Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

THE EFFECT OF COCONUT WATER INGESTION ON INTERMITTENT RUNNING EXERCISE PERFORMANCE

Harris Kamal Kamaruddin

Norhidayah Zamri

Faculty of Sport Science and Recreation, Universiti Teknologi MARA, Perlis Branch, Arau Campus, Malaysia

Hazwani Ahmad Yusof@Hanafi

Lifestyle Science Cluster, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Kepala Batas Pulau Pinang, Malaysia

Al-Hafiz Abu Bakar

Faculty of Sport Science and Recreation, Universiti Teknologi MARA, Perlis Branch, Arau Campus, Malaysia

Received: 23 April 2021 **Accepted: 9 August 2021** **Published: 15 Sept, 2021**

Corresponding Author

Harris Kamal Kamaruddin PhD
E-mail: harris540@uitm.edu.my
Faculty of Sports Science and Recreation,
Universiti Teknologi MARA,
Perlis Branch, Arau Campus, 02600 Arau Perlis, Malaysia.

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

THE EFFECT OF COCONUT WATER INGESTION ON INTERMITTENT RUNNING EXERCISE PERFORMANCE

Harris Kamal Kamaruddin[1], Norhidayah Zamri[2], Hazwani Ahmad Yusof@Hanafi[3], & Al-Hafiz Abu Bakar[4]

[124]Faculty of Sport Science, Universiti Teknologi MARA, Perlis Branch, Arau Campus, Arau Perlis, Malaysia

[3]Lifestyle Science Cluster, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Bertam, Kepala Batas Pulau Pinang, Malaysia

ABSTRACT

This research investigated the effects of coconut (COC) water ingestion during exhaustive intermittent running exercise performance. On separated two trials, 12 recreational male athletes (age 20 ± 2 years, body mass 59.9 ± 5.9 kg, fat percentage 11.8 ± 5.4%) completed a Yo-Yo Intermittent Recovery Test-Level 1 (Yo-yo IRT-1), running to exhaustion in a randomised counterbalanced order. The subjects were given 4 $mL{\cdot}kg^{-1}$ of either COC or carbohydrate-electrolyte (CHO-e) solution to be ingested prior to exercise. The distance covered, level of exhaustion, heart rate (HR), blood glucose, rating of perceived exertion (RPE), perceived arousal scale (FAS), and gastrointestinal discomfort (GI) were recorded intermittently during each trial. The distance covered with COC did not differ significantly from those data with CHO-e (CHO: 1066.7 ± 449.4 m; CHO-e:1106.7 ± 554.9 m, p = 0.85). There were also no significant differences in HR, RPE and FAS GI comfort between the trials (all p > 0.05) expect for GI (p< 0.05). The blood glucose was increased at the exhaustion of exercise, although, no significant difference was observed between the trials (p > 0.05). Ingesting COC provided no ergogenic benefits during intermittent running exercise compared to CHO-e. The result of the current study suggests that COC ingestion and CHO-e were incapable of reducing perceive exercise intensity during the trials.

Keywords: *Running, Carbohydrate, Yo-Yo IRT-1, Exhaustion, Coconut*

INTRODUCTION

Coconut (COC) water is high in potassium, contains sodium, chloride and carbohydrate with naturally composition characteristics (Kalman et al., 2012). A cup of COC water 100 mL per serving contains about 10 g of sugars contributing up to 46 calories. It also contains 173.5 mg of potassium (12% - 14% of daily value), 40-60 mg of sodium (2% - 3% of daily limit) and up to (49 mg) 6% and (15 mg) 10% of the daily calcium and magnesium needs, respectively (Prades et al., 2012). It is also being seen as the rehydration electrolyte drinks because of its mineral properties. The COC has a large amount of calcium, mineral and selenium, which is not found in carbohydrate electrolyte (CHO-e) sports drink (Yong et al., 2009). According to Kalman and colleagues (2002), the COC water is useful as an oral rehydration aid to recover electrolyte waste from the gastrointestinal from patients suffering severe dehydration due to diarrhoea. The COC water has an antioxidant property, which was also described as giving the same hydrating impact as CHO-e sports drink (Chaubey et al., 2017). According to Martins and Waldschutz (2012), COC ingestion seems to restore blood glucose faster than CHO-e.

Furthermore, COC water ingestion to improve blood volume restoration after conducting the experimental trial using a gradient exercise treadmill running compared to CHO-e [1]. Similarly, a study by Chaubey and colleagues (2017), shown an ergogenic benefit to increase exercise performance on walking exercise at self-selected speed to exhaustion by sodium enriched COC drink compared to CHO-e sports drink and plain water. Professional tennis player John Isner credited the role of COC water as a sports drink by re-boosting his energy to remain in good performance for his epic 11-hours marathon Wimbledon tennis tournament, where he became the winner (Passe et al., 2009). The new commercialized concern in COC water as a tropical sports drink have given better outcome on the rehydration advantages of potassium (Pérez-Idárraga & Aragón-Vargas, 2014). Thus, COC water has been applied as rehydration drink because it has been demonstrated to have a moderately low rehydration scale and has low sodium but a high potassium content (Ismail et al., 2007).

