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Title: **Differential acute effects of carbohydrate and protein rich drinks compared to water on cardiac output during rest and exercise in healthy young men.**

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Short running head: Protein vs. carbohydrate and cardiovascular hemodynamics

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ABSTRACT

The acute effects of drinks rich in protein *vs*. carbohydrate on cardiovascular hemodynamics and reactivity are uncertain. A randomized crossover design was used to compare 400 mL isoenergetic (1.1 MJ) drinks containing whey protein (44 g, PRO) or carbohydrate (57 g, CHO) *vs.* 400 mL water in 14 healthy men. The primary and secondary outcomes were changes in cardiac output, blood pressure, systemic vascular resistance (SVR) and digital volume pulse measured prior to and 30 min following consumption at rest, during 12 min of multi-stage bicycle ergometry, and 15 min post-exercise. The mean change (95% CI) in resting cardiac output at 30 min was greater for CHO than for PRO or water: 0.7 (0.4, 1.0), 0.1 (-0.2, 0.40) and 0.0 (-0.3, 0.3) L/min ($P < 0.001$) respectively; the higher cardiac output following CHO was accompanied by an increase in stroke volume and a lower SVR. The mean increments (95% CI) in cardiac output during exercise were CHO 4.7 (4.4, 5.0), PRO 4.9 (4.6, 5.2) and water 4.6 (4.3, 4.9) L/min with the difference between PRO *vs*. water being significant ($P < 0.025$). There were no other statistically significant differences. In summary, a CHO-rich drink increased cardiac output and lowered SVR in the resting state compared to a PRO-rich drink or water but the effect size of changes in these variables did not differ during or after exercise between CHO and PRO. Neither protein nor carbohydrate affected blood pressure reactivity to exercise.

KEY WORDS: Protein, Carbohydrate, Blood pressure, Cardiac output, Cardiovascular reactivity, Exercise

INTRODUCTION

Food ingestion leads to significant hemodynamic responses, depending on the meal size and composition. Postprandial hyperemia in the splanchnic area sustained for around 2 - 4 h serves for digestion and absorption and is mainly met by a considerable increase in cardiac output (Waaler et al. 1991; Sidery et al. 1994; Hoost et al. 1996). Amino acids from protein hydrolysis enter the portal vein and pass via the liver to the circulation within 15 - 30 min after protein intake (Boirie et al. 1997; Hall et al. 2003). Thirty minutes after protein intake, amino acid concentrations in blood are significantly increased, with time and magnitude of the peak concentration differing between different amino acids, occurring on average at 60 min or later and remaining increased for > 2 h (Brundin et al. 1994; Boirie et al. 1997). Maximal values in superior mesenteric artery blood flow were shown to occur at 15 min following intake of carbohydrate and at 45 min following protein, being of similar magnitude (Qamar et al. 1988).

Long-term exposure to repetitive blood pressure (BP) peaks in response to exercise (Palatini 1998) or other physical or psychological stressors appears to cause various pathophysiologic alterations that may lead to hypertension (Wilson et al. 1990) and CVD (Treiber et al. 2003; Jae et al. 2006). There is evidence showing that even small increases in diastolic BP in response to mild exercise could have the capacity to influence the development of future hypertensive complications (Brett et al. 2000) and that a single meal can influence cardiovascular reactivity (i.e. cardiovascular responses) to stressors. Several previous studies have investigated the acute effects of high fat meals on cardiovascular reactivity to physical and psychological stressors (Jakulj et al. 2007; Rontoyanni et al. 2010; Faulk et al. 2012; Rontoyanni et al. 2012; Sauder et al. 2012) but the effects of high carbohydrate (CHO) or high protein (PRO) meals have yet to be tested. Although several studies have compared a CHO meal with fat, the timing of stressors was selected based on the time course of fat metabolism and peak circulating triglyceride concentration (2-3 h following the meals) and

not when glucose and insulin concentrations peak (Edes et al. 1998; Monteleone et al. 2003; Suzuki et al. 2012). Ingestion of a CHO meal has been claimed to impair endothelial function in the early postprandial state (Suzuki, Watanabe et al. 2012), which may augment vascular resistance and BP responses to stressors. However, this contradicts the established vasodilatory action of insulin on the skeletal muscle vasculature. Earlier studies have postulated that dietary protein, via its effects on blood viscosity and plasma volume, may potentially acutely augment vascular resistance and cardiac output, leading to an elevated BP reactivity to stressors (Dickson et al. 2007; Faulk and Bartholomew 2012). However, these are speculations unsupported by controlled trials. The present study set out to test whether the hemodynamic responses at rest and cardiovascular reactivity to dynamic exercise between moderate-energy dense liquid loads, high in protein or carbohydrate differ. We hypothesised that a drink high in protein that causes rapid increases in blood amino acids, such as whey protein (Boirie et al. 1997), and which raises plasma albumin levels and plasma volume (Okazaki et al. 2009; James et al. 2014), would cause a greater increase in BP reactivity to exercise relative to carbohydrate.

