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THE PLACEBO EFFECT ON TIME TILL EXHAUSTION DURING CYCLE ERGOMETRY

(DISSERTATION SUBMITTED UNDER THE PHYSIOLOGY AND HEALTH AREA)

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THE PLACEBO EFFECT ON TIME TILL EXHAUSTION DURING CYCLE ERGOMETRY

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Abstract

Aim: The present investigation aimed to explore the placebo effect of pre-exercise carbohydrate feeding via the ingestion a carbohydrate sports drink on short duration high intensity exercise. A secondary aim was to examine the effectiveness of the carbohydrate drink on short duration high intensity exercise.

Methods: 8 subjects (3 males and 5 females, mean age ± SD = 21.1 ± 2.0 years, range = 18-25 years) completed the study. A randomised within-subjects repeated measures design was utilised to assess differences in: total performance duration, average heart rate, peak heart rate, RPE measured at minute two, five and immediately at the end of the exercise test. 30 minutes prior to exercise subjects were required to drink 250ml of either a carbohydrate drink, a non carbohydrate drink or a perceived 50/50 chance of receiving either drink (each subject unknowingly received the non carbohydrate drink for this condition). The experimental trials required subjects to continuously cycle until exhaustion on a cycle ergometer at a set cadence of 75RPM and at an intensity of 90% maximal power output.

Results: A repeated measures ANOVA test revealed a significant difference in the total performance duration between the “told carbohydrate” condition compared to the “told non carbohydrate condition” (P=0.01), and very close to the accepted significance of <0.05 between the “told carbohydrate” and the “told 50/50” condition (P=0.06). No significant difference was observed between the “told 50/50” condition and the “told non carbohydrate” condition (P=0.97). No difference was observed been trials in the average heart rates (bpm), peak heart rates (bpm) and RPE measured at minute two, 5 and at the end of the test (all P=>0.05).

Conclusion: The present study did not demonstrate a placebo effect of ingesting a 32g carbohydrate drink 30 minutes before high intensity short duration exercise. The present study did provide some indication of a possible performance enhancement from the actual ingestion of a 32g carbohydrate drink ingested 30 minutes before high intensity short duration exercise. The findings should however be treated with caution and further research should be undertaken addressing the limitations of the study before pre-exercise carbohydrate feeding or the placebo effects can be confirmed or rejected as a performance-enhancing aid in relation to high intensity short duration exercise.

1 INTRODUCTION

1.1 Background

In sport and health related exercise, it is well known and evidenced that a diverse range of ergogenic aids are used in an attempt to gain an advantage in performance; techniques range from accepted methods such as carbohydrate loading to the use of illegal and potentially harmful substances such as anabolic steroids (McClung & Collins, 2007; Thein, Thein & Landry, 1995). The positive influence on performance resulting from the use of ergogenic aids has been well researched. It has long been speculated in some research however, that these performance enhancements may not be solely attributable to physiological factors alone and may in part be associated with a psychological factor, a placebo response (Beedie & Foad, 2009).

In research, a wide variety of definitions have been used to define the placebo effect and a great debate exists over the definition (Wolf, 1959; Shapiro, 1964; Kirsch, 1999; Clark, Hopkins, Hawley & Burke, 2000; Vase, Riley & Price, 2002). However the definition as the "physiological or psychological response to an inert substance or procedure" is the most relevant definition (Geers, Weiland, Kosbab & Landry, 2005). The definition implies that the placebo effect is not limited to given sample groups for example, elite or non-elite athletes, a type of substance or procedure, and it is not limited to either physiological or psychological dependant measures such as rating of perceived exertion or performance time (Geers *et al.*, 2005). This is validated by the diverse range of research which has demonstrated a placebo effect across various interventions, performance measures and sample populations (Wolf, 1959; Ariel & Saville, 1972; Kirsch, 1999; Clark *et al.*, 2000; Vase, Riley & Price, 2002; Duncan, Lyons & Hankey, 2009).

Among the vast pool of research which has demonstrated the placebo effect there are however discrepancies in the literature which provide comparison of a presented intervention (placebo effect) to the actual pharmacological effects (Clark, *et al.,* 2000; McClung & Collins, 2007; Foad, Beedie & Coleman, 2008). Therefore simply making the assumption that a placebo presented as any ergogenic aid is an effective alternative to enhancing performance in sport and exercise when compared to the actual consumption of the presented ergogenic aid, as suggested in some research (McClung & Collings, 2007) should be taken with caution. The aim of the present study was therefore to examine and compare the placebo effect of a drink containing carbohydrates to the actual pharmacological effects on performance. A secondary aim was to examine the effectiveness of the carbohydrate drink, recently found in research to significantly improve performance capacity for short duration high intensity exercise (Galloway, Lott & Toulouse, 2014).

The following chapter provides an overview of the current literature that surrounds the placebo effect focusing on; the history of the placebo effect, the placebo effect in the medical field, the proposed theoretical perspectives, mental perception of fatigue and finally the effects of pre-exercise carbohydrate feeding on short term high intensity exercise. In the third chapter the methodology applied is outlined and the results from the present study are presented in chapter four. Finally, in chapter five the overall findings are discussed and a conclusion is presented.

2 LITERATURE REVIEW

2.1 Introduction

The placebo effect has been consistently demonstrated in both sport science and medical research in various sample populations, exercise modes/treatments and presented interventions (Wolf, 1959; Ariel & Saville, 1972; Kirsch, 1999; Clark et al., 2000; Vase, Riley & Price, 2002). Although the literature is in agreement that there is an improvement associated with a presented positive intervention disguised and administered as a placebo, the magnitude of the improvement when compared to the actual pharmacological effects of the intervention are less evaluated and the findings of those that are demonstrate discrepancies within the literature providing conflicting results (Clark, *et al*., 2000; McClung & Collins, 2007; Foad *et al*., 2008).

The following literature review initially describes the history of the placebo and its prevalence within the medical field before providing a brief overview of some of the existing findings of studies which have examined the placebo effect from a sports and exercise performance perspective. The theoretical perspectives which seek to provide some explanation towards how the placebo effect occurs are then discussed. Mental perception of fatigue is considered before pre-exercise carbohydrate feeding and its effects on short term high intensity exercise until exhaustion is then reported. Finally the literature is evaluated and the aims of the study are presented.

2.2 Etymology of the word "placebo"

The word *placebo* (Latin, 'I shall please') first entered the English language sometime around the 14th century appearing in the ninth verse of Psalm cxiv (16:9) (Straus & Cavanaugh, 1996; Craen, Kaptchuk, Tijssen & Kleijnen, 1999). In the time period of the 14th century the word placebo referred to professional mourners hired as stand-ins for members of the family of the deceased at funerals. Mourners would cry 'Placebo Domoino in regione vivorum', which translates in the Latin Vulgate as 'I shall please the Lord in the land of the living' (Straus & Cavanaugh, 1996; Craen, Kaptchuk, Tijssen & Kleijnen, 1999).

2.3 The placebo effect in the medical field

The earliest documented use of the term 'placebo' within the medical field dates as early as the 18th century and appeared in the 1785 new medical dictionary described as "a common place method or medicine" (Straus & Cavanaugh, 1996). Other early definitions define the placebo as a "medication given to please" (Dorland, 1901; cited in Geers *et al.,* 2005). It has been suggested by authors that a placebo effect can be so prevalent that until the early part of the 20th century the benefits of prescribed medicines were entirely the effect of a placebo responding (Lasagna, 1986; Straus, 1996; Shaprio & Shapiro, 1997; Geers *et al.*, 2005). Even in the age of modern medicine there is a vast abundance of empirical research reporting placebo effects in virtually all areas of patient care (Alina & Bogdan, 2010; Enck, Klosterhalfen & Zipfel, 2010; Teixeira, Guedes, Barreto & Martins, 2010; Leuchter, Hunter, Tartter & Cook, 2014). The placebo effects demonstrated in such research publications even extend as far as sham surgery with one particular study demonstrating significant improvement in disability and pain rating with no significant difference between a group of patients that received vertebroplasty treatment and a group of patients that underwent simulated procedure (Kallmes, Bryan, Comstock, Heagerty, Turner, Wilson, Dimond, Edwards, Gray, Stout, Owen, Hollingworth, Ghdoke, Annesley-Williams, Ralston & Jarvik, 2009).

2.4 The placebo effect in sport and exercise performance

Only in the last 10-15 years has the placebo effect become subject to regular research in sports and exercise science (Bottoms, Buscombe & Nicholettos, 2013). Over this time there has been a vast amount of literature published which has successfully demonstrated the prevalence of the placebo effect which can occur with presented interventions (for reviews see Trojan & Beedie, 2008; Beedie & Foad, 2009, also see table 1 and 2). Studies have demonstrated performance increases in endurance, strength and decreases in perceived exertion and pain (Ariel & Saville, 1972; McClung & Collins, 2007; Pollo, Carlino & Benedetti, 2008). The placebo effect has been recently recognised for its importance and possible role within coaching with authors suggesting that further examination of the placebo effect should focus on how coaches and clinicians could harness the positive effect (Bottoms *et al.*, 2013). McClung and Collins (2007) have also argued that the placebo effect could offer an alternative to performance enhancing drugs in sport.

