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Abstract

Background: Supplementation in the form of sports drinks has in latter years become an integral part of professional and amateur exercise. Currently much of the research is directed at carbohydrate-electrolyte (CE) drink supplementation for exercises lasting one hour or above and has been shown to improve performance. However the effects of supplementation prior to and during intense, short term exercise on performance is less understood. Therefore the purpose of the present study was to investigate the effects of ingesting different CE drinks prior and during exercise on an 8km time trial (TT) performance against a placebo.

Methods: Fifteen male subjects were randomised in a balanced double-blinded repeated measures crossover manner to consume three drinks A (8% CHO), B (5% CHO) and C (placebo) 5min prior (4.0 ml.kg^{-1}) and 1.0 ml.kg^{-1} at 3 and 6km during the 8km cycle TT. Tests were performed on standardised cycle ergonometers at room temperature (18-22°C) with seven days between trials.

Results: Time taken to complete the time trials were not significantly different between drink treatments A (11.43±1.31min), B (12.02±1.3min) and C (11.73±1.44). Mean heart rate for drink C (169±12.26bpm) and drinks B and A had slower heart rates of 1.7bpm and 3.7bpm respectively with no significant differences between drink treatments (p=0.388). No differences were found in physiological measurements of mean change in RPE, RPM, body weight and systolic and diastolic blood pressure, between drink treatments.

Conclusions: Performance and physiological function during a maximal cycling exercise lasting approximately 10min (8km) is not improved or limited by endogenous substrate availability prior and during the event.

Introduction

Sports drinks are used by a wide variety of athletes. They are consumed in association with sport to provide the edge over other competitors; at a professional level this is very important. Sports drinks can be simply defined as a liquid mainly comprised of water, with other nutrients and substances dissolved within, to create an ergogenic aid (Shirreffs, 2003). The main aims of sports drinks are to stimulate rapid fluid absorption, supply carbohydrate and other nutrients as substrates in exercise, speed up rehydration, reduce physiological stress and promote recovery after exercise (Shirreffs, 2003).

Maintaining a euhydrated fluid level is very important, as a fluid loss through sweat of only one percent can put strain on the cardiovascular and thermoregulatory systems, which in turn results in a reduction in exercise performance (Gonzalez-Alonso et al., 2000). A meta-analysis by Gigou et al. (2010) provides strong evidence that dehydration decreases aerobic performance measured as maximal oxygen uptake (VO_{2max}) was found to decrease by 2.9% for each percent loss fluid loss in bodyweight when above a threshold loss of 3.1% bodyweight compared to a euhydrated control (Aldridge et al., 2005).

Different variables can be manipulated to alter the functional characteristics of a sports drink. Varying carbohydrate (CHO) content, osmolality, electrolyte content, flavouring and the inclusion of other nutrients, has resulted in the creation of three sports drink types; isotonic, hypotonic and hypertonic. The commercially produced isotonic drink is the drink of choice by many athletes, consisting of 6-7% CHO and electrolytes, allowing for fast absorption and a CHO boost (Mettler et al., 2006).The standard isotonic sports drink encompasses the traditional ingredients CHO and sodium, however they now include other additives such as CHO polymers (maltodextin), Niacin and a variety of B vitamins (B5, B6 and B12).

Isotonic sports drinks appear to have a similar absorption rate to water as Hill et al. (2008) established when using a one hour treadmill exercise (55% heart rate max) to test three isotonic sports drinks with similar CHO (6-8 %), sodium (23-41mg per 100ml) content on 37 subjects. Bonetti and Hopkins (2010) compared the effects of three available sports drinks against a water control, consumed throughout a two hour fixed intensity cycle followed by a peak power test of sixteen subjects. The isotonic drinks compared to the hypotonic had the greatest effect on performance.

The consensus that prolonged exercise greater than one hour can be increased through the consumption of carbohydrate electrolyte drink is commonly accepted and demonstrated by many studies (Khanna & Manna, 2005; Below et al., 1995; Maughan et al., 1996). On the other hand, limited studies have investigated the effect of CHO electrolyte sports drinks on exercise performance of lasting less than thirty minutes. One study did however find that supplementing fifty-two undergraduate subjects with 24 ounces of Gatorade before a leg raising endurance activity, helped participants to keep their leg raised for longer (187s) compared to a water control (75s) (Freidman & Elliot, 2007). The cause of these ergogenic effects may have been due to carbohydrate receptors being stimulated in the mouth (Carter et al., 2004; Chambers et al., 2009). Contradicting evidence from studies conducted by Palmer et al. (1998) and Powers et al. (1990) indicates ingesting a drink containing 7% CHO had no effect on high intensity exercise lasting 30min.

Ingesting carbohydrate solutions more concentrated than 6-8% is not beneficial as consuming higher doses does not increase rates of exogenous glucose oxidation (Wagenmakers et al., 1993) and has been found to induce gastric discomfort limiting performance (Nieuwenhoven et al., 2005). Sports drinks more commonly included CHO a glucose, however many sports drinks include maltodextrin, a polymer of several glucose molecules. Maltodextrin is useful for endurance athletes as it produces a greater CHO concentration (10-20g per 100ml) yet maintains a low osmolarity giving fast absorption, allowing slower breakdown (Bean, 2010).

Sodium is an important ingredient of a sports drink as it promotes fluid retention and replacement, preventing performance decrements through dehydration. Shirrefs and Maughan (1998) supplemented six subjects hypohydrated by 2% with 0, 25, 50 and 100mmol/L Na+ drink after exercise induced hypohydration (2% body weight). They found higher amounts of sodium helped to maintain a higher net fluid balance by reducing urine volume excretion. Including 60mmol of Na+ to a drink increases the appetite for the drink as well as enhancing fluid absorption and uptake (Passe at al. 2009; Wald & Leshem, 2003).

B vitamins are commonly added to sports drinks based merely on scientific theory that they will enhance performance, whereas experimental proof is scarce. Niacin (vitamin B_3) is a main component of the coenzyme nicotinamide adenine dinucleotide, a carrier for hydrogen ions and electron accepters in energy systems. Evidence for performance enhancement is controversial as Frankau (1943) used 40-50mg doses of niacin and stated an increase in agility, whereas Hilsendager and Karpovich (1964) found it had no positive effect on a hand endurance test. The RDA for niacin is 6.6mg/1,00kcal, yet there is no present evidence to suggest a deficiency inhibits performance (Driskell & Wolinsky, 2006). Vitamin B_6 aids in the breakdown of amino acids for energy, conversion of alanine to glucose and utilization of muscle glycogen. People consuming more protein require more B_6 and a deficiency has led to reduced exercise performance (Suboticanec et al. 1990). Vitamin B_5 (pantothenic acid) acts as a coenzyme which helps in the synthesis of Acetyl coenzyme A, a vital coenzyme used in energy transfer between the energy systems glycolysis and the tricarboxylic acid cycle. Contrary to its scientific importance, no studies have found B_5 to have a direct effect on performance (Driskell & Wolinsky, 2006). Vitamin B_{12} is crucial for cell growth and replication. It acts as coenzymes in two reactions methylcobalamin in methione synthase and adenosykolamin in methyl malonyl CoA mutase. Numerous studies have investigated the effects of B_{12} performance, however none have found a significant effect (Read & McGuffin, 1983; Tin-May-Tan et al., 1978).