MATERIALS AND METHODS

Participants and screening procedure

Healthy men, aged 18–45 years were recruited from staff and students of King's College London, UK. Exclusion criteria were: current smoking habit; body mass index ≤18.0 or ≥30 kg/m^2; BP ≥140/90mmHg; self-reported history of myocardial infarction, angina, venous thrombosis, stroke, cancer, presence of gastrointestinal disorder; self-reported weekly alcohol intake of >28 standard units of alcohol (1 unit = 10 ml ethanol); systematic use of any medication. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Research Ethics Committee of King's College

London (REC number: 07/08-57). Participants were given a detailed outline of the study requirements and all provided written informed consent.

Body mass index and BP were confirmed to be within the prescribed limits prior to entry into the study as previously described (Rontoyanni et al. 2010). Waist circumference was measured to the nearest 0·1 cm using a tape measure and percentage body fat was estimated using bioelectrical impedance (Tanita UK Ltd, model: BC-418 MA; Middlesex, UK). In order to ensure participants were suitable to undertake the exercise test, VO_{2max}, an index of cardiorespiratory fitness, was estimated using Astrand-Rhyming cycle ergometer test, a nomogram and age correction factor (Astrand et al. 1954; Astrand 1960), as detailed elsewhere (Rontoyanni et al. 2010).

Experimental design

A randomised, crossover study design was undertaken to test the effects of PRO (44 g protein) or CHO (57 g carbohydrate) drinks, compared to water. Subjects were allocated to one of six treatment sequences in random order (ABC, ACB, BAC, BCA, CAB, CBA - orthogonal Latin square design). Power calculations were based on a change in cardiac output as the primary outcome with 18 participants completing. Each study visit lasted for approximately 2 h and study visits were separated by at least one week. On the day prior to each visit, subjects were asked to avoid alcohol, foods high in fat and protein, caffeine from midday and refrain from vigorous exercise, and they were provided with a standardized low-fat (≤10g fat) and low-protein dinner for their evening meal. They were asked to fast from 22:00 h the previous night, avoiding everything apart from water and to refrain from drinking water and exercise in the morning of the study.

Participants attended a metabolic research unit between 08:00 h and 11:00 h, body mass and height were measured and % body fat was estimated. Following a 20-min quiet, seated rest period, measurements of digital volume pulse (DVP)-stiffness index (SI) and DVP-reflection index (RI) were made in triplicate and of BP, heart rate (HR) and cardiac output in duplicate. Participants then

115 consumed the test treatment (PRO, CHO or water) within 5 min. Further seated measurements of
116 DVP, BP, HR and cardiac output were repeated 30 min postprandially, followed by a 12-min multi-
117 stage exercise stress test of moderate intensity on a programmable electrically braked cycle
118 ergometer (Ergoselect 100/200, Ergoline GmbH, Bitz, Germany) which has been previously used in
119 similar study protocols (Brett et al. 2000; Brett et al. 2006; Rontoyanni et al. 2010). Workload
120 increased by 25 W in 3-min intervals, starting at 25 W and pedalling frequency was kept constant at
121 60 rpm. During exercise, further measurements of BP, HR and cardiac output were determined at 3,
122 6, 9 and 12 min. Immediately post-exercise DVP was obtained and then subjects were allowed to
123 recover seated with further measurements of DVP, BP, HR and cardiac output determined at 15 min
124 post-exercise. An outline of the study protocol is shown in **Fig. 1**. Water ingestion was monitored
125 over the entire study visits period.
126
127 **Formulation of the test drinks**
128 Three test drinks (400 ml each, chilled to approximately 10 °C) were compared: tap water, a
129 protein enriched drink (PRO) and a carbohydrate enriched drink (CHO). The nutrient content was
130 estimated using food tables (Food Standards Agency 2002) and information provided by the
131 manufacturers (Table 1). The energy, protein, fat and carbohydrate content were 1.1 MJ, 44g, 4g
132 and 9g for PRO and 1.1 MJ, 0.8g, 5g and 57g for CHO, respectively. Protein in the PRO drink was
133 supplied as 40 g whey protein (Body Fortress whey protein strawberry flavor, Holland & Barrett
134 Retail Ltd., Nuneaton, Warwickshire, UK), and 4 g from skimmed milk. Carbohydrate in the CHO
135 drink was supplied as 38g maltodextrin powder (Polycal powder; Nutricia, Trowbridge, Wiltshire,
136 UK) and 19g sucrose as strawberry flavoured 20 g milkshake powder (Nesquik™; Nestlé Ltd.,
137 UK). While the drinks were matched for macronutrient content and volume, there were moderate
138 differences between drinks on micronutrients content, which are reported in supplementary Table
139 S1.

