



EFFICACY OF PRE EXERCISE CARBOHYDRATE DRINK (GATORADE) ON THE RECOVERY HEART RATE, BLOOD LACTATE AND GLUCOSE LEVELS IN SHORT TERM INTENSIVE EXERCISE

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Abstract Nutrition is an important tool in the field of sports practice; once well oriented it may reduce fatigue, which allows the athlete to train longer or recover better between the training sessions. The aim of this study was to investigate the efficacy of a carbohydrate drink (Gatorade) on the recovery heart rate and blood lactate levels. 20 healthy men were recruited as subjects. Flavoured water or Gatorade was given randomly to the subjects 20 minutes prior to exercise. The subjects were made to exercise under Bruce treadmill protocol. The peak exercise heart rate and blood pressure were recorded, when the subjects underwent passive recovery in supine lying, and the recovery heart rate was recorded. The post exercise blood sample was analyzed for blood lactate and glucose concentrations. The same subject was followed up after 48 hours for the second trial. The findings of the study indicate statistically significant differences between Gatorade and Placebo drinks ($p < 0.05$) in post exercise lactate ($t=3.04$) and glucose levels ($t=3.52$). Significant differences were also recorded in heart rates at the 3rd, 5th and 8th minutes of passive recovery with ($F=4.47$), ($F=5.60$) and ($t=4.35$) respectively. Gatorade increases performance by limiting lactate accumulation and improves cardiovascular responses by keeping a low heart rate thereby delaying the onset of fatigue.

Key words: Gatorade, Bruce treadmill protocol, recovery heart rate, blood lactate

INTRODUCTION

Nutrition is an important tool within the sports practice; once well oriented it may reduce fatigue, which allows the athlete to train longer or recover better between the training sessions [29]. Since many food nutrients provide energy and regulate the physiological process related to exercise, it is tempting to associate the dietetic changes with the improvement of athletic performance [29]. The fastest and most widely used method of gaining increased performance is through performance enhancing substances. Previous research has consistently shown that there are many exercise occasions when a sports drink provides benefits superior to water but no athletic occasion when water is superior to a properly formulated sports drink [28]. In its simplest sense, a sports drink is a drink consumed in association with sport or exercise – either in preparation for exercise, during exercise itself or as a recovery drink after exercise [31].

The amount and types of carbohydrates used in a sports drink are critical in optimizing the potential of the drink to improve performance. Research shows that a blend of simple carbohydrates (sucrose, glucose, and fructose) is most effective in stimulating rapid absorption and enhancing carbohydrate oxidation, the two important considerations whenever athletes are training and competing [28]. In the small intestine, multiple types of carbohydrates stimulate the fastest fluid absorption and help reduce the risk of gastrointestinal distress during vigorous exercise [28]. They also help sustain important cardiovascular functions [28]. One key ingredient in Gatorade that should decrease fatigue is carbohydrates. The carbohydrates in Gatorade replenish the fuel spent by the body but the essential part of this beverage is the added electrolytes. Nerve conduction for muscle stimulation as well as any other required action potential in the process of muscle contraction expend these electrolytes and require additional electrolytes to continue functioning at peak levels [32]. A study has looked at the effects of carbohydrate-electrolyte fluid on exercise performance and determined that the added nutrients provided in sports drinks reduce the onset of fatigue and keep performance levels higher [21]. Replenishing the electrolytes gives the cells more nutrients necessary to continue driving contraction through stimulation by action potentials. Previous research has

confirmed that well hydrated athletes do have generally increased performance endurance over dehydrated athletes [35]. It is well documented that carbohydrate ingestion before and during exercise is effective at maintaining or improving exercise performance [15, 16, 17, 18, 19, 20]. When taken before exercise, they have an objective to prevent or delay the homeostatic disturbances which may follow the physical activity, granting a suitable plasmatic volume from the beginning of the exercise. This also promotes a small fluids reserve in the gastrointestinal lumen, which will be absorbed during the activity.