Although all of these ingredients are included and marketed in hype by many sports drink companies, it is questionable whether they actually have an ergogenic effect on short term performance. To investigate this, the purpose of the present study was to develop and evaluate the effects of different sports drinks against a placebo on the performance and physiological function during repeated 8km time trials. During the trials measurements of time to complete, heart rate, RPE, RPM and were taken, to assess performance and physiological function.

Material and Methods

Design
Participants completed three intervention trials in a repeated measure, randomised cross over design at room temperature (mean 20°C). The cycle trial consisted of an eight kilometre time trial (TT), which was repeated for three weeks and each week a different sports drink was consumed, (drinks A, B, C [placebo]) in a randomised double blinded manner. If a subject was absent from one of the trials, the trial was repeated in a fourth week. Physiological measurements were recorded during the TTs.

Participant selection
The fifteen male undergraduate student volunteers, aged 21.3±1 years (mean n=6), with a mean weight and height of 82.2±15.4kg and 182±6cm respectively, were selected from the University of Plymouth. All subjects regularly participated in various exercises, three days a week. Prior to participation in the study, all subjects completed a physical activity questionnaire (to ensure they met physical activity inclusion criteria), a health screening questionnaire and consent form. Subjects were instructed to refrain from exercising for twenty-four hours and consumption of alcohol and caffeine twelve hours prior to physiological testing. Subjects recorded their diet twenty-four hours prior to the first trial and were required to repeat the same diet before the second and third trials. Subjects did not drink any fluid for one hour before each trial.

Drink Protocol
Three groups of students developed three sports drinks (drinks A, B and D) based on available ingredients (table 1). Due to a lack of time only two sports drinks were selected to be used in the trials (drinks A, B), and a Robinsons sugar free orange drink placebo acted as a control (drink C). The placebo was prepared and provided by the project advisors prior to testing. The ingredients of the drinks A, B, C and D designed, are outlined in table 1. The drink ingredients were multiplied according to create a 10L solution to be used by all three groups over the three trials. After formulation a double blinded approach was taken as the drink was labelled and prior to the exercise test and prepared in different containers, to be provided to the students on the morning of the trial.

The volume of drink consumed by each participant was dependant on the body mass of the assessed individual, 4.0 ml.kg^{-1} body mass of sports drink was consumed five minutes before the TT and 1.0 ml.kg^{-1} body mass at 3km and 6km into the TT. It was recommended for subjects to use their own drinking bottle to ensure comfortable ingestion.

Drink preparation
To create the 10L drink D solution, 4ml of 1% Niacin solution was measured to give 40mg, 2ml of 1% vitamin B_5 solution to give 20mg, 4ml of 0.1% vitamin B_6 solution to give 4mg and 0.2ml of 0.0001% B_{12} solution to give μg. B_3, B_5, B_6 solutions were measured using 10ml pipettes, B_{12} 1ml pipette and emptied into a 2000ml measuring beaker. This solution was diluted with water to make up one litre and then equally split into two 5L tubs. One litre of Robinson's sugar free orange squash was measured using the 2000ml beaker and added to each 5L tub. A digital scale, plastic cups and plastic spoons were used to measure 150g of maltodextrin, 50g of glucose,

and 4g of salt to each tub. A further 3.5L of water was added to each tub and ingredients were mixed together using a whisk. Both 5L tubs were labelled and stored in a refrigerator for use in the three trials. Similar drink preparation methods were used to formulate drinks A and B.

Table 1. Maximum amount of ingredients allowed to be used in the sports drink and ingredients for a 500ml solution for drinks A, B, C and D.

Drink Ingredients	Max amount of ingredients allowed to use	Sports Drinks (per 500ml)			Placebo C (per 500ml)
		A	B	D	
Glucose	25g	20g		5g	Sugar free orange squash concentrate
Maltodextrin	25g	20g	25g	15g	
Sodium	0.4g	0.125 g	0.4 g	0.4g	
Niacin (B_3)	3.1mg	2.0 mg	2.55 mg	2mg	
Pantothenic acid (B_5)	2.0mg	0.75 mg	0.9 mg	1mg	Water
B6	0.4mg	0.3 mg	0.3 mg	0.2mg	
B12	0.2 µg	0.15 µg	0.15 µg	0.1mg	

Cycling trial

The subjects were familiarised with all of the equipment and performed a warm up period on a cycle ergometer prior to the 8km TT. The subjects were then instructed to cycle at a set preferred resistance which was recorded and repeated throughout all of the trials. The subjects were also required to cycle 8km in the quickest time possible. After completion of the TT the subjects kept active until the body reached its pre-exercise state.

Physiological assessment

Body weight (BW) was measured at the start and completion of the TT using digital scales. Height was recorded at the start using a stadiometer. Time to complete was recorded using a stopwatch. Heart rate as beats per minute (bpm) was continuously recorded at 15-s intervals using a short range telemetry device (Polar A1, Polar Electro, Kempele, Finland). RPM was recorded continuously at 15-s intervals, from the display of the cycle ergometer. Rate of perceived exertion (RPE) was assessed every minute throughout the trial using the 15 point Borg scale. Systolic (SBP) and diastolic (DBP) blood pressure was recorded at rest and on completion of the TT using the OMRON IntelliSense M10-IT upper arm blood pressure monitor.

Statistical analysis

Data from the three trials were analysed using the 'Statistical Package for the Social Sciences', computer software. Paired t-tests were used to analyse the significant difference between the means of two groups of data, such as pre and post body weight, DBP and SBP. The difference in effects of the three drink treatments on all of the variables were analyzed using a repeated measures one-way ANOVA (Gravetter & Wallnau, 2004). A significant difference was accepted if the tests present a p value below 0.05. Bar charts were produced using SPSS and were presented with the mean, plus or minus one standard deviation (SD).

Results

Hypothesis

Ho: There is no difference in effect of sports drink A, B and C on time to completion, heart rate, revolutions per minute, body weight and systolic and diastolic blood pressure, during an 8km time trial.

H1: There is a difference in effect of sports drink A, B and C on time to completion, heart rate, revolutions per minute, body weight and systolic and diastolic blood pressure, during an 8km time trial.

The effects of drinks A, B and C on Time to Completion
The results from a repeated measures one-way ANOVA (ANOVA) (table 2), show that drink treatment B induced the fastest mean time to completion (11.43±1.31min) and time to completion for drinks A and C were slower by 4.9% and 2.6% respectively. However results from the ANOVA indicate that there is no significant difference in time to complete (p=0.088) between drink treatment groups A, B and C (table 2). Although there is no difference between groups, there is a trend of significance as the p value is close to p=0.05 and the SD are low, therefore the data is accurate. Fourteen of the fifteen subjects were analysed as one was excluded due to not completing one of the time trials.