Hemodynamic measurements

All measurements were performed with the subject relaxing in an upright seated position in a quiet and temperature-controlled (23 °C) room. Cardiac output was measured non-invasively using an inert gas rebreathing device (InnoCor™, Innovision A/S, Odense, Denmark); participants were familiarized with the rebreathing technique at the beginning of the first study visit prior to any measurements being taken. A finger arterial BP monitor, the Finometer™ Model-1 (Finapres Medical Systems BV, Amsterdam ZO, The Netherlands), was used to measure systolic and diastolic BP, mean arterial pressure (MAP) and HR on a beat-to-beat basis. The Finometer offers continuous monitoring of the finger arterial pressure waveform and has been shown to provide reliable data during exercise (Gizdulich et al. 1996). Application of corrective measures, such as waveform filtering and level correction, a height correction system and arm-cuff return-to-flow calibration provides accurate BP measurement (Imholz et al. 1998). The finger cuff was applied on the index finger of the left hand and the arm cuff wrapped around the left arm. Values for BP, MAP and HR represent means for 30 s epochs for resting and post-exercise measures and means for 5-15 s epochs during exercise, all recorded immediately before each cardiac output rebreathing manoeuvre to avoid overestimation due to forced rebreathing. Stroke volume was calculated from cardiac output divided by HR values. SVR was estimated from MAP divided by cardiac output. DVP measurements were made in triplicate at each time point using the PulseTrace™ device (Micro Medical Ltd., Kent, UK) which was attached to the index finger of the right hand. The PulseTrace™ obtains the DVP by photoplethysmography and is considered to be the sum of direct and reflected pressure waves. The relative delay in the reflected waves when compared to the direct wave is strongly related to pulse wave velocity (PWV) in the aorta and large arteries and thus, provides an index of large artery stiffness (DVP-SI). The amplitude of the reflected component is used to calculate reflection index (DVP-RI), which depends on vascular tone of peripheral arteries and thus, is markedly affected by vasoactive drugs (Chowienczyk et al. 1999; Millasseau et al.

2002). Since DVP-SI is strongly influenced by BP changes, its responses to exercise would not be interpreted as a change in large artery stiffness. The hands were kept warm (with the help of a hand electric blanket) during study visits.

Sample size calculation

Initial sample size calculations for 18 participants completing were based on a mean cardiac output of 5.5 L/min with a within-subject SD of differences of 0.47 L/min for measurements on different days, with 14 participants completing the study having 80% power at $P<0.05$ to detect a 0.5 L/min change in cardiac output allowing for comparisons between three groups.

Statistical analysis

The primary and secondary outcomes were changes in hemodynamics and DVP during exercise (at 3, 6, 9, 12 min) from pre-exercise (30 min postprandial rest) values. Secondary outcomes included changes in hemodynamics and DVP at 30 min rest from baseline (fasting, 0 min) and at 15 min post-exercise from pre-exercise. The main exposure was treatment (3 groups) at different time points. Least square regression models were used to test the effects of treatment and time within subjects. Period was also included as a factor but then omitted from the model if there were no significant effects. Interactions between treatment x time, period x time, period x treatment and period x treatment x time were tested but excluded from the model if they were not statistically significant. Analyses were adjusted for baseline fasting values (for resting condition), and for pre-exercise values (for exercise and post-exercise conditions). Multiple comparisons between treatments were adjusted using a Bonferroni correction. All regression analyses were performed separately for resting, exercise and post-exercise conditions. Differences were considered significant at $P < 0.05$. Values in the results are means (95% CI), unless otherwise specified. Analyses were performed using SPSS statistical software (version 17.0; SPSS, IBM, USA).

