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Post-exercise rehydration in man: comparison between water and carbonated drink

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ABSTRACT: Effects of fluids (water and carbonated drink) provided for rehydration after muscular exercise were compared in 12 male subjects (19 – 30 yrs). The muscular exercise involved two cycling sessions T_1 and T_2 on bicycle ergometer. Recovery period of one hour was allowed for complete absorption of water after T_1 before starting T_2 after which the carbonated drink was used. Cardiovascular responses [heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP)], body weight, haematocrit, plasma volume, haemoglobin concentration and subjective feelings were determined before exercise and after fluid rehydration. Subjects were dehydrated by 0.8 ± 0.4% ($p < 0.05$) of their body weight. There were no significant differences when the effects of the fluids were compared except for SPB ($p < 0.02$) and HR ($p < 0.001$) for water and carbonated drink respectively. We conclude, therefore, that either of the two fluids can be used after exercise.

Key Words: Dehydration; Rehydration; Water; Carbonated drinks; Exercise.

Introduction

Dehydration, hypothermia and muscle glycogen depletion are major factors contributing to hypoglycaemia and particularly exhaustion during muscular exercise (1 – 5). During physical exercise, exhaustion (fatigue) occurs before muscle glycogen stores become fully depleted. However, recent studies suggest that ingestion of a volume of beverages containing 10% glucose or less may maintain body function as effectively as water does, even with additional benefit (7 – 11). Therefore, the present study was undertaken to investigate the beneficial claim of either water or carbonated drink on post-exercise dehydration in young adult Nigerians.

Materials and Methods

Twelve healthy, non-smoking, untrained males aged between 19 and 30 years (24.4 ± 0.92) were admitted into this study. Only subjects who were certified free from any cardiopulmonary disease or other chronic systemic diseases were allowed into the study. In general, the subjects were certified clinically fit by physicians at the University Health Centre. The antropometric measurements were made in the

laboratory (Table 1). The experimental procedure was carefully explained to the subjects until they were accustomed to it.

Table 1: Antropometric data.

Age (Years)	Height (m)	Weight (kg)
24.5 ± 0.9	1.73 ± 0.0	59.9 ± 1.9

Figures represent the means ± SEM.

Experimental Procedure

The subjects were dehydrated by 0.8 ± 0.4% ($P < 0.05$, $n = 12$) of their body weight by maximal exercise achieved by cycling on computerized bicycle ergometer (Weider TG-700P) for 3 minutes.

On the day of the study, subjects were allowed to sit comfortably for a minimum of 10 minutes during which the experimental procedure was carefully explained to them. there was a pre-exercise resting period after which control values of cardiovascular variables (SBP, DBP and HR) were measured in duplicate and averaged for each subject. Haemoglobin concentration was determined by colorimetry (13) and haematocrit by standard microhaematocrit technique (14, 15). However, the percentage change in plasma volume was also measured. Haematocrit and haemoglobin values were also measured in duplicate and averaged for each sample.

Maximal level of exercise was attained using modified Leeds University exercise method (16, 17). Cardiovascular variables, haematologic variables and body weight were measured after exercise and subsequently after dehydration. To compare the effects of the experimental fluids, each protocols had two exercise sessions (T_1 and T_2) separated by one hour recovery period. The mode of dehydration involved ingesting water (700 ml) after first maximal exercise. Thirty minutes was allowed for complete intestinal absorption before the measurements were taken. In addition, another period of 30 minutes was allowed for complete recovery from the first maximal exercise (T_1). The exercise was repeated (T_2) and the second experimental fluid (700 ml carbonated drink) was administered. the same procedure for the first fluid was applied to the second fluid.

In this study, measurements were usually taken 30 minutes in the post-absorptive period (i.e. 30 minutes after the oral load). Pre-exercise values were recorded as the control values. Subjective feelings were noted after fluid ingestion.

The control data were compared with the data obtained during the post exercise rehydration to determine a response. The differences in the effects of the rehydrating fluids on the variables were also determined. Significant responses were determined by Student's t-test for paired comparisons (18). Differences were considered significant for p-values of 0.05 or less.

Results

Response to exercise

Pre-exercise values of body weight, HR, SBP and DBP were 59.9 ± 1.9 kg, 65.5 ± 2.1 beats min^{-1}, 113.8 ± 2.5 mmHg and 73.3 ± 1.9 mmHg, respectively. Nine subjects were slightly dehydrated while the remaining three subjects showed either an increase or no change in dehydration level. The overall reduction in weight was from the control level of 59.9 ± 1.8 kg to 59.3 ± 1.8 kg (0.8 ± 0.4%, $p < 0.05$, $n = 12$). All subjects showed an increase in HR after exercise. The HR increased from control level of 67.5 ± 2.0 to 82.6 ± 1.8 beats min^{-1} (23.4 ± 5.1%, $p < 0.001$, $n = 12$).