Table 1 shows studies which have examined the placebo effect.

Study	Sample population	Design	Performance measure	Intervention		% Change
				Informed	Received	
Ariel & Saville (1972)	6 sub-elite weightlifters	Within-subjects design	Strength (bench press, military press, seated press, squat)	Anabolic steroid	Placebo	9.5
Beedie, Stuart, Coleman & Foad (2006)	6 sub-elite cyclists	Within-subjects design	Endurance 10km cycling power	0mg/kg caffeine	Placebo	-1.4
				4.5mg/kg caffeine	Placebo	1.3
				9.0mg/kg caffeine	Placebo	3.1
Pollo, Carlino & Benedetti (2008)	44 sub-elite athletes	Mixed design	Strength (leg extension)	Caffeine	Placebo	11.8
				Caffeine after conditioning procedure	Placebo	22.1
			Perceived fatigue	Caffeine	Placebo	-0.3
				Caffeine after conditioning procedure	Placebo	-7.8
Kalasountas, Reed & Fitzpatrick (2007)	42 untrained students	Between-subjects design	Strength (bench press, seated leg press)	Amino acids	Placebo	19.6
			Strength (bench press, seated leg press)	Amino acids then placebo	Placebo	6.3

Untrained = no regular training; Sub-elite = regularly training but not above national status.

2.4.1 The placebo effect versus administration of interventions in sport

Whilst there are vast amounts of literature which have demonstrated the placebo effect in sports and exercise performance, there is less published literature which has demonstrated the placebo effect in comparison to the true pharmacological effect of the presented intervention. The findings from studies which have made such a comparison do show some discrepancies within the results. For example, a study by Clarke *et al.* (2000) found that the participants who were informed that they were receiving a carbohydrate when they had actually received a placebo showed a greater improvement in performance (4.3%) than participants who were correctly informed that they had received the carbohydrate. In contrast to these findings, a similar study by Foad *et al.* (2008) showed that under conditions where participants believed they had not received caffeine when in fact they had, they showed a greater improvement in performance (3.5%) compared to the condition whereby participants believed they had been given caffeine when in fact they had not (2.6%). A study by McClung & Collins (2007) examined the placebo effects in comparison to the actual administration of sodium bicarbonate. Results showed that the participants who correctly believed they were receiving the sodium bicarbonate improved overall performance (1.7%). They also demonstrated that the expectation alone of receiving the proposed intervention in the absence of its actual administration also improved performance (1.5%). The performance improvements are very similar and the findings as suggested by McClung and Collins (2007) and Maganaris *et al.* (2000) could propose an argument against the use of performance enhancing drugs in sport performance. However as discussed in a study by Benedetti, Carlino & Pollo (2007) this could propose potential ethical issues. There appears to be some disagreement within the literature, as results show that placebo effects do not always equate the pharmacological effects of the presented intervention nor produce a larger performance enhancement. Therefore simply making the assumption that a placebo presented as any ergogenic aid as an effective alternative to enhancing performance in sport and exercise when compared to the actual consumption of the presented ergogenic aid should be taken with caution (McClung & Collings, 2007). For an overview of the studies discussed see table 2.

Table 2 shows studies which have examined the placebo effect in comparison to the administration of interventions.

Study	**Sample population**	**Design**	**Performance measure**	**Intervention**		**% Change**
				Informed	**Received**	
McClung and Collins (2007)	16 sub-elite endurance athletes	Within-subjects Latin square balanced placebo design	1,000m running time trial.	Sodium bicarbonate	Sodium bicarbonate	1.7
				Sodium bicarbonate	Placebo	1.5
Clarke *et al.* (2000)	43 sub-elite endurance cyclists	Between subjects Latin square design	40km cycling time trial	Carbohydrate feedings	Placebo (50% of subjects), Carbohydrate (50% of subjects)	4.3
				Placebo	Placebo (50% of subjects), Carbohydrate (50% of subjects)	0.5
				50/50 chance of receiving carbohydrates or placebo	Placebo (50% of subjects), Carbohydrate (50% of subjects)	-1.1
					Overall placebo effect (true placebo effect–carbohydrate effect).	3.8
Foad *et al.* (2008)	14 sub-elite cyclists	Within-subjects Latin square balanced placebo design	Endurance 40km cycling power	Caffeine	Placebo	2.6
				Placebo	Caffeine	3.5

Untrained = no regular training; Sub-elite = regularly training but not above national status.

2.5 Theoretical perspectives of the placebo effect

The results from previous research have provided evidence to conclude that a placebo effect certainly occurs, however little is known about the mechanisms of the placebo effect (Geers *et al.,* 2005). The placebo effect is a psychological phenomenon and a great deal of debate exists surrounding the theoretical explanations of how the placebo effect occurs (Montgomery & Kirsch, 1996; Stewart-Williams, 2004; Geers *et al.*, 2005). It has been speculated that the main theories associated with the placebo effect are the classical conditioning view, response-expectancy view and the motivational view. These three views have been considered as competing theoretical explanations. It is in more recent research that conceptual integrations of the theoretical perspectives have been offered and the interaction of these variables has been recognised (Montgomery & Kirsch, 1996; Stewart-Williams, 2004; Geers *et al.*, 2005; Benedetti, Carlino & Pollo, 2011; Beedie & Foad, 2009).

2.5.1 The classical conditioning perspective

The classical conditioning view considers active interventions i.e. an active medicine as an unconditioned stimulus and the methods of which the interventions are administered as a controlled stimuli which together allow the conditioned response, the placebo effect (Craen *et al.,* 1999; Geers *et al.,* 2005). Although there is some evidence shown in studies which have tested this theory, problems when accounting for the placebo effect entirely with this view are apparent (Flaten & Blumenthal, 1999; Geers *et al.,* 2005). For example the theory does not offer a physiological mechanism whereby the placebo effect is manifested, nor an explanation as to why prior experience with an active intervention does not always increase placebo response.

2.5.2 The response-expectation effect

The expectation or belief of receiving something perceived to be beneficial to sports performance has been speculated to be a strong contributor towards the positive performance effects observed from receiving a chemically inert placebo (Kirsh, 1985; Geers *et al.,* 2005; McClung & Collins, 2007). Thus the expectation of an outcome can lead to that outcome being achieved. Several research studies have demonstrated within their results an indication that the expectancy of the presented ergogenic aid and its known performance benefits influences the placebo responding (Maganaris, Collins and Sharp, 2000; Clark *et al.,* 2002; McClung & Collins, 2007). Although expectancy has been indicated to influence the placebo response, a flaw to this theory is that similar to the classical conditioning perspective, there are no physiological mechanisms that have been determined which show how the expectation is produced to become the placebo responding (Stewart-Williams & Podd, 2004; Geers *et al.,* 2005).

2.5.3 The motivational view

This perspective considers the placebo effect to be the outcome of one's desire to feel better or to feel a reduced anxiety (Price, Millings, Kirsch, Duff, Montgomery & Nicholls, 1999). Another view is that the placebo effect may be the result of an individual's desire to cooperate with the researcher/health care professional (Orne, 1962). Few studies have examined the role of motives in the placebo responding however those that have do provide some indication to support the theory (Geers *et al.,* 2005). For example a study by Jensen & Karoly (1991) administered to participants pills which were informed to participants to have a sedating effect. Two conditions were assigned, one high motivation in which participants were informed that those who showed a reaction to the pills would have a positive personality type and those who did not respond a more negative personality type. The second, low motivation was similar but participants were informed that the relationship between the reaction to the pill and personality type was very weak. The results from the study provided support for a motivational view of the placebo responding as a greater number of participants from the high motivation condition reported greater sedation effects to the chemically inert pill then the group which were not equally motivated to respond.

2.6 Mental perception of fatigue

Studies which have examined the placebo effect in medicine and sports performance have consistently demonstrated a significant decrease in perceived pain with the introduction of a placebo presented as an intervention when compared to control conditions (Pollo, Carlino & Benedetti, 2008; Kallmes *et al.,* 2009). Pain is therefore considered to be highly placebo responsive with the suggestion that placebo effects exert an analgesic effect on at least three stages of pain processing (Trojian & Beedie, 2008; Beedie, 2010). Trojian & Beedie (2008) speculated that the placebo effect influences the pre-stimulus expectation of pain relief, changes perception of pain and alters post event pain rating. Bottoms *et al*. (2013) supports this theory by suggesting that it is the brain which makes the final decision even at the point of fatigue the brain still makes a decision based on all relevant factors, including for example the knowledge that a performance enhancing intervention has been provided. This may partially explain why when an exercise test administered, which by definition is based on an all-out maximal effort has produced no significant changes in objective physiological measures yet has shown significant changes in the performance measures and perceived exertion.