RESULTS

Of the 23 subjects who were screened for the study, 14 subjects completed the study and their details are presented in **Table 2**. Exercise HR and BP (and calculated stroke volume and SVR) data from one subject were excluded from the analysis due to poor finger arterial pressure waveform output (due to cold hands). Cardiac output, stroke volume, HR, MAP and SVR responses to the different treatments at rest, during exercise and post-exercise are illustrated in **Fig. 2 and 3** as changes from fasting.

Resting postprandial hemodynamics

Statistically significant treatment effects were found for cardiac output ($P < 0.001$), stroke volume ($P = 0.006$), HR ($P < 0.001$), systolic BP ($P = 0.033$), SVR ($P = 0.002$) and DVP-RI ($P < 0.001$). As shown in **Table 3**: cardiac output increased and SVR fell following the CHO compared with PRO and water, and stroke volume increased after the CHO compared with PRO. Heart rate decreased and DVP-RI increased following water but not following CHO and PRO. Systolic BP increased after the CHO versus water. There were no further statistically significant differences.

Exercise postprandial hemodynamics

Exercise increased cardiac output, stroke volume, HR, systolic and diastolic BP and MAP and concomitantly decreased SVR and DVP-RI after treatments (time effect, $P < 0.001$). Results show statistically significant treatment effects in response to exercise for cardiac output ($P = 0.022$), and borderline treatment effects on stroke volume ($P = 0.065$) and diastolic BP ($P = 0.050$). As shown in Table 3: cardiac output reactivity to exercise was greater after the PRO compared to water ($P < 0.025$); the mean increases (95% CI) in cardiac output in response to exercise were 4.7 (4.4, 5.0), 4.9 (4.6, 5.2) 4.6 (95% CI: 4.3, 4.9) L/min after CHO, PRO and water, respectively. Values for all

214 variables returned close to those pre-exercise 15 min after exercise with no significant differences
215 between treatments (Fig. 2 and 3).
216
217 **DISCUSSION**
218 The present study compared the acute effects of moderate-energy dense drinks high in rapidly
219 digested carbohydrate or (whey) protein *vs*. water on cardiovascular hemodynamics at 30 min rest,
220 during exercise and post-exercise. Earlier studies have investigated cardiovascular reactivity to
221 exercise solely following large, solid mixed meals or high fat meals, and of high energy content (2.8
222 - 6.9 MJ) (Kelbaek et al. 1987; Waaler et al. 1990; Yi et al. 1990; Eriksen et al. 1994; Rontoyanni et
223 al. 2010). Our research adds new information by studying the effects of PRO and CHO test-meals in
224 liquid form with a moderately low total energy content (1.1 MJ) using more robust measures of
225 cardiac output (Agostoni et al. 2005). Large concentrations of amino acids appear in the blood
226 within 20 min following ingestion of whey protein (Boirie et al. 1997). We observed increased
227 cardiac output and reduced SVR at 30 min postprandial rest in response to CHO but not PRO.
228 However, the increase in cardiac output as an effect of CHO was not enhanced compared to PRO
229 during exercise, and BP reactivity to exercise did not differ between PRO and CHO.
230
231 Compared with water, the CHO drink produced larger increases in cardiac output and stroke
232 volume, and decreases in SVR; water caused a smaller increase in HR but larger increase in DVP-
233 RI. Similar cumulative effects of the CHO load and exercise on hemodynamics have been reported
234 in earlier studies of solid mixed meals of a greater total energy content (Kelbaek et al. 1987; Waaler
235 et al. 1990; Yi et al. 1990; Eriksen and Waaler 1994; Matheson et al. 2000). Our findings at rest
236 agree with those of earlier studies (Avasthi et al. 1987; Sidery et al. 1991; Waaler et al. 1992;
237 Uijtdehaage et al. 1994; Hoost et al. 1996). As the CHO drink appeared to increase cardiac output
238 via an increase in stroke volume rather than in HR, this would suggest changes either in cardiac