The benefits of COC ingestions as rehydrating beverages were widely studied (Chaubey et al., 2017; Kalman et al., 2012; Prades et al., 2012; Saat et al., 2002), however, the effect of COC ingestion as energy drinks or to be consumed before exercise was limitedly studied. A study by Laitano and colleagues (2014) investigated the effect in ergogenic benefits of COC water ingestion before exercise during cycling capacity. The author examined the effect of pre hydration of COC ingestion on the urine output, GI distress and cycling capacity in the heat compared to plain water and flavoured drink. The limitation of this study was the use of flavoured drink (orange) was less likely to provide ergogenic benefit compared to caloric contained CHO beverages. To date, the study exploring the effect of COC water ingestion is still inconclusive. In spite of that, many ingestion studies mostly shown ergogenic to exercise performance due to rehydration aspect (Chaubey et al., 2017; Kalman et al., 2012). The effectiveness of COC water as an energy drink before exercise is yet to be discovered.

While many studies have shown that COC water as prominent rehydrating beverages compared to CHO-e (Chaubey et al., 2017; Kalman et al., 2012), the use of COC water as the main source of energy beverages before exercise remains inconclusive. To date, a study by Martins and Waldschutz (2012) demonstrated that COC water was proven to improve endurance power (VO_{2peak}) among ageing athletes. According to Saat and colleagues (2002), the intake of fresh young COC water as a pure tropical fruit refreshing electrolyte could be utilized for entire body rehydration after physical activity. However, the true potential of COC water as energy drinks during real performance testing could be still be argued. Hence, most of the study investigated the COC water as rehydrating drinks after exercise for recovery and the potential of its ergogenic property as energy drinks persist indecisively. Yet, there was a lack of study to elucidate the COC water as energy drinks, particularly before exercise. Thus, this could be a novelty to examine the performance outcome after the fluid intake. Therefore, the purpose of this study is to investigate the effect of COC water as the main source of energy drinks during the prolonged endurance exercise test.

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

MATERIALS AND METHODS

Subjects

A total of 12 recreational male athletes participated in the present study (age 20 ± 2 years; body mass 59.9 ± 5.9 kg; height 1.71 ± 0.03 m; body mass index 20.6 ± 1.9 kg.m^{-2}; fat 12 ± 5 %;). Subjects were runners who trained 2-3 times a week (~ 45 min/day) and were physically active in 5 km and 10 km running competitions. All subjects were initially recruited with the following inclusion criteria; had no history of major lower limb problems, a non-smoker, did not report any history of cardiovascular, metabolic, neurological, or orthopaedic disorders, volunteered to participate in this study. The subject's characteristics were shown in Table 1. This study was a double-blinded study in which the subjects were not completely informed of the actual purpose of the study and were told that there were 2 type of solutions used during the intermittent running test. All results were untold from the subjects until the end of the study when they were debriefed. This study was approved by UiTM Faculty's Research Ethics Committee (600-UiTMPs (HEA/KPP/KK-5/2) Bil(22) following the Helsinki guidelines.

Table 1: Demographic Characteristic of Subjects

Characteristics	Mean ± SD
N	12
Age (years)	20 ± 2
Body Mass (kg)	59.9 ± 5.9
Height (m)	1.71 ± 0.03
Body Mass Index (kg·m^{-2})	20.6 ± 1.9
Fat (%)	12.0 ± 5.0
Pre-exercise hydration (USG)	1.012 ± 0.003

STUDY DESIGN

The study used a double-blind, randomized design between the subject trials. The COC water and CHO-e experimental trials were blinded and randomized between the subjects. Each subject visited the laboratory on 3 separate occasions. The first visit took place 1 week prior to the experimental trials to familiarize them with the experimental procedures. During the visit,

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

the subject's anthropometric measurement and dietary intake were recorded. Then, subject was briefed on the equipment, scale and performed 20 m Yo-Yo Intermittent Recovery Test Level 1 (Yo-Yo IRT-1) running test. This will allow the subject to familiarised with the equipment, procedure and running protocol. Next, the subjects were engaged with subsequent 2 trials, which consisted of by Yo-Yo IRT-1 until exhaustion. During the Yo-Yo IRT-1 exercise protocol, heart rate (Polar FT1, Kempele, Finland) and blood glucose (Accu-check Perfoma, Mannheim, Germany) were measured. The psychological scale of perceived exertion (RPE) [15], arousal level (FAS) (Svebak & Murgatroyd, 1985) and gastrointestinal comfort (GI comfort) (Rollo et al., 2010) were recorded intermittently during the exercise. All exercise trials began between 0800 h to 1100 h and were conducted in an indoor court. The time interval between experimental trials was 7 days washout periods. The subjects were instructed to avoid alcohol and caffeine consumption 24 h prior to exercise testing and replicated their dietary intake before subsequent trials. The schematic diagram of the exercise protocol is shown in Figure 1.

