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Research report

The effect of post-exercise drink macronutrient content on appetite and energy intake ☆

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ABSTRACT

Carbohydrate and protein ingestion post-exercise are known to facilitate muscle glycogen resynthesis and protein synthesis, respectively, but the effects of post-exercise nutrient intake on subsequent appetite are unknown. This study aimed to investigate whether protein induced satiety that has been reported at rest was still evident when pre-loads were consumed in a post-exercise context. Using a randomised, double blind, crossover design, 12 unrestrained healthy males completed 30 min of continuous cycling exercise at ~60% VO_2peak, followed by five, 3 min intervals at ~85% VO_2peak. Ten min post-exercise, subjects consumed 500 ml of either a low energy placebo (15 kJ) (PLA); a 6% whey protein isolate drink (528 kJ) (PRO); or a 6% sucrose drink (528 kJ) (CHO). Sixty min after drink ingestion, a homogenous *ad-libitum* pasta lunch was provided and energy intake at this lunch was quantified. Subjective appetite ratings were measured at various stages of the protocol. Energy consumed at the *ad-libitum* lunch was lower after PRO (5831 ± 960 kJ) than PLA (6406 ± 492 kJ) ($P < 0.05$), but not different between CHO (6111 ± 901 kJ) and the other trials ($P > 0.315$). Considering the post-exercise drink, total energy intake was not different between trials ($P = 0.383$). There were no differences between trials for any of the subjective appetite ratings. The results demonstrate that where post-exercise liquid protein ingestion may enhance the adaptive response of skeletal muscle, this may be possible without affecting gross energy intake relative to consuming a low energy drink.

Introduction

The maintenance of a stable body weight is achieved through careful balance between energy intake and energy expenditure. However, mismanagement of this balance on a global scale has led to an increase in the prevalence of obesity and obesity related comorbidities (Finucane et al., 2011; Malik, Willett, & Hu, 2013). Exercise and energy restriction are commonly used to create energy deficits during weight loss programs, but these methods appear to have disparate effects on appetite and subsequent energy intake (King et al., 2011). Energy intake appears to be unaffected by an acute bout of exercise, although chronic exercise programs appear to induce some level of compensation (Blundell, Stubbs, Hughes, Whybrow, & King, 2003). By contrast, acute energy restriction has been shown to markedly increase feelings of hunger and energy intake (Hubert, King, & Blundell, 1998). Increased feelings of hunger are cited as a key factor culminating in poor dietary adherence (Dansinger, Gleason, Griffith, Selker, & Schaefer, 2005), and as such, developing methods to suppress hunger and energy intake, whilst inducing a negative energy balance, should be the primary goal of modern weight management programmes.

Following exercise, the consumption of fluid helps restore any plasma volume losses (Nose, Mack, Shi, & Nadel, 1988; Shirreffs, Taylor, Leiper, & Maughan, 1996), and the addition of protein to post-exercise drinks might aid post-exercise rehydration (James, 2012), as well as being critically important for myofibrillar and mitochondrial protein synthesis (Wilkinson et al., 2008). From a weight management perspective, it is also important to consider whether consuming energy in a post-exercise recovery drink will weaken the energy deficit induced by the exercise session, and how accurately the energy contained in the drink will be compensated for during subsequent feeding.

High protein diets have been shown to promote greater feelings of satiety than normal protein diets, whilst promoting losses in body fat and preservation of lean body mass (Leidy, Carnell, Mattes, & Campbell, 2007). Significant evidence also exists that acute protein feeding at rest enhances satiety (Hill & Blundell, 1986; Stubbs, van Wyk, Johnstone, & Harbron, 1996) and reduces subsequent energy intake (Araya, Hills, Alvina, & Vera, 2000; Poppitt, McCormack, & Buffenstein, 1998; Porrini et al., 1997) compared to carbohydrate and fat. Additionally, protein has an increased thermogenic effect

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compared to carbohydrate and fat (Feinman & Fine, 2004) which may further decrease energy balance by increasing energy expenditure. Whilst there may be differences in food rheology between providing energy in liquid or solid form, several studies have demonstrated that a liquid protein meal also suppresses appetite and reduces acute energy intake compared to an isoenergetic carbohydrate or water control (Anderson & Moore, 2004; Astbury, Stevenson, Morris, Taylor, & MacDonald, 2010; Bertenshaw, Lluch, & Yeomans, 2008; Bowen, Noakes, Trenerry, & Clifton, 2006a). Conversely, other studies have reported no difference in energy intake between protein and carbohydrate pre-loads (Bowen, Noakes, & Clifton, 2007), as well as between low dose whey protein drinks and water (Poppitt et al., 2011). Whilst several studies have failed to observe any attenuation in energy intake, the majority of studies have reported an increase in subjective perceptions of satiety after consuming protein containing drinks (Bowen et al., 2007; Harper, James, Flint, & Astrup, 2007; Poppitt et al., 2011). This suggests that the consumption of protein containing drinks leads to enhanced satiety which may affect food intake or food choices (i.e. reduced snacking) under free-living conditions (Poppitt et al., 2011).

