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EFFECTS OF SPORTS DRINK MOUTH RINSE ON CYCLING PERFORMANCE IN A WARM AND HUMID ENVIRONMENT AMONG TRAINED JUNIOR CYCLISTS

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ABSTRACT

The carbohydrate-electrolyte mouth rinse has been widely documented as one of the cooling strategies that attenuate the rise in core temperature and subsequently contribute to enhanced exercise performance. However, this is the first study investigating the effects of sports drink mouth rinse (100Plus®) on trained junior cyclists during 15-min time trial performance in the warm-humid environment. This study aimed to investigate whether sports drink mouth-rinse (carbohydrate-electrolytes) conferred performance and thermoregulatory responses benefits while cycling in a hot and humid environment; and whether the timing (pre and during exercise) of rinses was of importance when compared with a control rinsing with plain water only. Eight male Kelantan state junior cyclists ages 17 ± 1.8 years old completed carbohydrate-electrolytes (100Plus®) mouth rinse and control trial (plain water) during the fixed intensity cycling at 55% VO_2max for 45-min and 15-min work-dependent self-paced cycling time trial. Each cyclist rinsed his mouth with 25 ml bolus (100Plus®) sports drink or plain water at every 15-min (15,30 and 45-min) for 10-second during the duration of fixed intensity cycling. Heart rate, rectal and skin temperatures, and Borg's rating of perceived exertion (RPE), thermal discomfort and sensation scale were recorded. Results showed that 100Plus® mouth rinse did not improve cycling performance in thermally stress and demonstrated a higher work completed in control (144.7 ± 15.8 kJ) compared to sports drink mouth-rinse (126.2 ± 20.2 kJ) trials. Thus, the most obvious finding from this study was that sports drink mouth-rinse before and during exercise were unable to improve exercise performance in a warm and humid environment.

Keywords: *Mouth rinse, cycling performance, warm and humid*

INTRODUCTION

Excessive fluid loss or dehydration, as a result, impairs an athlete's physical performance especially in a hot and humid environment (Ferreira, Farias-Junior, Mota, Elsangedy, Marcadenti, Lemos, Okano, & Fayh, 2018). The athletes are advised to drink enough fluid to replace sweat losses or consumed electrolytes beverages during exercise to maintain homeostasis thus exercise performance will not be compromised (Kerksick, Wilborn, Roberts, Smith-Ryan, Kleiner, Jäger, Collins, Cooke, Davis, & Galvan, 2018; Racinais, Cocking, & Périard, 2017). The finding on Silva, Barros, Mendes, Garcia, Valenti, de Abreu, Garner, Espindola, & Penha-Silva, (2019) suggests that hot temperatures reduce exercise performance and increase the probability of disorders caused by maximal effort. Carbohydrate supplementation can delay the onset of fatigue and improve work output and capacity (Ali, Moss, Yoo, Wilkinson, & Breier, 2017), with the combination of an appropriate carbohydrates and electrolytes composition and administration regiment subsequently delivering major benefits to endurance performance (Maughan, Burke, Dvorak, Larson-Meyer, Peeling, Phillips, Rawson, Walsh, Garthe, & Geyer, 2018). The prescriptive use of ingesting carbohydrate-containing sports drinks for anyone exercising at risks of heat illness and ways in which heat illness can be minimised was well researched. Furthermore, excessive fluid loss or dehydration, as a result, impairs an athlete's physical performance especially in a hot and humid environment (Ferreira et al., 2018).

Consuming sports drinks containing 6-8% carbohydrates and 10-20 mmol/L of sodium during exercise lasting longer than 60-min will increase performance (Scrivin & Black, 2018). In addition to the recommendations described previously, a new strategy known as carbohydrate mouth rinse is being studied extensively by refreshing the mouths with carbohydrate solution or sports drinks, rinsing, and spitting without swallowing it during exercise. Carter, Jeukendrup, & Jones (2004) was the first to publish a study on carbohydrate mouth rinse on endurance cyclists. Interestingly they found mouth rinsing with a carbohydrate solution resulted 3% improvements in a time trial cycling performance. Later, several investigations into the carbohydrate mouth rinse effect on exercise performance, take Beaven, Maulder, Pooley, Kilduff, & Cook (2013) for instance, showing that carbohydrate and caffeine mouth rinse can enhance cycling sprint power production among recreationally trained cyclists. As has been noted, carbohydrate mouth rinse demonstrated beneficial effects for cycling performance in short and intermittent sprint, then Luden, Saunders, D'Lugos, Pataky, Baur, Vining, & Schroer (2016) provided the first evidence that carbohydrate mouth rinse should be considered to be applied in endurance cycling to optimise performance at the late stages of competition. Correspondingly, their protocol consists of 120-min cycling at 55% W_{max} followed by a 30-km time trial and the cyclists have been given three carbohydrate mouth rinses during the time trial. Similarly, the study on 6.4% glucose mouth rinse improved 40-km cycling time trial performance (Murray, Paris, Fly, Chapman, & Mickleborough, 2018). In running performance, the subjects were able to run 29% longer with carbohydrate mouth rinsing when compared to placebo (Fraga, Velasques, Koch, Machado, Paulucio, Ribeiro, & Pompeu, 2017).

The likely explanation on positive results are related to central nervous system alteration by the presence of carbohydrate in the oral cavity (Fraga et al., 2017), maintained neuromuscular activation during exercise (Bastos-Silva, Araujo, Franco, Melo, Learsi, Lima-Silva, & Bertuzzi, 2017), and an increase in central drive or motivation (Carter et al., 2004). There have been consistent observations of carbohydrate mouth rinse improved exercise performance in short and high intensity, intermittent sprint and endurance cycling and running. Not all studies on carbohydrate mouth rinse proven to improve exercise performance as did not improve 60-min track running performance in female recreational runners (Chryssanthopoulos, Ziaras, Oosthuyse, Lambropoulos, Giorgios P, Zacharogiannis, Philippou, & Maridaki, 2018). In the same way, different concentrations of 3%, 6%, and 12% carbohydrate mouth rinse failed to improve 20-km cycling time trial performance in recreationally active males (James, Ritchie, Rollo, & James, 2017; Kulaksız, Koşar, Bulut, Güzel, Willems, Hazir, & Turnagöl, 2016). On the other hand, in a fasted and glycogen-reduced state, Ali et al., (2017) found carbohydrate mouth rinse showed no performance enhancement among moderately trained male cyclists.