Table 2. The difference in effect between drinks A, B and C on time to completion.

Physiological/ Performance Measure	Sports Drink	Mean	Standard Deviation	Subjects	P value
Time to completion (min)	Drink A	12.02	1.3	14	0.088
	Drink B	11.43	1.31	14	
	Drink C	11.73	1.44	14	

The effects of drinks A, B and C on Heart Rate
An ANOVA shows that drink C produced the highest mean heart rate throughout the trial (169±12.26bpm n=15) with drinks B (168.04±9.78bpm, n=13) and A (166.07±15.89bpm, n=15) having slower heart rates of 1.7bpm and 3.7bpm respectively. However there is no significant difference in mean heart rate between the three drink treatment groups (p=0.388). As there was no effect on the variable between drink groups, an ANOVA was performed on mean change from rest to peak heart rate and showed drink B (113.85±28.29bpm) had less change in HR, followed by drinks C (116.39±10.43bpm) and A (166.47±14.13bpm) respectively (figure 1). The difference in effect on mean change in heart rate between drink treatments A, B and C was not significant (p=0.921) (figure 1). Rest HR data for subjects five and six in drink B and C trials were missing, so they were excluded from the ANOVA test.
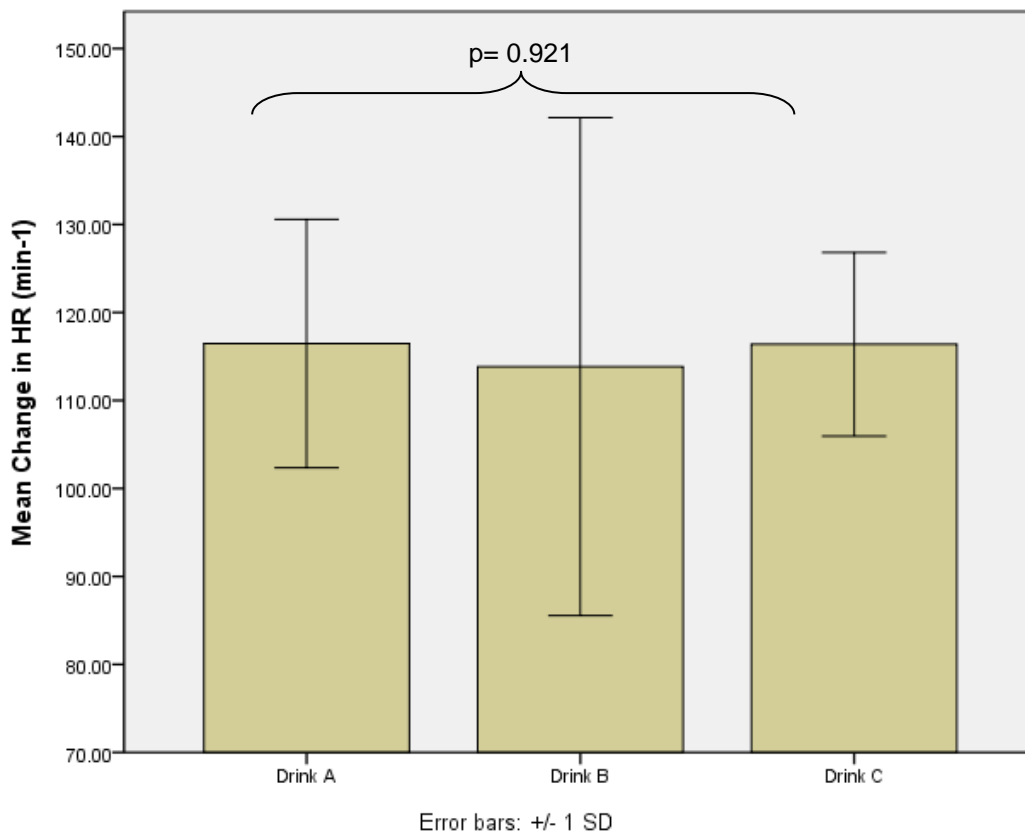
Figure 1. The differences in effects of sports drinks A(n=15), B (n=13) and C (n=13) on mean subject change in resting to peak HR (bpm), 166.47±14.13, 113.85±28.29, 166.39±10.43 respectively.

