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THE EFFECTS OF OXYGENATED WATER ON EXERCISE PHYSIOLOGY DURING INCREMENTAL EXERCISE AND RECOVERY

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ABSTRACT

THE EFFECTS OF OXYGENATED WATER ON EXERCISE PHYSIOLOGY DURING INCREMENTAL EXERCISE AND RECOVERY. **Nancy Willmert, John P. Porcari, Carl Foster, Scott Doberstein, Glenn Brice. JEPonline.** 2002;5(4):16-21. The breathing of supplemental oxygen has been used as a potential ergogenic aid for many years. Recently, consumption of water that is purported to contain 7-10 times the normal amount of oxygen ("super oxygenated" water) has been marketed with claims that it can enhance both exercise performance and recovery between bouts of exercise. The purpose of this study was to refute/substantiate those claims. Twelve college-aged volunteers (6 male, 6 female) completed two, sequential maximal exercise tests using a modified Bruce protocol, on two separate days. Fifteen minutes before exercise, subjects' randomly consumed 500 mL of either super oxygenated water or bottled water. Variables measured included resting, sub maximal, and maximal heart rate, blood pressure, ratings of perceived exertion, and blood lactate. There were no significant differences between conditions for any of the variables at rest or during exercise. Data collected during the second test in the sequence were done to assess recovery. There were no differences between conditions for any of the variables measured during this test. The results suggest that the consumption of oxygenated water has no effect on incremental exercise to VO_2max or on recovery from strenuous exercise.

Key Words: Ergogenic Aid, Breathing, Supplemental Oxygen

INTRODUCTION

The breathing of supplemental oxygen during exercise results in increased arterial oxygen content, decreased pulmonary ventilation, lower submaximal heart rate and blood lactate values, and increased maximal oxygen consumption (1-4,6,10-12). However, in order to be of benefit, the oxygen must be breathed *during* exercise. Studies investigating the breathing of supplemental oxygen before or after exercise have generally shown it to be of little or no benefit (5,9,13). Breathing supplemental oxygen during exercise is obviously not practical outside of a laboratory setting and would certainly pose ethical issues during competition.

In the past several years, a number of oxygenated water beverages have appeared on the market. These so-called "super oxygenated" waters are advertised to contain 7-10 times more O_2 than normal tap water. The higher concentration of O_2 in these drinks purportedly leads to increased oxygen absorbed by the body, resulting in benefits similar to those seen when breathing hyperoxic gas mixtures.

At the present time, only two studies have been conducted investigating the effects of consuming oxygenated water on performance. An unpublished study conducted in 1997 at Texas Women's University (3) found that after drinking oxygenated water, subjects ran a 5 km time trial an average of 15 s faster compared to drinking regular bottled water. The moderately trained subjects in that study ($VO_2max>54$ ml/kg/min) had a 31 s decrease in 5 km time. A more recent study conducted by Jenkins and colleagues (7) investigated the effects of oxygenated water on percentage of hemoglobin-oxygen saturation (SaO_2) and exercise performance during cycle ergometry. They found significant differences in SaO_2 values between the oxygenated water and bottled water conditions (91.3% vs. 87.3%), but found no corresponding improvements in endurance performance. Similar to Duncan (3), however, when the subject pool was subdivided by fitness level, subjects with a higher VO_2max (>47 ml/kg/min) exercised 28 s longer and had higher SaO_2 values at the end of the maximal exercise test after consuming oxygenated water.

Since the above studies suggest the possibility of improved performance or an increased oxygen carrying capacity of the blood following the consumption of oxygenated water, additional research is warranted. Neither study measured blood lactate concentrations or studied recovery from exercise, which are additional markers of increased blood oxygenation. The purpose of this study was to compare the effects of super oxygenated water vs. regular tap water on heart rate (HR), blood pressure (BP), and blood lactate (bLa^-) responses to exercise, maximal aerobic capacity (VO_2max), as well as these parameters measured during recovery from intense exercise.

METHODS

Subjects

Twelve college-aged individuals (6 males and 6 females) volunteered to serve as subjects in the current study. All subjects were physically active and free from any injury or illness that would preclude them from participating in the study. Prior to undergoing any testing procedures, each subject provided informed consent. The research protocol had been previously approved by the Institutional Review Board for the Protection of Human Subjects.