Moreover, the consumption in the pre-exercise period can optimize the glucose concentrations in the flowing blood through the supply of carbohydrates [29, 37]. Several studies involving cycling protocols have shown that carbohydrate intake enhances performance of a high intensity exercise task of approximately one hour's duration, compared to water or an artificially sweetened placebo [2, 3, 4, 5]. In these situations muscle glycogen stores are not considered to be limiting, especially if the athlete has "fuelled up" prior to the event [18]. Instead, a number of investigators speculate that carbohydrate intake exerts a favorable effect on sensory input to the central nervous system [3, 4]. It is well documented that when used during exercise, carbohydrates can improve the performance as shown in a study [5]. An increase in exercise intensity results in a parallel increase in carbohydrate utilization by the working muscles. Carbohydrate supplementation should therefore maintain the necessary intramuscular levels of tricarboxylic acid cycle intermediates required for the increase in energy expenditure [15]. Although the bulk of evidence suggests that the benefits of ingesting carbohydrates are limited to exercise lasting more than 90 minutes, where muscle glycogen depletion is a potential cause of fatigue [7], it is common practice for athletes performing for shorter periods to ingest commercially available carbohydrate electrolyte drinks prior to exercise. The ingestion of carbohydrates within the hour prior to exercise can cause an increase in both blood glucose and insulin concentrations. This may be detrimental to homeostasis at the onset of exercise as there is a rapid fall in blood glucose as a consequence of the combined stimulatory effects of hyperinsulinaemia and increased muscle contractile activity [17]. Notwithstanding this, the metabolic alterations associated with carbohydrate ingestion in the 30–60 minutes before exercise have the potential to improve exercise performance [13, 17, 23], and on balance there appears to be no justifiable reason as to why carbohydrate consumption should be avoided within the hour before exercise [17]. The drink used in the study – Gatorade, a Pepsi Co product – has a carbohydrate concentration of 6% (60 grams per liter or about 14 grams per 8 ounces); as research has indicated, that level appears to provide the optimal amount of carbohydrates needed for palatability, rapid gastric emptying and intestinal absorption, as well as for the enhanced carbohydrate oxidation required for improved performance.

The effect of this drink in pre exercise in relation to metabolism and performance is still questioned as it is widely used as a recovery drink and not as a pre exercise drink. Therefore, this work aims to clarify the effects of the prior consumption of Gatorade drink on blood lactate, recovery heart rate and blood glucose, etc.

MATERIALS AND METHODS

SUBJECTS

In order to reduce any outlying variables that could skew the data, many steps were taken to ensure their validity. Twenty healthy untrained males were chosen by their general physical fitness (age 21.37 ± 0.4 years; height 176.16 ± 1.06 cm, weight 70.48 ± 1.96 kg). They were familiarized with the experimental protocol and informed about the possible risk and benefit involved with the study both verbally and in writing before obtaining written consent. Only healthy subjects without any history of pathology or orthopedic limitation were inducted in the study. Furthermore, VO_{2max} more than or equal to $40 \text{ mL}\cdot\text{kg}\cdot\text{min}^{-1}$ was determined as minimal aerobic capacity by *Queen's College Step test* in order for one to be included in the study [27]. To rule out climate variables all tests were performed in the exercise physiology laboratory which remained at the same or similar temperature, humidity, and wind speed (0 mph) during every trial [32].

TESTING PROTOCOL

The study protocol was approved by the Institutional Ethics Review Board, Guru Nanak Dev University. The study constituted a double-blind controlled, randomized cross-over design. All trials were performed at the same time of day to negate diurnal variation. For 3 days prior to the first experimental trial, all subjects were required to follow their "usual" diet, and weigh and record all foods consumed. The same diet was then consumed before the second trial as well. In order to facilitate compliance, diet sheets were given to each subject; all subjects completed two experimental trials in random order separated by a minimum of 48 hours. For each trial, the subjects consumed either a carbohydrate electrolyte solution (Gatorade) or a non-carbohydrate electrolyte placebo consisting of water, 20 minutes prior to exercise. The drinks were identical in taste, colour, temperature, and texture, and they were presented in the same coloured containers for all trials [11]. Gatorade is a lime flavoured non alcoholic, non carbonated drink containing water, 30 gm of carbohydrates (dextrose), 30 gm of sugar, citric acid, sodium citrate, monopotassium phosphate, flavoring / colouring ingredients and 225 mg sodium delivering 120 kcal of energy per 500 ml servings.