Figure 2 presents the effects of each drink A, B and C on mean subject heart rate over time, from 15s to 9.45min as some subjects finished before others and the mean would not show an accurate representation. Figure 2 indicates that from the start at 15s HR for the placebo drink C is consistently higher by 5-10 bpm, up until approximately 3.15min into the TT. Heart rate is fairly consistent from 5.30min to 10min TT, yet drink B has a greater mean HR from 5min to 9.45min.
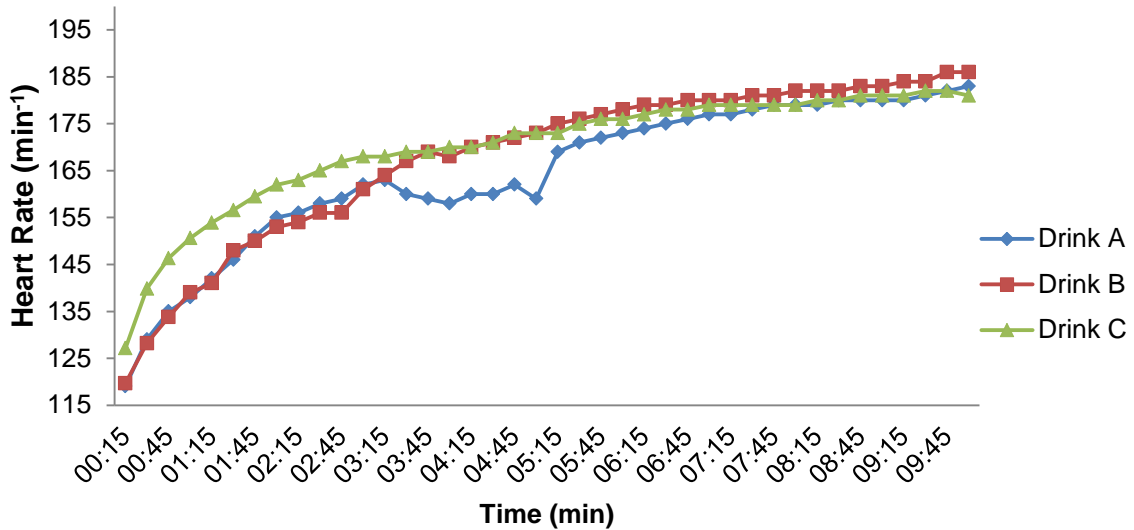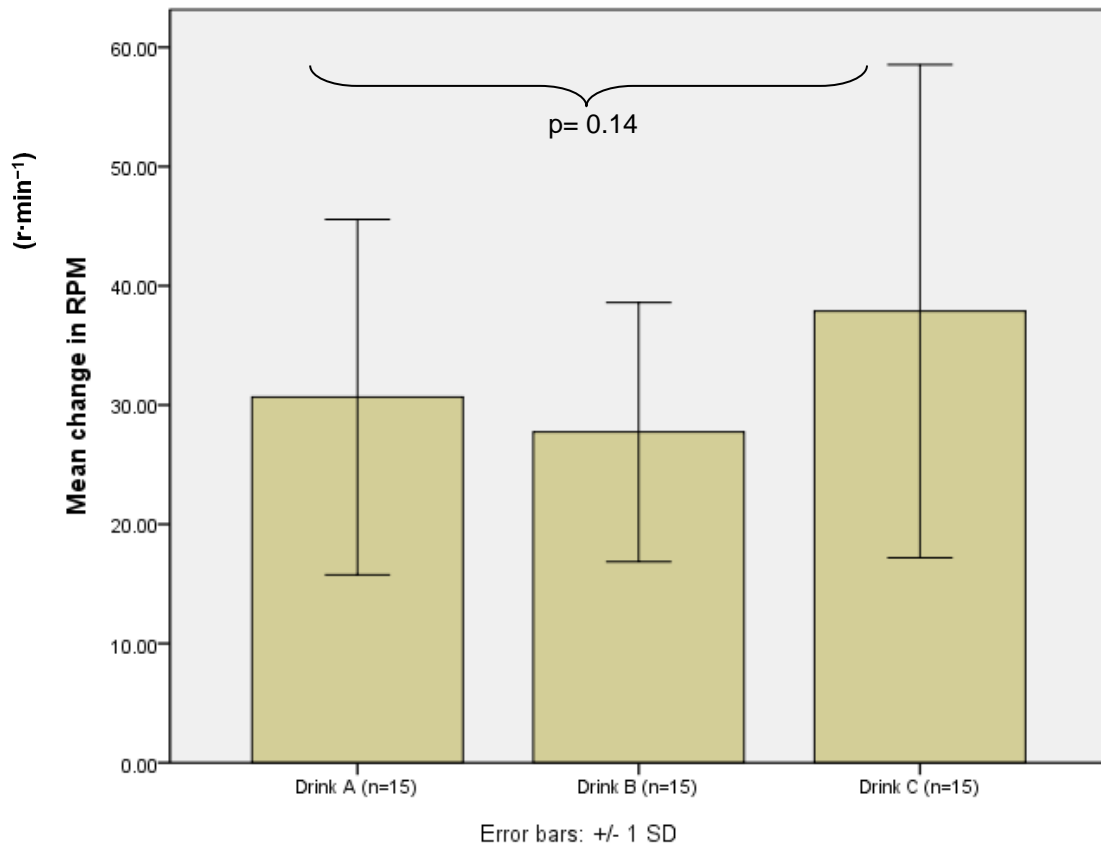
Figure 2. The differences in effects of the three drink treatments on subject mean heart rate over exercise duration (min).
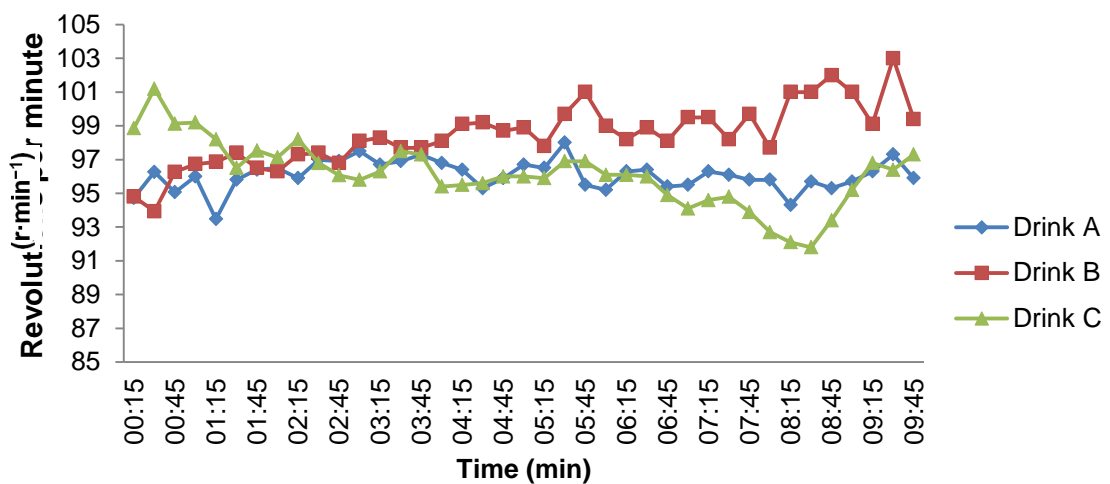
The effects of drinks A, B and C on Revolutions per Minute

Analysis of data through use of an ANOVA**,** shows the mean RPM of fifteen subjects, is fastest in those who consumed drink B (99.92 ± 10.12r.min^{-1}), and was slower by 2.62% (drink C 96.13 ± 12.94r.min^{-1}) and 3.41% (drink A, 96.92 ± 10.12r.min^{-1}) respectively. These results also indicated no significant difference in mean RPM ($p=0.248$) between the three drink groups. A secondary ANOVA was performed on mean change in RPM from the lowest to highest value for each subject. The mean values of change in RPM appear different, however the SDs overlap, rendering the difference in effect between groups non-significant ($p=0.14$) (figure 3).

RPM for subjects consuming drinks A, B and C varies over the duration of the time trial. Figure 4 represents mean student RPM for each of the drinks from 15s to 9.45min as some subjects finished before others and the overall mean would not be an accurate representation. Three minutes into the TT, drink B has the highest consistent mean RPM over time remaining above 97r.min^{-1}. RPM for drink C starts the highest but gradually begins to slow down and decreases dramatically at 6.30min to approx. 90r.min^{-1}, then begins to increase at 8.30min. Mean subject RPM is consistently the same for all drink treatments between 93-97r.min^{-1} throughout the duration of the cycle.

Figure 3. The differences in effects of sports drinks A, B and C on mean subject change in lowest to highest RPM value (p=0.14) (Mean values for RPM (r.min^{-1}) change for drink A, B and C are 30.67±14.91, 27.74±10.87 and 37.87±20.69 respectively.