As aforementioned, not all investigations have demonstrated the ergogenic effect of carbohydrate mouth rinse during exercise. Again, all the previous studies have been carried out in thermoneutral condition, contrary to this present study which investigates carbohydrate-electrolytes (sports drink) mouth rinse during exercise in a warm and humid environment. In

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the event of the laboratory setting in the thermal stress condition, during open-looped or fixed-intensity protocol and closed-loop or self-selected workloads performance are reduced due to attainment of high core body temperature of 40ºC to avoid risk of heat-stroke (Hanson, Martinez, Byl, Maceri, & Miller, 2019; Ruddock, Robbins, Tew, Bourke, & Purvis, 2017). Therefore, a novel aspect of this study is to investigate the impact of sports drink (100plus®, Fraser and Neave Limited, Malaysia) mouth rinse on cycling performance in warm and humid environment. Finding from this study will benefit an athlete as a strategy to reduce heat-related illness during training or competition in the condition of thermal stress. Equally important for Muslim athletes who are training and competing during Ramadhan fasting, sports drink mouth rinse strategy could be advantageous to maintain or improve exercise performance.

RESEARCH METHODOLOGY

Participants

Eight healthy, junior male cyclists provided their informed consent to participate in the study. The participants' characteristics were (mean ± SD): age, 17 ± 1.8 years; height, 1.7 ± 0.1 m; weight, 57 ± 11.5 kg; VO_2peak, 61.2 ± 8.4 ml/kg/min; maximal heart rate, 181 ± 14 beats/min and peak aerobic power, 278 ± 28 W. All participants were well-trained cyclists with at least 2 years of competitive experience at the national level. The protocol was approved by the Human Ethics Committee of Universiti Sains Malaysia (USM/JePEM/19020109) and performed in according to the latest Declaration of Helsinki. Participants arrived at the laboratory for all experimental trials having refrained from strenuous exercise, caffeine, and tobacco for a period of 24-h.

Experimental Overview

Participants visited the laboratory on a total of four occasions. In the following order, these visits included: (1) preliminary submaximal and maximal test, (2) experimental familiarization, (3 and 4) experimental trials. All the visits were separated by 7 days, conducted at the same time of day. Experimental trials consisted of a plain water mouth rinse (Control) and 100Plus®

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mouth rinse trials. A schematic diagram can be seen in *Figure 1*. All the trials were completed on an electronically braked cycle ergometer (Excalibur Sport, Lode Groningen, Nederland), used either in the cadence-independent mode (hyperbolic mode, for steady-state) or a cadence-dependent mode (linear mode, for time trial).

Preliminary Trial and Familiarization

Following body weight (Tanita, Japan) and height (Seca, Germany) measurements, this session was conducted in a moderate laboratory environment (22-25ºC) with a fan located in front of the participants with and airflow of 20 km/h. A submaximal test required the participants to cycle on an electronically brake cycle ergometer (Lode Excalibur, The Netherlands) for 6-min at each of four consecutive submaximal power output which was 100 W, 150 W, 200 W, and 250 W. Following a 30-min rest, VO_2max was determined by a ramp protocol with 15 W/min until volitional fatigue. Expired gases were collected continuously (ParvoMedics TrueOne, Murray, Utah, USA) for the determination of ventilation and VO_2 and heart rate (Polar Electro Oy, Finland) were collected continuously throughout both tests. Following this, a linear relationship between the mean rate of VO_2 during the last 2-min of each submaximal stage and power output was determined and used to calculate a power output which would elicit 55% (steady-state) and 75% (time-trial) of VO_2peak for each participant for the remaining three trials.

A familiarization trial was conducted in a warm-humid environment at dry-bulb temperature of 31 ± 0.1ºC and relative humidity of 70 ± 0.7% with a fan located in front of the participants with an airflow of 20 km/h. This session was undertaken to ensure the participants were accustomed to the procedures employed during the investigation and to minimise any potential learning or anxiety effects during experimental trials.

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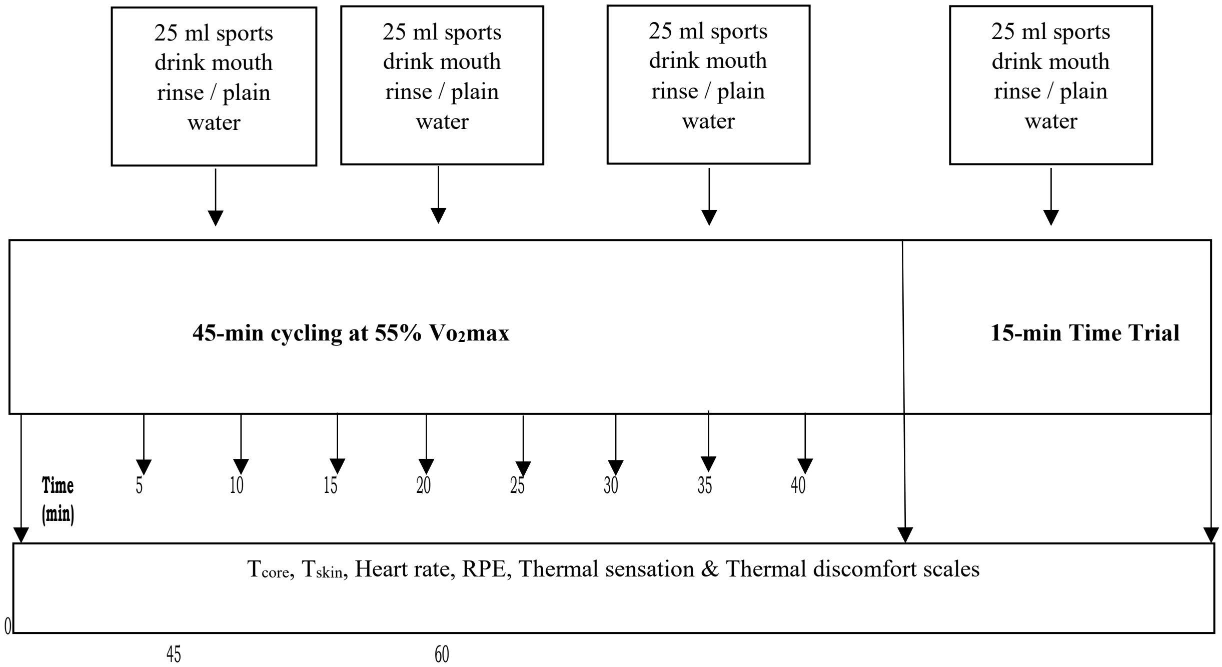

Figure 1. A schematic overview of the experimental protocol.