A recent meta-analysis stated that studies utilising interventions that combine exercise with dietary restriction are the most successful for long term, sustainable weight loss and maintenance (Franz et al., 2007). High intensity intermittent exercise is characterised by brief vigorous exercise bouts interspersed with periods of rest, and has been shown to be a time-efficient and enjoyable training method for cardiovascular and skeletal muscle adaptations, linked to improved health outcomes (Bartlett et al., 2011; Gibala, Little, MacDonald, & Hawley, 2012). Both dietary restriction and exercise have an influence on appetite, and whilst the acute appetite response to a protein pre-load provided at rest has been well researched, no studies have attempted to investigate this in combination with exercise. Due to the popularity of consuming commercial protein and carbohydrate drinks after exercise, the aim of this study was to assess whether the macronutrient content of a drink has any effect on subsequent appetite and energy intake following 60 minute exercise session consisting of endurance and high-intensity intermittent exercise. As protein consumption at rest has been shown to attenuate subsequent energy intake, it was hypothesised that consuming protein in a post-exercise recovery drink may lead to a reduction in energy intake at a subsequent meal. These is some evidence to suggest that chronic exercise may increase energy intake in some individuals (Blundell et al., 2003), and as such the consumption of a protein containing drink after exercise may have the potential to offset this effect, therefore becoming an effective aid for weight loss and management. A 30 g dose of protein has been shown to maximally stimulate muscle protein synthesis after exercise (Moore et al., 2009; Witard et al., 2014) and whey protein has been shown to attenuate appetite to a greater extent than other forms of protein (Hall, Millward, Long, & Morgan, 2003). Therefore, in this study a 6% (500 ml) whey protein isolate drink was compared to an isoenergetic carbohydrate drink and low energy placebo.

Methods

Subjects

After ethical approval, subjects completed a medical screening questionnaire, a three-factor eating questionnaire (Stunkard & Messick, 1985) and provided written consent. Subjects were twelve healthy, weight stable, recreationally active males (mean ± SD) (age: 24 ± 2 y, weight: 71.2 ± 5.7 kg, height: 1.75 ± 0.05 m, BMI: 23.2 ± 1.4 kg·m^{-2}, VO_2 peak: 52 ± 8 ml·kg^{-2}). Subjects were not restrained, disinhibited or hungry eaters.

Preliminary trials

Subjects completed two preliminary trials. During the first, they completed a discontinuous incremental exercise test on an electrically braked cycle ergometer (Lode Corival, Groningen, Holland) to determine peak oxygen consumption (VO_2peak). Increments lasted 4 min, were separated by ~5 min rest and workload increased until volitional exhaustion. Expired air was collected into a Douglas Bag during the last min of each increment, whilst heart rate (Polar Beat, Kempele, Finland) and rating of perceived exertion (RPE) (Borg, 1973) were measured at the end of each increment. Expired air was analysed for O_2 and CO_2 concentration (Servomex 1440 Gas Analyser, Sussex, UK), volume (Harvard Dry Gas meter, Harvard Apparatus Ltd, Kent, UK) and temperature (Edale, Cambridge, UK).

During the second preliminary trial, subjects completed a full replication of an experimental trial including the *ad-libitum* pasta meal, with water ingested as the post-exercise drink.

Pre-trial standardisation

Subjects completed a weighed food diary in the 24 h preceding the first experimental trial and replicated this in the 24 h before each subsequent trial. Strenuous exercise and alcohol ingestion were not permitted during this period.

On the day of each experimental trial, subjects consumed a standard breakfast providing 15% of estimated energy requirements (RMR (Mifflin et al., 1990) multiplied by 1.7) 2 h before exercise commenced. This amounted to 1810 ± 80 kJ and is consistent with the absolute amount of energy provided at breakfast in studies of this nature (Bertenshaw et al., 2008; Bertenshaw, Lluch, & Yeomans, 2013; Poppitt et al., 2011). The breakfast consisted of cereal (Rice Snaps, Tesco, Cheshunt, UK) and semi-skimmed milk (Tesco, Cheshunt, UK) in a ratio of 30 g cereal: 125 ml milk. Water was permitted *ad-libitum* and recorded on the morning of the first trial until subjects arrived at the lab, and was then repeated prior to subsequent trials.

Experimental design

Participants arrived at the laboratory between 9.30–10.30 am and voided their bladder and bowels, before nude body mass was measured. Subjects then completed 30 min steady state cycling exercise at ~60% VO_2peak followed by 5 min rest and then five 3 min intervals at ~85% VO_2peak, each separated by 2 min rest. Total exercise time was therefore 60 min. Expired air was collected between 14–15 min and 29–30 min steady state exercise and during the final minute of the third and fifth interval. Heart rate and RPE were measured at 15 min and 30 min during steady state exercise and at the end of each interval. Subjects consumed 100 ml of water at 15 min, and prior to intervals one, three and five.

Upon completion of exercise, nude body mass was measured and subjects assumed a seated position. Ten minutes post-exercise, subjects were provided with a recovery drink (Table 1) to consume within five minutes and an *ad-libitum* lunch was provided 75 min post-exercise whilst subjects rested in a comfortable environment (23.5 ± 1.8 °C).

Table 1
Composition of test drinks.

	Placebo (PLA)	Protein (PRO)	Sucrose (CHO)
Energy (kJ)	15	529	529
Protein (g)	0.3	30.3	0.3
Carbohydrate (g)	0.6	0.6	30.8
Fat (g)	0	0.1	0