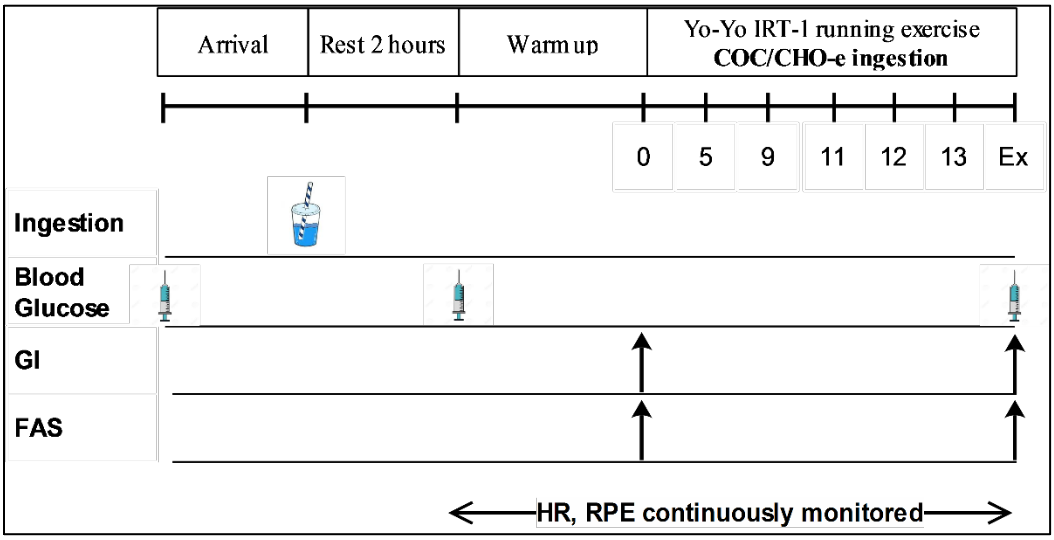

Figure 1. Schematic Representation of the Experimental Protocol. GI: Gastrointestinal Scales, FAS: Perceives Activation Scale, HR: Heart Rate, RPE: Rating Perceived Exertion

Visit 1: Familiarization

The first visit consists of the anthropometric measurements of the stature and body weight of each subjects. After a standardized warm-up, the running test was conducted at 20 m runs by

PENERBIT PRESS UNIVERSITI TEKNOLOGI MARA

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

Yo-Yo IRT-1. During this trial, the subjects were briefed on the experimental protocols and all the procedures. The subjects were equipped with all measuring devices, such as polar heart rate, blood glucose and rating perceived exertion (RPE), perceived activation scale (FAS) and gastrointestinal comfort scale (GI). The subjects signed a consent form before the trial begins on visits 2 and 3.

Visit 2-3: Experimental trials

On the day of the trial, upon arrival, the urine and blood glucose sample were collected to determine the urine specific gravity (USG) using a refractometer (Atago, Tokyo, Japan) and blood glucose concentration using (Accucheck Active, Manhein Germany). Thereafter, the subjects consumed a standardized high CHO breakfast that contained 2.5 $g \cdot kg^{-1}$ body mass of CHO (149.75 ± 14.8 g). This breakfast consists of a combination of glycemic index foods [14]. The subjects rested in an air condition (24˚C) room for 2 hours. After rest, the subjects subsequently used the instrument to perform a standardized warm-up and engaged with the Yo-Yo IRT-1 intermittence running exercise. The subjects were asked for their subjective RPE on a categorical scale of 6 – 20 Borg scale (Borg, 1982) at every level during the Yo-Yo IRT-1 test. Their heart rate was measured continuously and monitored telemetrically with a short-range transmitter-receiver (Polar FT1, Kempele, Finland). Once the Yo-Yo IRT-1 completed, the subjects dismount and removed the instrument.

Yo-Yo Intermittent Recovery Test-Level 1 (Yo-Yo IRT-1)

The Yo-Yo IRT-1 test was conducted at the indoor court with a width of 1.5 m and a length of 20 m. In brief, Yo-Yo IRT-1 consists of two 20 m runs (down and back) at a progressively increasing speed, which was controlled by auditory cues from an overhead speaker. Each running period was dispersed by a 10 second active recovery bout where the subjects walk or run around a marker placed 5 m behind the starting line. The subjects were allowed two fails in the test to consider complete and the distance recorded. A fail was indicated by a researcher if any of the subject fails to traverse the initial 20 m leg of the test or change direction and reach the finishing line in time. To ensure accurate administration of the testing protocol, group sizes

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

were limited to no more than five subjects. This protocol has been used by the previous researcher during CHO-e beverage study (Dolan et al., 2017). The schematic diagram of the Yo-Yo IRT-1 exercise protocol is shown in Figure 2. The test had a high reliability and validity (*r* = 0.71) in assessing physical capacity and fitness performance (Krustrup et al., 2003).

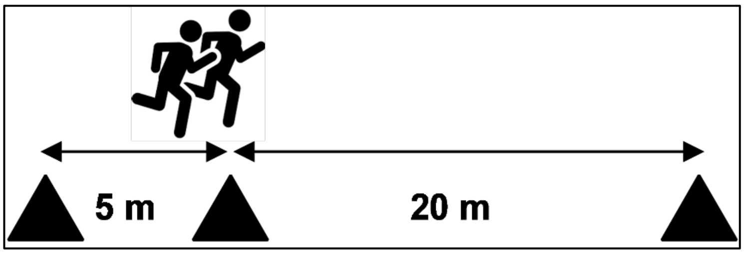

Figure 2: Schematic Diagram of Yo-Yo Intermittent Recovery Test- Level 1

STATISTICAL ANALYSIS

To determine the sample size, this study used the previously reported differences in perceived exertion (RPE) during an exercise session (Dolan et al., 2017). Calculated that that six subjects were needed to detect this association with a two-tailed; a = 0.05 and 1-b = 0.80 [18]. All results were presented as mean ± standard deviation (Dupont & Plummer, 1990). The main effect of solution of (level and distance covered) were used a repeated measure ANOVA with Bonferroni correction. If there was a significant difference detected, a post-hoc paired sample T-test was used to compare the effect of COC water and CHO-e ingestion on intermittent running performance. Continuous variables, such as HR and RPE scale were analysed using one-way repeated measure ANOVA with Bonferroni Post-Hoc adjustment for multiple comparison. All data in this study were analysed using the IBM SPSS Statistic version 25.0 (IBM Corporation, Chicago IL., USA).

