Title: The effect of galactose ingestion on affect and perceived exertion in recreationally active females.

Running Title:

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Abstract

The beneficial effects of acute carbohydrate (CHO) supplementation on exercise performance have been well described. Also reported is the attenuation of perceived exertion and enhancement of affect during prolonged exercise following CHO ingestion. However, no studies to date have assessed the impact of the type of CHO ingested on affective responses during moderate intensity exercise, lasting 60 min or less. Therefore, the aim of the present study was to investigate the effects of consuming a galactose (GAL) CHO drink versus a glucose (GLU) CHO or placebo (PLA) drink before and during exercise on affect and perceived exertion. Nine recreationally active females undertook three trials, each consisting of running for 60 min at 65% VO_2max followed immediately by a 90 min rest period. Prior to (300 ml) and at every 15 minutes during exercise (150 ml), participants consumed either a GLU or GAL drink each containing 45g of CHO, or an artificially-sweetened PLA drink. Ratings of pleasure-displeasure and perceived activation were measured throughout exercise and the rest period and measures of perceived exertion were measured during exercise. Plasma glucose and serum insulin were significantly greater throughout exercise and rest following the GLU trial compared with the GAL and PLA trials ($P<0.05$). Measures of perceived activation and pleasure-displeasure were not enhanced nor RPE reduced as a result of ingestion of a CHO solution. In conclusion, the GAL beverage elicited a more favourable metabolic profile in the exercising females but this did not translate into an enhanced affective profile. Indeed, CHO ingestion had no noticeable effect on the assessed psychological indices during 60 min of moderate-intensity exercise in females. It is suggested that the maintenance of a positive affective profile may be explained more by the level of hydration as opposed to fuel availability. Therefore, those seeking to use beverages containing CHO to enhance their exercise experience may take note of these findings as this practise appears unjustified.

Keywords

Carbohydrate, affect, RPE, pleasure-displeasure, females, exercise.

Introduction

A well-established evidence base supports the beneficial effects of acute carbohydrate (CHO) supplementation on exercise performance. Such findings have been consistently outlined when CHO is consumed before, during and after, moderate or intense aerobic activity (Carter, Jeukendrup, Mundel, & Jones, 2003; Coggan & Coyle, 1991; Costill, 1988; Coyle, 1991; Ivy, 1999; Jeukendrup, Brouns, Wagenmakers, & Saris, 1997). Mechanisms by which CHO feedings are proposed to improve endurance performance include maintaining blood glucose levels and increased carbohydrate oxidation, the sparing of endogenous glycogen or a central effect (Jeukendrup, 2004). Yet these findings are not necessarily applicable to recreational exercise, and less is known regarding the effects of carbohydrate feedings and exercise in moderately trained individuals. In addition, whilst the evidence base pertaining to the performance, physiological and biochemical effects of CHO ingestion is well established, less is known about the psychological effects.

To date, the dominant focus has been on assessing the impact of CHO supplementation and availability on 'what' a person feels, as measured by the Rating of Perceived Exertion (RPE) scale (Burgess, Robertson, Davis, & Norris, 1991; Coggan & Coyle, 1987; Ivy, Costill, Fink, & Lower, 1979; Kang et al., 1996; Utter et al., 1999). Findings demonstrate that increases in circulating blood glucose levels and rates of CHO oxidation attenuate RPE. However, many of these studies have focused only on localised resistance exercise or prolonged cycling protocols using a male population.

Whilst there is a strong theoretical basis for the recommendation of CHO ingestion based on its performance benefits as well as attenuations in perceived exertion, there has been much less attention afforded to the potential benefits to constructs such as affect ('how' a person feels). This is somewhat surprising given that whether one feels good or bad during exercise has been linked to an individual's task persistence (Acevedo & Gill, 1996). Of those studies assessing the impact of CHO on cognition and affect, many have focused on the impact of chronic dietary intakes (Achten et al., 2004; Brinkworth, Buckley, Noakes, Clifton, & Wilson, 2009; D'Anci, Watts, Kanarek, & Taylor, 2009; Halyburton et al., 2007), rather than the acute effects accompanying a supplemented exercise bout. Whilst some findings indicate a positive relationship between CHO intake and cognitive behaviour, other studies have found no effects of a CHO rich meal (Christensen & Redig, 1993) or a sucrose-containing beverage on affective states (Reid & Hammersley, 1995) at rest.

Recently, O’Neal and colleagues (2013) reported that CHO ingestion consumed by recreational exercisers during 60 min of moderate intensity intermittent cycling did not alter mood or perceived exertion. As with other studies in the field, specific mood states were only assessed before and after exercise using the Profile of Mood States (POMS; (McNair, Lorr, & Droppleman, 1981)). However, in the context of exercise, the POMS has been criticised for its inability to detect acute changes during exercise and its bias towards negative mood state assessment (Backhouse, Ekkekakis, Bidle, Foskett, & Williams, 2007). Thus, Backhouse and colleagues (2007) have called for a shift from an assessment of categorical states before and after exercise to a more encompassing representation of the subjective experience during exercise (Hardy & Rejeski, 1989; Svebak & Murgatroyd, 1985). Using the Feeling Scale (Hardy & Rejeski, 1989) as a dimensional measure of pleasure-displeasure, research has shown that well-trained athletes (Backhouse, Bishop, Biddle, & Williams, 2005) and physically active males (Peacock, Thompson, & Stokes, 2012) ‘feel better’ as early as 15 min into exercise when they ingest a CHO drink compared to a placebo or ad-libitum water. Moreover, enhanced feelings of pleasure have been noted in the first 5 min of a 30 min self-paced run when CHO has been mouth rinsed (Rollo, Williams, Gant, & Nute, 2008).

The brain is wholly dependent on circulating blood glucose for fuel and relies on readily digestible forms of carbohydrates within the diet. As such, blood glucose levels are maintained in the range of 3.5 to 5.5 mmol/l. It has been suggested that hypoglycaemia (blood glucose level less than 3.3 mmol/l) can negatively influence indicators of mood including irritability, mental alertness, anxiety and fatigue (Benton, 2002). With this in mind, the question arises as to whether acute CHO feedings can play a role in mediating our affective responses. In normal healthy individuals, a true hypoglycaemic response is uncommon. However, a rise and fall in blood glucose levels has been associated with reductions in mood (Benton, 2002). Benton (2002) also noted that males who ingested breakfasts providing a more sustained level of glucose reported better mood and less irritability than those whose blood glucose levels fell more rapidly following a glucose tolerance test (Benton, Kumari, & Brain, 1982). Examining the nature of the CHO consumed, in particular whether glucose is slowly or rapidly released into the blood stream compared to other types of CHO, is warranted.