2.7 Pre-exercise carbohydrate feeding

Pre-exercise carbohydrate feeding is recognised for its performance benefit in endurance exercise tasks and is known to reduce liver glucose output, stimulate glucose uptake and oxidation (Temesi, Johnson, Raymond, Burdon & O'Connor, 2011; Cermak & Van Loon, 2013). A pre-exercise elevation of blood glucose and insulin concentration mediated by pre-exercise carbohydrate feeding has been shown to activate the pyruvate dehydrogenase complex (PDC) at a faster rate (Tsintzas, Williams, Constantin-Teodosiu, Hultman, Boobis & Greenhaff, 2000). The PDC complex converts pyruvate into Acetyl CoA by a process called pyruvate decarboxylation (Timmons, Gustafsson, Sundberg, Jansson, Hultman, Kaijser, Chwalbinska-Moneta, Constantin-Teodosiu, Macdonald & Greenhaff, 1998). Acetyl CoA is then subsequently utilised in the tricarboxylic acid (TCA) cycle as illustrated in Figure 1 (Timmons *et al.,* 1998; Tsintzas *et al.,* 2000). Therefore a faster rate of PDC activation would increase availability of Acetyl CoA for its use in the TCA cycle mediating a faster onset of oxidative ATP production.

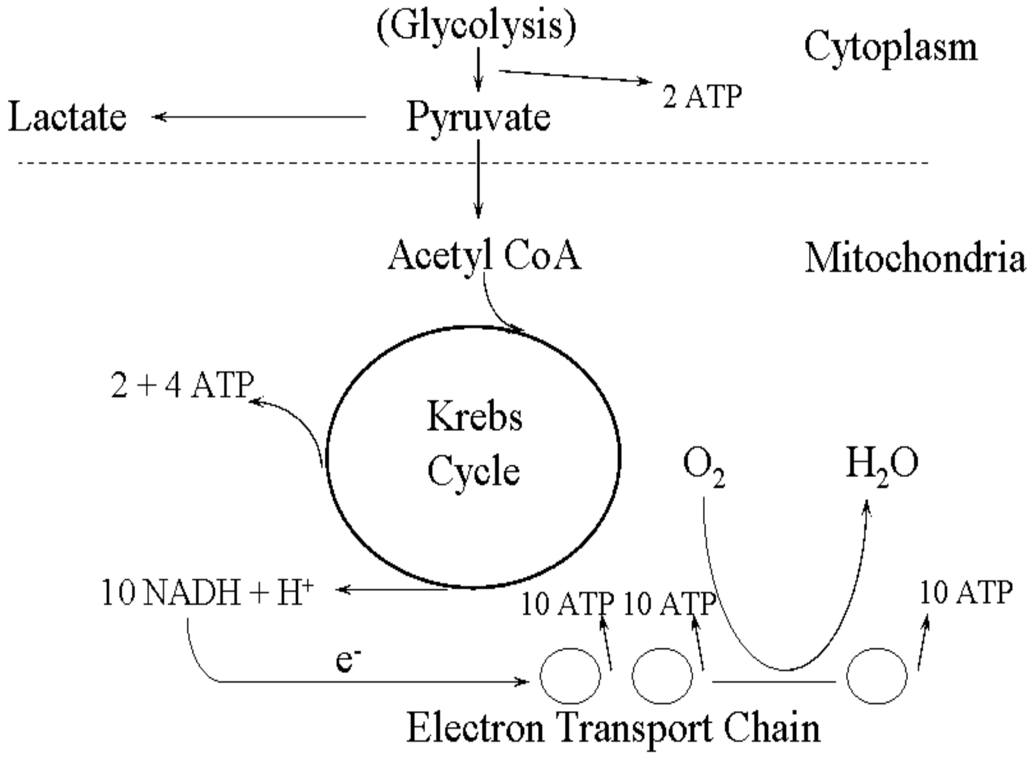

Figure 1. Aerobic metabolism of CHOs (from McArdle, Katch & Katch, 2010).

Galloway, Lott & Toulouse (2014) recognised the metabolic effects of pre-exercise carbohydrate feeding and considered the potential benefit that it may have on high intensity short duration exercise. They hypothesised that, with an optimal timing and concentration of pre-exercise carbohydrate feeding glucose uptake and oxidation could be maximised, thus aiding to match the supply and demand for ATP and releasing energy for muscle contraction during high intensity short duration exercise. Subsequently 17 recreationally active males were recruited for their study and split into two groups to examine the timing of carbohydrate intake and the concentration of carbohydrate intake and the effects on performance capacity. Following an exercise test which required the participants to cycle until volatile exhaustion at 90% of maximal power output (MPO), the results from the study demonstrated a significant increase in exercise capacity of 17% with the ingestion of a 32g carbohydrate drink 30 minutes prior to exercise when compared with the placebo trial. Therefore a need for carbohydrate intake before short duration high intensity exercise tasks cannot be dismissed.

The majority of studies examining the effects of carbohydrate feeding on sport and exercise performance have focused on prolonged exercise performance or the timing of pre-exercise carbohydrate feeding (Below, Mora-Rodríguez, González-Alonso & Coyle, 1994; Temesi *et al.,* 2013; Galloway, Lott & Toulouse, 2014). It is clear from these studies that carbohydrates are viewed to be beneficial only to long duration exercise, with current guidelines specifying that there is no requirement for carbohydrate ingestion for exercise tasks lasting less than 45 minutes (Galloway, Lott & Toulouse 2014). It is also apparent within the literature that there has been a limited focus on pre-exercise carbohydrate feeding before short duration (<10min) high intensity (>85%max) exercise tasks as only one peer-reviewed article published by Galloway, Lott & Toulouse (2014) could be found.

2.8 Literature review conclusion

The above literature review addresses a number of studies which have either explored the placebo effect or sought to provide some explanation of the phenomena. Of the studies that have examined the placebo effect against true pharmacological effects, conflicting results have been demonstrated. Therefore an assumption that any presented intervention administered as a placebo could produce an equal or greater performance improvement should not be made. This therefore justifies a requirement to research all types of interventions and procedures and their placebo performance effects. As previously highlighted there are few studies that have examined pre-exercise carbohydrate feeding on short term high intensity exercise with only one peer-reviewed published article found. The results of this showed a greater performance improvement with ingestion of a 32g carbohydrate drink 30 minutes prior to exercise.

In consideration of the presented literature the present study therefore aimed to examine the placebo effect of pre-exercise carbohydrate feeding, mediated by a carbohydrate sports drink on short duration high intensity exercise, and secondly to examine the effectiveness of the carbohydrate drink on short duration high intensity exercise. Based on the findings of previous studies discussed in the literature review above it was hypothesised that results would demonstrate a placebo responding with the known possibility of receiving a carbohydrate drink. Results were hypothesised to show a much greater total performance duration at a set intensity of 90% MPO with a known possibility of receiving a carbohydrate drink compared to knowingly receiving an unbeneficial non carbohydrate drink. The ingestion of the carbohydrate drink compared to its absence is also hypothesised to show significantly greater total performance duration at the same set intensity (90% MPO).

3 METHODS

3.1 Participants

Following ethical clearance awarded through Cardiff Metropolitan University, eight recreationally active Cardiff Metropolitan University sports students (3 men and 5 women, mean age ± SD = 21.1 ± 2.0 years, range = 18-25 years) volunteered to take part in the study. Before taking part in the study participants were fully informed both verbally and in writing about the purposes of the study and the risks involved (for participant information sheet, see Appendix 1). A general health questionnaire was administered and an informed consent was completed (see appendix 2 and 3). Each participant was asked to refrain from vigorous exercise in the 24 hours prior to the laboratory visit and to maintain their "normal" diet throughout their participation in the study. Participants were also asked not to consume alcohol or caffeine in the 12 hours before testing and not to drink any fluid other than water in the three hours prior to the laboratory visit and nothing in the final 30 minutes before the prescribed exercise task was to begin.

3.2 Study Design

The study employed a within-subjects repeated measures design, with the order of the conditions randomised. Participants were truthfully told that they were participating in a study which aimed to examine the placebo effect of a drink containing carbohydrates and the effectiveness of the carbohydrate drink on short duration high intensity exercise, previously shown in research to significantly improve performance capacity. Participants were required to visit the laboratory on three separate occasions, one week apart, at the same time of day to control for circadian variation and to provide rest periods between visits (Saunders, Sale, Harris, & Sunderland, 2014). Upon each laboratory visit one of three experimental conditions were applied. The three experimental conditions were as follows:

- **Carbohydrate drink:** Participants were truthfully told that they would receive a carbohydrate drink and that it should benefit them in their performance.
- **Non carbohydrate drink:** Participants were truthfully told they would receive a non carbohydrate drink and that it would not provide a performance benefit to their exercise task.
- **"50:50" (Always non carbohydrate drink):** Participants were told there that they may receive either the carbohydrate drink or the non carbohydrate drink and were not told which one until the end of the experimental conditions. It was however always the non carbohydrate drink that each participant received for this test condition.

3.3 Materials

Drink solution: a branded drink, Lucozade (see full details below), was utilised for the study as it is commercially available and contains 16g of carbohydrates, or 6.4%, which in recent previous research has been found to contribute to a greater exercise capacity during short duration, high intensity exercise efforts (Galloway, Lott & Toulouse, 2014). The Lucozade brand also offer a non carbohydrate version of the drink in the same flavour which tastes the same as the carbohydrate version.

Carbohydrate drink: 250ml Lucozade **sport orange** (Lucozade Ribena Suntory Limited, Uxbridge, United Kingdom).