Figure 4. The differences in effects of the three drink treatments, on subject mean RPM over exercise duration (min).
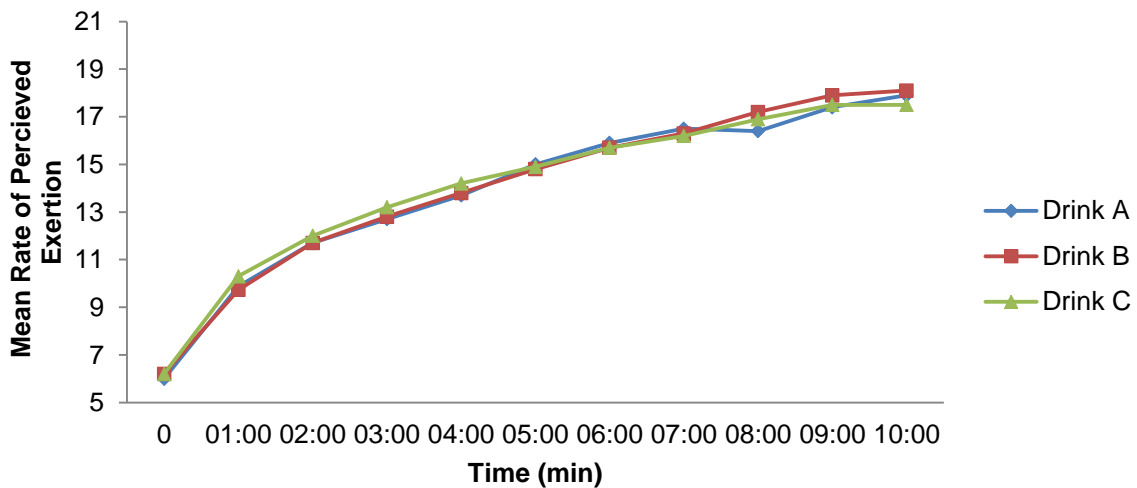
The effects of drinks A, B and C on Rate of Perceived Exertion
Table 3 shows that subjects who consumed drink B had the lowest mean RPE of
14.66±1.7, followed by RPE increases of 0.04 and 0.14 drinks A and C respectively.
The SD values for these data are very small showing a degree of accuracy. The
ANOVA also provides a p value of 0.956 indicating that there is no significant
difference between the effects of drinks A, B and C on mean RPE (table 6).

Table 3. The difference in effect of drinks A, B and C on mean rate of perceived exertion.

| Physiological/ Performance Measure	Sports Drink	Mean	Standard Deviation	Subjects	P value
Mean Rate of Perceived exertion (RPE)	Drink A	14.7	1.33	15	0.956
	Drink B	14.66	1.7	15	
	Drink C	14.8	1.82	15	

Mean RPE of drinks A, B and C doesn't seem to vary much throughout 0 to 10min of
the TT and consistently increased as the duration of the TT increases (figure 4).
Even though some subjects took up to fifteen minutes to complete the TT, analysis
of mean RPE over time only included data up to 10min, as some subject data was
not available after this point. Drinks A, B and C have similar effects on RPE as the
lines that represent each drink are very close together (figure 4).

Figure 5. The differences in effects of three drink treatments, on mean rate of perceived
exertion rate of over exercise duration (min).

The effects of drinks A, B and C on Body Weight
It is clear through the use of a series of paired t-tests, that there is a significant increase of body weight from pre-trial to post trial assessment of 0.29kg, 0.22kg and 0.25kg for drinks A, B and C respectively (figure 6). The SD around the means assessed are quite large rendering the data will low accuracy.
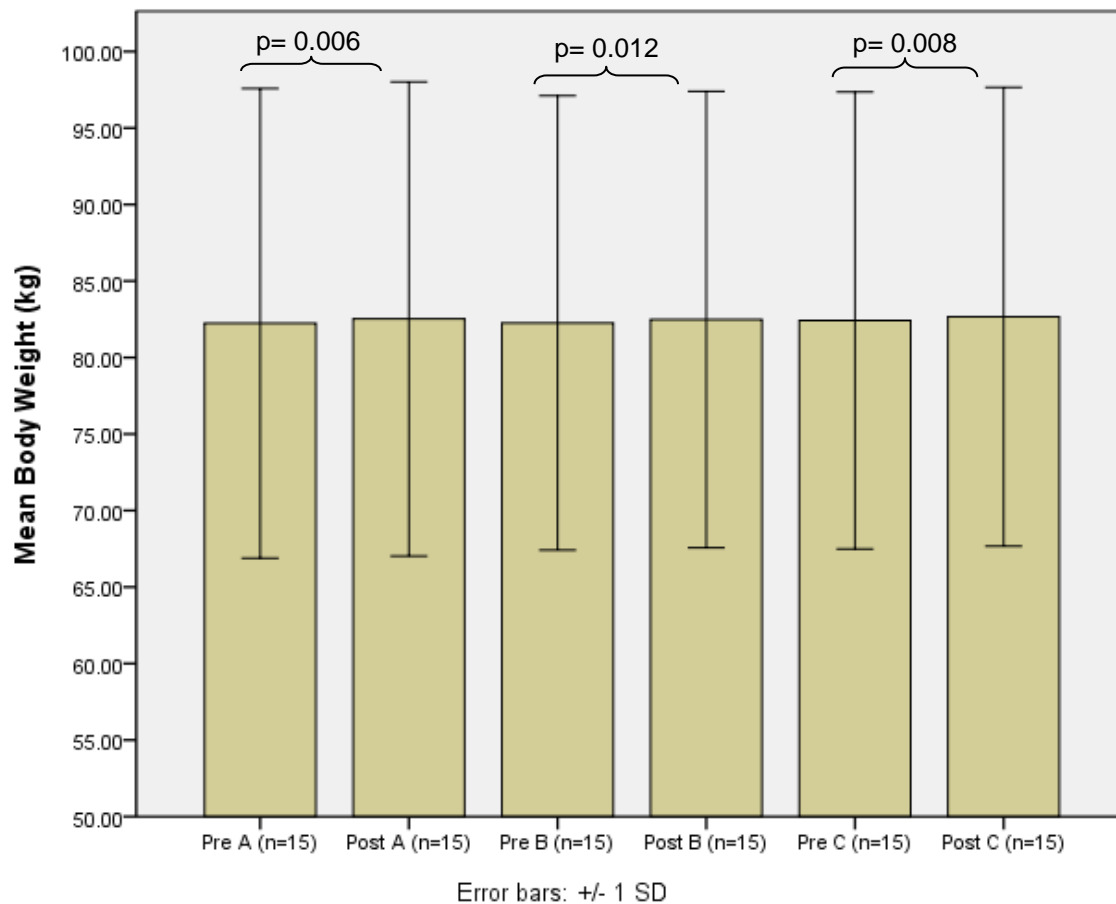
Figure 6. The effects of drink A, B and C on the difference between pre and post mean BW (kg). Mean BW for, pre-trial are 82.23±15.35, 82.26±14.85 and 82.42±14.93, drinks A, B and C respectively and post-trial 82.52±15.49, 82.48±14.91, 82.67±14.99, drinks A, B and C respectively.