The subjects were divided into two groups. Group A were given a placebo drink 20 minutes prior to the exercise bout and the subjects in group B were given Gatorade sports drink, following a 12 hour fast. Preceding the exercise protocol, resting heart rate and blood pressure were assessed and blood lactate was measured by Analox PLM 5 lactate analyzer, while glucose was assessed using a capillary blood sample taken from the fingertip. 500 ml of drink was given to the subject randomly by the assistant blinding both the subject and the investigator about the type of drink (placebo or Gatorade).

20 minutes after the ingestion, the subjects volunteered to run on a treadmill according to Bruce protocol. Both groups underwent passive recovery, blood samples were again taken to measure post exercise blood lactate and glucose levels and the heart rate was recorded at the 1st, 2nd, 3rd, 5th, and 8th minutes after exercise.

STATISTICAL ANALYSIS

All data are presented as the Mean \pm Standard Deviation (SD). The data were analyzed for statistical significance by using the Statistical Package for Social Sciences (SPSS 16.0) software. Paired Student's t test and one way ANOVA were used. The level of statistically significant difference was defined with respect to 95 % likelihood, i.e., $p \leq 0.05$.

RESULTS

The mean values and standard deviations of post exercise blood lactate and glucose concentration values of the placebo and Gatorade trial groups show significant differences ($t = 3.04$, $p < 0.05$) and ($t = 3.52$, $p < 0.05$) respectively. The peak heart rate also showed significant difference in the two groups ($t = 2.85$, $p < 0.05$). Table 1 shows the descriptive indicators of the variables studied.

Table 1. Descriptive statistics of the variables studied (PLC: Placebo trial, GTR: Gatorade trial, HR: Heart rate)

Groups	PLC post lactate (Mmol/dl)	GTR post lactate (Mmol/dl)	PLC post glucose (Mg/dl)	GTR post glucose (Mg/dl)	PLC peak HR (beats/min)	GTR peak HR (beats/min)
Mean \pm SD	7.67 \pm 2.05	5.88 \pm 2.62	69.5 \pm 8.66	78.85 \pm 11.99	185.0 \pm 43.9	175.0 \pm 64.1
t value	3.04		3.52		2.85	
p value	$p < 0.05$		$p < 0.05$		$p < 0.05$	

ANOVA for Recovery Heart Rate at 3rd, 5th and 8th minutes: One way ANOVA analysis of recovery heart rate in the 3rd, 5th and 8th minutes of recovery period reveals a statistically significant difference in the heart rate ($F=4.46$, $p < 0.05$), ($F=5.60$, $p < 0.05$), ($F=4.35$, $p < 0.05$) respectively (Tables 2).

Table 2. ANOVA heart rate recovery results for 3rd, 5th and 8th minutes of recovery period

3 rd minutes of recovery	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1440.00	1	1440.00	4.476	0.041
Within Groups	12223.90	38	321.68		
Total	13663.90	39			
5 th minutes of recovery	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1729.23	1	1729.23	5.609	0.023
Within Groups	11715.75	38	308.31		
Total	13444.98	39			
8 th minutes of recovery	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	912.03	1	912.03	4.351	0.044
Within Groups	7965.95	38	209.63		
Total	8877.98	39			

HEART RATE AND RECOVERY HEART RATE

Maximum post exercise heart rate for Placebo and Gatorade were 185.0 \pm 43.89 bpm and 175.0 \pm 11.99 bpm, respectively. Differences were observed between Placebo group vs. Gatorade group ($p < 0.05$). In the relaxation period, the heart rate was observed higher in the Placebo trial after the 1st and 2nd minutes with ($p > 0.05$) and lower in the 3rd, 5th and 8th minutes of relaxation ($p < 0.05$).