Non carbohydrate drink: 250ml Lucozade **sport lite orange** (Lucozade Ribena Suntory Limited, Uxbridge, United Kingdom).

Information pack: In accordance with protocols used previously, before the experimental trials began, and with the aim of reinforcing expectancy of the carbohydrate drink, participants were provided with a previously published research article which demonstrated findings of pre-exercise carbohydrate feeding and high intensity short duration exercise. The published literature provided was as follows:

Galloway, S.D.R., Lott, M.J.E., and Toulouse, L.C. (2014). Pre-exercise carbohydrate feedings and high-intensity exercise capacity: Effects of timing of intake and carbohydrate concentration. *International Journal of sport nutrition and exercise metabolism, 24:* pp 258 – 266.

3.4 Pre-test procedure

Upon each arrival to the laboratory, participants were asked to complete a health questionnaire. If the questionnaire showed no concerns over participants taking part in the study then they continued to act as a research participant. The first visit to the laboratory involved a briefing session in which participants were provided with a published research article which demonstrated findings of pre-exercise carbohydrate feeding and high intensity short duration exercise. Participants were then asked to consume 250ml of one of two drinks described previously, dependant on the test condition and presented in a clear plastic cup. A second questionnaire was then provided which aimed to validate the participant's compliance to the pre-test instructions given (see appendix 4). Body mass (kg) (Digital scales, SECA-Model 770, Hamburg, Germany) and stature (cm) (Anthropometer, Harpenden Anthropometer, WA, U.S.A) were also recorded and used to calculate an estimated maximal power output (MPO), established according to Wasserman, Hansen, Sue, Stringer & Whipp (2005):

Estimated MPO on an upright cycle ergometer in watts (W) =

[(height in cm – age in years) x 14 for women – 150 + (6 x weight in kg)]/10

[(height in cm – age in years) x 20 for men – 150 + (6 x weight in kg)]/10

3.5 Experimental procedure

Approximately 20 minutes after the consumption of the drink a heart rate monitor was fitted (Heart Rate Monitor, Polar Electro, RS4000, Polar Electro, Kemple, Finland) and a 5 minute warm up was performed on a cycle ergometer (Monark cycle ergometer, Models Bikes: 824e, 894e, 884e, 874, Monark Exercise AB, Varberg, Sweden) working at a cadence of 75RPM corresponding to a work load of 45% MPO. Upon completion of the warm up, at an optimal time period for an effective uptake of carbohydrates of 30 minutes after the consumption of the drink participants were asked to cycle until volatile exhaustion at a cadence of 75RPM at a workload which corresponded to 90% of their MPO. A clear countdown to begin was called, “1-2-3-GO” and on the word “GO” the “start” button on the heart rate monitor was pressed and data collection began. In accordance with previous studies no motivation was given and performance time remained hidden from the research participant’s view. At minute two, five and immediately at the end of the exercise test a rating of perceived exertion was measured using a Borg Category-Ratio (CR10) scale questionnaire ranging from 6-20. Peak heart rate, average heart rate and total exercise duration were measured on the heart rate monitor previously fitted and the data was extracted off the device onto a computer once the exercise test had finished using software package (Heart Rate Monitor Software, Polar ProTrainer 5, Version 5.41.002, Polar Electro, Kemple, Finland). The test was ended at the instance the participant could no longer continue to cycle at the selected cadence of 75RPM. Immediately after the end of the exercise test the participants were asked to remain on the cycle ergometer and perform a three minute cool down by cycling at a self-selected cadence against no resistance. This procedure was repeated three times as per the experimental conditions (carbohydrate, non-carbohydrate and 50/50 chance) as previously described. None of the performance measures were released to the participants until all of the experimental test conditions had been completed.

3.6 Statistical analysis

The software used for all statistical analysis was SPSS version 20.0 (SPSS, Inc, Chicago, IL) Changes in peak heart rate, average heart rate, RPE and performance time across the experimental conditions were analysed using a repeated measures analysis of variance (ANOVA). *Post hoc* analysis using Bonferroni adjustment was also performed. Statistical significance was accepted at $P < 0.05$. All data in tables and text are presented as mean ± standard deviation.

4 RESULTS

4.1 Baseline results

Eight volunteers (as described in methods) all completed the study. Participant's characteristics are summarised and expressed as mean ± SD and shown below in Table 3.

Table 3: Participant's characteristics expressed as mean ± SD.

Characteristics	Mean ± SD
Stature (cm)	167.25 ± 11.25
Mass (kg)	68.77 ± 9.57
Age (years)	21.12 ± 2.03
Estimated Maximal power output (W)	265.55 ± 63.36

4.2 Summary data

Summary data expressed as mean ± SD for all variables; performance time (s), RPE minute two, RPE at the end of exercise, peak heart rate (bpm) and average heart rate (bpm) are shown in Table 4.

Table 4: Performance time, RPE minute 2, RPE end of exercise, peak heart rate and average heart rate across conditions (mean ± SD).

Performance measures	Carbohydrate Drink		Non-Carbohydrate Drink		Told 50/50	
	M	SD	M	SD	M	SD
Performance time (s)	357	127.06	320.38	110.11	321	116.34
RPE minute two	15.25	1.58	15.38	1.30	15.63	1.41
RPE end of exercise	19.38	0.74	19.38	0.52	19.38	0.52
Peak heart rate (BPM)	179.25	8.73	178.25	8.96	177.25	8.68
Average heart rate (BPM)	167.89	9.30	166.25	9.35	166	10.25

4.3 Total performance duration across conditions

There were significant differences in the total performance duration between the carbohydrate condition compared to the non carbohydrate condition (P=0.01) and very close to the accepted significance of <0.05 the “told 50/50” condition (P=0.06). Figure 2 illustrates this and it is immediately clear from the figure that in the carbohydrate condition participants continued for longer than in the non carbohydrate condition (mean difference = 36.62) and “told 50/50” condition (mean difference = 36). It is also clear from the graph that there was no significant difference between the “told 50/50” condition and the “told non carbohydrate” condition (P=0.97). Seven of the eight participants stated that in the “told 50/50” condition they were not sure which drink they had received and one of the eight stated that they were sure they had received the non carbohydrate drink. None of the eight participants stated that they believed they had consumed the carbohydrate drink.

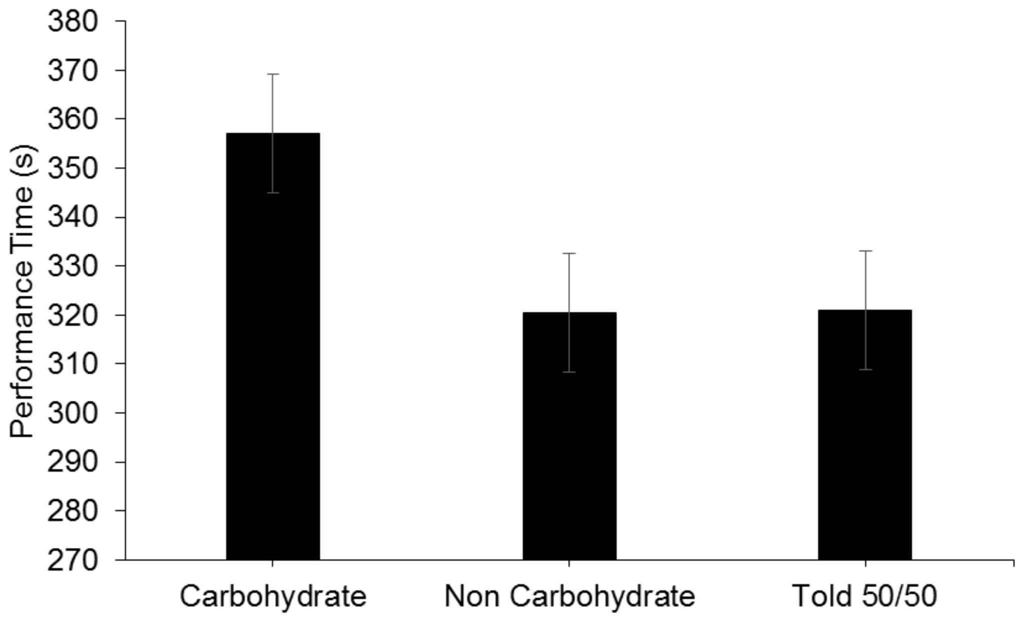

Figure 2 shows mean total performance duration across the three conditions.

4.4 Perceived exertion across conditions

There was no significant differences in RPE at minute two (P=1.00), minute five (P=1.00) and at the end of the exercise test (P=1.00) between any of the conditions. RPE for minute two is illustrated in figure 3 and RPE for minute five is demonstrated in figure 4. RPE for the end of exercise test did not differ from 19.38 from each of the three conditions and is demonstrated in the level height of the bar chart shown in figure 5.