Experimental Trials

On arrival to the laboratory subjects voided and nude body weight was measures. Participants then self-inserted a rectal thermistor (YSI Incorporated, United State) to depth of 12 cm beyond the anal sphincter and entered the environmental chamber wearing only cycling short, shoes and socks. The heart rate monitor (Polar Electro Oy, Finland) was positioned across the chest and four skin surface thermistors (YSI Incorporated, United State) were attached to the chest, arm, thigh, and calf on the right side of the body. All thermistors were then connected to temperature monitor (Libra Medical Corporation, United States). Weighted mean skin temperature was calculated according to the equation of Ramanathan (1964).

On the ergometer, participants received either 25 ml bolus 100Plus® or plain water (Control), which they rinsed for 10-sec before expectorating into a beaker. Participants cycled for 45-min at the pre-determined power output that estimated to elicit 55% VO_2max with the ergometer set in cadence-independent mode. Every 10-min an expired gas sample was collected for 2-min (ParvoMedics TrueOne, Murray, Utah, USA), and every 5-min heart rate, rectal and skin temperature reading were recorded. Borg's rating of perceived exertion, thermal

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discomfort and sensation scale were taken every 15-min throughout the experimental trials. Every 15-min (at 15, 30 and 45-min) interval, the participants received either 25 ml bolus sports drink or plain water and rinsed the fluid around their mouths for 10-sec, and then spat the fluid back into a beaker.

Immediately on completion of the 45-min steady-state period, the ergometer was set to linear mode, based on the formula of Jeukendrup, Saris, Brouns, & Kester (1996). During this time, the participants were asked to complete as much work as possible in the 15-min with the only information received being when every 3-min had elapsed. Following completion of the time-trial, participants performed a low-intensity cool-down for at least 5-min where recovery was monitored.

Statistical Analysis

The statistical analysis was conducted using SPSS software for Windows (IBM SPSS Statistics 24). Data were checked for normality using Shapiro-Wilk test. Paired sample t-test was used to determine the difference between cycling time trial performance between experimental trials (Control vs. Sports drink) whereas all other measures were analysed by 2-way (trial x time) ANOVA for repeated measures with post-hoc pairwise analyses performed where main or interaction effects occurred, with statistical significance set at $P<0.05$. sphericity was assessed and where the assumption of sphericity could not be assumed, adjustment to the degrees of freedom were made ($\varepsilon > 0.75$ = Huynh-Feldt; $\varepsilon < 0.75$ = Greenhouse-Geisser).

A two-way (trial × time) repeated measures analysis of variance (ANOVA) was conducted to determine the difference between trials on core temperature, skin temperature, heart rate, and RPE. Descriptive values were obtained and reported as means and standard deviation with statistical significance set at $p<0.05$.

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RESULT

Time Trial Performance

The average work completed in the 15-min time trial for the control and sports drink trials were 144.7 ± 15.8 kJ and 126.2 ± 20.2 kJ, respectively *(Figure 2)*. Participants work completed in the 15-min time trial significantly greater ($p<0.05$) during control trial compared with the sports drink trial.