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

RESULTS

Exercise Performance

The mean running distance covered recorded was 1066.7 ± 449.4 and 1106.7 ± 554.9 m for COC and CHO-e trials, respectively (Figure 3). The statistical analysis revealed that was no significant differences for distance covered between all trials (t (733) = 0.189, p = 0.854). The level of exhaustion was recorded at level 16 ± 1 and 16 ± 2 for COC and CHO-e trials at the exhaustion, respectively (Figure 4). The statistical analysis revealed that there was no significant difference between all trials (t (2) = 0.001, p = 1.000).

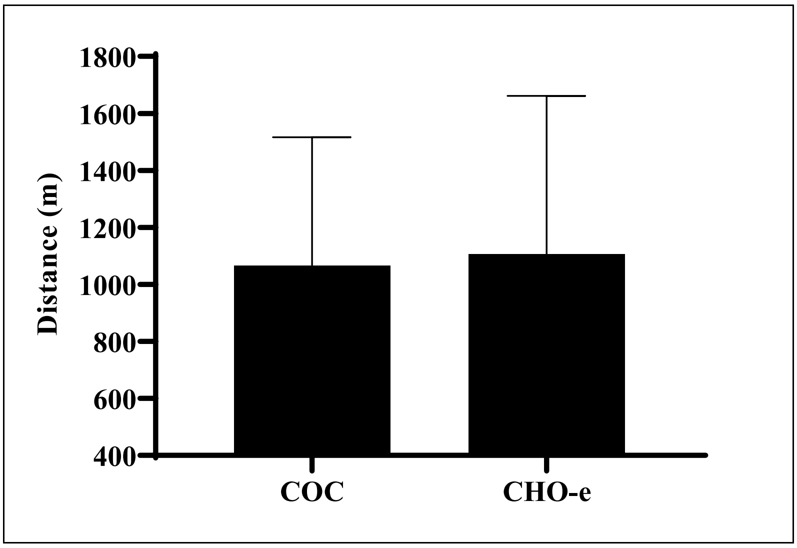

Figure 3: The Distance Covered for COC and CHO-e trials. Data presented in mean ± SD.

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

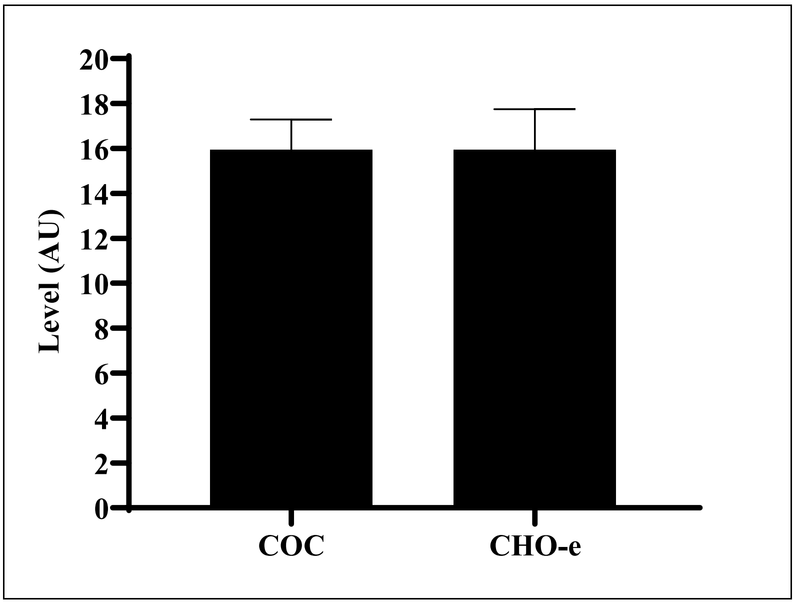

Figure 4: The Level of Exhaustion for COC and CHO-E Trials. Data presented in mean ± SD. AU: arbitrary unit.

Heart Rate and Metabolic Response

The mean heart rate was steadily increased throughout the exercise with 185.8 ± 8.9 b.min^{-1} and 183.4 ± 12.6 b.min^{-1} for COC and CHO-e trials during exhaustion, respectively (Figure 5). One-way repeated measure ANOVA analysis revealed that there was a significant effect of time (F = 259.83; df = 2; p = 0.001). However, there was no significant effect between the solutions (F = 0.57; df =2; p = 0.626). The mean blood glucose recorded at pre- and post-exercise for COC were at 6.2 ± 2.2 mmol·L^{-1} and 5.4 ± 0.9 mmol·L^{-1}; 6.0 ± 2.5 mmol·L^{-1} and 5.3 ± 1.3 mmol·L^{-1} for CHO-e (Table 2). One-way repeated measure ANOVA analysis revealed that there was no significant effect of time (F = 3.74; df = 1; p = 0.066) and no significant difference on solutions (F = 0.39; df = 1; p = 0.53).