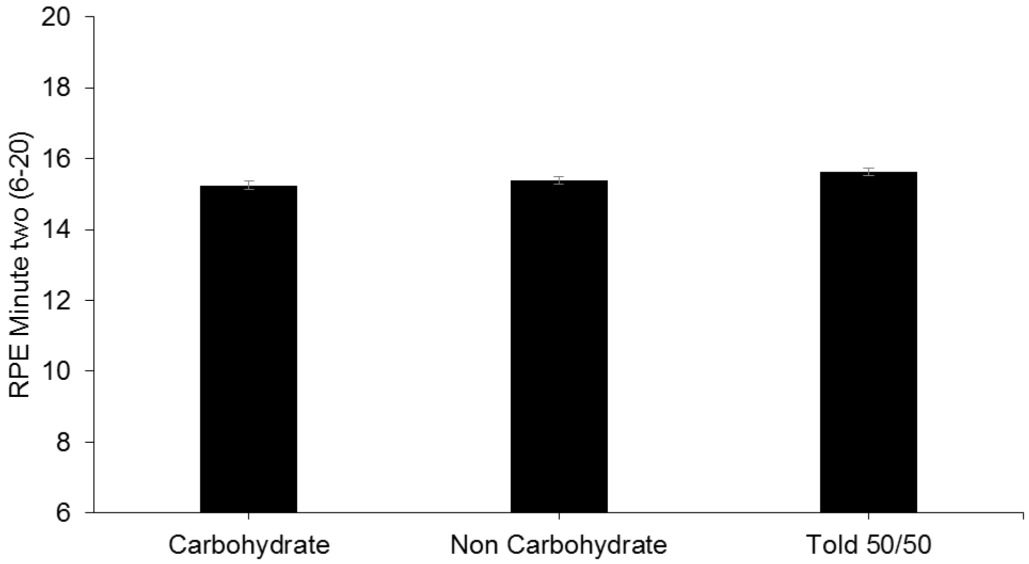

Figure 3 shows mean RPE measured at minute two across the three conditions.

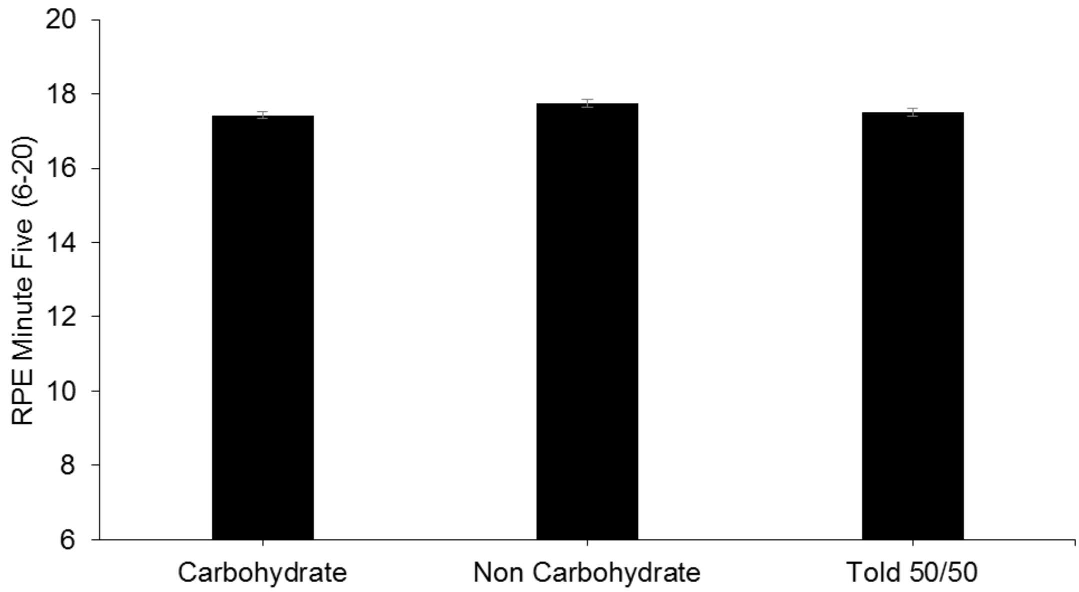

Figure 4 shows mean RPE measured at minute five across all three conditions.

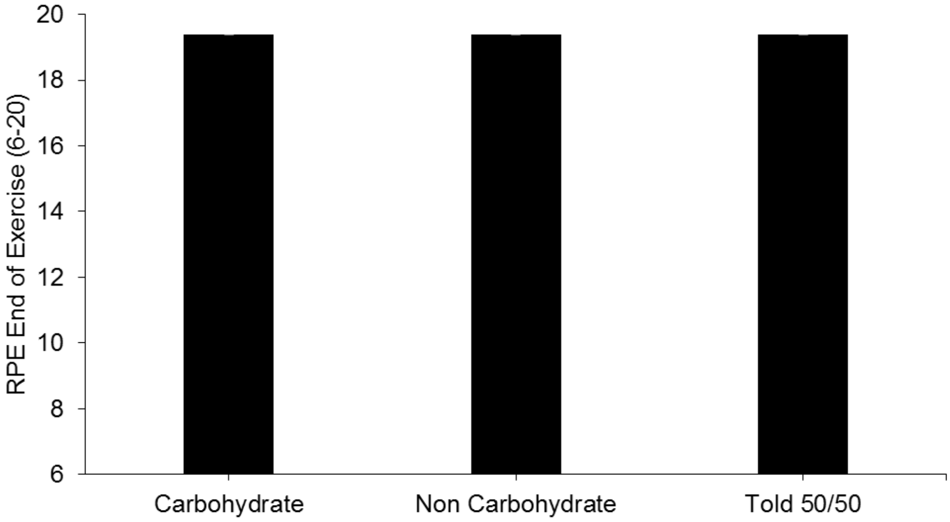

Figure 5 shows mean RPE at the end of the exercise task across all three conditions.

4.5 Heart rate across conditions

No significant differences in average heart rate between conditions “told carbohydrate” and “told non carbohydrate” were determined (P=0.33), nor between conditions “told 50/50” and the “told carbohydrate” and “told non carbohydrate” conditions (P=1.00). Figure 6 illustrates this with the reasonably level height shown on the bar chart. Furthermore no significant differences in peak heart rate were observed across any of the conditions. The “told carbohydrate” compared to the “told non carbohydrate” produced a P value of 0.83. The “told 50/50” condition compared to the “told carbohydrate” and “told non carbohydrate” produced P values of P=0.55 and P= 1.00 respectively. Again the relatively close non significant values are illustrated in figure 7.

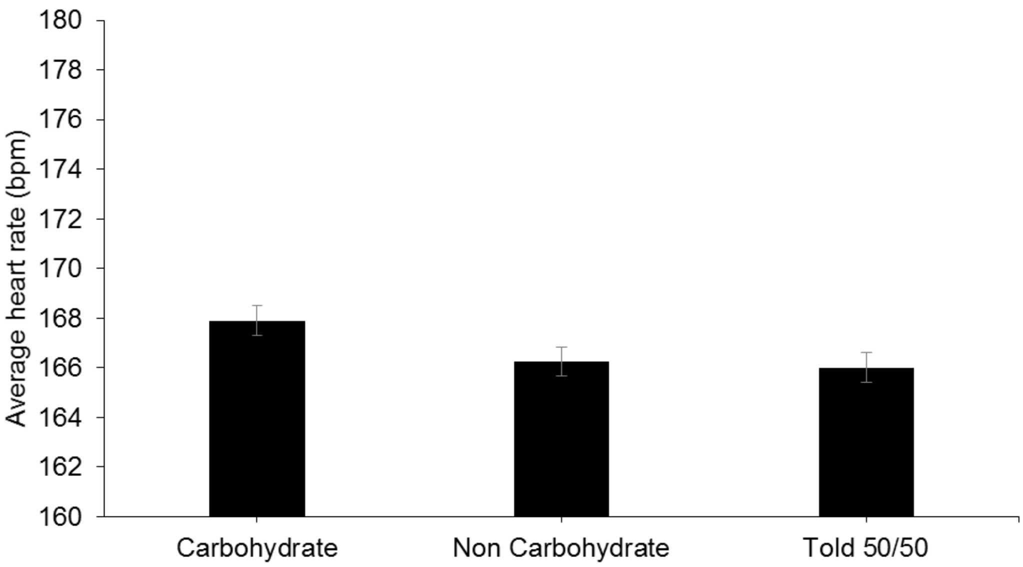

Figure 6 shows average heart rate (bpm) across all three conditions.