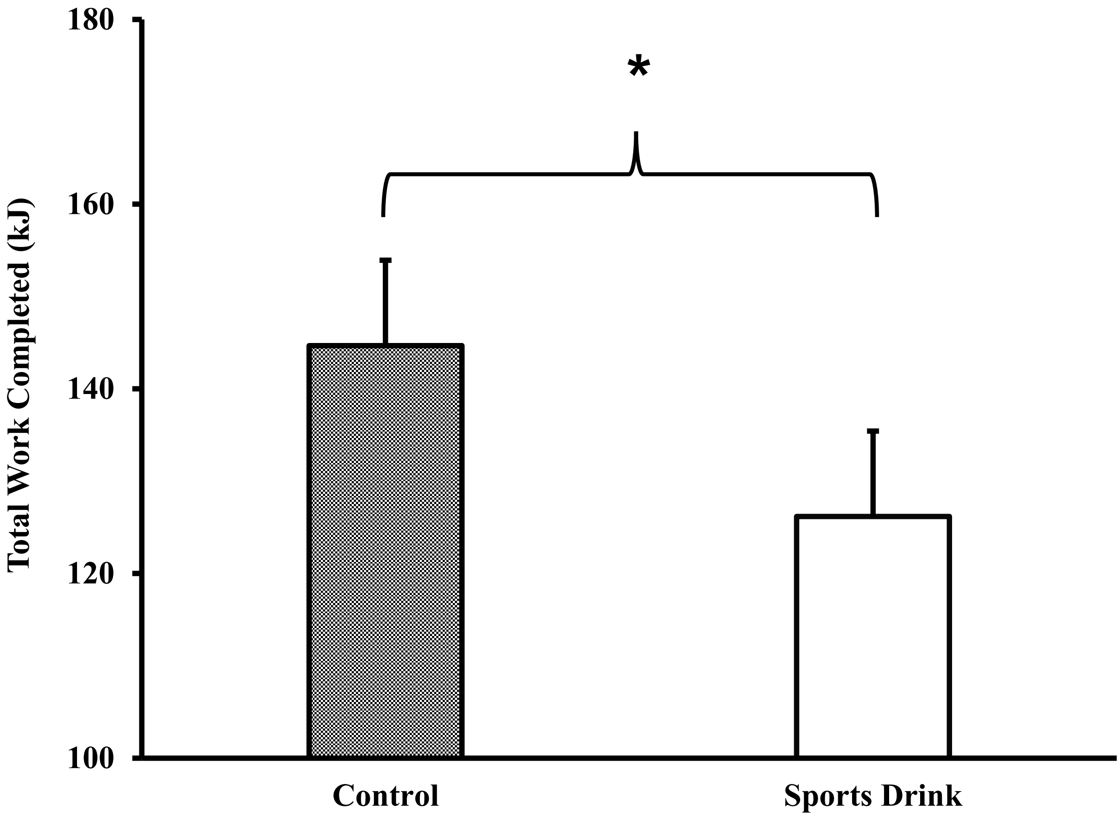

Figure 2. Total work completed (kJ) during 15-min time trial for control and sport drink Mouth rinse trials. Data are expressed as mean ± SD. indicates significantly different to Control.*

Thermoregulatory Responses

Thermoregulatory measures of rectal and mean skin temperatures are depicted in *Figure 3*. There was no significant difference of rectal temperature between control and sports drink trials ($p=0.98$, $p>0.05$). There was a significant effect of rectal temperature with time ($p<0.001$). Pre-

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cycling rectal temperature were similar between both trials (p>0.05; control: 37 ± 0.5ºC; sports drink mouth rinse: 37.1 ± 0.4ºC). Meanwhile during cycling, rectal temperature increased above resting levels from 5-min and continued to rise, such that rectal temperature was higher for sports drink trials during the time trial. Similarly, there was no significant difference of mean skin temperature between control and sports drink trials (p>0.05). However, there was a significant effect of mean skin temperature with time (p<0.001).

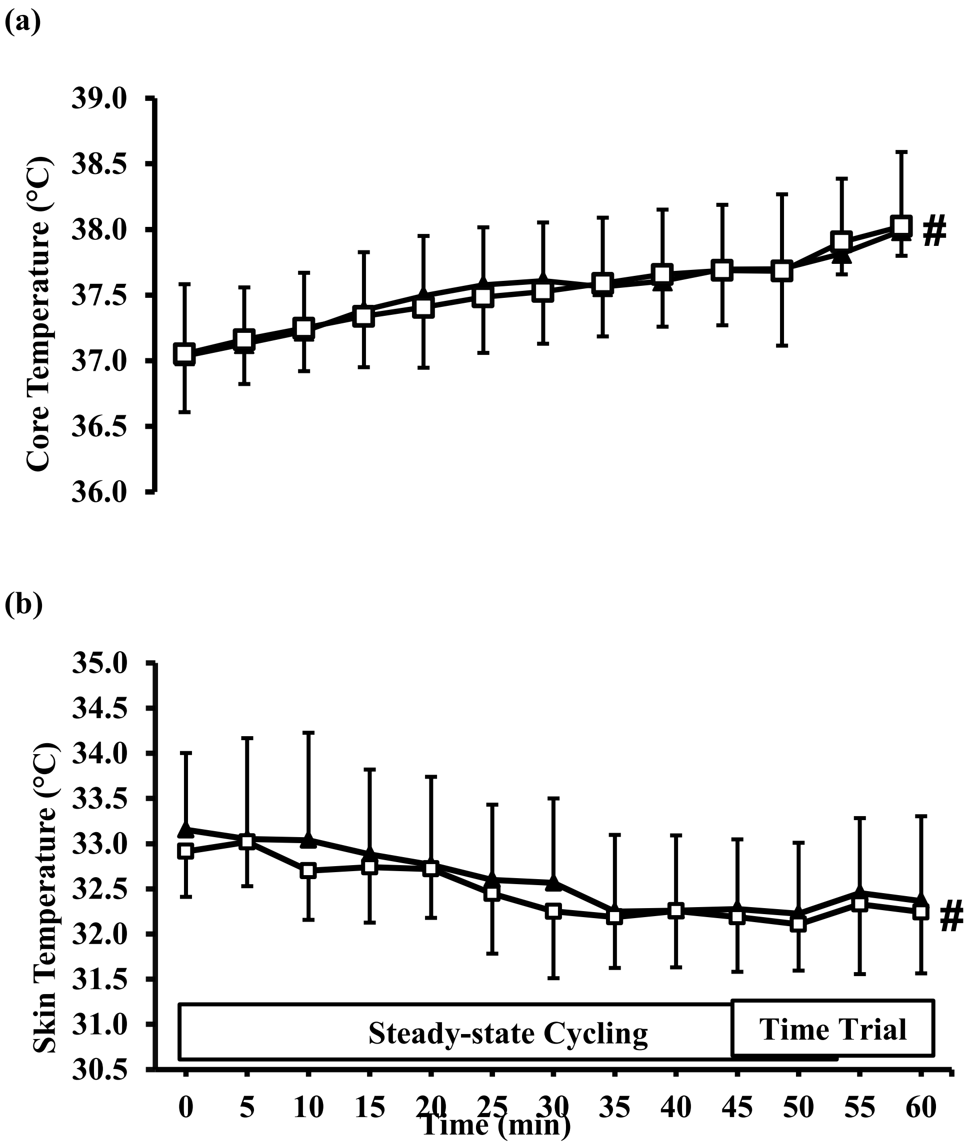

Figure 3: Rectal temperature (a), and mean skin temperature (b) at rest, steady-state cycling and 15-min time trial for control trial (▲) and sports drink trial (□). Data are expressed as mean ± SD.
 # denotes significant main effect of time (p<0.01).

Cardiovascular Response

There was no significant mean difference of heart rate between control and sports drink mouth rinse trials (p=0.831, p>0.05). However, a significant effect of heart rate with time (p<0.001) was observed which increased from 125 ± 18.1 and 125 ± 4.5 bpm after 5-min to 135 ± 16.7 and 136 ± 6.4 bpm at 45-min before increasing further to 148 ± 32.3 and 164 ± 12.7 bpm at the end of the time trial for the control and sports drink mouth rinse trials, respectively *(Figure 4)*.