The vast majority of research regarding CHO used in sports drinks has focused on the monosaccharide’s glucose and fructose, the disaccharide sucrose and the synthetic polymer maltodextrins (glucose polymers) (Coombes & Hamilton, 2000).

Sports drinks based on a galactose formulation (GI~20) state that this third primary sugar absorbs into the blood stream quickly and does not stimulate the release of insulin, meaning much like low GI foods, it gives steadier blood sugar levels over time (Gannon, Khan, & Nuttall, 2001). The benefits of using GAL in a sports drink is that it provides CHO at an adequate rate, with a corresponding small insulin response which results in prolonged CHO availability to the muscle as well as a reduced rebound hypoglycaemia (as observed with glucose intake). For the recreational exerciser, the potential to suffer from hypoglycaemia is limited and this lessons the risk of declining affective states owing to rebounding glucose levels (Gold, MacLeod, Frier, & Deary, 1995). Consequently, it is of interest to examine how the type of CHO may impact 'how' one feels during exercise.

Given the infancy of this line of research, the suggestion of a mechanistic link between affective states and blood glucose is, at present, only speculatory. As suggested by Backhouse and colleagues (2007) it would be of interest to consider the influence of CHO type and dose, as to date only glucose solutions have been considered. Moreover, examining an ecologically valid exercise protocol which is commonly employed by recreationally active females (i.e., a 60 min moderate intensity run on a motorised treadmill) is warranted. Therefore, the aim of the present study was to investigate the effects of consuming a GAL CHO drink versus a GLU CHO drink or PLA drink before and during exercise on affect and perceived exertion.

Material and methods

Participants

Nine healthy, recreationally active females (mean ±SD: age 21.8±3.4 years, height 170.0±0.6 cm, weight 63.3±7.6 kg and VO_2max 50.7±7.0 ml/kg/min) were recruited to participate in this study. None of the participants were pregnant or lactating or reported any medical conditions, and had normal resting haemoglobin levels (11.5-16.5 g/dl). All trials were carried out during the follicular phase (days 1-14) of the menstrual cycle. A criterion for inclusion in the study was that participants exercised regularly, scored at least 2 on the International Physical Activity Questionnaire (IPAQ (Craig et al., 2003)) and were able to run for one hour continuously at about 65% VO_2max. Leeds Metropolitan University Faculty Ethics Committee approved the protocol and all participants gave their written informed consent.

Preliminary measurements

Following familiarisation with treadmill running and experimental procedures, participants undertook two preliminary tests in order to determine: 1) the relationship between running speed and oxygen uptake using a 16 min incremental test and 2) their VO_2max using an uphill incremental treadmill test to exhaustion. All preliminary tests were conducted according to procedures previously described (Williams et al., 1990). Based on the results of the two preliminary tests, the running speed equivalent to 65% of each participant's VO_2max was determined.

Experimental Protocol

For 48 hours before the first trial, participants recorded their diet and exercise routine so that it could be repeated before the following trials to minimise differences in pretesting intramuscular substrate concentrations between experimental trials.

All participants completed three experimental trials in a randomised crossover design separated by at least 5 days. In two of the trials, participants consumed carbohydrate (CHO) containing beverages providing 45 g of CHO (~0.75 g/min) before and during the trial. Differing in CHO composition, one of these drinks contained glucose (D-Glucose monohydrate, Thornton and Ross, Huddersfield, UK) and the other galactose (D-galactose, Hollandche, Melk & Suiker, Fabrique, The

Netherlands). For the remaining trial, the drink consumed was an artificially sweetened placebo. Each drink was identical in flavour and appearance and the participants were unaware of the content of the drinks in each trial.

For each main trial, participants were provided with their breakfast to consume at home on the morning of the experiment (at 0800 hours) after an overnight (12 hour) fast. This meal was equivalent to 10% of the individual's daily energy requirement and the proportion of energy from protein, fat and carbohydrate was 14, 14 and 72% respectively. Following this, participants were asked to refrain from eating or drinking (apart from water) until they arrived at the laboratory at 1000 hours. On arrival at the laboratory, participants were asked to void before anthropometric variables and blood pressure was collected and subjective scales were completed.

After resting quietly for at least 10 minutes, a resting blood sample was collected from an antecubital vein by cannulation. Immediately following this, participants consumed 300ml of the prescribed drink (either glucose: GLU, galactose: GAL or placebo: PLA) within 5 minutes. Participants then completed a 5-minute warm up at 60% VO_2max on a motorized treadmill (Model ELG 70, Woodway, Weilam Rhein, Germany) after which the speed was increased to that which represented 65% of their VO_2max for 60 minutes. Heart rate was monitored continuously by a radio telemetry monitor (Polar vantage NV, Kemple, Finland). Samples of expired air were collected continuously using an online automated gas analysis system (Meta-Max 3B, Cortex, Leipzig, Germany), and samples were averaged for 5 minute periods at 10-15, 25-30, 40-45 and 55-60 minutes during exercise for the determination of VO_2 and VCO_2. Blood samples were collected and subjective scales were recorded at 15 minute intervals. After these, participants ingested 150ml of the prescribed drink.

At the end of the exercise period, participants removed surface sweat and were weighed in minimal clothing. Participants were then asked to rest in the laboratory lounge for a further 90 minutes and blood and expired air samples were collected at regular intervals. Subjective scales were recorded immediately following blood samples. Participants were instructed not to eat or drink anything other than water throughout this period, which was available *ad-libitum* throughout the first trial, and matched for volume during the following trials.

All trials were performed at the same time of day and under similar experimental conditions. The same motorised treadmill was used throughout the study. In order to enable continuous monitoring of expired air, participants were required to wear a mask throughout the exercise trials. During the rest period, participants wore a mask for a 5 minute period before each 5 minute collection sample. Ambient temperature and relative humidity were recorded each morning during the trials. Temperature was maintained between 17°C and 21°C, and humidity was between 42% and 56%.