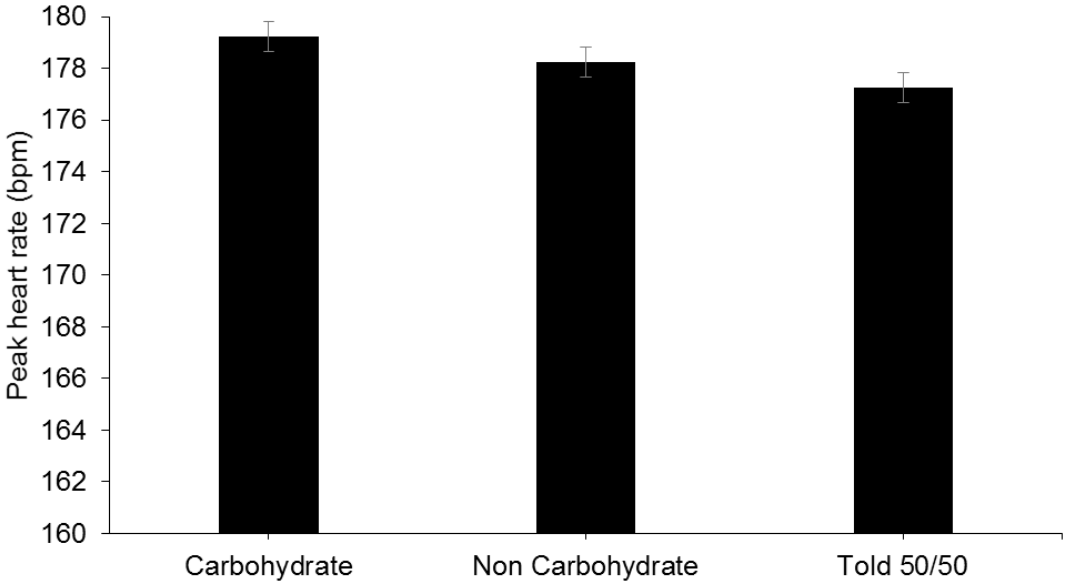

Figure 7 shows peak heart rate (bpm) across all three conditions.

5 DISCUSSION

The primary aim of the present study was to examine the placebo effect of pre-exercise carbohydrate feeding mediated by a carbohydrate drink on short duration high intensity exercise. In addition to this, a secondary aim of the study was to examine the effectiveness of a carbohydrate drink on short duration high intensity exercise. It was found that when told that there was a 50/50 chance of receiving either the carbohydrate drink or the non carbohydrate drink (participants unknowingly each received the non carbohydrate drink), performance duration at a set intensity of 90% MPO remained very close to knowingly receiving the unbeneficial non carbohydrate drink. It was also found that knowingly consuming a carbohydrate drink resulted in an ability to perform (at a set intensity of 90% MPO) for significantly longer when compared to knowingly consuming the non carbohydrate drink.

In this chapter the placebo effect of pre-exercise carbohydrate feeding will be discussed first before the effectiveness of pre-exercise carbohydrate feeding on short duration high intensity exercise is addressed. Finally the limitations of the study are evaluated before recommendations for future research are suggested.

5.1 Placebo effect of pre-exercise carbohydrate feeding

In order to obtain a placebo effect measure, the present study utilised a novel “told 50/50” condition whereby subjects were told that they may receive either the carbohydrate or the non carbohydrate drink. However each subject unknowingly received the non carbohydrate drink. A repeated measures analysis of variance (ANOVA) was used to establish any statistically significant differences between the “told 50/50”, the “told carbohydrate” and the “told non carbohydrate” conditions in the performance measures of total performance duration, RPE at minute two, five and at the end of the exercise test. Objective measures of average heart rate and peak heart rate were used to monitor physiological exertion.

5.1.1 Placebo effect on performance duration

Contrary to the hypothesis, it was found that there was no significant difference in performance duration in the "told 50/50" condition compared to the "told non carbohydrate" condition (P=>0.05, mean difference = 0.62). There was however a P value produced of P=0.06, which was very close to the accepted statistical significance of 0.05 between the "told 50/50" condition and the "told carbohydrate" condition. Again this result was not expected. A possible explanation for this discrepancy may have been produced by the methodological design which was applied. In the present study the subjects did not have a strong belief or expectation of receiving a beneficial carbohydrate drink in the "told 50/50" condition. Seven of the eight subjects, after finishing the "told 50/50" condition confirmed that they could not be certain which drink they had received and one of the eight stated that they were sure they had been given the non carbohydrate drink. Crucially, none of the subjects stated that they believed they had received the carbohydrate drink. As discussed earlier, the expectation or belief of receiving something perceived to be beneficial to sports performance has been speculated to be a strong contributor towards the formation of a placebo effect (Kirsh, 1985; Geers et al., 2005; McClung & Collins, 2007; Bottoms, Buscombe & Nicholettos, 2013). A study by Clark *et al.* (2000) which examined the placebo effect of carbohydrate feeding during a 40km cycling time trial illustrates this point. The results provided a clear indication that expectations influence the placebo effect and reported that the greatest increase in performance was in the "told carbohydrate" condition, irrespective of whether subjects received the carbohydrate or placebo drink. Furthermore, previous studies have tended to utilise a deceptive administration protocol (Clark, et al., 2000; McClung & Collins, 2007; Foad, Beedie & Coleman, 2008; Bottoms, Buscombe & Nicholettos, 2013). The designs elicit belief and expectancy in the subject's perception of what they believe they will be receiving when they are actually given the opposite. This method provides a decent measurement of true psychological and/or pharmacological effects.

Although the findings of the present study are contrary to previous research which has successfully demonstrated the placebo effect, the present study does lend some support to a finding in the study of Clark *et al.* (2000). The authors did utilise a deceptive administration protocol, however they also incorporated an additional "told 50/50" condition. The results in the "told 50/50" condition did not show a performance increase but reported a 1.1% decrease in performance relative to baseline measures. The authors speculated that the uncertainty about the treatment in the 50/50 condition caused some subjects to actively search for performance effects and increase effort in the exercise test compared to the baseline measure whereas others resigned themselves to poorer performance and did not exert as much effort. The present study did not include a baseline measure and thus was unable to make this comparison. Nevertheless, it could be suggested that a similar behaviour of the subjects may have occurred in the 50/50 condition as the majority of the subjects were not certain that they knew which drink they had received and performance duration remained very close to the known non carbohydrate condition. Furthermore it is often suggested in the literature that an uncertainty about an intervention or placebo condition allocation likely reduces the magnitude of placebo effects observed (Kirsch & Weixel, 1988; Beedie & Foad, 2009). This may have provided some influence on the results seen in the present study and also shows some disagreement with the suggestion by Fiorillo, Tobler & Schultz (2003) that a degree of uncertainty might be required to elicit a placebo effect.

5.1.2 Placebo effect on rating of perceived exertion

It was determined that there were no significant differences in RPE measures between the “told 50/50” condition, “told carbohydrate” and “told non carbohydrate” conditions for measurements taken at minute two, five and at the end of the exercise test (all P=>0.05). A finding which has been consistently demonstrated in studies that have examined the placebo effect is a reduced RPE with a presented intervention deceptively administered as a placebo (Pollo, Carlino & Benedetti, 2008; Kallmes et al., 2009). Higher RPE values have also been reported in the perceived placebo deceptively administered intervention conditions (Docherty & Smith, 2005; Duncan, Lyons & Hankey, 2009).

The finding of no significant difference is contrary to previous research however methodological variances such as modes of exercise, presented interventions and duration of the study make direct comparisons of studies difficult (Bottoms, Buscombe & Nicholettos, 2013). A possible speculative explanation for the discrepancy shown in the results may be related to the nature of the exercise protocol prescribed in the study. Subjects were required to continually cycle at a set cadence of 75RPM at 90% of their estimated maximal power. This is an extremely high intensity exercise and it has been suggested in research that psychological factors become less important at high exercise intensities and peripheral sensations become the dominant source of effort perception (Noble & Robertson, 1996; Hampson, Gibson, Lambert, Dugas, Lambert & Noakes, 2004). A second possible contribution towards the discrepancy in the results may be the lack of consistency when RPE was measured. The subject's familiarity of the RPE scale was assumed and the scale was not always held up for the subjects to visually see for them to select their most appropriate rating. It has been shown previously that monitoring exercise of moderate to high intensity without allowing subjects to visually view the scale may result in an underestimation of exertion (Abadie, 1996).

5.2 Effectiveness of pre-exercise carbohydrate feeding

To determine the effectiveness of the carbohydrate drink on short duration high intensity exercise, the results from each of the three conditions were compared using a repeated measures analysis of variance (ANOVA). This aimed to establish any statistically significant differences between the performance measures of total performance duration, RPE at minute two, five and at the end of the exercise test. Objective measures of average heart rate and peak heart rate were also used to monitor physiological exertion.

5.2.1 Pre-exercise carbohydrate feeding effects on performance

In agreement with the hypothesis the present study determined that there was a significant increase in performance duration in the condition told carbohydrate drink compared to the condition told non carbohydrate drink ($P=0.01$) (shown in table 4 and figure 2). There were no significant differences in average heart rate and peak heart rate measures between each conditions ($P=>0.05$), this suggests that physiological strain was consistent between the conditions however the high intensity nature of the exercise task may have caused subjects to end the exercise test due to peripheral fatigue as opposed to cardiovascular strain thus future research might use other measures to monitor physiological strain such as blood lactate (Bergstrom, 1967; Duncan, Lyons & Hankey, 2009; Galloway, Lott & Toulouse, 2014). As previously discussed the RPE across conditions for measurements taken at minute two, five and at the end of the exercise task demonstrated no significant differences ($P=>0.05$). Although this could provide further indication that performance effort from each subject was consistent across the conditions as previously mentioned the consistently of the measure of RPE did not remain constant which may have affected the subjects estimation of their perceived exertion (Abadie, 1996).