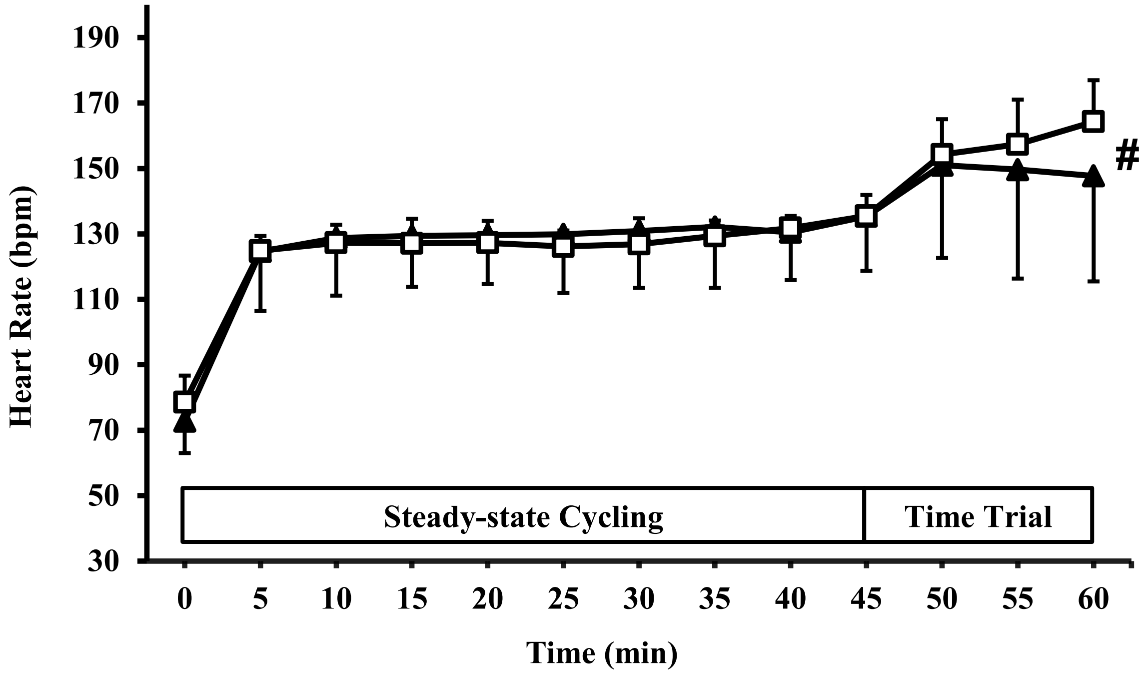

Figure 4: Heart rate for control trial (▲) and sports drink trial (□). Data are expressed as mean ± SD. # denotes significant main effect of time (p<0.01).

Perceptual Responses

There was no significant mean difference of rate of perceived exertion (RPE) between control and sports drink trials (p=0.528, p>0.05). There were significant differences for all mean RPE scores with the time for both control and sport drink trials (p<0.01). As can be seen in *Figure 5*, perceived exertion during steady-state cycling remained constant (10 ± 2) but increased (p<0.05) following time trial (12 ± 3). In thermal discomfort response, there was no significant

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mean difference of thermal discomfort scales between trials (p=0.555, p>0.05). Similarly, no significant mean difference of thermal sensation scales between both trials (p=0.315, p>0.05).