Subjective scales: measures of affect and perceived exertion

The Rating of Perceived Exertion scale (G. A. Borg, 1982a) was used to assess perceived exertion during exercise, with values recorded every 15 minutes. The 15-point scale ranging from 6-20 with anchors at “very, very light” to “very, very hard” has been found to be a valid and reliable measure of perceived exertion during exercise (G. Borg, 1982b). The Feeling Scale (FS: (Hardy & Rejeski, 1989)) was used as a measure of the affective dimension of pleasure-displeasure. It is an 11-single-item bipolar measure of pleasure-displeasure and was developed especially for use in an exercise setting. The scale ranged from -5 to +5 with anchors provided at the 0 point (“neutral”) and at odd numbered integers, ranging from “very bad” (-5) to “very good” (+5). Participants were asked to rate how they felt at that particular moment. The Felt Arousal Scale (FAS: (Svebak & Murgatroyd, 1985)) is a six-point, single-item measure of perceived activation/arousal and has been used extensively in the context of reversal theory research, including exercise related studies (Hall, Ekkekakis, & Petruzzello, 2002; Kerr & Vlaswinkel, 1993). The scale ranges from 1 to 6 with anchors at 1 (“low arousal”) and 6 (“high arousal”). Again, participants were asked to rate how they felt at that particular moment. The FS and FAS have an advantage over most other self-report scales of being easily administered during exercise. During collection periods, the RPE scale was presented first, followed by the FS and then the FAS. RPE was only assessed during the exercise period.

Analytical methods

Blood samples were collected into separate EDTA-coated tubes for the assessment of plasma samples, or tubes without anticoagulant for the assessment of serum. Plasma samples were stored on ice until the end of the rest period and analysed within three hours of sampling, and serum samples were left for at least 30 minutes to clot. Whole blood was spun at 3000rpm at 10°C for 10 minutes and plasma/serum was aliquoted into tubes as required for analysis. Aliquots were frozen at -80°C until further analysis. Plasma samples were analysed enzymatically for glucose on a semiautomatic analyser (ILab 2300 stat plus analyser, Instrumentation Laboratories, Warrington, UK). Serum insulin concentrations were transported to the Department of Chemical Pathology at Leeds General Infirmary and analysed by an ADVIA sandwich immunoassay using chemiluminescent technology (Siemens ADIVA Centaur, IL, USA).

Statistical analysis

The PASW software version 17 statistical package was used for all data analysis (IBM SPSS Statistics, Chicago, IL, USA). Descriptive statistics including mean, and the standard errors of the mean (± SEM) were calculated for all outcome variables and are reported within the text, tables and figures. Area under the curve (AUC) was calculated using the trapezoid method glucose, insulin and total CHO and fat oxidation between trials. Prior to analysis, data were checked for acceptable values of normality (Kolmogorov-Smirnov test) and homogeneity of variance (Levene's test); the alpha was set to 0.05 for all statistical analysis.

Paired samples t-tests were used to check for differences in baseline values for all variables. A repeated measures analysis of variance (ANOVA) was used to determine if there were significant differences between the three treatment conditions (GLU, GAL and PLA) for physiological, metabolic and subjective responses. If significance was found, post hoc analyses were done using a Bonferroni's step-wise test. Separate ANOVA were conducted on the pre- to during-exercise time points (pre, 15, 30, 45, 60 min) and from pre-exercise to rest time points (pre, 15R, 30R, 60R, 90R min). This approach allowed for direct comparisons to baseline values. Statistical significance was set at $p < 0.05$

Results

Hydration status and physiological responses to the exercise protocol

Oxygen uptake, heart rate and VO_2max did not differ between the trials demonstrating that the participants were exercising at the same relative intensity during all treatments (68.8±1.2%, 67.4±1.3% and 66.1±0.9% in the GLU, GAL and PLA trials respectively). Heart rate during exercise ranged from 154 to 165 beats/min.

Body masses before the start of exercise, body mass losses and fluid intakes during the rest period were no different between the three experimental trials (63.3±7.6 kg, and 0.7±0.1 and 366.3±104.9 mls respectively).

Blood parameters

There was a significant main trial effect for plasma glucose concentrations (F(2, 12)=7.417, P=0.022) which were higher in the GLU trial compared to the GAL (P=0.032) and PLA (P=0.027) trials (Figure 1A). Values for the GLU trials were significantly greater than both GAL and PLA trials at 30, 60, 15R and 30R min timepoints (P<0.05). The incremental area under the curve (IAUC) for plasma glucose was significantly greater throughout the GLU trial (341±29 mmol/l/hour) compared to the GAL (315±18 mmol/l/hour) and the PLA trials (304±20 mmol/l/hour) (P<0.05), thus confirming the main trial effect.

There was a main trial effect for serum insulin concentrations to be higher throughout the GLU trial (F(2, 16)=21.045, P=0.000) when compared to GAL (P=0.030) and PLA (P=0.000) trials (Figure 1B). In addition concentrations were significantly higher throughout the GAL trial compared to the PLA trial (P=0.013). The IAUC for serum insulin throughout the trial was greater in the GLU trial (692.9±50.2 mU/L/hour) compared to the GAL (543.2±67.1 mU/L/hour) and PLA (314.0±29.1 mU/L/hour) trials (P<0.05) again confirming the main trial effect.

After ingestion of the drinks and commencement of exercise, blood lactate concentrations increased in all three trials and peaked at 15 min during exercise. Throughout the exercise and rest period, there were no significant differences between trials and concentrations remained between 0.76 and 1.91 mmol/l. At the end of the rest period, blood lactate had returned to baseline levels or below for all trials (Figure 1C).

After consumption of the drinks, serum FFA concentrations increased throughout the exercise period in all three trials (Figure 1D). After 15 minutes of the resting period, values in all conditions decreased but remained elevated above resting values. There was a main trial effect for serum FFA concentrations ($P<0.0001$), such that concentrations in the PLA trial were significantly greater than GLU and GAL trials at several time points ($P<0.05$).

Perceived activation (FAS) and pleasure-displeasure (FS)

Compared with baseline, perceived activation was elevated throughout exercise in all three trials ($P<0.05$). This increase in activation appeared more pronounced in the CHO trials but a significant treatment effect was not noted. (Figure 2A). Upon the cessation of exercise, perceived activation rebounded below baseline levels.