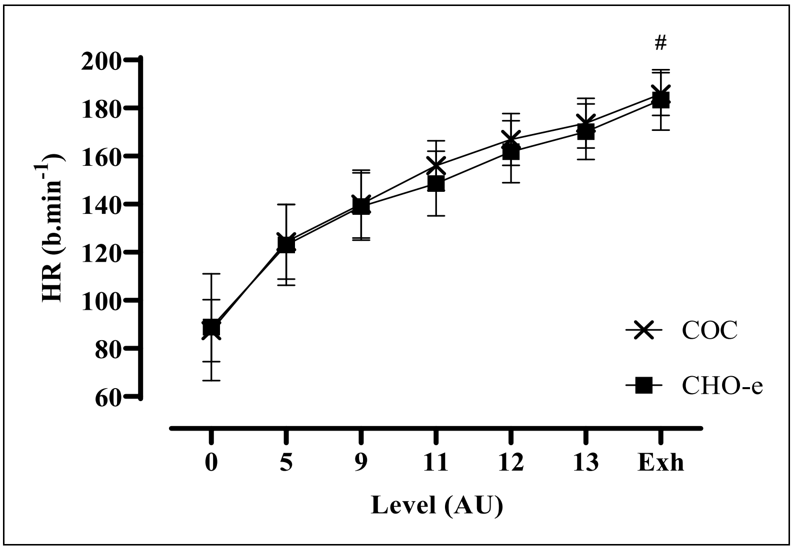

Figure 5: Mean Heart Rate (mean ± SD) Response During Yo-Yo IRT-1 for COC Water (COC) and Carbohydrate-electrolyte (CHO-e). # Significant effect of time (p < 0.001)

Table 2. Mean Blood Glucose (mean ± SD) responses at pre and post during Yo-Yo IRT-1 for COC and CHO-e.

Blood Glucose ($mmol{\cdot}L^{-1}$)	Pre	Post
COC	6.2 ± 2.2	5.4 ± 0.9
CHO-e	6.0 ± 2.5	5.3 ± 1.3

Note: Data presented in mean ± SD.

Psychological Response

The RPE increased steadily throughout the exercise for all the trials (Figure 6A). The rating of perceived exertion was recorded at exhaustion 17.0 ± 1.5 and 17.7 ± 1.7 for COC and CHO-e trials, respectively. There was a significant difference in the effect of time (F = 218.99; df = 2; p < 0.001), however, no significant difference was found in the effect of solutions (F = 0.64; df = 2; p = 0.55). Gastrointestinal comfort was recorded at pre- and post-exercise at 1.0 ± 1.3 and 2.4 ± 2.4; 0.8 ± 0.9 and 3.4 ± 2.2 for COC and CHO-e trials, respectively (Figure 6B). Similarly, gastrointestinal comfort value showed a significant difference in time (F = 21.59; df = 1; p < 0.001), however, no significant differences between the solutions in trials (F = 1.83; df = 1; p = 0.18). The FAS recorded at pre- and post-exercise at exhaustion was 3.1 ± 1.2 and 3.2 ± 0.9; 3.1 ± 1.6 and 2.9 ± 1.0 for COC and CHO-e trials, respectively (Figure 6C). The statistical analysis revealed that there was no significant difference in the effect of time (F =

0.017; *df* = 1; *p* = 0.89) and as expected, there was no significant difference in the effect between solutions (F = 0.15; *df* = 1; *p* = 0.70).

DISCUSSION

The main finding of this study indicated that COC ingestion does not have any ergogenic benefit on intermittent running performance compared to CHO-e (Figure 3). The physiological variables of heart rate do not have any differences compared to CHO-e trials. Similarly, the psychological responses of RPE, FS and GI were similar throughout the exercise.

The present results were in line with a study by Kalman and colleague (2012), which indicated that COC ingestion did not improved distance covered during exhaustive running exercise. Furthermore, a study by Peart et al. (2017) explained that COC ingestion did not elevate the markers for hydration during sub-maximal exercise and performance in a subsequent 10 km cycling time-trial compared to water ingestion alone. The authors explained that the lack of improvement from COC ingestion during cycling exercise was relatively due to the small amount of COC ingested (250 mL), which was impractical to influence the exercise performance (Peart et al., 2017). Similarly, Chaubey et al. (2017) showed that the difference was not statistically significant between plain water, COC water, CHO-e and sodium enriched olive COC drink during a graded exercise using a treadmill, which required the subjects to exercise until volitional exhaustion. In the present study, the amount of solution given to the subjects was ~ 239.6 mL of COC prior to the exercise. We speculated that the small amount of COC ingested was not able to provide any ergogenic benefit during Yo-Yo IRT-1, as previously observed (Peart et al., 2017).