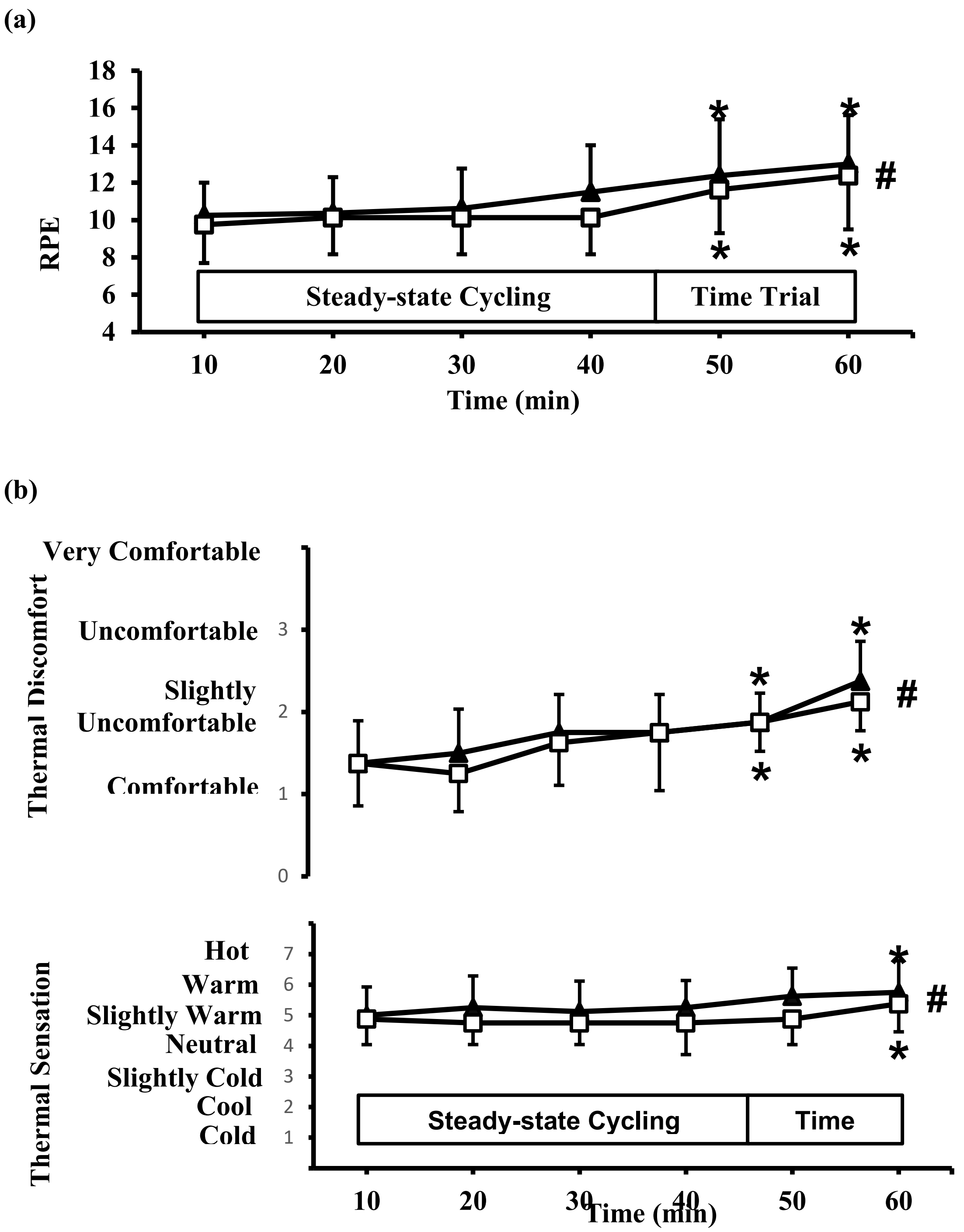

Figure 4: RPE (a), thermal discomfort and thermal sensation (b) for control trial (▲) and sports drink trial (□). Data are expressed as mean ± SD.
 # denotes significant main effect of time (p<0.01).
** denotes a significant difference from 10-min (p<0.05).*

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DISCUSSION

This is the first study investigating the effects of sports drink (100Plus®, Fraser and Neave Limited, Malaysia) mouth rinse on 15-min time trial performance in the warm and humid environment on trained junior cyclists. It was hypothesised that a sports drink mouth rinse prior and during cycling exercise would improve mean work completed in 15-min time trial in trained cyclists. But based on the present result of the time trial, it was clearly showed that sports drink mouth rinse did not improve cycling performance in thermally stress with higher work completed in control (144.7 ± 15.8 kJ) compared to sports drink mouth rinse trials (126.2 ± 20.2 kJ). This outcome is contrary to that of Che Muhamed, Mohamed, Ismail, Aziz, & Singh (2014) who found the enhancement in performance with mouth rinsing among Ramadan-fasted cyclists in hot and humid condition. According to Lane, Bird, Burke, & Hawley (2013), there was an increase in average power output with a 10% CHO solution. However, in accordance with the present time trial result, the previous study of Ferreira et al., (2018) has demonstrated that mouth-rinse intervention was not effective in enhancing the performance of cyclists in the 30-km time trial. This present finding may be somewhat explained by antipathy of sports drinks mouth rinse during exercise as most of participants complained uncomfortable and sticky saliva after a series of sports drink mouth rinsing. Beelen, Berghuis, Bonaparte, Ballak, Jeukendrup, & van Loon (2009) also reported mouth rinsing with an isotonic solution did not improve the 1-h cycling time trial compared to water rinse placebo.

Desbrow, Anderson, Barrett, Rao, & Hargreaves (2004) found that sports drink mouth rinse does not improve the cycling performance during short high-intensity exercises of less than 60-min due to the influence of dietary variables on high-intensity cycling performance of approximately 1-h duration. Watson, Nichols, & Cordery (2014) investigation also failed to support the role of oral sensing of carbohydrate in influencing performance during prolonged exercise in warm conditions, in contrast to several published studies (Fares & Kayser, 2011; Gam, Guelfi, & Fournier, 2013) demonstrating significant improvements in cycle time trial performance in temperate conditions. Although carbohydrate mouth rinse strategy has been included in American College of Sports Medicine (ACSM) as one of the alternatives to

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carbohydrates replacement in short-duration exercises (Ferreira et al., 2018; Thomas, Erdman, & Burke, 2016), the present study did not observe improvements on performance.

Recent evidence showing ergogenic effects of mouth rinsing carbohydrate on endurance performance is substantial. However, there is still a lack of dose-effect research. Wright & Davison (2013) concluded that mouth rinsing with a carbohydrate-electrolytes solution increases endurance running efficiency but there is no dose-response effect with a higher concentration (12%) compared to a standard 6% solution. James et al., (2017) also found that mouth rinsing and expectorating a solution of 7% maltodextrin was routinely correlated with improved cycle time trial output of about 1-h in length for 5-secs during exercise and also increasing the rinsed solution's carbohydrate concentration from 7% to 14% resulted in no further improvement in performance.

The finding of the current study also does not support the previous research with alteration of thermoregulatory response (core temperature) that lead to decrement exercise performance in tropical environments, which had the combination of heat and high humidity environment. Therefore, it was proposed that a high core temperature caused fatigue (Chabert, Hermand, & Hue, 2019). It is surprising that core temperature only reached a maximum of 38ºC at the end of the time trial for both trials and without increasing further to an alarming rate. A significant decline in power output has been observed when core temperature exceeds 38.5ºC (Al-Horani, Wingo, Ng, Bishop, & Richardson, 2018). On the contrary, the finding of the current study on the rectal temperature does not reflect the time trial performances where core temperature peaked around 38.5ºC or less, with the power output maintained. Furthermore, the self-paced time trial was significantly decreased in the hot environment but without differences in performance at a core temperature of 38.2ºC (Ely, Cheuvront, Kenefick, & Sawka, 2010). A possible explanation for core temperature response might be that participants in this study were young and well-trained cyclist who are accustomed to the warm and humid environment as they were regularly training and participating in cycling race throughout the year. Endurance-trained and heat-acclimatised individuals who are well-hydrated have less body heat storage and perform optimally during exercise-heat stress (Sawka, Young, Cadarette, Levine, & Pandolf, 1985). It seems repeated heat exposure leads to a decrease in core temperature during

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experimental trials (Racinais, Sawka, Daanen, & Périard, 2019) 2019). In addition, the researchers speculated that short (less than 2-h) exposure to hot and humid condition in the laboratory during experimental trials was associated with lowering core temperature (below 39ºC) at the end of the exercise.