239 contractility (inotropy), or in filling pressure and end diastolic volume (preload) due to a change in
240 relaxation (a lusitropic effect). The different cardiovascular responses to CHO versus PRO can be
241 attributed to the dilatory effects of insulin and glucose on the skeletal muscle vasculature, and their
242 sympathoexcitatory effects (i.e. on muscle sympathetic nerve activity) (Anderson et al. 1991; Baron
243 1994; Kearney et al. 1996; Hoffman et al. 1999). However, glucose and insulin were not measured
244 in the present study.
245
246 Our data showed that neither carbohydrate nor (whey) protein acute loading augmented pressure
247 wave reflection (DVP-RI) compared to water, which might suggest no redistribution of blood flow
248 from the periphery to the splanchnic area to facilitate the postprandial hyperemic response. The
249 decrease in pressure wave reflection immediately post-exercise as indicated by DVP-RI was in line
250 with the fall in exercise SVR and/or the increase in HR, hence reflecting vasodilation occurring in
251 the exercising vasculature and/or alterations in the timing of the reflected pressure wave (Wilkinson
252 et al. 2000; Wilkinson et al. 2002).
253
254 **Limitations, conclusions, and future research.**
255 The drinks were matched for macronutrients but there were minor differences in their micronutrient
256 content; the PRO drink contained moderately higher amounts of some minerals and the CHO drink
257 was fortified with vitamins. Fewer participants completed the study than planned but *post hoc*
258 calculations indicate the effect size for the change cardiac output was greater than that for which the
259 study was powered. All 23 participants screened were eligible to participate, but only 14 completed
260 the study (reasons include loss of interest and time constraints). Poor finger arterial pressure
261 waveform output during exercise in 1 participant resulted in exclusion of data derived from these
262 measurements. As this study was conducted in healthy non-obese young men, the findings cannot
263 be generalized to females or individuals with hypertension or altered vascular function. Since an

exaggerated BP response to dynamic exercise is an independent predictor of future hypertension (Manolio et al. 1994; Singh et al. 1999) and CVD mortality (Mundal et al. 1994), future research to test cardiovascular reactivity to exercise following meals/drinks of varying macronutrient composition in those with early hypertension or individuals with high normal BP would contribute to current evidence in the prevention of hypertension and to simultaneously monitor changes in insulin and glucose concentrations.

In conclusion, the findings of the study do not provide support for the hypothesis that a protein rich drink prior to exercise has adverse effect compared to carbohydrate on blood pressure reactivity in response to exercise. However, this study showed that a carbohydrate rich drink acutely increased resting cardiac output and lowered SVR compared with a protein rich drink or water but did not differ from protein or water during exercise.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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434

Table 1. Macronutrient composition* of the test drinks

Energy and Macronutrients	PRO	CHO
Energy (MJ)	1.06	1.08
Fat (g)	5	5
Carbohydrates (g)	9	57
Sugars (g)	7.5	21
Protein (g)	44	1
L-Glutamic Acid (g)	5.8	-
L-Aspartic Acid (g)	4.6	-
L-Leucine (g)	4.4	-
L-Lysine (g)	3.7	-
L-Threonine (g)	3.2	-
L-Arginine (g)	1.2	-
L-Methionine (g)	0.9	-

***Estimated using food tables (Food Standards Agency 2002) and information provided by the manufacturers.**

Table 2. Details of the male participants

Variables	
Age (y)	25.8 (22.7, 28.8)
BMI (kg/m^2)	22.7 (21.5, 23.9)
Body fat (%)	12.2 (9.8, 14.6)
Waist circumference (cm)	82.5 (78.8, 86.2)
Waist-to-hip ratio	0.83 (0.80, 0.85)
VO_{2max} (mL/kg/min)	46.3 (40.3, 52.3)
Systolic BP (mm Hg)	121.5 (115.7, 127.3)
Diastolic BP (mm Hg)	71.9 (68.7, 75.2)

Values are $\bar{x}$ (95% confidence intervals), n=14; VO_{2max}, maximal oxygen uptake; BP, blood pressure

Table 3. Changes after a high protein drink (PRO), high carbohydrate drink (CHO) or water in hemodynamics and digital volume pulse (DVP) at 30 min rest from fasting (0 h), followed by changes from pre-exercise (30 min) during 12 min exercise.