Although there is a significant difference between pre and post body weight for each drink group, an ANOVA shows there is no significant difference between the three drink groups in mean change in pre to post body weight (p=0.783). The SDs of the data are large indicating change in weight varied a lot in subjects between groups (figure 7).
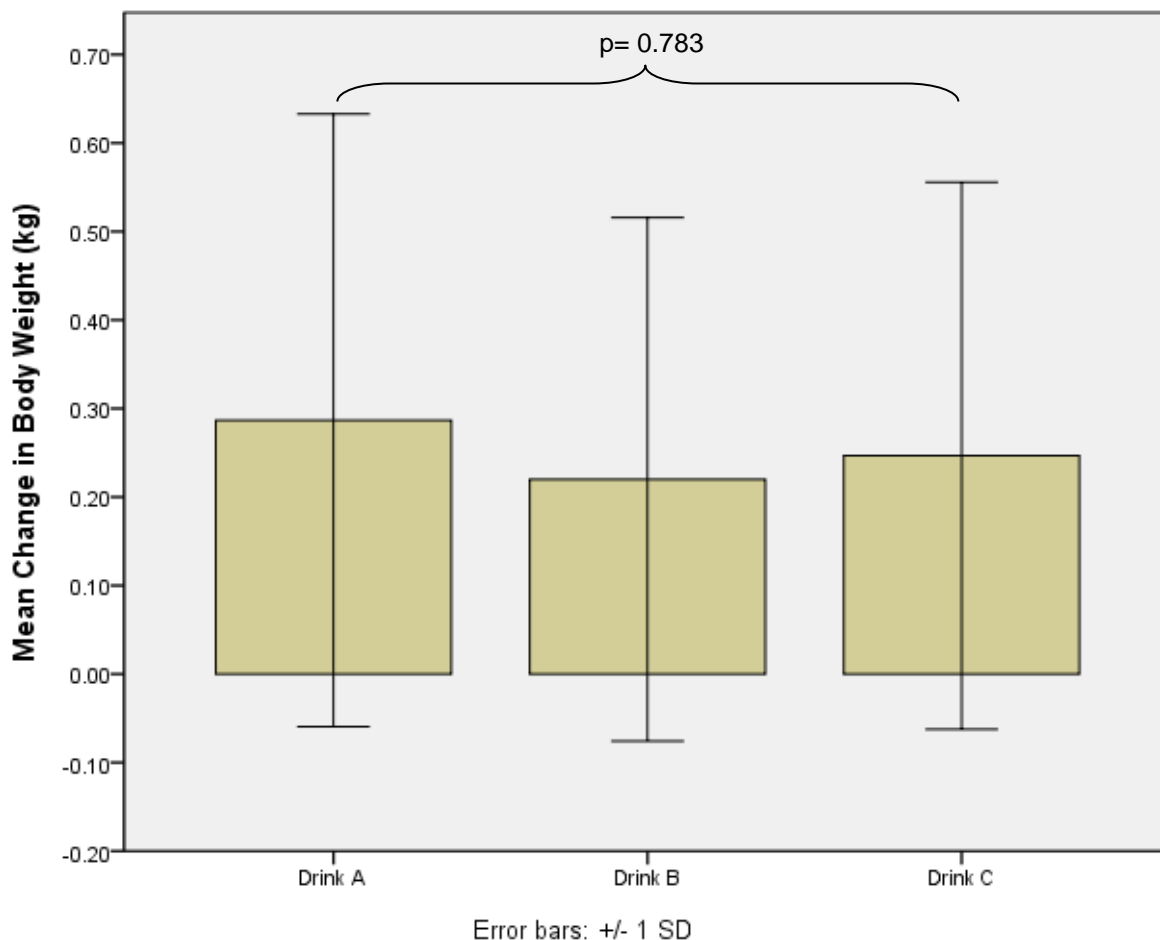
Figure 7. The difference in effects of sports drinks A (n=15), B (n=15) and C (n=15) on mean change in pre to post body weight (kg) (mean body weight change for drinks A, B, C = 0.29±0.35, 0.22±0.3, 0.25±0.31).

The effects of drinks A, B and C on Blood Pressure

Systolic blood pressure
Paired t-tests performed on mean pre and post time trial SBP data indicates there is a significant mean increase in blood pressure for drinks B (p=0.05) and C (p=0.042) of 12.33 and 10.53 (mmhg), yet no significant increase in pre to post SBP for drink A (p=0.876) (figure 8).

An ANOVA was then used and could not distinguish a difference in effects between the mean values of drink A (0.73±17.94), B (12.33±14.22) and C (10.53±18.26) on change in systolic blood pressure from pre to post trial of fifteen subjects (p=0.152). Even though there appears to be substantial differences between the means, the SDs of the means are so high that no significant differences can be established.
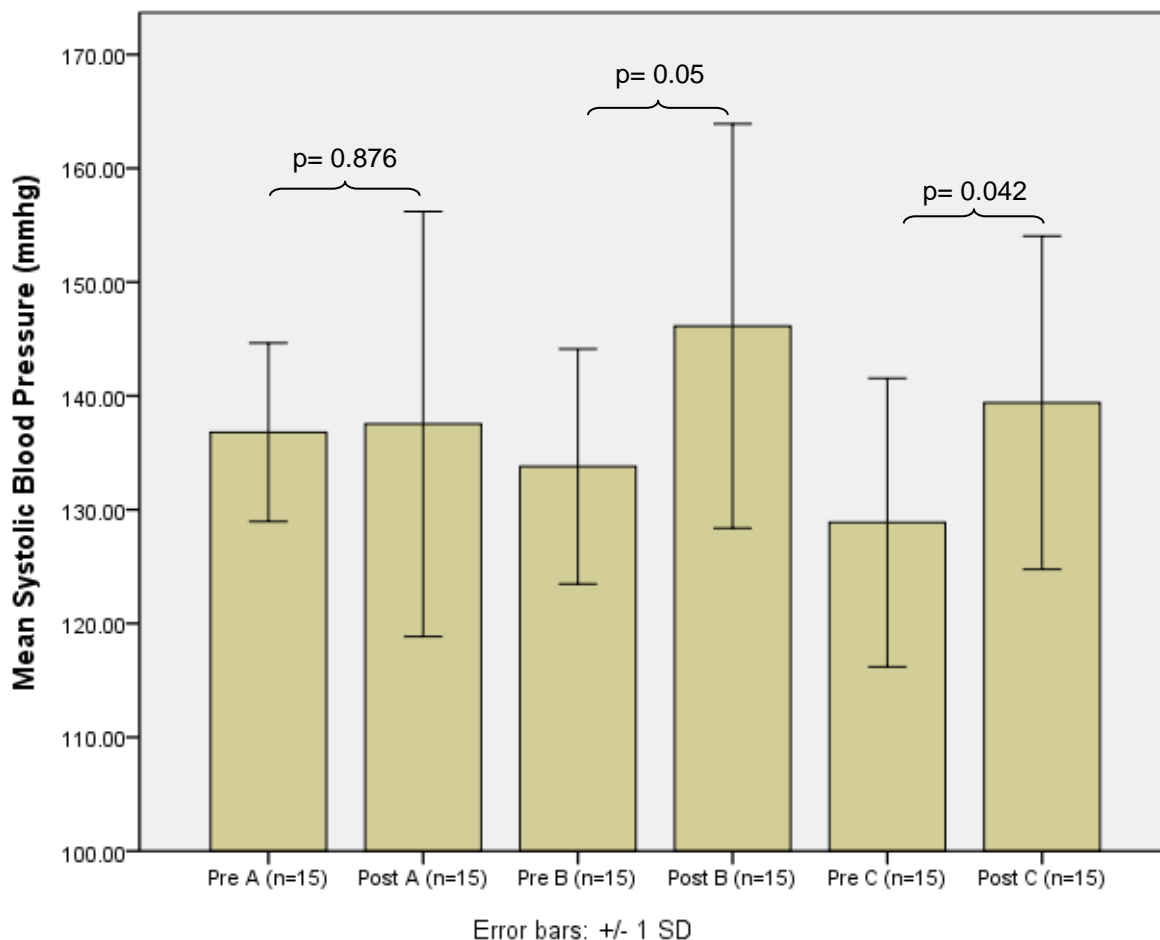
Figure 8. The effects of drink A, B and C on the difference between mean pre and post systolic blood pressure. Mean Pre SBP for drinks A, B and C =136.8±7.85, 133.8±10.33 and128.87±12.67 and mean Post SBP =137.5±18.68, 146.13±17.76 and 139.4±14.64.