Feelings of pleasure were maintained throughout exercise and participants reported a positive affective state. However, no significant differences were noted in pleasure ratings between trials and no time effect was observed (Figure 2B).

Rating of perceived exertion (RPE)

RPE increased throughout the exercise period ($F(3, 24)=4.293$, $P=0.046$) across all conditions, from average values of 10.4±0.07 at 15 min to 11.2±0.06 at 60 min (Figure 2C). There were no significant differences between trials overall or at any time point assessed.

Discussion

The aim of the present study was to examine the effects of ingesting a GAL CHO drink, versus a GLU CHO drink or PLA drink on affective responses and perceived exertion during a 60 min bout of moderate intensity exercise. Findings of the study highlighted that feelings of pleasure and perceived activation were maintained and even enhanced during exercise in all trials. This positive affective profile was elicited irrespective of the beverage ingested. These results indicate that the participants found the exercise stimulus to be pleasurable and felt comfortable with the intensity and duration. This is reinforced by ratings of perceived exertion which averaged out at 'fairly light' towards the end of the exercise period. Supporting the subjective findings was the observation that there were no incidences of hypoglycaemia in any of the trials throughout the exercise or rest periods, indicating that euglycaemia would have been maintained without exogenous carbohydrate ingestion. Despite this, ingestion of the GAL drink resulted in a more constant blood glucose level when compared to the GLU drink, a finding which has previously been associated with better mood states (Benton, 2002).

It has been proposed that deterioration in psychological indices is related to low levels of blood glucose and elevated brain serotonin (Cox, Gonder-Frederick, Schroeder, Cryer, & Clarke, 1993; Sommerfield, Deary, & Frier, 2004; Utter et al., 1999). Whereas maintenance of higher blood glucose and lower free fatty acid concentrations (and corresponding reductions in free tryptophan) through CHO feedings have been purported to be the mechanisms behind an enhanced activation and central nervous system (CNS) functioning (Backhouse, Ali, et al., 2007; Lieberman, Falco, & Slade, 2002; Welsh, Davis, Burke, & Williams, 2002). Despite this, a rise and fall in blood glucose levels, associated with high glycemic feedings, has been associated with reductions in mood (Benton, 2002). Supporting previous research by Stannard et al. (2009), the present study showed significantly higher blood glucose levels in the GLU, compared to the GAL and PLA trials, throughout the majority of exercise and the first 30 minutes during the rest period. This was followed by a marked reduction in glucose levels towards the end of the 90 minute rest period, whereas after the consumption of galactose, circulating blood glucose levels were more stable. In the study by Stannard et al. (2009), greater FFA levels were reported in the galactose trial after 20 minutes of exercise, a finding not corroborated by the present study. These differences are likely to be due to the participants having arrived in a fasted state in the aforementioned study and thus the slower metabolic processing of galactose, which has been shown to increase plasma FFA levels. This is further supported by studies in which there were no differences in plasma FFA levels between low and high glycemic trials, when participants were fed (Stevenson, Astbury, Simpson, Taylor, & Macdonald, 2009) and improved metabolic profiles when exercising at a moderate intensity in a fed compared to fasted state (Paoli et al., 2011).

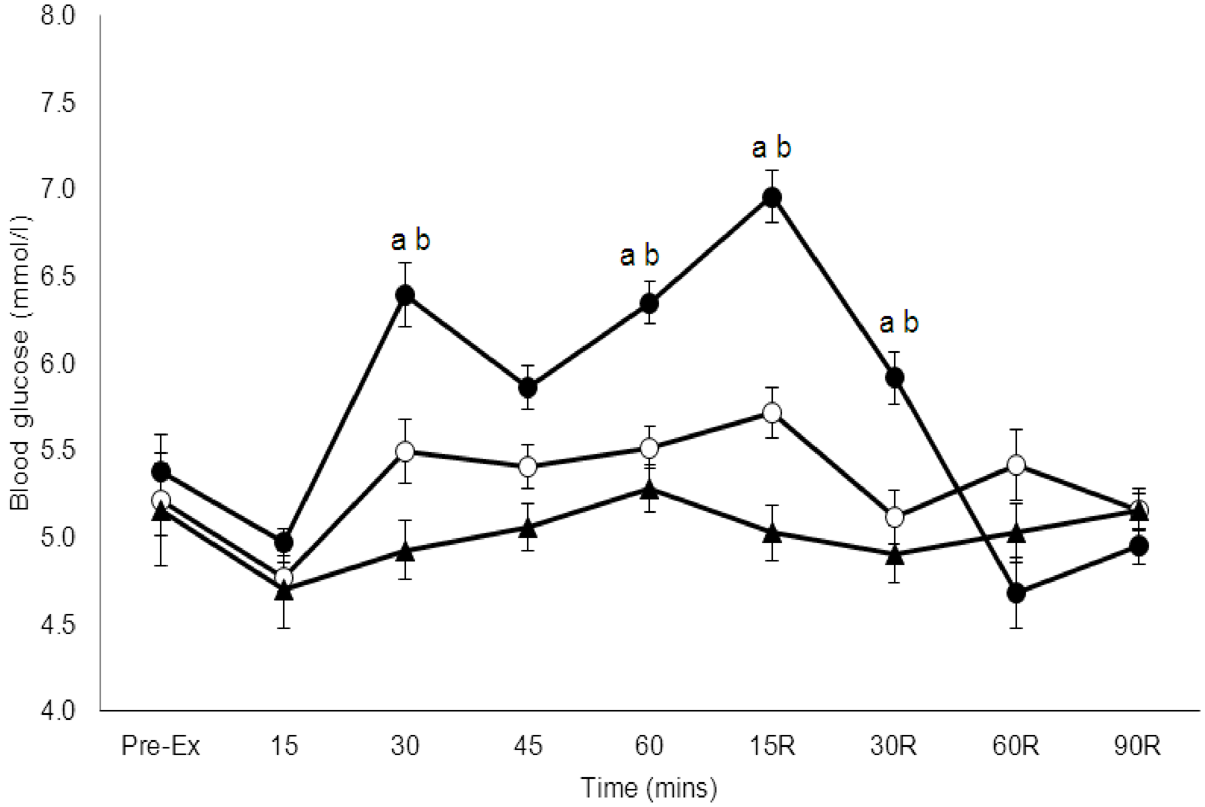
Within the present study, significant increases in blood glucose in the GLU trial compared to the GAL and PLA trials, resulted in no differences in FS or FAS scores. These findings confirm those of O'Neal et al. (2013) who noted that CHO ingestion consumed during a 60 minute moderate exercise session, in a fed state, did not alter post-exercise mood or perceived exertion in recreational exercisers. No metabolic parameters were assessed in the study by O'Neal et al. (2013) so distinct comparisons are difficult to make, yet in the present study it appears that the continuous intake of the drinks and the moderate intensity of the exercise protocol seems to have resulted in a reduction in glucose requirements as the main fuel substrate. O'Hara et al. (2012) corroborates this conclusion as they reported a progressive increase in exogenous carbohydrate oxidation and sparing of liver glycogen stores after pre-exercise consumption of a GAL solution (compared to a GLU solution). However, these differences were only evident after 60 minutes of exercise, which indicates that any potential benefits in performance would only be evident for longer endurance activities. In addition, previous studies report differences in affect in the latter stages of exercise, specifically after 45 min (Welsh et al., 2002) and 60 min (Backhouse, Ali, et al., 2007) of high-intensity intermittent exercise and 10 hours of sustained aerobic activity (Lieberman et al., 2002). Changes in substrate oxidation and mood state therefore are only likely to occur when endogenous glycogen stores are reduced (Bosch, Weltan, Dennis, & Noakes, 1996; Leijssen, Saris, Jeukendrup, & Wagenmakers, 1995). Thus, positive affective changes following the consumption of CHO beverages may only be noted in exercise bouts that extend beyond 60 min, and that ask participants to commence the exercise protocol in a fasted state as they place a greater reliance on exogenous carbohydrate as the main substrate. However, the present study employed an ecologically valid protocol which looked to replicate recommended habitual submaximal fixed-duration exercise in females (Kim, Ko, Lee, Lim, & Bang, 2012) and current UK recommendations. Indeed, mood has been shown to improve with moderate-intensity (50–70% VO_{2max}) exercise (Yeung, 1996) and walking-based exercise, and at durations of 10–15 min (Ekkekakis, Hall, VanLanduyt, & Petruzzello, 2000). Such an intensity and duration (65% VO_{2max} for 60 minutes) has also been used in previous studies to assess differences in pre-exercise feedings in healthy women (Stevenson et al., 2009; Stevenson, Williams, Nute, Humphrey, & Witard, 2007). In addition, participants consumed breakfast prior to the trial, likely to have offset the reliance on exogenous carbohydrate, yet this is common practise among recreational active individuals and has been associated with better mood (Benton, Slater, & Donohoe, 2001).