All subjects except two showed a significant increase in SBP. The increase was from a control level of 113.8 ± 2.5 to 126.0 ± 4.5 mmHg (10.9 ± 5.1%, $p < 0.001$, $n = 12$). However, the DBP response was not significant (Table 2).

Table 2: Effect of exercise on weight and cardiovascular variables.

	Weight (kg)	HR (beats min^{-1})	SBP (mmHg)	DBP (mmHg)
Control (Mean ± SEM)	59.9 ± 1.9	67.5 ± 2.1	113.8 ± 2.5	73.3 ± 1.8
Maximal Exercise (Mean ± SEM)	59.3 ± 8.1	82.6 ± 1.8	126.0 ± 4.5	77.0 ± 2.4
% Δ	0.8 ± 0.4	-23.4 ± 5.1	-1.0 ± 3.1	-3.8 ± 3.3
n	12	12	12	12
P	< 0.05	< 0.001	< 0.001	> 0.1

HR = Hear Rate; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure.

Body weight responses to rehydration after exercise

Eight subjects showed a decrease in weight while three subjects showed an increase but only one subject showed no change after ingesting water or carbonated drink. Overall response was an insignificant decrease from 59.9 ± 1.9 kg to 59.3 ± 1.8 kg (0.92 ± 0.6%, $p > 0.5$, $n = 12$. Table 3) after ingesting water. Overall response was also an insignificant change in body weight from 59.9 ± 1.9 kg to 59.5 ± 1.8 kg (0.4 ± 0.8%, $p > 0.5$, $n = 12$, Table 4) after taking carbonated drink.

Table 3: Responses to rehydration with water after exercise.

	Weight (kg)	HR (beats min^{-1})	SBP (mmHg)	DBP (mmHg)
Exercise (Mean ± SEM)	59.3 ± 1.8	82.6 ± 1.8	126.0 ± 4.5	77.0 ± 2.4
Water rehydration (Mean ± SEM)	59.3 ± 1.8	71.2 ± 2.9	105.5 ± 2.6	75.5 ± 2.2
% Δ	-0.1 ± 0.5	15.9 ± 2.3	15.7 ± 2.8	5.3 ± 3.1
n	12	12	12	12
P	> 0.1	< 0.001	< 0.001	> 0.1

HR = Heart Rate; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure.

Blood pressure response to rehydration after exercise

Only one subject showed an increase in SBP after water rehydration. seven subjects showed a decrease while four subjects showed no response. The overall response was a change from control level of 113.8 ± 2.5 to 105.5 ± 2.6 mmHg (7.0 ± 2.4, $p < 0.02$, $n = 12$, Table 3). When carbonated drink was ingested, four subjects showed an increase in SBP, while there was a decrease in five subjects. No change was observed in three subjects. The overall response indicated an insignificant fall in SBP from control values of 113.8 ± 2.5 to 110.5 ± 10.4 mmHg (2.5 ± 2.2%, $p > 0.5$, $n = 12$, Table 5). However, there were no significant changes in DBP whether water or carbonated drink was ingested (Tables 3 and 5).

Table 4: Responses of haematologic parameters to water rehydration after exercise.

	HbC (g/dl)	PCV	PV
Control (Mean ± SEM)	14.7 ± 0.6	41.0 ± 1.0	59.0 ± 1.0
Water rehydration (Mean ± SEM)	14.5 ± 0.4	39.2 ± 0.4	60.8 ± 0.8
% Δ	0.9 ± 2.8	0.4 ±	3.1 ± 1.0
n	12	12	12
P	> 0.5	< 0.01	> 0.02

HbC = Haemoglobin concentration; PCV = Packed Cell Volume; PV = Plasma Volume.

Table 5: Responses of cardiovascular variables to rehydration with carbonated drinks after exercises.

	HR (beats min^{-1})	SBP (mmHg)	DBP (mmHg)
Exercise (Mean ± SEM)	59.3 ± 1.8	82.6 ± 1.8	77.0 ± 2.4
Carbonated drink rehydration (Mean ± SEM)	59.5 ± 1.8	73.0 ± 2.4	76.7 ± 1.4
% Δ	0.5 ± 0.7	9.2 ± 2.8	-0.3 ± 2.7
n	12	12	12
P	> 0.1	< 0.001	> 0.1

HR = Heart Rate; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure.