Procedures

The study was conducted using a double-blind, cross-over design. The subject pool was randomly separated into two groups with 6 subjects in each group. The groups were then randomly assigned to drink either 500 mL of super oxygenated water (AquaRush, Couer d'Alene, ID) or regular tap water. They then sat quietly in a chair for 5 min while HR, BP, bLa^-, and VO_2 were measured. An incremental test was then performed on a treadmill using the modified Bruce protocol. The modified Bruce protocol included an initial stage of 1.7 mi/hr with a 0% grade. At the end of each stage and at maximal exertion HR, BP, VO_2, and ratings of perceived exertion (RPE) were recorded. Blood lactate was measured during the second min of the first stage. After the subject reached volitional exhaustion, the treadmill was immediately returned to the initial stage (1.7 mph, 0% grade) and the subjects completed a second maximal test using identical procedures. After completion of the second maximal test, bLa^- was measured 2 min into recovery. After one week, subjects returned to the laboratory and completed the same protocol using the opposite condition.

Instrumentation

VO_2 was measured using open circuit spirometry, BP was measured in the left arm by auscultation, and HR was recorded using radio-telemetry. The Borg scale (range: 6-20) was used to determine RPE values. Blood lactate was measured using a Yellow Springs Instruments lactate analyzer on capillary blood samples obtained from a fingertip.

Statistical Analyses

Demographic data were summarized using standard descriptive statistics. Differences between conditions and stages of the test were evaluated using repeated measures ANOVA. Statistical significance was accepted at an alpha of $p<0.05$. Data are presented as mean±SD.

RESULTS

The descriptive characteristics of the twelve subjects who participated in the study are presented in Table 1.

Table 1. Descriptive characteristics of the subjects (N=12).

	Age (yrs)	*Height (cm)*	*Weight (kg)*
Males (n=6)	20.6±3.4	183.8±6.86	77.8±5.59
Females (n=6)	21.4±2.9	168.9±5.33	60.2±9.50

HR, SBP, DBP, RPE, VO_2, and bLa^- were measured at various time points throughout each session. Because all subjects completed at least three sub maximal stages, data are presented for resting values, stages 1-3, and maximal exercise. Data for HR, SBP, and DBP are presented in Table 2. Data for RPE, VO_2, and bLa^- are presented in Table 3. The times to reach exhaustion for the tap water and super oxygenated water conditions were 15.80±1.53 min and 16.00±1.54 min for the first test in the sequence and 14.70±1.97 min and 14.90±2.02 min for the second test in the sequence, respectively. There were no significant differences ($p>0.05$) between conditions for any of the variables at any of the time points measured.

Table 2. Mean data for heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) between the tap water (placebo) and super oxygenated water (treatment) conditions.

	HR		*SBP*		*DBP*	
Condition	Placebo	Treatment	Placebo	Treatment	Placebo	Treatment
Rest	70±14.1	66±10.2	116±9.7	112±11.1	62±13.5	64±64.13
Stage 1	85±13.8	85±12.6	126±16.4	123±13.8	63±12.4	67±11.8
Stage 2	102±13.7	100±12.1	133±18.0	130±17.2	58±10.8	63±12.2
Stage 3	120±15.3	120±13.5	146±16.1	142±16.8	55±7.7	56±10.7
Max	184±11.4	182±12.2				
Stage 1	121±15.8	125±16.1	170±15.3	167±14.8	53±10.2	56±10.7
Stage 2	121±12.0	125±15.6	142±19.5	149±17.8	55±11.6	55±10.9
Stage 3	136±14.2	140±16.5	139±17.1	137±13.2	49±8.4	49±6.9
Max	181±10.8	182±11.7				
Recovery	131±14.9	134±17.1	167±17.7	167±17.3	53±8.8	53±11.0

*SBP and DBP were not measured at maximal exertion due to the difficulty in getting accurate measurements

The water used in the current study (Aquarush) was advertised to contain ten times more oxygen than tap water. The Aquatic Toxicology Laboratory at the University of Wisconsin – La Crosse tested three separate bottles of Aquarush and three samples of tap water to determine oxygen content. The Aquarush had an average of 13.5 mL O_2/L and the tap water had an average of 4.8 ml O_2/L. Thus, the Aquarush used in the current study only had approximately three times as much oxygen as tap water.