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

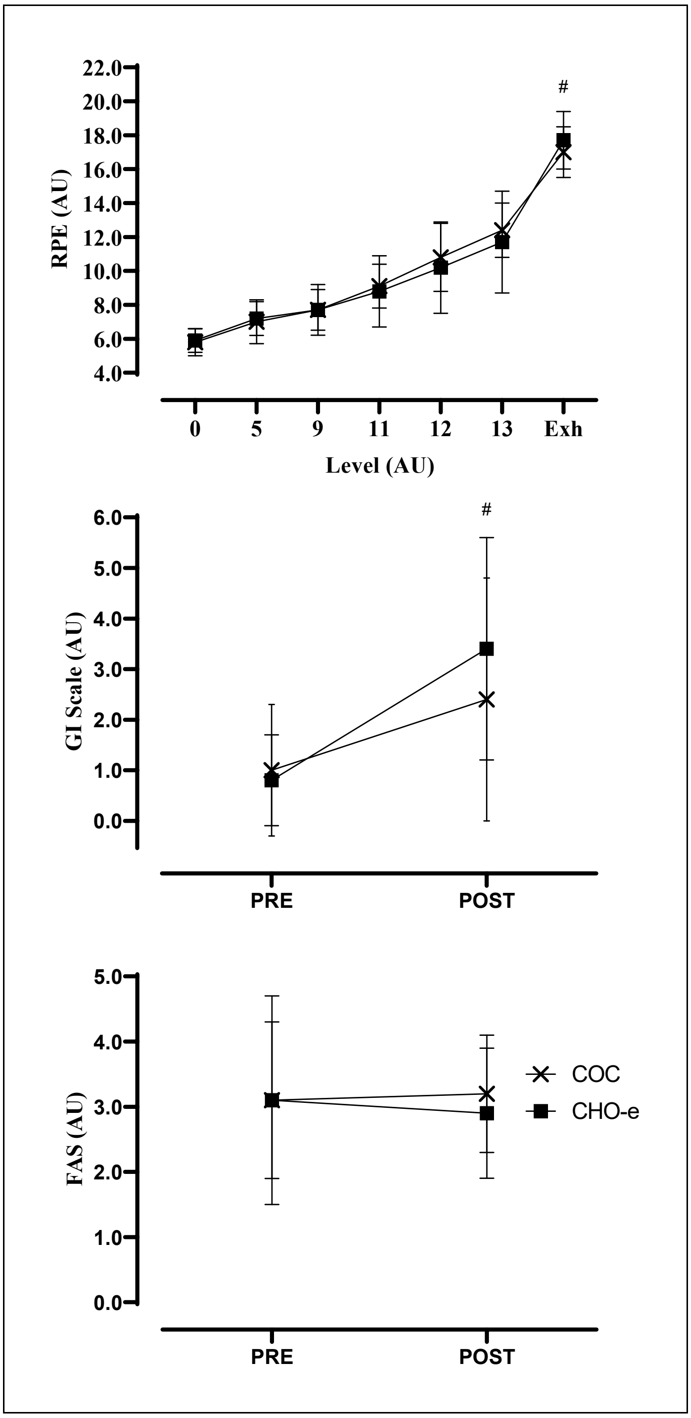

Figure 6. Psychological responses at pre- and post-Yo-Yo IRT-1 for COC and CHO-e. A: Rating perceived exertion (RPE); B: Gastrointestinal scale (Gi); Perceived arousal level (FAS). #significant effect of time ($p < 0.001$)

Another potential reason that there was a lack in the benefits of COC ingestion before exercise was the gastrointestinal discomfort during exercise. The COC ingestion was reported to increase the risk of stomach upset, where the subject somewhat felt bloated and experience

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

mild stomach discomfort during exercise (Kalman et al., 2012). Numerous studies reported similar findings of gastrointestinal discomfort when consuming fluid, particularly, among runners, during exercise (Dion et al., 2013; Peters et al., 2000; Sharwood et al., 2004). Indeed ~50% of endurance runners of endurance athletes experience some level of gastrointestinal issues during exercise (Beis et al., 2012). Moreover, Martins and Waldschutz (2012) suggested that athletes should drink an adequate amount of fluids necessary to maintain the optimal hydration while exercising regularly to prevent the sensation of epigastric fullness during exercise. The data observed in this study showed that the level of gastrointestinal discomfort (Figure 6B) was indifference between solution, thus, indicated that the subjects performed in less stomach discomfort. Therefore, the gastrointestinal discomfort was less likely to affect the Yo-Yo IRT-1 exercise performance due to COC or any kind of fluid ingestion.

Despite the lack of ergogenic benefits of COC ingestion, few studies have shown a positive effect during exercise performance. The study by Martins and Waldschutz (2012) showed that COC ingestion restores the blood glucose levels faster and keeps the levels within the physiological range compared to CHO-e beverages. During exercise, the rate of glucose intake by the active muscles was 20 times greater than the resting state. The blood glucose concentration was regulated by the process of glycolysis or gluconeogenesis (Xiong et al., 2011). In order to provide the essential amount of carbohydrate, a high rate of fluid replacement could be reached at rest even when the CHO concentration is high. Hence, the presence of glucose in COC ingestion makes it an interesting electrolyte for the restoration of both fluid and glucose during the rehydration state (Martins & Waldschutz, 2012). In contrast to the previous reports, this present study showed that the ingestion of either COC or CHO-e does not result in changes in the blood glucose level (Table 2).