Enhanced feelings of pleasure have previously been reported in males performing gymnasium-based exercise following ad-libitum ingestion of a low energy 2% CHO solution in a euhydrated state (Peacock et al., 2012) and a dehydrated state (Peacock, Thompson, & Stokes, 2013). In these studies, the positive affective profile may be explained by the stimulation of a greater voluntary fluid intake (i.e., 45% increase; (Peacock et al., 2012)) and more adequate hydration during exercise than an increased delivery of CHO. Indeed, for the recreational exerciser, there is evidence of a greater relative need to supply water over fuel during exercise (Peacock, Stokes, & Thompson, 2011). As such, the findings of the present study suggest that the exercise stimulus was positively perceived by the participants because fluid balance was maintained across all trials and the endogenous supply of CHO energy stores to exercising muscles was not significantly impacted as a result of the exercise task. Based on the findings of this study, CHO supplementation during moderate exercise intensity for 60 min or less appears unjustified and does not elicit a 'feel good' effect.

As expected, perceptions of exertion increased as the exercise bout continued, attributed to the physiological stress placed on the participant. Despite this, the increases in RPE reported were minimal ranging from 10.4 at to 11.2 ('fairly light') compared to values of between ~15 and ~17 after 120 minutes (Backhouse et al., 2005) and 150 minutes (Utter et al., 1999) of intense exercise. This is supported by relatively stable levels of blood lactate in all trials throughout the exercise period with the highest level of 1.9 mmol/l reported. Furthermore, no differences existed in the central sensory variable of heart rate between trials, which has previously been linked to mediating the perception of effort (Mihevic, 1981). As highlighted previously, the relationship between CHO ingestion and fatigue during prolonged exercise has been well documented (Burgess et al., 1991; Kang et al., 1996; Utter et al., 1999; Welsh et al., 2002), with findings indicating that perceived exertion is attenuated during the latter stages of exercise with CHO ingestion. It has been proposed that a reduction in CHO availability and associated intensified perceptions of fatigue may be explained by alterations in skeletal muscle contractile properties and neurological function (Utter et al., 1999), such that reductions in blood glucose and muscle glycogen can lead to localised muscle fatigue. Thus, the sustained low levels of subjective perceptions of effort within the present study provide further evidence that the endogenous supply of carbohydrate energy stores to exercising muscles was not significantly impacted as a result of the exercise duration and intensity. Despite this, previous studies have reported similar levels of RPE (10-11) at the lactate threshold (Hetzler et al., 1991; Steed, Gaesser, & Weltman, 1994), defined as the transition from an intensity that can be maintained through aerobic metabolism to an intensity that requires supplementation by anaerobic means, and thus of a defined ‘moderate’ intensity (Ekkekakis, Hall, & Petruzzello, 2004). As outlined by Marcus et al. (2000), both men and women are more likely to adopt and maintain such moderate intensity activity, therefore further studies examining such ecologically valid protocols are warranted. There were no differences in RPE between trials in agreement with a previous study by Jentjens and Jeukendrup (2003) who found no differences in overall body RPE between glucose, galactose and trehalose solutions. Such findings are encouraging given that blood glucose levels were significantly lower in the GAL trial compared to the GLU trial during exercise, indicating no increases in the perception of effort despite a more sustained carbohydrate delivery.