	Drinks	0 min (fasting)	Δ (30 min – 0 min) [2]	Δ (exercise – 30 min) [2]
Cardiac output (*L/min*)	PRO	5.5 (4.9, 6.0)	0.1 (-0.2, 0.4) [a]	4.9 (4.6, 5.2) [a]
	CHO	5.7 (5.1, 6.2)	0.7 (0.4, 1.0) [b]	4.7 (4.4, 5.0) [a,b]
	Water	5.6 (5.1, 6.2)	-0.0 (-0.3, 0.3) [a]	4.6 (4.3, 4.9) [b]
Stroke volume (*mL*)	PRO	83.9 (73.6, 94.3)	2.6 (-3.2, 8.5) [a]	12.8 (6.0, 19.6)
	CHO	85.5 (75.2, 95.8)	13.4 (7.6, 19.3) [b]	13.6 (6.8, 20.3)
	Water	84.5 (74.1, 94.8)	9.7 (3.9, 15.6) [a,b]	10.1 (3.4, 16.8)
HR (*bpm*)	PRO	66.7 (63.0, 70.5)	-1.0 (-3.6, 1.5) [a]	37.8 (32.5, 43.2)
	CHO	66.7 (62.9, 70.4)	-2.2 (-4.8, 0.3) [a]	39.2 (33.9, 44.5)
	Water	66.9 (63.2, 70.7)	-7.0 (-9.6, -4.5) [b]	36.6 (31.3, 42.0)
Systolic BP (*mmHg*)	PRO	121.0 (115.5, 126.4)	7.2 (2.7, 11.6) [a,b]	19.3 (14.1, 24.4)
	CHO	125.5 (120.0, 130.9)	8.8 (4.4, 13.2) [a]	17.5 (12.3, 22.7)
	Water	123.6 (118.2, 129.1)	2.1 (-2.2, 6.5) [b]	16.6 (11.4, 21.7)
Diastolic BP (*mmHg*)	PRO	73.1 (69.5, 76.7)	-0.2 (-2.9, 2.5)	7.6 (4.4, 10.8)
	CHO	74.4 (70.8, 77.9)	0.5 (-2.2, 3.2)	7.9 (4.7, 11.1)
	Water	73.9 (70.3, 77.5)	0.7 (-2.0, 3.4)	5.9 (2.8, 9.1)
MAP (*mmHg*)	PRO	90.7 (86.4, 95.0)	1.8 (-1.4, 4.9)	13.4 (9.4, 17.5)
	CHO	92.9 (88.6, 97.2)	3.0 (-0.1, 6.1)	13.2 (9.2, 17.3)
	Water	92.3 (88.0, 96.6)	1.1 (-2.0, 4.2)	12.2 (8.2, 16.3)
SVR (*Wood Units*)	PRO	16.8 (15.0, 18.6)	0.1 (-0.7, 0.9) [a]	-6.2 (-6.8, -5.6)
	CHO	16.9 (15.0, 18.7)	-1.4 (-2.2, -0.6) [b]	-6.2, (-6.7, -5.6)
	Water	17.1 (15.2, 18.91)	0.3 (-0.5, 1.1) [a]	-5.9 (-6.5, -5.4)
DVP-RI	PRO	72.3 (67.8, 76.9)	0.8 (-3.5, 5.2) [a]	-12.2 (-18.3, -6.2)

(*%*)	CHO	73.8 (69.3, 78.3)	-1.9 (-6.0, 2.1) [a]	-16.0 (-22.0, -10.0)
	Water	72.1 (67.6, 76.6)	6.4 (2.7, 10.1) [b]	-9.7 (-15.9, -3.5)
DVP-SI (*m/s*)	PRO	6.7 (6.3, 7.2)	-0.1 (-0.3, 0.2)	0.6 (0.3, 1.0)
	CHO	6.7 (6.2, 7.1)	-0.2 (-0.4, -0.1)	0.6 (0.3, 1.0)
	Water	6.6 (6.2, 7.1)	-0.3 (-0.6, -0.04)	0.8 (0.5, 1.2)

Values are $\bar{x}$ (95% confidence intervals); $n = 14$ (for exercise HR, BP, stroke volume and SVR, $n = 13$); BP, blood pressure; DVP-RI, DVP-reflection index; DVP-SI, DVP-stiffness index; HR, heart rate; MAP, mean arterial pressure; SVR, systemic vascular resistance.

The point estimates and 95% CI were derived from the mixed linear model, adjusted for fasting absolute values. Values in the same column of a single outcome variable with different superscripts are significantly different, $P < 0.05$; Bonferroni correction.

LIST OF FIGURES