Diastolic blood pressure
Similar to the results of SBP, a paired t-test performed on pre to post diastolic blood pressure (DBP) on each of the drink treatments, revealed that there is no significant difference between pre and post DBP for drink A, but there is a significant reduction from pre to post DBP for drinks B (p=0.096) and C (p=0.051) of 4.07 and 5.1 (mmhg) respectively (figure 9). There is no significant difference (p=0.956) between mean DBP changes from pre to post trial of fifteen subjects between the drink treatments A (-4.1±13.24), B (-4.1±8.82) and C (-5.1±9.18).
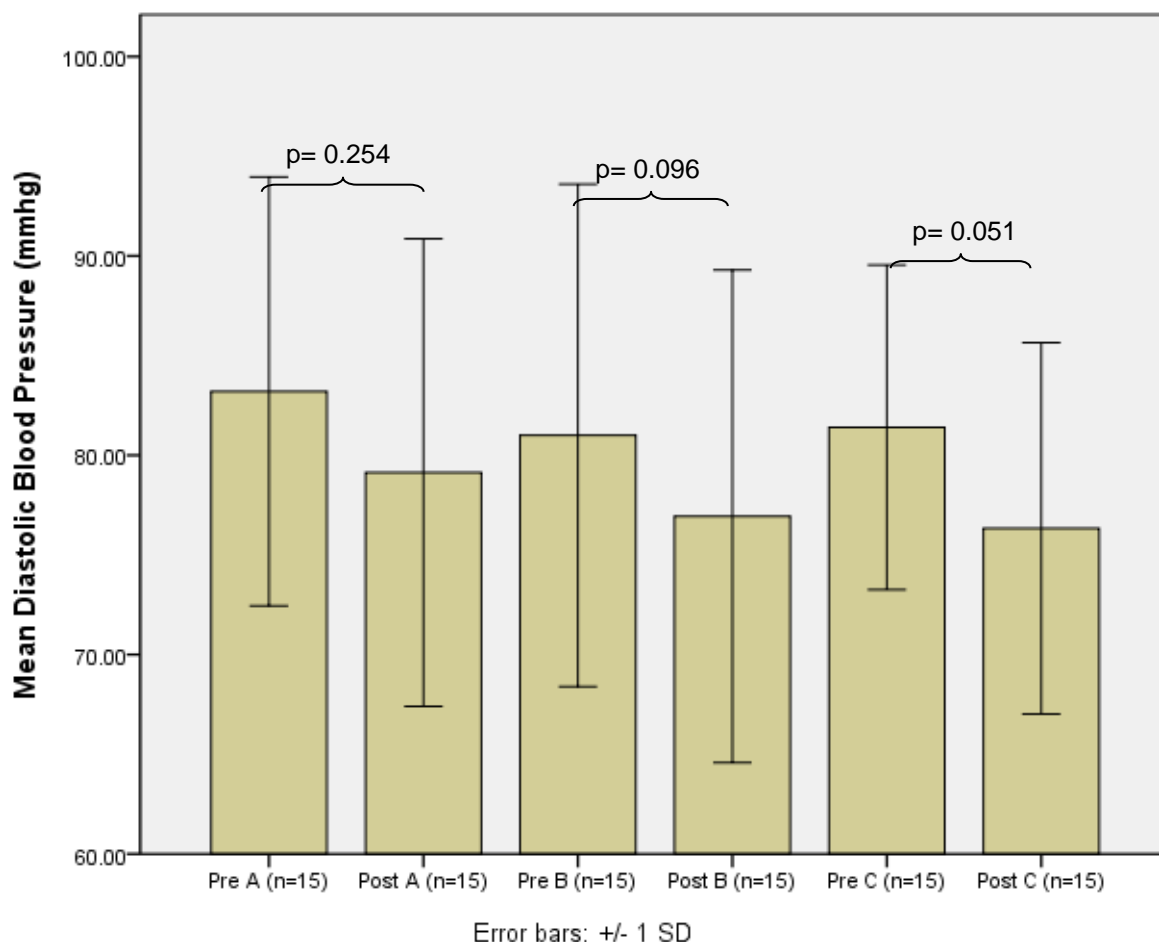
Figure 9. The effects of drink A, B and C on the difference between mean pre and post DBP. Mean Pre DBP for drinks A, B and C =83.2±10.76, 81±12.6 and81.4±8.12 and mean Post SBP =79.13±11.73, 76.93±12.36 and 76.3±9.32.

Discussion

The main finding of this study is that the intake of 4.0 ml.kg^{-1} body mass of CE drinks containing 8% (A) and 5% (B) CHI, consumed five minutes before an 8km time trial and 1.0 ml.kg^{-1} body mass at 3km and 6km into the time trial had no added effect on performance over ingestion of a placebo drink. Subjects who ingested drink B, took the least amount of mean time to complete the TT, however the time of completion was not significantly different to the times of subjects who ingested drinks A and C.

In concordance the findings, Jeukendrup et al. (2008) investigated the effects of ingesting six a percent CE solution or two placebo drinks, on the performance of twelve endurance cyclists during a simulated 16km time TT. The drinks were ingested at the start (4ml kg^{-1}) and 1.4ml kg^{-1} was consumed at 25, 50, and 75% of the TT. Similarly they found no observed differences in effect between the treatments on time to completion (p=0.945), as time in minutes were 25:30±1:34, 25:27±1:46, for the two placebo trial and 25:38±1:59. In a study of Palmer et al. (1998) it was found that ingesting a bolus of 6.8g/100ml of carbohydrate immediately before a 20km cycle TT, did not improve performance compared to a placebo. Powers et al. (1990) also found that ingestion of a 7% CHO electrolyte drink had no

significant effect on high intensity exercise (85% of VO_{2max}) compared to a non-CHO electrolyte drink and non-electrolyte placebo. On the other hand Jeukendrup et al. (1996) investigated the effects of ingestion of a 7.6% CHO electrolyte solution during a cycle time trial lasting one hour. They found that the CHO drink significantly increased performance (0.001) by 2.9%. Similar studies by Bonetti and Hopkins (2010) and Khanna & Manna (2005) agree with this and support the theory that blood glucose rises caused by CE ingestion, spares muscle glycogen to be used later in the exercise (McConell et al., 1999). However these investigated trials are all longer than one hour and have a lower intensity and ultimately substrate utilisation may be different.