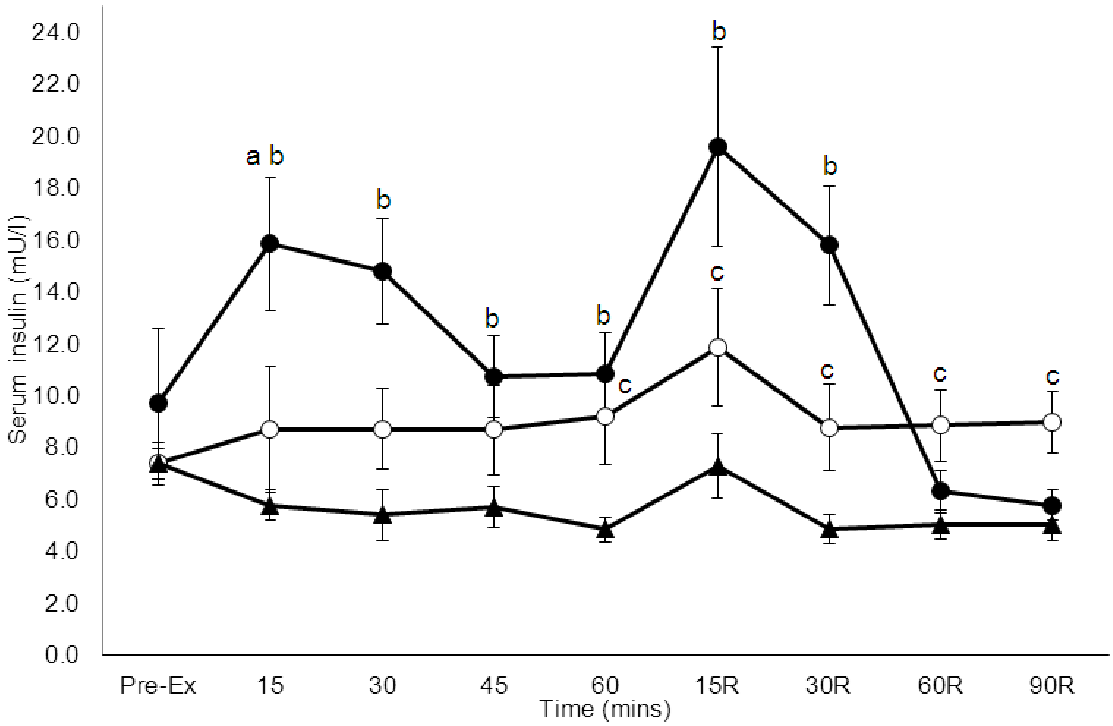
In conclusion, this is the first study to examine the effects of different types of CHO ingestion, not only on measures of RPE but also the dimensions of pleasure-displeasure and perceived activation during moderate intensity exercise. Our results suggest that exercise of a moderate intensity does not negatively impact feelings of pleasure and has a positive impact on activation in recreationally active females. Although the consumption of GAL CHO beverage elicited a more favourable metabolic profile in the exercising females, it did not enhance their affective profile. For physically active adults who exercise for health and fitness or for those concerned with achieving weight loss, ingestion of a high-energy sports drink appears unjustified (Peacock et al., 2013) and findings from the present study would discourage CHO supplementation on the basis that a ‘feel good’ effect was not elicited following ingestion. Instead, the importance of maintaining fluid balance during exercise is reinforced. Future research should continue to explore these constructs and the interventions that may positively impact affective states, given that recent studies carried out in UK populations suggest low physical activity participation levels, whereby only 28% of women achieved the minimum requirements (Information Centre, 2006).

FIGURE 1



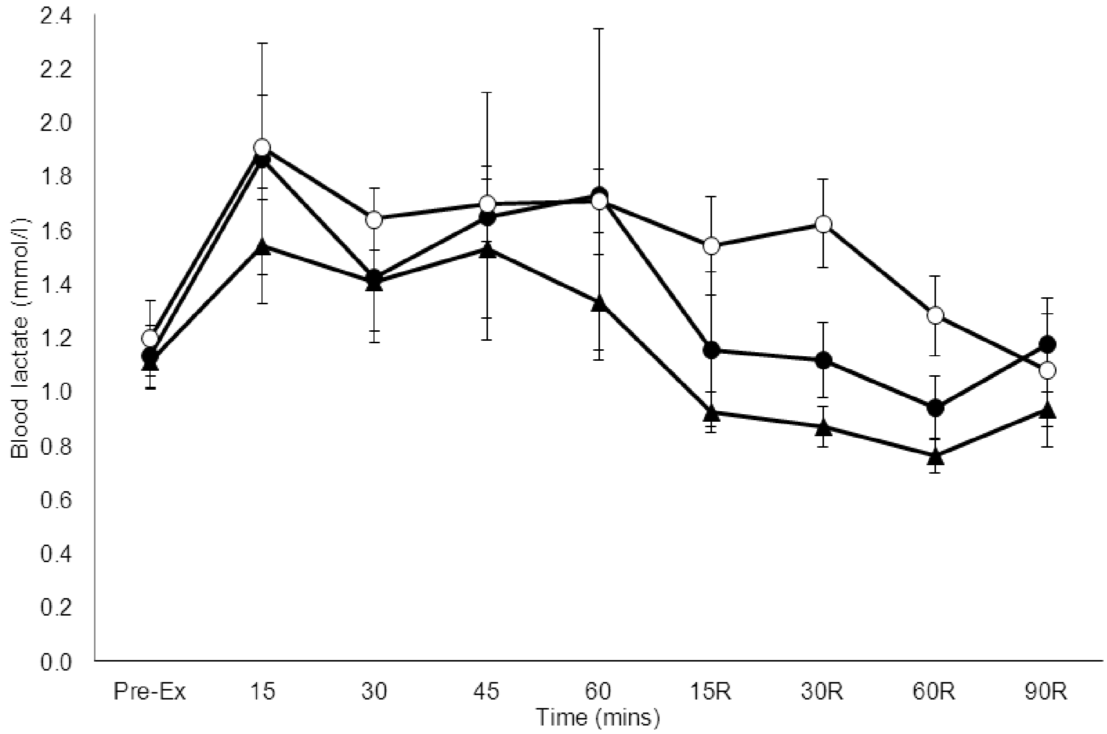
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
Blood glucose (mmol/l)
a b
Pre-Ex
15
30
45
60
15R
30R
60R
90R
Time (mins)