Collectively the data observed from the present study does provide an indication of a possible performance benefit of pre-exercise carbohydrate feeding of a 16g of carbohydrate (6.4%) drink ingested 30 minutes prior to undertaking short duration high intensity exercise. It should be noted however that although performance duration in the “told 50/50” condition of which subjects each received the non carbohydrate drink remained very close to the condition in which subjects were told that they were receiving the non carbohydrate drink there was not a condition in which subjects were “told 50/50” and given the carbohydrate drink which would have provided further data analysis of the pharmacological effects of the carbohydrate drink. Furthermore a deceptive administration protocol was not implemented in the present study thus it could be argued that placebo effects were not controlled for thus the performance enhancement observed in the “told carbohydrate” drink condition compared to the “told non carbohydrate” drink condition could largely represent a placebo responding and not true pharmacological effects of the carbohydrate drink ingested. However the difference in performance duration observed between the “told carbohydrate” and “told non carbohydrate” conditions was sizeable (mean difference = 36.66s) and produced a strong significance value (P=0.01) therefore from a coaching perspective provides a strong argument for the use of utilising pre-exercise carbohydrate feeding by ingesting a 32g commercially available carbohydrate drink 30 minutes prior to high intensity short duration exercise, regardless of whether the mechanisms for performance enhancement orientate from placebo responding’s or metabolic effects.

5.2.2 Metabolic effects of pre-exercise carbohydrate feeding

Previous studies which have examined the effects of pre-exercise carbohydrate feeding on sport and exercise performance have focused on prolonged, intermittent exercise, timing and concentration (Below *et al.*, 1994; Temesi *et al*., 2011; Galloway, Lott & Toulouse, 2014). Only one peer reviewed published study could be found which examined pre-exercise carbohydrate feeding on short duration high intensity exercise (Galloway, Lott & Toulouse, 2014), therefore the research on this topic is relatively new. There are currently no studies which have examined the mechanisms by which pre-exercise carbohydrate feeding possibly mediates a performance enhancement in short duration high intensity exercise, thus further study focusing on metabolic and peripheral neuromuscular control mechanisms is warranted. There are however a number of speculative explanations that can be considered of the metabolic effects of what might induce a performance benefit of pre-exercise carbohydrate feeding on short duration high intensity exercise.

5.2.3 Speculative explanations

Pre-exercised carbohydrate feeding is known to reduce liver glucose output and stimulate an accelerated glucose uptake and oxidation in skeletal muscle in the early stages of exercise when pre-exercise blood glucose concentration is greater (Tsintzas *et al.,* 2000 Temesi, *et al.,* 2011; Cermak & Van Loon, 2013). A pre-exercise elevation of blood glucose and plasma insulin concentration following pre exercise carbohydrate ingestion has been shown to activate the PDC complex at a faster rate (Tsintzas *et al.,* 2000). The PDC complex converts pyruvate into Acetyl CoA by a process called pyruvate decarboxylation (Timmons *et al.,* 1998). Acetyl CoA is then subsequently utilised in the TCA cycle. (Timmons *et al.,* 1998; Tsintzas *et al.,* 2000). Therefore a faster rate of PDC activation would increase availability of Acetyl CoA for its use in the TCA cycle mediating a faster onset of oxidative ATP production. Similar to the exercise prescribed in the present study which lasted around 5-10 minutes in duration there would still have been a significant aerobic component (Galloway, Lott & Toulous, 2014). Therefore an increased flux through glycolysis would have aided a greater matching of the ATP to supply and demand (Timmons *et al.,* 1998). The greater performance duration observed in the present study may be explained by such metabolic occurrences however it must be highlighted that this is purely speculative and the present study does not provide an insight into the metabolic effects of pre-exercise carbohydrate feeding when considering short duration high intensity exercise.

5.3 Methodological limitations

Administration protocol

The present study utilised a “told 50/50” condition to measure placebo effects. In addition to this in order to measure the pharmacological effects of carbohydrate feeding two conditions, “told carbohydrate” and “told non carbohydrate” were compared. As previously discussed this may not have been an accurate method of which to measure the two variables of interest. The placebo effect was not evident in the present study which may have been attributable to a lack of expectancy of which the “told 50/50” condition allowed. The large differences in the “told carbohydrate” and “told non carbohydrate” conditions may also be attributable to placebo effects between the two conditions as no placebo control condition was utilised. A deceptive administration protocol would therefore have been a more robust methodological approach to measure the placebo and pharmacological effect of pre-exercise carbohydrate feeding. The deceptive nature of this approach however would have not complied with the Cardiff Metropolitan University ethics committee approval.

Estimated maximal aerobic power

The present study utilised Wassermans *et al.* (2005) estimation of maximal power output (for equation see methods section). Maximal power output could have been calculated through the use of a VO_2max Wingate test. However this would have required subjects to attend an additional visit to the laboratory which was not possible due to time constrains (Gacesa, Barak & Grujic, 2009).

Presented intervention

The present study utilised pre-exercise carbohydrate feeding of a carbohydrate drink as a presented performance-enhancing intervention for short duration high intensity exercise. As previously discussed, the majority of studies that have looked at carbohydrate feeding have investigated its effects on prolonged or intermittent exercise performance (Murray, Eddy, Murray, Seifert, Paul & Halaby, 1987; Below *et al.*, 1994; Temesi *et al.*, 2013). Guidelines that are presented to the public specify that there is no requirement for carbohydrate ingestion for exercise tasks which last less than 45 minutes in duration (Galloway, Lott & Toulouse 2014). It may therefore be reasonable to suggest that a perception exists that carbohydrate intake is only beneficial to longer duration exercise tasks. Although the subjects in the present study were provided with literature which demonstrated performance-enhancing effects of pre-exercise carbohydrate feeding on short duration high intensity exercise (Galloway, Lott & Toulouse, 2014), the subjects may not have had high expectations of performance-enhancing effects of the carbohydrate drink on their performance in the exercise tests assigned in the study.

RPE measures

As previously discussed RPE was not always consistently measured by visually holding up the scale for the subjects to select their appropriate rating. A finding in the research of Abadie (1996) is that monitoring RPE in exercise of a moderate to high intensity without a visual aid of the scale may result in underestimations of exertion.

Number of participants

A small number of participants completed the study (N=8) thus the reliability of group analysis is reduced. A much larger sample size (N=>20) would be ideal and provide more reliable data however due to only eight subjects volunteering and the time constraints by which the study needed to be completed no more than eight subjects were included in the study.

5.4 Future directions

Knowledge of the placebo effect in comparison to the pharmacological effects of pre-exercise carbohydrate feeding on high intensity short duration exercise would facilitate a clear comparison of any differences or similarities between psychological and physiological effects (MucClung & Collins, 2007). The data could then be presented to coaches and athletes as a consideration for practical use. The present study did not observe a placebo effect which as previously discussed could have been caused by the methodological approach (Kirsh, 1985; Geers *et al*., 2005; McClung & Collins, 2007; Bottoms, Buscombe & Nicholettos, 2013). The placebo effect was also not controlled for when measuring the pharmacological effects of the carbohydrate drink. A lack of research examining pre-exercise carbohydrate feeding on high intensity short duration exercise coupled with discrepancies in the available literature which examines the placebo effect compared to pharmacological effect warrants further research (Clarke *et al.,* 2000; McClung & Collins, 2007; Foad *et al.*, 2008). Future research may therefore consider utilising a four cell Latin square design with a deceptive administration protocol which allows for all combinations of “active/placebo” and “assumed received/assumed not received”. A clear expectancy versus pharmacological effects comparison could then be made in addition to an examination of placebo and pharmacological effects.

Exploration of the potential metabolic, central neural and peripheral neuromuscular control mechanisms by which pre-exercise carbohydrate possibly benefits high intensity short duration requires further study. Current literature focuses on prolonged or intermittent exercise and timing and concentration of carbohydrate feeding (Below *et al.,* 1994; Temesi *et al*., 2013; Galloway, Lott & Toulouse, 2014). No study has yet independently sought to examine metabolic, central neural or peripheral neuromuscular control of how pre-exercise carbohydrate feeding might benefit short duration high intensity exercise (Galloway, Lott & Toulouse, 2014). Findings oh such mechanisms could then be presented to athletes and coaches in practical guidance.

6 CONCLUSION

The present study did not determine a placebo effect from ingesting a 32g carbohydrate drink 30 minutes before high intensity short duration exercise. The findings are contrary to previous placebo effect research and may, as previously discussed, be a reflection of the limitations to the design of the methodology used. The present study did however provide some indication of a possible performance enhancement from the actual ingestion of a 32g carbohydrate drink ingested 30 minutes before high intensity short duration exercise, as is concordant with current literature. The present study did not however include a control for possible placebo effects when pharmacological effects were measured, nor did the study use a baseline measure. The findings should therefore be treated with caution and further research should be undertaken addressing the limitations of the study before pre-exercise carbohydrate feeding can be confirmed or rejected as a performance enhancing aid in relation to high intensity short duration exercise.

Further research is required with a methodological design which would allow for a combination of “active/placebo” and “assumed received/assumed not received” conditions to measure for the true pharmacological and placebo effects. Future studies should also examine the metabolic, central neural or peripheral neuromuscular control of how pre-exercise carbohydrate feeding might benefit high intensity short duration exercise.