Regardless, the factors that influence one's RPE during exercise are extremely complicated as RPE is believed to be influenced by various factors, including effort, strain, pain, discomfort and or fatigue (St Gibson, Lambert, Rauch, Tucker, Baden, Foster, & Noakes, 2006). Furthermore, Abbiss, Peiffer, Meeusen, & Skorski (2015) found that there was a dissociation between the RPE and heart rate when exercising at low or maximal such as all-out intensities. However, RPE during steady-state cycling remained constant but increased following time trial based on this present finding. Therefore, the RPE is highest at the end of the time trial due to the participants performing an 'all-out' effort at their self-paced cycling to complete as much work as possible in 15-min time trial. Thus, Bridge, Weller, Rayson, & Jones (2003) reported that exercise in a hot environment showed a higher RPE rating compared to similar exercises in cooler environments, indicating a greater hesitancy to continue exercising. The RPE increased significantly in both trials in the Mündel, King, Collacott, & Jones (2006) study, from subjects rating their exertion as 'light' to values representing exertion as 'very hard ' at the end of exercise. Pires, Brietzke, Pinheiro, Veras, De Mattos, Rodacki, & Ugrinowitsch (2018) observed that the lower RPE slope in the condition of carbohydrate mouth rinse might also be an advantage in time trial competitions, as the slower rise in RPE throughout the trial may enable cyclists to boost the effort at the end of a race. Therefore, the RPE and effort are both considered extremely important in the regulation of intensity during self-paced physical activity (Abbiss et al., 2015).

In summary, one of the more significant findings to emerge from this study is that sports drink (100Plus®, Fraser and Neave Limited, Malaysia) mouth rinse is not the first choice for performance improvement technique compared to other hydration strategies for young well-trained cyclists competing or training in a warm and humid environment. The finding of this research provides insights for one of practical cooling strategy (mouth rinse) strategies to improve exercise performance in real training session and competitions in warm and humid environment. However, the sports drink mouth rinses such 100Plus® strategy appeared to not affect 15-min cycling time trial performance. Nonetheless, when attempting to generalise this study finding, further consideration must be given to some of the limitations of the current research and hence what future research is warranted. The strongest limitation of this work lies in the potential for a placebo effect as compared to water-only control and limited by the absence of diet and physical activity control prior to experimental trials as most of the participants were called up to undergo their training programme.

REFERENCES

Abbiss, C. R., Peiffer, J. J., Meeusen, R., & Skorski, S. (2015). Role of ratings of perceived exertion during self-paced exercise: what are we actually measuring? *Sports medicine, 45*(9), 1235-1243.

Al-Horani, R. A., Wingo, J. E., Ng, J., Bishop, P., & Richardson, M. (2018). Precooling and warm-up effects on time trial cycling during heat stress. *Aerospace medicine and human performance, 89*(2), 87-93.

Ali, A., Moss, C., Yoo, M. J. Y., Wilkinson, A., & Breier, B. H. (2017). Effect of mouth rinsing and ingestion of carbohydrate solutions on mood and perceptual responses during exercise. *Journal of the International Society of Sports Nutrition, 14*(1), 4.

Bastos-Silva, V. J., Araujo, G. G. d., Franco, S. V. d. S., Melo, A. d. A., Learsi, S. K., Lima-Silva, A. E., & Bertuzzi, R. (2017). Carbohydrate mouth rinse reduces rating of perceived exertion but does not affect performance and energy systems contribution during a high-intensity exercise. *Motriz: Revista de Educação Física, 23*(3).

Beaven, C. M., Maulder, P., Pooley, A., Kilduff, L., & Cook, C. (2013). Effects of caffeine and carbohydrate mouth rinses on repeated sprint performance. *Applied Physiology, Nutrition, and Metabolism, 38*(6), 633-637.

Beelen, M., Berghuis, J., Bonaparte, B., Ballak, S. B., Jeukendrup, A. E., & van Loon, L. J. (2009). Carbohydrate mouth rinsing in the fed state: lack of enhancement of time-trial performance. *International journal of sport nutrition and exercise metabolism, 19*(4), 400-409.

Bridge, M. W., Weller, A. S., Rayson, M., & Jones, D. A. (2003). Ambient temperature and the pituitary hormone responses to exercise in humans. *Experimental physiology, 88*(5), 627-635.

Carter, J. M., Jeukendrup, A. E., & Jones, D. A. (2004). The effect of carbohydrate mouth rinse on 1-h cycle time trial performance. *Medicine & science in sports & exercise, 36*(12), 2107-2111.

Chabert, C., Hermand, E., & Hue, O. (2019). Triathlon and Ultra-Endurance Events in Tropical Environments. In *Heat Stress in Sport and Exercise* (pp. 283-296): Springer.

Che Muhamed, A. M., Mohamed, N. G., Ismail, N., Aziz, A. R., & Singh, R. (2014). Mouth rinsing improves cycling endurance performance during Ramadan fasting in a hot humid environment. *Applied Physiology, Nutrition, and Metabolism, 39*(4), 458-464.

Chryssanthopoulos, C., Ziaras, C., Oosthuyse, T., Lambropoulos, I., Giorgios P, P., Zacharogiannis, E., Philippou, A., & Maridaki, M. (2018). Carbohydrate mouth rinse does not affect performance during a 60-min running race in women. *Journal of sports sciences, 36*(7), 824-833.

Desbrow, B., Anderson, S., Barrett, J., Rao, E., & Hargreaves, M. (2004). Carbohydrate-electrolyte feedings and 1h time trial cycling performance. *International journal of sport nutrition and exercise metabolism, 14*(5), 541-549.

Ely, B. R., Cheuvront, S. N., Kenefick, R. W., & Sawka, M. N. (2010). Aerobic performance is degraded, despite modest hyperthermia, in hot environments. *Medicine & science in sports & exercise, 42*(1), 135-141.

Fares, E., & Kayser, B. (2011). Carbohydrate mouth rinse effects on exercise capacity in pre- and postprandial States. *Journal of nutrition and metabolism, 2011*.

Ferreira, A. M., Farias-Junior, L. F., Mota, T. A., Elsangedy, H. M., Marcadenti, A., Lemos, T. M., Okano, A. H., & Fayh, A. P. (2018). Carbohydrate mouth rinse and hydration strategies on cycling performance in 30 km time trial: a randomized, crossover, controlled trial. *Journal of sports science & medicine, 17*(2), 181.

