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Research report

The effect of a whey protein supplement dose on satiety and food intake in resistance training athletes ☆

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Objective: Many athletes perform resistance training and consume dietary protein as a strategy to promote anabolic adaptation. Due to its high satiety value, the regular addition of supplemented dietary protein could plausibly displace other key macronutrients such as carbohydrate in an athlete's diet. This effect will be influenced by the form and dose of protein. Therefore, this study assessed the impact of liquid whey protein dose manipulation on subjective sensations of appetite and food intake in a cohort of athletes. Design: Ten male athletes who performed both resistance and aerobic (endurance) training (21.2 ± 2.3 years; 181.7 ± 5.7 cm and 80.8 ± 6.1 kg) were recruited. In four counter-balanced testing sessions they consumed a manipulated whey protein supplement (20, 40, 60 or 80 g protein) 1 hour after a standardised breakfast. Subsequent energy intake was measured 3 hours after the protein supplement using an *ad libitum* test meal. Subjective appetite sensations were measured periodically during the test day using visual analogue scales. Results: All conditions resulted in a significant decrease in ratings of hunger (50–65%; $P < 0.05$) at the time of supplement consumption. However, there were no significant differences between the conditions at any time point for subjective appetite sensations or for energy consumed in the *ad libitum* meal: 4382 ± 1004, 4643 ± 982, 4514 ± 1112, 4177 ± 1494 kJ respectively. Conclusion: Increasing whey protein supplement dose above 20 g did not result in a measurable increase in satiety or decrease in food intake. However, the inclusion of additional whey protein supplementation where not otherwise consumed could plausibly reduce dietary intake.

Introduction

The exploration of drivers of appetite and food intake has increasing relevance to athlete groups who often experience challenges in optimising their dietary intake. However, research on appetite regulation in athletes is limited. In non-athlete groups, there is compelling evidence that protein is the most satiating macronutrient (Barkeling, Rossner, & Bjorvell, 1990; Benelam, 2009; Halton & Hu, 2004; Latner & Schwartz, 1999) and that the protein content of food is significantly correlated with satiety scores (Holt, Miller, Petocz, & Farmakalidis, 1995). Due to its satiating efficiency, protein consumption has generally been favoured for its role in controlling food intake to favour weight loss and prevent weight gain in athlete and non-athlete groups.

In addition to the effect on satiety, dietary protein consumption is favoured by many athletes due to its role in promoting muscle protein synthesis (MPS) and functional adaptations when combined with resistance exercise (i.e. the progressive and structured training using weights or weight machines) (Slater & Phillips, 2011). In addition, athletes who undertake endurance or aerobic training in conjunction with resistance exercise (termed concurrent training) (Leveritt, Abernethy, Barry, & Logan, 1999) may favour supplemental and dietary protein consumption. However, for concurrently trained athletes, it is plausible that due to its satiating effect prioritised protein consumption could displace their intake of other important nutrients including carbohydrate. Evidence in non-athletes also suggests a weak coupling between energy intake (EI) and energy expenditure (EE) (Blundell & King, 1998; King, Lluch, Stubbs, & Blundell, 1997; King, Snell, Smith, & Blundell, 1996; King, Tremblay, & Blundell, 1997; Schubert, Desbrow, Sabapathy, & Leveritt, 2013), suggesting that some athletes who perform resistance exercise and have a high energy requirement due to a large body size, proportional lean mass and volume of exercise (Blundell et al., 2012; Stensel, 2010) may also experience challenges in meeting their energy requirements when favouring the consumption of dietary and supplemental protein.

As whey protein is commonly supplemented by resistance training athletes, this study explored the impact of whey protein

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consumption on satiety and food intake. In combination with other factors, whey protein has rapid absorption kinetics and a high leucine content, making consumption beneficial for promoting MPS in comparison to other proteins (Hulmi, Lockwood, & Stout, 2010; Pennings et al., 2011). Similarly, whey protein has been shown to potently impact satiety and food intake, both acutely (Anderson, Tecimer, Shah, & Zafar, 2004; Bowen, Noakes, Trenerry, & Clifton, 2006; Hall, Millward, Long, & Morgan, 2003; Veldhorst et al., 2009) and chronically (Baer et al., 2011). Preload studies have consistently shown that large doses of pure whey protein (40–60 g) when consumed as a beverage prior to an *ad libitum* meal reduce subsequent food intake (Anderson et al., 2004; Bowen et al., 2006; Hall et al., 2003). However, protein doses of 20 g may also impact subjective appetite sensations and decrease *ad libitum* food intake (Abou-Samra, Keersmaekers, Brienza, Mukherjee, & Macé, 2011) and are recommended to promote MPS in combination with resistance exercise (Moore et al., 2009; Slater & Phillips, 2011).