DISCUSSION

The main findings of the study indicate that Gatorade sports drink when ingested 20 minutes prior to exercise delays fatigue and improves performance. This improvement in performance is consistent with other published literature (see table below for an overview of the literature); however, the majority of these studies used an experimental protocol that involved the ingestion of the carbohydrates 30-60 minutes before exercise or immediately before and during exercise [11].

Table 3. Overview of carbohydrate ingestion prior to exercise performance [11]

Reference	Timing of carbohydrate ingestion before exercise	Exercise outcome
Nicholas et al. (1995)	Immediately before and during exercise	<i>Increase</i> in performance
Tsintzas et al. (1996)	Immediately before and during exercise	<i>Increase</i> in performance
Patterson and Gray (2007)	Immediately before and during exercise	<i>Increase</i> in performance
Shirreffs and Merson (2003)	20 minutes	<i>Increase</i> in performance
Gleeson et al. (1986)	45 minutes	<i>Increase</i> in performance
Kirwan et al. (1998)	45 minutes	<i>Increase</i> in performance
Sherman et al. (1991)	60 minutes	<i>Increase</i> in performance
Thomas et al. (1991)	60 minutes	<i>Increase</i> in performance

Hydration status is a critical determinant of the athlete's physiological capacity to train, compete, and recover successfully [29]. Whenever muscles work hard, they rely predominantly on carbohydrates as a fuel; even slight dehydration (e.g., a 1-2% loss in body weight) has a negative effect on physiological function and performance. An athlete who fails to replace body fluids lost as sweat typically experiences many adverse functional changes, including a higher exercise heart rate, a higher plasma osmolality, a lower blood flow to the skin, and a higher core temperature. Gatorade has a carbohydrate concentration of 6% (60 grams per liter or about 14 grams per 8 ounces); research has indicated that this level appears to provide the optimal amount of carbohydrates needed for palatability, rapid gastric emptying and intestinal absorption, as well as for the enhanced carbohydrate oxidation required for improved performance [28]. A previous study used a design similar to the present investigation and demonstrated an improvement in exercise to exhaustion following the administration of a commercially available carbohydrate electrolyte drink 20 minutes prior to and during exercise [30]. Moreover, studies determining the relationship between carbohydrates and intermittent exercise performance usually favor the option of ingesting before in addition to during exercise, while there is a need to ascertain if carbohydrate supplementation prior to but not during intermittent exercise can increase performance as effectively. Bruce protocol was specifically selected as a mode of exercise as its initial stages include slow intermittent exercise followed by exhaustive exercise in the later stages [11]. We specifically chose to include an intermittent exercise protocol before exhaustive exercise in order to attempt to decrease muscle glycogen levels in all experimental groups, and therefore demonstrate that any increase in performance during the exercise may be due to a greater availability of blood glucose and possible sparing of muscle glycogen as a result of carbohydrate ingestion.