Other than that, the benefits of COC ingestion was its palatability because subjects found it to be sweeter than other drinks and were likely to cause upset stomach, which allowed better compliance in the ageing population. Moreover, the unavailability of exercise-associated muscle cramp (EAMC) after COC ingestion is in contrast to carbohydrate-electrolyte beverages (CEB) group, where COC ingestion is known as a better source of cytokines (kinetin) found in nature (Ge et al., 2005). The action of cytokines as an anti-inflammatory

Malaysian Journal of Sport Science and Recreation
Vol. 17. No. 2, 188 - 205, 2021.
DOI: https://doi.org/10.24191/mjssr.v17i2.15388

factor in response to stress to the muscle fibre has already been demonstrated in the pertinent and relevant literature (Appell et al., 1992). In addition, a study by Saat and colleagues (2002) stated that COC water has been used as oral rehydration in patients with diarrhoea to replace fluid loss from the gastrointestinal tract (Chavalittamrong et al., 1982) and in an extreme situation, such as short term intravenous hydration fluid in a patient (Campbell-Falck et al., 2000).

As with blood glucose, COC water did not effect the heart rate, RPE, and FAS during the Yo-Yo IRT-1 (Table 2, Figure 6A and Figure 6C, respectively). The absence of physiological differences between the conditions may well explain the insignificant effect of COC water solution. Kalman and colleague (2012) reported the same result, where no difference was noted between the conditions for heart rate, systolic blood pressure, or diastolic blood pressure. The current study of COC ingestion elucidated no reduction in RPE with the effect of time. The result of the current study suggests that COC ingestion and CHO-e were incapable of reducing the perceived exercise intensity during the trials. As it may be due to the high-intensity mode of the exercise, which required the subjects to run and maintain the fixed running pace as long as possible and they could not pace themselves. It elucidated the high intensity because the subjects have to maintain an increasing workload at each level with increasing speed through running. Jeukendrup and colleagues (2008) also observed that water ingestion (this study used CHO beverage) showed no significant improvement during high-intensity cycling exercise.

Moreover, in the present study, there was no difference shown in the FAS result during Yo-Yo IRT-1 (Figure 6C). A slight difference was noted between COC ingestion and CHO-e in the markers of exercise performance, where additional studies with more demanding exercise protocol will be needed in the future. Most research regarding fluid ingestion prior to or during exercise has been conducted in young well-trained athletes or sports students and does not accurately reflect the physiological status of ageing athletes that have been conducted by Martins and Waldschutz (2012). The study indicated that fresh young COC water used by ageing athletes has greater benefits compared to CEB with regards to improving exercise endurance by completing the cardiopulmonary fitness testing.

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

This study was limited as it was impossible to taste-match between COC and CHO-e beverages given to the subjects. However, it controlled this limitation by the double-blind and randomized procedures employed in this study. The true purpose and beverages given to the subject were remained untold until the completion of the exercise trials.

CONCLUSION

Considering the above, our data showed that running performance of recreational athletes in the Yo-Yo IRT-1 was not significantly impacted by ingesting COC compared to CHO-e. Additional study is needed with the inclusion of a more demanding exercise protocol, aiming at enhancing the performance obtained in the present investigation may be warranted. While Yo-Yo IRT-1 is routinely used in performance studies, the use of a time trial test as the measure of exercise performance may be more appropriate. Investigators may consider these suggestions when designing future studies focused on the potential to measure performance associated with the ingestion of COC or other beverages.

Acknowledgement

The authors would like to thank the staff members of Exercise Physiology Laboratory, Faculty of Sports Science and Recreation, Universiti Teknologi MARA Perlis, Malaysia.

REFERENCE

Appell, H.-J., Soares, J. M. C., & Duarte, J. A. R. (1992). Exercise, muscle damage and fatigue. *Sports Medicine*, *13*(2), 108–115.

Beis, L. Y., Wright-Whyte, M., Fudge, B., Noakes, T., & Pitsiladis, Y. P. (2012). Drinking behaviors of elite male runners during marathon competition. *Clin J Sport Med*, *22*(3), 254–261. https://doi.org/10.1097/JSM.0b013e31824a55d7

Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*, *14*(5), 377–381.

Campbell-Falck, D., Thomas, T., Falck, T. M., Tutuo, N., & Clem, K. (2000). The intravenous use of coconut water. *The American Journal of Emergency Medicine*, *18*(1), 108–111.

Chaubey, A., Sharma, M., & Bhatnagar, B. (2017). Comparitive Study on Coconut Water, Carbohydrate Electrolyte Sports Drink and Sodium Enriched Coconut Drink on Measures of Hydration and Physical Performance in Athletes. *IORS*, *4*(3), 46–51.

Chavalittamrong, B., Pidatcha, P., & Thavisri, U. (1982). Electrolytes, sugar, calories, osmolarity and pH of beverages and coconut water. *Magnesium (MEq/L)*, *16*(1.61), 1–2.

Dion, T., Savoie, F. A., Asselin, A., Gariepy, C., & Goulet, E. D. B. (2013). Half-marathon running performance is not improved by a rate of fluid intake above that dictated by thirst sensation in trained distance runners. *European Journal of Applied Physiology*, *113*(12), 3011–3020. https://doi.org/10.1007/s00421-013-2730-8

Dolan, P., Witherbee, K. E., Peterson, K. M., & Kerksick, C. M. (2017). Effect of Carbohydrate, Caffeine, and Carbohydrate + Caffeine Mouth Rinsing on Intermittent Running Performance in Collegiate Male Lacrosse Athletes. *J Strength Cond Res*, *31*(9), 2473–2479. https://doi.org/10.1519/jsc.0000000000001819

Dupont, W. D., & Plummer Jr., W. D. (1990). Power and sample size calculations. A review and computer program. *Control Clin Trials*, *11*(2), 116–128.