An explanation for no significant performance enhancements between each drink treatment throughout the 8km time trial is that the rise in blood glucose after the ingestion of a CHO drink may not be the most required substrate for short intense exercise. Coyle et al. (1995) show that muscle glycogen is the primary energy substrate contributing 40-45% of energy expenditure compared to glucose only contributing 5%, during exercise (65-75% of maximal oxygen uptake) lasting 30min or less. The requirement of blood glucose only substantially increases as the duration of the intense exercise surpasses one hour, which explains the previous findings by Jeukendrup et al. (1996).

Neither CE drinks A and B had significantly different effects from each other or the placebo, on mean heart rate and mean change in heart rate. This was the same for mean RPM, RPE and mean change in RPM and RPE. Some patterns did emerge in that subjects who consumed drink B (5% CHO), were able to maintain a higher RPM during the later stages of the TT compared to drink A and C. Although the drink B subjects came under greater physiological strain to enable maintenance of the increase in mean RPM as it was mirrored by an increase in mean HR over time. Although there was greater physiological strain in the later stages of the TT for treatment drink B, measures of RPE did not increase accordingly. Throughout the trials the research team found measurement of HR very difficult as the watch used to receive the HR reader malfunctioned on several occasions. In event of this malfunction HR was recorded from the monitor on the cycle ergometer itself however these readings were slightly different to the watch readings, thus questioning the reliability of the data. Subject age data was missing for nine subjects and therefore intensity to which they were cycling at could not be calculated as a percentage of HR max, to establish whether subjects were putting in maximal effort or not.

Unlike other studies by Forjaz et al. (1998), Piepoli et al (1994) and Hagberg et al. (1987), who found exercising above 70% VO_{2max} reduced normatensive subject post SBP and DBP, subjects who consumed drink A (8%CHO), had no significant reported changes in mean pre to post trial SBP (p=0.876) and DBP (p=0.254), compared to drink B and C which had significant changes. This indicates that the drink with the highest CHO content (A) could have reduced cardiovascular strain, as a lower blood pressure response to the trial reflects a lower cardiac output (Wilmore et al., 2008), which in turn allowed the subjects to maintain a more stable RPM (figure 4). Although the difference between pre to post SBP and DBP for treatment drink A was significant, this change was not significantly different to the mean change in SBP and DBP of treatment groups B and C, concluding that neither drink had superior effects on blood pressure.

From pre to post study, mean subject body weight had significantly increased with no difference between drink treatments, ruling out the possibility of exercise induced dehydration having an effect on performance. However the fact that hydration status was not assessed prior to our study indicates that hypohydration could have increased variability in subject performance and the true effects of the drinks may have been masked. The impact of prior hypohydration on aerobic performance has been extensively researched. Casa et al. (2010) recruited seventeen subjects (age 27±7yr) that completed four looped 4km runs amounting to 12km in a hypohydrated or euhydrated condition. Between each run, physiological measurements were taken. Casa et al. (2010) found that the hypohydrated subjects reported higher RPE scores than euhydrated indicating much greater effort was required to compensate for physiological strain brought on by dehydration. For all of the 4km race trial runs, race time were faster for hydrated subjects compared to dehydrated [loop 1 = hydrated 17.85±1.94 versus dehydrated 17.77±2.06 minutes (p=0.028) and loop 2 = hydrated 17.85±2.05m versus 18.42±2.46 minutes (p=0.01)].

This study poses several limitations which may have reduced the accuracy of the results. The variation in training status of the subjects across the study is quite large and in fact most of the subjects were more suited to running activities. As some individuals were and weren't suited to cycling, the variation in performance caused by poor technique may have cloaked the effects of the drinks. Recruiting subjects with similar training status, outside of the Plymouth university campus or through a cycle group would limit this problem. Conducting the 8km trial on a weekly basis may have had a positive training effect, so when the final session was reached the ability and fitness of each subject to complete the exercise would be increased. The subjects were aware their current cycling pace and time and may have tried to beat previous performances. These limiting factors were minimized through the randomised repeated measure study design.

Over the course of the study some of the subjects fell ill and were not able to participate in one of the three trials. A fourth week was allocated so tests could be repeated; however performing the test on a different day or time could have reduced reliability of the results, as Reilly and Baxter (1983) found that performance of eight females during a series of maximal cycling tests (95% VO_{2max}), was greater in the evening (06.30h) than the morning (22.00h).
The clothing worn during the trial was not standardised, however most subjects wore t-shirt, shorts and running trainers. This clothing was not likely to be influentially restrictive on movement or heat radiation to cause a reduction in performance. The mean room temperature during the trials was quite low (mean 20°C), ruling out the possibility of a hyperthermic temperature (39.3°C) causing increased cardiovascular stress (reduced stroke volume by 7-8%) (Gonzalez et al., 1997). Other limiting factors such as varied positioning of the cycle ergonometer seat and the inexperience of the research team to record and handle data may have contributed to the large variation in the results.

Motivational encouragement was not controlled during the trial and therefore performance may have varied due to motivational cues rather than the ingestion of drinks. Chitwood et al. (1997) conducted a treadmill exhaustion exercise, to which twenty eight subjects were randomly assigned to either having verbal encouragement or not. The results along with similar findings by McNair et al. (1996) suggest that verbal encouragement increase performance as exercise time to

completion was less than the non-verbal encouragement group. Motivational encouragement could be controlled by repeating the trials with no encouragement.

Had we included drink D into the study, it would have been expected to produce similar effect on performance and physiological function to the other drinks. This assumption is made purely on the fact that the CHO and sodium concentrations of drink D are at a median of drink A and C and as there was no difference in performance between these to two drinks, it shouldn't have any additional effects. To create better control over pre diet on exercise performance removing the influence glycogen loading (Maughan & Poole, 1981) an overnight fast should have been implemented rather than asking the subjects to perform the difficult task of consuming the same food pre-trial.

It is questionable whether the ingestion of fluid is actually required during such a short intense trial and in fact ingestion of any drink may limit performance time, as it was observed that the drinking motion and volume of the drink ingested, reduced cycle RPM at 3km and 6km and similar to the Nieuwenhoven et al. (2005) study it caused some discomfort during cycling.

Conclusion
In conclusion performance times and physiological measurements of HR, RPE, RPM, during the 8km TT were not significantly different when consuming CE (5, 8% CHO) and placebo drinks. This supports the notion that maximal cycling exercise performance lasting approximately 10min (8km) is not improved or limited by endogenous substrate availability prior and during the event.

The confidence of our findings is questionable due the vast variability in results and many limitations outlined. Conversely, in favour of the study, it is consistent with previous research, derived from studies which have achieved greater control. The current resources could only permit a relatively small sample size, however increase the number of subjects participants would increase the reliability and validity of the results.

Acknowledgements

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