Fraga, C., Velasques, B., Koch, A. J., Machado, M., Paulucio, D., Ribeiro, P., & Pompeu, F. A. M. S. (2017). Carbohydrate mouth rinse enhances time to exhaustion during treadmill exercise. *Clinical physiology and functional imaging, 37*(1), 17-22.

Gam, S., Guelfi, K. J., & Fournier, P. A. (2013). Opposition of carbohydrate in a mouth-rinse solution to the detrimental effect of mouth rinsing during cycling time trials. *International journal of sport nutrition and exercise metabolism, 23*(1), 48-56.

Hanson, N. J., Martinez, S. C., Byl, E. N., Maceri, R. M., & Miller, M. G. (2019). Increased rate of heat storage, and no performance benefits, with caffeine ingestion before a 10-km run in hot, humid conditions. *International Journal of Sports Physiology and Performance, 14*(2), 196-202.

James, R. M., Ritchie, S., Rollo, I., & James, L. J. (2017). No dose response effect of carbohydrate mouth rinse on cycling time-trial performance. *International journal of sport nutrition and exercise metabolism, 27*(1), 25-31.

Jeukendrup, A., Saris, W. H., Brouns, F., & Kester, A. D. (1996). A new validated endurance performance test. *Medicine and Science in Sports and Exercise, 28*(2), 266-270.

Kerksick, C. M., Wilborn, C. D., Roberts, M. D., Smith-Ryan, A., Kleiner, S. M., Jäger, R., Collins, R., Cooke, M., Davis, J. N., & Galvan, E. (2018). ISSN exercise & sports nutrition review update: research & recommendations. *Journal of the International Society of Sports Nutrition, 15*(1), 38.

Kulaksız, T. N., Koşar, Ş. N., Bulut, S., Güzel, Y., Willems, M. E. T., Hazir, T., & Turnagöl, H. H. (2016). Mouth rinsing with maltodextrin solutions fails to improve time trial endurance cycling performance in recreational athletes. *Nutrients, 8*(5), 269.

Lane, S. C., Bird, S. R., Burke, L. M., & Hawley, J. A. (2013). Effect of a carbohydrate mouth rinse on simulated cycling time-trial performance commenced in a fed or fasted state. *Applied Physiology, Nutrition, and Metabolism, 38*(2), 134-139.

Luden, N. D., Saunders, M. J., D'Lugos, A. C., Pataky, M. W., Baur, D. A., Vining, C. B., & Schroer, A. B. (2016). Carbohydrate mouth rinsing enhances high intensity time trial performance following prolonged cycling. *Nutrients, 8*(9), 576.

Maughan, R. J., Burke, L. M., Dvorak, J., Larson-Meyer, D. E., Peeling, P., Phillips, S. M., Rawson, E. S., Walsh, N. P., Garthe, I., & Geyer, H. (2018). IOC consensus statement: dietary supplements and the high-performance athlete. *International journal of sport nutrition and exercise metabolism, 28*(2), 104-125.

Mündel, T., King, J., Collacott, E., & Jones, D. A. (2006). Drink temperature influences fluid intake and endurance capacity in men during exercise in a hot, dry environment. *Experimental physiology, 91*(5), 925-933.

Murray, K. O., Paris, H. L., Fly, A. D., Chapman, R. F., & Mickleborough, T. D. (2018). Carbohydrate mouth rinse improves cycling time-trial performance without altering plasma insulin concentration. *Journal of sports science & medicine, 17*(1), 145.

Pires, F. O., Brietzke, C., Pinheiro, F. A., Veras, K., De Mattos, E. C., Rodacki, A. L., & Ugrinowitsch, C. (2018). Carbohydrate mouth rinse fails to improve four-kilometer cycling time trial performance. *Nutrients, 10*(3), 342.

Racinais, S., Cocking, S., & Périard, J. D. (2017). Sports and environmental temperature: from warming-up to heating-up. *Temperature, 4*(3), 227-257.

Racinais, S., Sawka, M., Daanen, H., & Périard, J. D. (2019). Heat Acclimation. In *Heat Stress in Sport and Exercise* (pp. 159-178): Springer.

Ramanathan, N. (1964). A new weighting system for mean surface temperature of the human body. *Journal of applied physiology, 19*(3), 531-533.

Ruddock, A., Robbins, B., Tew, G., Bourke, L., & Purvis, A. (2017). Practical cooling strategies during continuous exercise in hot environments: a systematic review and meta-analysis. *Sports medicine, 47*(3), 517-532.

Sawka, M. N., Young, A. J., Cadarette, B. S., Levine, L., & Pandolf, K. B. (1985). Influence of heat stress and acclimation on maximal aerobic power. *European journal of applied physiology and occupational physiology, 53*(4), 294-298.

Scrivin, R., & Black, K. (2018). Sports Drinks Consumed During Exercise, Which Affect Thermoregulation and/or Athletic Performance in the Heat: A Review. *Strength & Conditioning Journal, 40*(5), 108-119.

Silva, R. P., Barros, C. L., Mendes, T. T., Garcia, E. S., Valenti, V. E., de Abreu, L. C., Garner, D. M., Espindola, F. S., & Penha-Silva, N. (2019). The influence of a hot environment on physiological stress responses in exercise until exhaustion. *PloS one, 14*(2).

St Gibson, A. C., Lambert, E. V., Rauch, L. H., Tucker, R., Baden, D. A., Foster, C., & Noakes, T. D. (2006). The role of information processing between the brain and peripheral physiological systems in pacing and perception of effort. *Sports medicine, 36*(8), 705-722.

Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: nutrition and athletic performance. *Journal of the Academy of Nutrition and Dietetics, 116*(3), 501-528.

Watson, P., Nichols, D., & Cordery, P. (2014). Mouth rinsing with a carbohydrate solution does not influence cycle time trial performance in the heat. *Applied Physiology, Nutrition, and Metabolism, 39*(9), 1064-1069.

Wright, B. F., & Davison, G. (2013). Carbohydrate Mouth Rinse Improves 1.5 h Run Performance: Is There A Dose-Effect? *International journal of exercise science, 6*(4), 328.

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