The results of this study may therefore interest sports performers that do not have the opportunity to ingest fluids during exercise, but have aspirations to delay fatigue and enhance performance during prolonged high-intensity exercise [11]. Elevated blood glucose levels as a result of carbohydrate feeding during exercise have consistently been reported [6, 11, 34]. In the present study, there was a significant increase in blood glucose concentration 20 minutes after carbohydrate drink consumption. Considering post blood glucose results, there was an increase in blood glucose levels as compared to placebo. Our study corroborates with the findings of a previous study which demonstrates that this increase may be due to the greater availability of blood glucose and possible sparing of muscle glycogen as a result of carbohydrate ingestion [11]. Therefore, it is reasonable to postulate that augmented carbohydrate availability in the later stages of exercise may have contributed to the overall increase in performance as observed in the present study [1, 36]. The blood lactate in all the groups increased over the course of exercise. Although significant differences were not observed in blood lactate level in studies that used the consumption of a carbohydrate-electrolyte drink [12, 13, 29], in our study a significant difference was found between the Gatorade and placebo groups. This could be due to the presence of additional glucose concentration in the peripheral circulation which may have allowed the subjects to increase exercise intensity, thereby delaying fatigue and improving performance. The data suggest that lactic acid accumulation and resultant metabolic acidosis had a disturbing effect on performance as shown by increased levels of blood lactate in the placebo group. The accumulation of blood in veins and the reduction in the stroke volume results in the decreased central blood volume and a reduction in cardiac output [14, 26]. Compensation for this decreased cardiac output normally occurs through a small increase in the heart rate [25]. This is supported by evidence of an increase in the heart rate during the

placebo trial. Previous studies reported that, during a moderate intensity exercise, the magnitude of the increase in the heart rate was directly related to the degree of dehydration [14, 16, 25]. Perhaps the ingestion of carbohydrate electrolyte fluid maintained skin blood flow and thermoregulation, and reduced dehydration and hyperthermia induced fatigue [38]. Replacing the electrolytes lost in sweat aids overall hydration because of the osmotic properties of the electrolytes (in this case, "osmotic properties" refers to the ability of electrolytes to hold on to fluid in the blood and muscles).

Sodium is most critical in this regard because of the singular role it plays in maintaining fluid balance. Ingesting sodium in a sports drink helps maintain the osmotic drive to drink, stimulating greater voluntary fluid intake than is achieved when only plain water is ingested. Once in the bloodstream, sodium helps maintain blood volume at higher levels than can be achieved when only plain water is consumed. A higher blood volume translates into a lower heart rate and greater blood flow to muscle and skin, all of which are essential in helping sustain performance. Ingesting sodium in a sports drink also reduces fluid loss via the kidneys, an additional benefit to hydration. It is recommended that a sports drink deliver at least 70 mg of sodium per 8-oz serving (18 mmol/L) to provide sufficient osmotic impact to benefit hydration. Therefore, the presence of optimal amount of sodium and carbohydrate in Gatorade provides a dual effect in lowering the heart rate. The current study does not provide clarification of the mechanisms. Similar studies have identified sports drinks such as Gatorade to be more appropriate for exercise as they produce more muscle for greater endurance [10]. However, few studies have been concerned with carbohydrate electrolyte drink ingestion during rest period and recovery. In laboratory studies, few studies have been able to postpone exhaustion after a specific protocol by supplying glucose solution orally [8, 9, 33]. In field studies, it has been reported that there are beneficial effects of carbohydrate electrolyte drink ingestion on exercise performance by sparing muscle glycogen [22, 24]. We did not quantify serum protein in our study. The value of adding protein to a sports drink is another issue where the existing science is inconclusive. There are always scientific studies on both sides of any issue, so it is important to keep in mind that an accurate scientific conclusion is not developed simply by counting the number of studies on either side of the fence.

Arriving at an accurate conclusion requires careful examination of the quality and the quantity of research in a particular area. In the case of protein, the vast majority of the best quality studies show no performance benefit when protein is ingested during exercise [28]. The results should be interpreted with caution, since there was "no feasible scientific rationale" that could explain their findings.

CONCLUSION

In conclusion, the ingestion of a commercially available Gatorade drink 20 minutes prior to the onset of exercise improves run time to exhaustion, possibly as a result of maintaining blood glucose concentration and increasing available energy to the working muscles. Gatorade is formulated to provide everything in a correct amount which is important for an athlete's body during exercise – and nothing more.

PRACTICAL APPLICATION

Ingestion of pre exercise carbohydrate drink (Gatorade) is one of the effective ways to prevent dehydration, delay fatigue and enhance performance to help keep athletes safe and performing at their best.

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