Heart rate response

Nine subjects showed an increase in heart rate, while two showed an decrease but only one showed no change after water dehydration. The overall response was an insignificant increase in heart rate from control level of 67.5 ± 2.1 to 71.2 ± 2.9 beats min^{-1} (5.6 ± 3.2%, $p > 0.5$, n = 12, Table 3). All subjects showed an increase in heart rate while only one showed no change in heart rate after carbonated drink rehydration. Overall response was an increase from control level of 67.5 ± 2.1 to 73.0 ± 1.9 beats min^{-1} (8.1 ± 1.9%, $p < 0.01$, n = 12, Table 5).

Haematologic response

Seven subjects showed a decrease in haematocrit (PCV) and an increase in plasma volume after water dehydration. The overall response in haematocrit was a decrease from the control level of 41.0 ± 1.0 to 39.2 ± 0.4% (4.1 ± 1.3%, $p < 0.01$, n = 12, Table 3). The overall response was a significant increase in plasma volume from 59.0 ± 1.0 to 60.8 ± 0.8% (3.1 ± 1.0%, $p < 0.02$, n = 12, Table 4). Moreover, six subjects showed an increase in haemoglobin concentration while five subjects showed a decrease. In one subject there was no change after water rehydration. The overall response was an insignificant decrease from

control level of 14.7 ± 0.6 to 14.5 ± 0.4 g/dl (0.92 ± 2.8%, $p > 0.5$, n = 12, Table 3). Eight subjects showed a decrease in haematocrit and an increase in plasma volume while the remaining subjects showed no response in haematocrit and plasma volume after rehydration with carbonated drink.

The overall response in haematocrit was a significant decrease from control level of 41.1 ± 1.0 to 39.3 ± 1.0% (4.0 ± 0.9%, $p < 0.01$, n = 12, Table 6). Also, the overall response of plasma volume was a significant increase from a control level of 59.0 ± 1.0 to 60.4 ± 1.5 (2.4 ± 0.6%, $p < 0.01$, n = 12). Moreover, eight subjects showed a decrease while four subjects showed an increase in haemoglobin concentration after carbonated drink rehydration. The overall response was an insignificant change from 14.7 ± 0.6 to 15.0 ± 0.6 g/dl (1.5 ± 4.7%, $p > 0.5$, n = 12, Table 6).

Table 6: Responses of haematologic parameters to carbonated drink rehydration after exercise.

	HbC (g/dl)	PCV	PV
Control (Mean ± SEM)	14.7 ± 0.6	41.0 ± 1.0	59.0 ± 1.0
Carbonated drink rehydration (Mean ± SEM)	15.0 ± 0.6	39.3 ± 1.0	2.4 ± 0.6
% Δ	-1.5 ± 4.7	4.0 ± 0.9	2.4 ± 0.6
n	12	12	12
P	> 0.5	< 0.001	< 0.01

HbC = Haemoglobin concentration; PCV = Packed Cell Volume; PV = Plasma Volume.

Subjective feelings

Eleven subjects felt satisfied and preferred carbonated drink (700 ml) to water (700 ml). The remaining one subject had the same feeling after taking any of the two fluids.

Discussion

The results of this study show a significant dehydration by los of weight (0.8 ± 0.4%, $p < 0.05$, Table 2) after maximal muscular exercise. The loss in weight may be due to loss of water through sweating and respiratory water (insensible) loss (5, 19, 20).

From this study, rehydration with water and carbonated drink produced no significant change in weight suggestive of adequate fluid replacement by either carbonated drink or water. This is in contrast to the report of other authors (21,22) where prolonged exercise was involved. In the present study, the exercise was for a short period.

The cardiovascular responses show a large increase in heart rate (25.3 ± 5.1%, $p < 0.001$) and systolic blood pressure (11.0 ± 5.1%, $p < 0.001$) after maximal muscular exercise. However, the increase in heart rate and systolic blood pressure are in agreement with previous reports (23,24). The positive chronotropic change and elevation of systolic pressure may result from a common physiological mechanism such as endocrine secretion influencing sympathetic discharge to increase cardiac output (25,26). The insignificant change in diastolic blood pressure suggest the little involvement of diastolic pressure in cardiovascular adjustment to muscular exercise (17). The two fluids did not evoke a strong cardiovascular response after exercise (7-9). Furthermore, rehydration with either fluid produced similar effect on plasma volume (i.e. haematological indices in which the general trend was a decrease, haemodilution).

In conclusion, this study has shown that there are no significant differences between water and carbonated drink for post-exercise rehydration. Therefore, either of the two rehydration fluids may be used for rehydration after exercise.

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