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APPENDICES

Appendix 1 – Participant Information Sheet

Appendix 2 – Participant Consent Form

Appendix 3 – Health and physical activity questionnaire

Appendix 4 – Test Preparation Questionnaire

Appendix One - Participant Information Sheet

Ethics approval reference number: 14-05-360U

Title of Project: The placebo effect on time to exhaustion during cycle ergometry.

Background and the aim of the research project

Various supplements are considered to have a positive effect on exercise performance. However, some research also suggests that the positive effects on performance may in part or even entirely attributable to psychological effects, the so-called ‘placebo effect’. The purpose of this study is to explore the potential placebo effects of receiving a carbohydrate sports vs. a non-carbohydrate drink.

The findings will be presented as an undergraduate dissertation.

Your participation in the research project

If you choose to voluntarily participate in the study and you are deemed eligible to participate according to your health status you will asked to sign a consent form to become a research participant. This will mean that the data gathered from the study will be based on your results. Your involvement within the study will last over a three week period requiring you to visit the laboratory three times, once per week. The study will end with a brief review and a discussion of your test results.

Procedures

All testing will be performed within the physiology laboratory facility of Cardiff Metropolitan University, Cardiff, UK. You will be required to visit the laboratory three times, once a week over three weeks, always on the same time of day for approximately 45 minutes. During each visit to the laboratory you will be asked to complete a health questionnaire. If you are deemed suitable to continue participating in the study you may proceed. You will then be asked to consume either 250ml of a commercially available carbohydrate drink or 250ml of the non-carbohydrate equivalent. The drink you did not receive will then become the drink which you will be given the following week. On your third visit, you will receive either the carbohydrate or the non-carbohydrate drink but you will not be told which one you are actually receiving. You must decide which one you think you have been given and tell the researcher after the exercise test has ended which drink you thought you had received. Following ingestion of the drink, during a 30 minute waiting period you will be asked to complete a brief questionnaire which is designed to check for compliance with pre-test instructions and your height (cm) and weight (kg) will be measured. You will also complete a warm-up as detailed below.

Warm-up

Using the data from your recorded height, weight and age, your maximum power output (MP) will be estimated. This will then be used to calculate half of your 90% MP which will be the set workload for a 5 minute duration on the cycle ergometer.

Exercise test

A heart rate monitor will be fitted and you will be asked to perform your maximal effort at 90% of your estimated MP until you cannot physically perform any longer. After the exercise test you will be required to pedal for a further 3 minutes without any resistance for a cool down.

Performance measures

Your heart rate and peak heart rate will be measured throughout the exercise test. Your performance time until exhaustion will also be measured. You will also be asked to rate your perceived exertion on a scale presented to you known as the Borg scale for feeling in both your overall body and in the active muscle. Your performance results will not be given to you until after the entire study has been completed.

Necessary preparation prior to each laboratory visit

To control for variables which could affect the study's results you are kindly asked to adhere to the following criteria:

1) Not to drink any fluid other than water in the three hours prior to exercise and none in the 30 minutes before the exercise test.
2) Maintain your "normal" diet.
3) Not to undertake vigorous exercise in the 24 hours before the laboratory visit.
4) Not to drink alcohol or caffeine in the 12 hours before to the laboratory visit.

Necessary criteria for participation within the project

You must be free from any health problems and allergies, which will be established with the use of a health questionnaire. It is important that you are not currently consuming any pre-exercise supplements. You must also be aged 18-25 and injury free.

Are there any risks?

Participation within the study will involve undertaking strenuous exercise. This form of exercise is not suited to individuals with health problems, therefore honest answers on the health questionnaire are essential. As previously mentioned, the exercise will require maximum effort therefore you may feel light-headed post-exercise. The cool down will minimise the risk of such occurrence.

You must identify any known allergies as the study involves ingesting a solution. If you experience any discomfort during and after the exercise test it is important to tell the researcher for the appropriate action to be taken.

Are there any benefits from taking part?

Through participating within this study you will receive information regarding your results of the tests. This will include the performance measures of heart rate, peak heart rate, time to exhaustion and scores from your perceived exertion scale. You will also receive information regarding the performance changes observed for each of the experimental conditions.

What happens next?

If you choose to participate within this study, you will be required to first complete a health questionnaire provided by the researcher. If you meet the requirements for the study you will be asked to sign a consent form.

How we protect your privacy

Your privacy will be taken seriously. Participant information, names and address will remain anonymous to all but my supervisor and myself. Any data obtained about you from the study will be coded, meaning that information will not be labelled using your name but by a number thus ensuring that you cannot be personally identified from any of the data; however we will need to keep a record of the codes to compare the data and the trials.

All information will be stored securely and destroyed once the relevant data has been analysed and presented together in a student undergraduate dissertation. However consent forms will be retained for ten years in accordance with the Cardiff Metropolitan University requirements.

Your rights

It must be made clear that participation within this research study is entirely voluntary and you will have the right to withdraw from the study at any point. Should you wish to not participate within the study or choose to withdraw from the study any relationships with Cardiff Metropolitan University or the researcher will not be affected.

Thank you for taking the time to read this.

Further information

If you have any questions about the research and wish to obtain further information you can contact:

Researcher: Amanda Wightman □ st20026583@cardiffmet.ac.uk
Supervisor: Eric Stöhr □ estohr@cardiffmet.ac.uk

Appendix Two – Participant Consent Form

Reference Number:

Participant name or Student Number:

Title of Project: The placebo effect on time to exhaustion during cycle ergometry.

Name of Researcher: Amanda Wightman

Participant to complete this section: Please initial each box.

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and I have had these answered satisfactorily. ☐

2. I agree to the procedure described on the information sheet. ☐

3. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. ☐

4. I confirm that I have read and completed the health questionnaire to the best of my knowledge. ☐

5. I agree to take part in the above study. ☐

Signature of Participant ______________________ Date (DD/MM/YYYY) ______________

Name (PRINT) ______________________ Date (DD/MM/YYYY) ______________

**Upon completion one copy will be kept by the participant and one copy will be kept by the researcher.*

Appendix Three - Health and physical activity questionnaire

AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire

Assess your health needs by marking all *true* statements.

History

You have had:

___ A heart attack
___ Cardiac catheterization
___ Coronary angioplasty (PTCA)
___ Pacemaker/implantable cardiac defibrillator/rhythm disturbance
___ Heart valve disease
___ Heart failure
___ You have diabetes

Symptoms

___ You experience chest discomfort with exertion
___ You experience unreasonable breathlessness
___ You experience dizziness, fainting, blackouts
___ You take heart medications

Other health issues

___ You have asthma or other lung disease
___ Heart surgery
___ You have burning or cramping in your lower legs when walking short distances
___ You have musculoskeletal problems that limit your physical activity
___ Heart transplantation
___ Congenital heart disease
___ You have concerns about the safety of exercise
___ You take prescription medication(s)
___ You are pregnant

If you marked any of the statements in this section, consult your physician or other appropriate healthcare provider before engaging in exercise. You may need to use a facility with a ***medically qualified staff****.*

Cardiovascular risk factors

___ You are a man older than 45 years
___ You are a woman older than 55 years, you have had a hysterectomy, or you are postmenopausal
___ You smoke, or have given up within the previous 6 months
___ Your BP is greater than 140/90
___ You don't know your BP
___ You take BP medication
___ Your blood cholesterol level is >200 mg/dl
___ You don't know your cholesterol level
___ You have a close blood relative who had a heart attack before age 55 (father or brother) or age 65 (mother or sister)
___ You are physically inactive (i.e. you get less than 30 minutes of physical activity on at least 3 days per week)
___ You are more than 20 pounds overweight
___ None of the above is true

If you marked two or more of the statements in this section, you should consult your physician or other appropriate healthcare provider before engaging in exercise. You might benefit by using a facility with a **professionally qualified exercise staff** to guide your exercise program.

You should be able to exercise safely without consulting your physician or other healthcare provider in a self-guided program or almost any facility that meets your exercise program needs

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Balady et al. (1998). AHA/ACSM Joint Statement: Recommendations for Cardiovascular Screening, Staffing, and Emergency Policies at Health/Fitness Facilities. *Medicine & Science in Sports & Exercise, 30*(6). (Also in: *ACSM's Guidelines for Exercise Testing and Prescription*, 8th Edition, 2009. Lippincott Williams and Wilkins http://www.lww.com)
www.acsm-msse.org/pt/pt-core/template-journal/msse/media/0698c.htm

Appendix Four - Test Preparation Questionnaire

Please answer the following questions which are designed to check for your compliance to guidelines given at the beginning of the study, adding detail in the space provided:

a) Have you had anything to drink in the last 3 hours? (If so give details)

____
____
____

b) Have you maintained normal dietary patterns in the last 24 hours? (If not give details)

____
____
____

c) Have you undertaken vigorous exercise in the last 24 hours? (If so give details)

____
____
____

d) Have you consumed any caffeine or alcohol in the last 12 hours? (If so give details)

____
____
____

* When you have answered these questions and you are happy with the explanations given, please sign below.

I have read this form and understand the test procedures that I will perform. I consent to participate in the test and for this information provided to be used for the purposes of the study.

Signature of Participant   Date (DD/MM/YYYY)

_________________________________   ____________________

Name (PRINT)   Date (DD/MM/YYYY)

_________________________________   ____________________