Comparative dose–response studies are required to determine whether different protein doses (for example 20 g in comparison to 40 g) differentially affect satiety when the intake of other macronutrients or energy intake is controlled. Studies in non-athletes have supported a protein dose–response effect for protein intake, with increasing doses increasing satiety scores or decreasing subsequent food intake up to 80 g of protein on sensations of satiety and consequent food intake (Latner & Schwartz, 1999; Veldhorst et al., 2009). However, no studies have been undertaken in athletes, and methodological differences and inconsistent macronutrient manipulations in studies in non-athletes make it difficult to draw clear conclusions. In addition, the habitual protein intake of the participants is not commonly reported, which is important as protein gastric emptying and satiety response has been demonstrated to have a reduced effect on individuals with high habitual protein intakes (Long, Jeffcoat, & Millward, 2000; Shi et al., 1997). There is evidence to suggest that many athletes already consume protein above the current recommendations (Rodriguez, Di Marco, & Langley, 2009); in the range of ~1.5–2.5 g·kg day^{-1} (Bradley et al., 2015; Cole et al., 2005; Lundy, O'Connor, Pelly, & Caterson, 2006; Schokman, Rutishauser, & Wallace, 1999), and therefore may have a differing satiety response to supplemental protein than non-athletes or individuals with lower protein intakes.

Therefore, this study will assess the impact of a manipulation of protein dose (20, 40, 60 and 80 g) in a liquid whey protein supplement on subjective sensations of appetite and food intake in a cohort of concurrently training athletes who consume protein in excess of current recommendations (Rodriguez et al., 2009). It is hypothesised that the consumption of higher doses of a manipulated liquid whey protein supplement (20, 40, 60 or 80 g protein) will be adequate to suppress sensations of hunger, desire to eat and increase fullness over 3 hours, and will reduce energy consumed in an *ad libitum* test meal 3 hours after its consumption in a cohort of concurrently trained athletes.

Methods

A convenience sample of participants was recruited via email, flyers and briefings from exercise-related courses at the Queensland University of Technology. Ten male participants (21.2 ± 2.3 years; 181.7 ± 5.7 cm and 80.8 ± 6.1 kg) were recruited and provided informed consent. All participants were university students who regularly performed resistance exercise (>3× per week) and trained aerobically for sports, including competitive rugby union, rugby league, touch football or soccer. Human Research Ethics Clearance was obtained by the Queensland University of Technology Human Research Ethics Committee (QUT Ethics Approval Number 1200000158).

Introductory measurements

Participants completed an introductory session including a background assessment interview, body composition measurement and food-frequency questionnaire. An initial body composition and weight assessment were undertaken by air-displacement Plethysmography (Bodpod™, Concord, CA) in the fasted state with bladder voided. Body density was corrected for body surface, and predicted lung volume and proportions of fat mass and fat free mass were calculated using the Siri equation (Siri, 1961). Participants wore form-fitting clothing and a skin-tight head cap, and were instructed to minimise movement and breathe normally during the measurement.

Height was measured by the lead researcher on a wall-mounted stadiometer (Harpenden, HAR-98.602, Holtain Limited, Crymych, Dyfed) by stretch stature to the nearest 0.1 cm (Marfell-Jones & Stewart, 2012). The background assessment interview was based on the nutrition assessment portion of the Nutrition Care Process (Bueche et al., 2008). Habitual food intake (over the previous 6 months) was assessed using the Australian Food Frequency Questionnaire (the Australian Eating Survey) (Watson, Collins, Sibritt, Garg, & Dibley, 2013).

Research design

Participants attended 4 half-day testing sessions at the Human Appetite Research Centre (HARC) at QUT Kelvin Grove. Participants were instructed to arrive in a fasted state between 6.30 and 9:00 am. Thereafter the appetite testing sessions were conducted at the same time on a weekly or fortnightly basis. Participants completed an arrival bladder void and weight prior to breakfast. One hour after completing breakfast they consumed a liquid whey protein supplement (intervention whey protein supplement) that contained 20, 40, 60 or 80 g of protein (432, 779, 1127, 1475 kJ respectively) in a counter-balanced design.

Subjective sensations of appetite were measured by visual analogue scales (VAS). VAS measurements were administered immediately prior to breakfast, immediately after breakfast and for half hourly intervals for 1 hour until the intervention whey supplement consumption. The VAS measurements were continued immediately after the intervention whey protein supplement and were repeated at half hourly intervals for three hours until an *ad libitum* test meal. Meal palatability measurements of all provided meals were undertaken.

Body weight

Upon arrival the participants were weighed on calibrated Wedderburn digital scales (BWB600, Willawong, QLD, Australia) when the participant was fasted, bladder voided and in minimal clothing.

Estimated energy requirement

Recorded energy intakes were compared to estimated resting metabolic rate (Harris–Benedict equation) (Harris & Benedict, 1919). The average energy intake of each participant was divided by the calculated RMR for each participant. The resultant calculated physical activity levels (PAL) were compared to a predicted activity factor of 1.75, which reflects active population values (Brooks, Butte, Rand, Flatt, & Caballero, 2004).

Subjective sensations of appetite

Subjective sensations of appetite (hunger, fullness and desire to eat) were measured in a fasted state using an electronic appetite

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