A



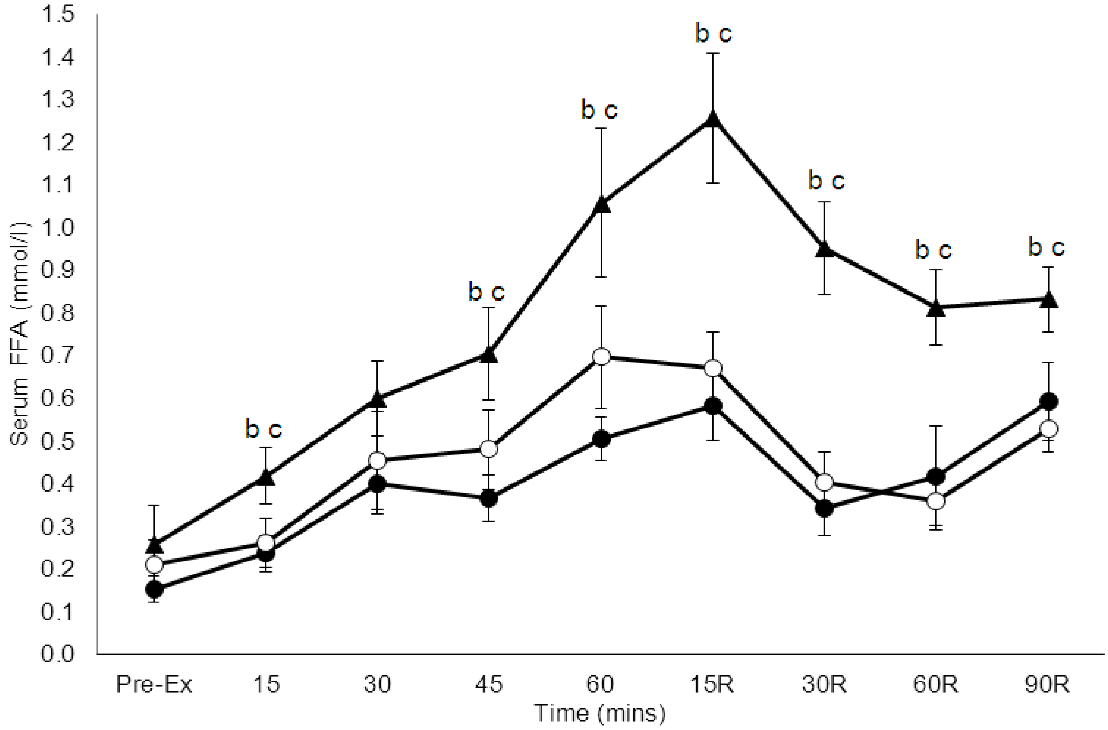
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Serum insulin (mU/l)
a b
b
c
Pre-Ex
15
30
45
60
15R
30R
60R
90R
Time (mins)

B



Blood lactate (mmol/l)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Pre-Ex
15
30
45
60
15R
30R
60R
90R
Time (mins)

C



Serum FFA (mmol/l)
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
b c
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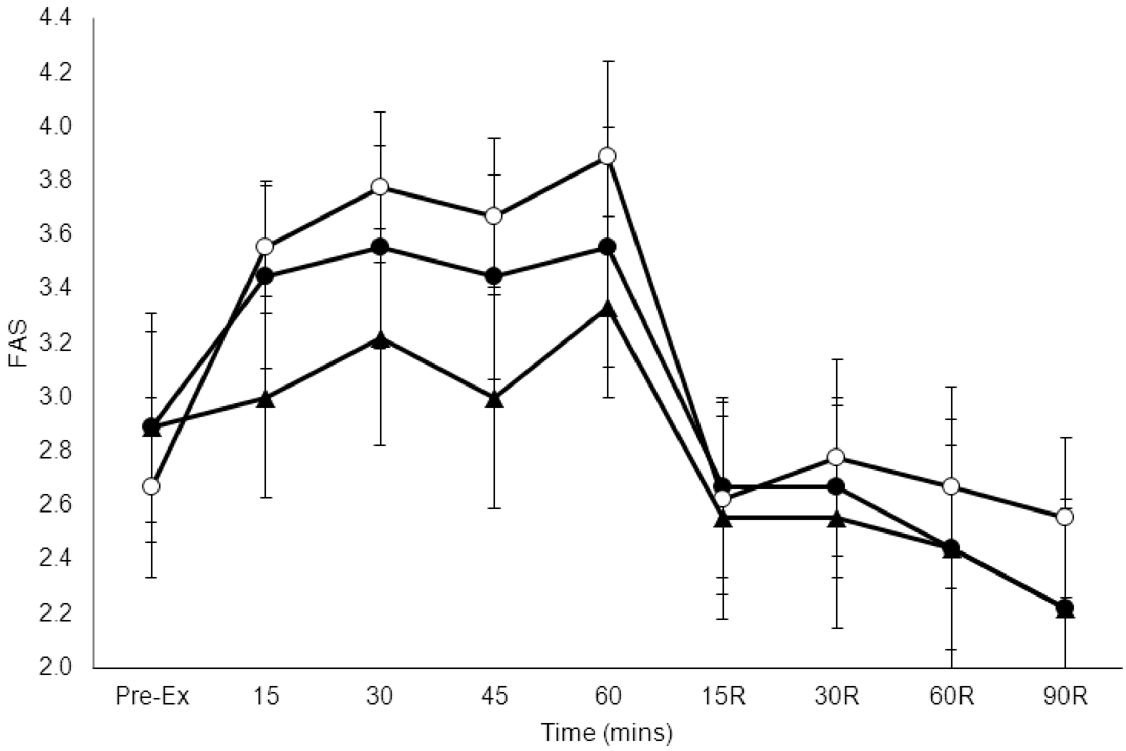
b c
b c
b c
Pre-Ex
15
30
45
60
15R
30R
60R
90R
Time (mins)