Ge, L., Yong, J. W. H., Goh, N. K., Chia, L. S., Tan, S. N., & Ong, E. S. (2005). Identification of kinetin and kinetin riboside in coconut (Cocos nucifera L.) water using a combined approach of liquid chromatography–tandem mass spectrometry, high performance liquid chromatography and capillary electrophoresis. *Journal of Chromatography B*, *829*(1–2), 26–34.

Ismail, I., Singh, R., & Sirisinghe, R. G. (2007). Rehydration with sodium-enriched coconut water after exercise-induced dehydration. *Southeast Asian Journal of Tropical Medicine and Public Health*, *38*(4), 769.

Jeukendrup, Hopkins, S., Aragon-Vargas, L. F., & Hulston, C. (2008). No effect of carbohydrate feeding on 16 km cycling time trial performance. *Eur J Appl Physiol*, *104*(5), 831–837. https://doi.org/10.1007/s00421-008-0838-z

Kalman, D. S., Feldman, S., Krieger, D. R., & Bloomer, R. J. (2012). Comparison of coconut water and a carbohydrate-electrolyte sport drink on measures of hydration and physical performance in exercise-trained men. *Journal of the International Society of Sports Nutrition*, *9*(1), 1. https://doi.org/10.1186/1550-2783-9-1

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Pedersen, P. K., & Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine & Science in Sports & Exercise*, *35*(4), 697–705.

Laitano, O., Trangmar, S. J., Marins, D. de M., Menezes, E. S., & Reis, G. da S. (2014). Improved exercise capacity in the heat followed by coconut water consumption. *Motriz: Revista de Educação Física*, *20*(1), 107–111.

Lane, S. C., Bird, S. R., Burke, L. M., & Hawley, J. A. (2013). *Effect of a carbohydrate mouth rinse on simulated cycling time-trial*. *139*(November 2012), 134–139.

Martins, A., & Waldschutz, D. (2012). Coconut Water as a Sports Drink and Its Effects on the Fitness of Aging Athletes. *Asian Journal of Exercise & Sports Science*, *9*(2).

Passe, D. H., Stofan, J. R., Rowe, C. L., Horswill, C. A., & Murray, R. (2009). Exercise condition affects hedonic responses to sodium in a sport drink. *Appetite*, *52*(3), 561–567.

Peart, D. J., Hensby, A., & Shaw, M. P. (2017). Coconut water does not improve markers of hydration during sub-maximal exercise and performance in a subsequent time trial compared with water alone. *International Journal of Sport Nutrition and Exercise Metabolism*, *27*(3), 279–284.

Pérez-Idárraga, A., & Aragón-Vargas, L. F. (2014). Postexercise rehydration: potassium-rich drinks versus water and a sports drink. *Applied Physiology, Nutrition, and Metabolism*, *39*(10), 1167–1174.

Peters, H. P., Wiersma, J. W., Koerselman, J., Akkermans, L. M., Bol, E., Mosterd, W. L., & de Vries, W. R. (2000). The effect of a sports drink on gastroesophageal reflux during a run-bike-run test. *Int J Sports Med*, *21*(1), 65–70. https://doi.org/10.1055/s-2000-8858

Prades, A., Dornier, M., Diop, N., & Pain, J.-P. (2012). Coconut water uses, composition and properties: a review. *Fruits*, *67*(2), 87–107.

Rollo, I., Cole, M., Miller, R., & Williams, C. (2010). Influence of mouth rinsing a carbohydrate solution on 1-h running performance. *Med Sci Sports Exerc*, *42*(4), 798–804. https://doi.org/10.1249/MSS.0b013e3181bac6e4

Saat, M., Singh, R., Sirisinghe, R. G., & Nawawi, M. (2002). Rehydration after exercise with fresh young coconut water, carbohydrate-electrolyte beverage and plain water. *Journal of Physiological Anthropology and Applied Human Science*, *21*(2), 93–104.

Sharwood, K. A., Collins, M., Goedecke, J. H., Wilson, G., & Noakes, T. D. (2004). Weight changes, medical complications, and performance during an Ironman triathlon. *British Journal of Sports Medicine*, *38*(6), 718–724. https://doi.org/10.1136/bjsm.2003.007187

Svebak, S., & Murgatroyd, S. (1985). Metamotivational dominance: a multimethod validation of reversal theory constructs. *J Pers Soc Psychol*, *48*(1), 107.

Xiong, Y., Lei, Q. Y., Zhao, S., & Guan, K. L. (2011). Regulation of glycolysis and gluconeogenesis by acetylation of PKM and PEPCK. *Cold Spring Harbor Symposia on Quantitative Biology*, *76*, 285–289.

Yong, J. W. H., Ge, L., Ng, Y. F., & Tan, S. N. (2009). The chemical composition and biological properties of coconut (Cocos nucifera L.) water. *Molecules*, *14*(12), 5144–5164.