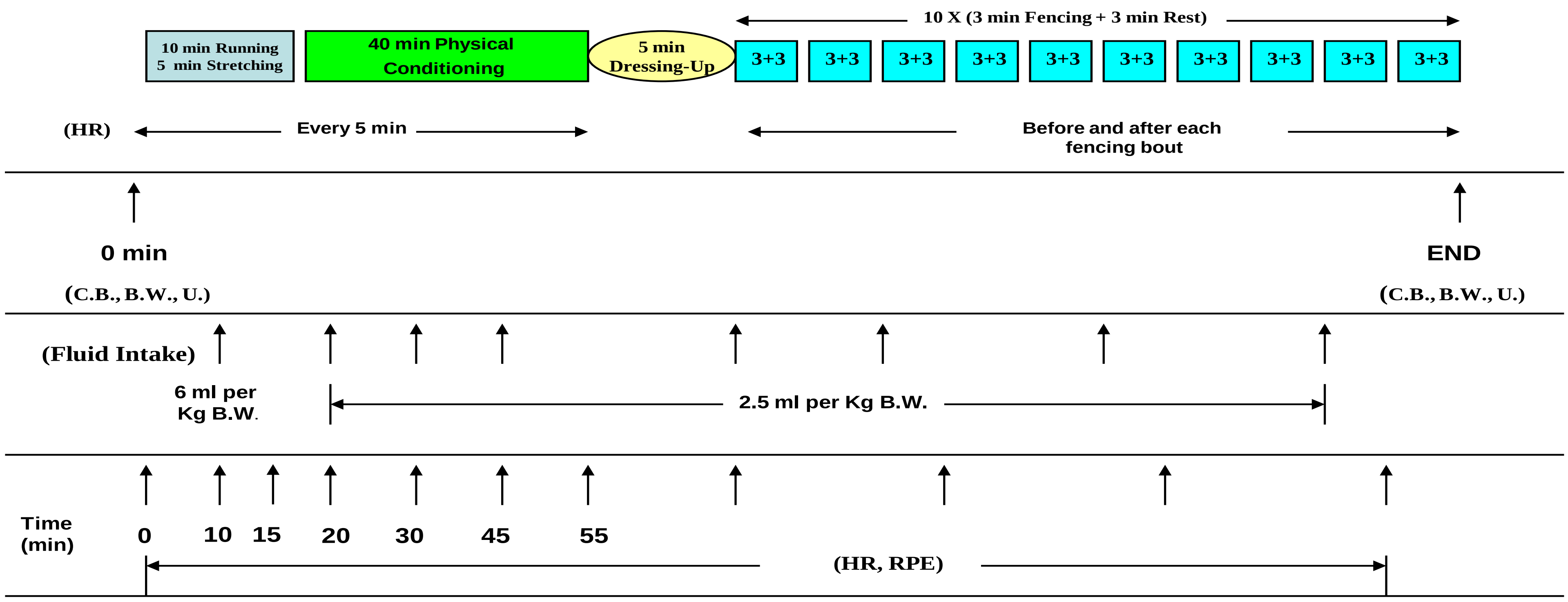

HR= Heart Rate ; C.B. = Capillary Blood Sample ; B.W.= Body Weight ; U= Urine Sample ; RPE= Rate of Perceived Exertion