D

FIGURE 2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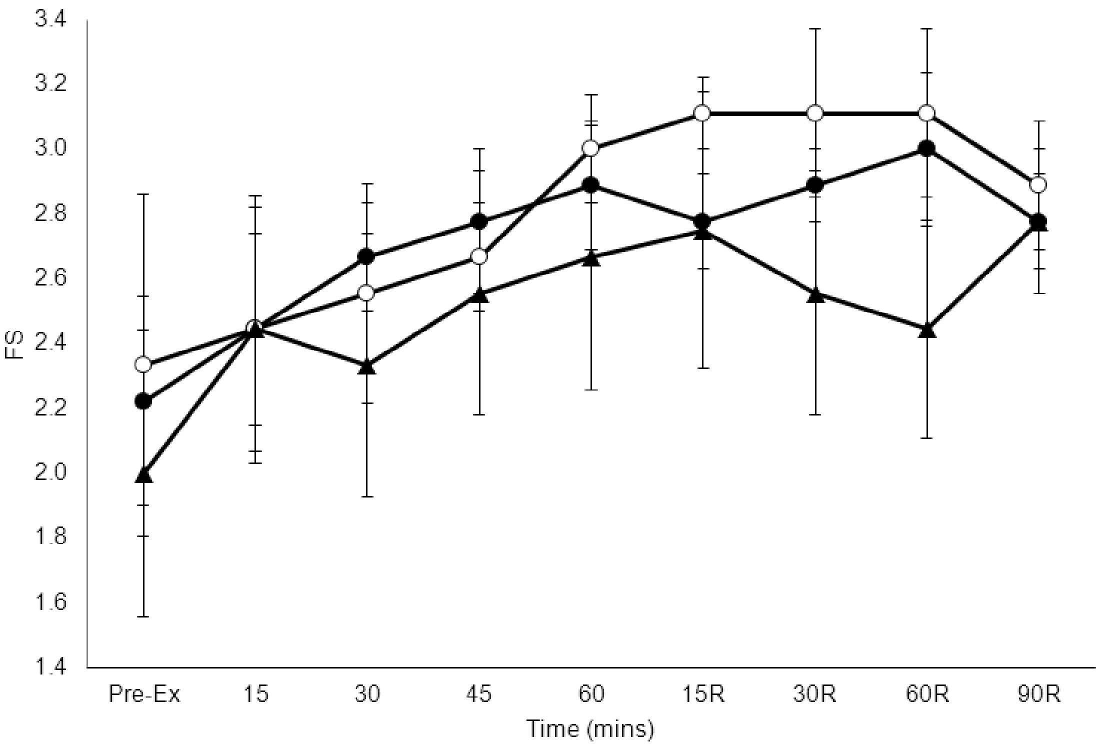
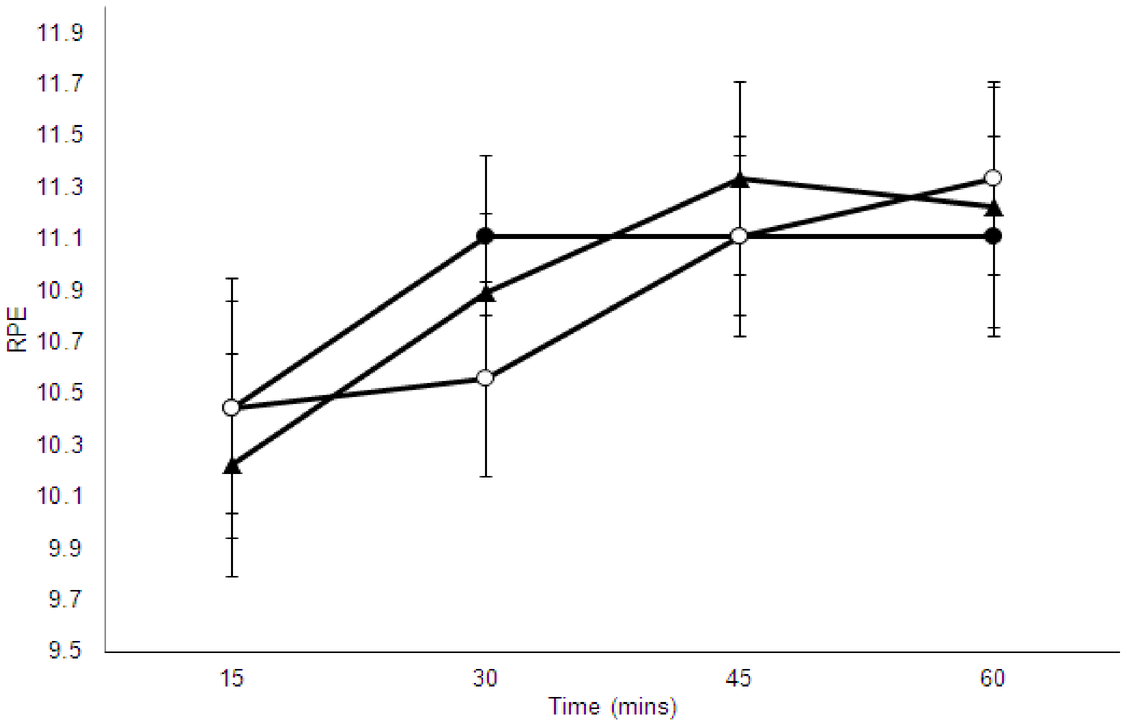
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
FAS
Pre-Ex
15
30
45
60
15R
30R
60R
90R
Time (mins)

A


3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
FS
Pre-Ex
15
30
45
60
15R
30R
60R
90R
Time (mins)

B


11.9
11.7
11.5
11.3
11.1
10.9
10.7
10.5
10.3
10.1
9.9
9.7
9.5
RPE
15
30
45
60
Time (mins)

C

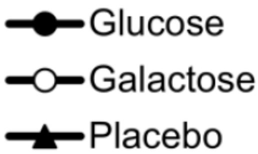
Figure captions

FIGURE 1 Effects of GLU, GAL and PLA trials on concentrations of blood glucose (A), serum insulin (B), blood lactate (C) and serum FFA (D) during exercise and rest (R). Values are means ± SEM.

[a]significant difference between GLU and GAL trials (*P*<0.05). [b]significant difference between GLU and PLA trials (*P*<0.05). [c]significant difference between GAL and PLA trials (*P*<0.05).

FIGURE 2 Effects of GLU, GAL and PLA trials on perceived activation (FAS) (A), pleasure-displeasure (FS) (B) and perceived exertion (RPE) (C). Values are means ± SEM.

Figure legends



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