Table 3. Mean data for ratings of perceived exertion (RPE), oxygen consumption (VO_2), and blood lactate (bLa^-) between the tap water (placebo) and super oxygenated water (treatment) conditions.

	RPE		VO_2		Lactate	
Condition	Placebo	Treatment	Placebo	Treatment	Placebo	Treatment
Rest			5.7±1.0	5.5±1.3	2.9±0.7	2.8±1.0
Stage 1	6.8±1.0	7.0±0.9	10.5±1.6	10.8±2. 6	2.7±0.7	2.7±0.8
Stage 2	8.3±1.1	8.1±1.2	16.4±2.0	17.0±2.1		
Stage 3	10.9±1.3	10.3±1.4	23.5±2.6	24.2±2.2		
Max	17.5±1.2	17.3±0.9	48.8±8.0	48.6±6.9	11.5±4.0	12.5±5.2
Stage 1	8.7±1.6	9.0±2.0	16.9±2.4	17.9±3.5		
Stage 2	10.0±1.4	10.4±2.0	20.1±1.9	21.0±2.8		
Stage 3	11.8±1.3	12.3±1.2	26.5±2.4	27.5±3.0		
Max	17.4±1.0	17.8±1.1	47.0±8.1	47.3±7.4	10.3±4.5	11.9±4.7
Recovery			21.3±5.3	20.7±4.4		

*Blood lactate was only assessed at rest, during stage 1 of the first test, and maximal levels of exercise for both tests.

DISCUSSION

This study found that the consumption of super oxygenated water had no effect on resting HR, BP, or bLa^-. Similarly, there was no effect on HR, BP, or bLa^- values during either sub maximal or maximal exercise. Nor was there any difference in time to exhaustion. The second maximal test was conducted immediately after the first test to investigate the effects of super oxygenated water on recovery. If additional oxygen had gotten into the blood and been delivered to the tissues, there should have been reductions in sub maximal exercise HR and bLa^-, and increases in VO_2max and exercise time on the second test. There were no differences between conditions. Apparently, the blood oxygenation levels were either not elevated or not elevated sufficiently to significantly effect oxygen delivery to the tissues or tissue metabolism.

The results of this study are in contrast to the findings of both Duncan (3) and Jenkins et al. (7), who found oxygenated water to have a beneficial effect on performance. Duncan found an improvement of 15 s in 5 km time trial for the overall group, and a 31 s improvement in highly fit subjects. Similarly, Jenkins et al. found that moderately fit subjects (VO_2max > 47/ml/kg/min) exercised 28 s longer on a maximal exercise test after consuming oxygenated water. The authors of the latter study suggested that the extra oxygen supplied by the water may have increased the oxygen saturation of hemoglobin (SaO_2), as blood SaO_2 can be compromised in certain moderate to highly fit subjects (2). Eight subjects in the present study had a VO_2max in excess of 47 ml/kg/min. Subgroup analysis found no significant benefit attributable to drinking oxygenated water in these subjects.

Several questions concerning the potential benefit of consuming oxygenated must be addressed. One question centers around the absorption of the oxygen in the water and whether or not it actually gets into arterial blood. Once consumed, the water is absorbed into the bloodstream across the intestinal epithelium. It is highly likely that the cells in the gut consume the extra oxygen. Even if the oxygen did get absorbed, it would be absorbed into venous blood, where it is on it's route back to the lungs for oxygenation, not to active muscle. As soon as that blood passes through the lungs the first time, the blood would either release the extra oxygen at the alveolar membrane, or more likely, not need to pick up as much oxygen in the lung in the process of attaining a typical blood partial pressure of oxygen.

The second major question concerns the small amount of oxygen actually in the water. Based upon our calculations, if AquaRush were to contain oxygen levels "ten times higher than the tap water you are drinking at home", one 500 ml bottle would contain approximately 24 mL of additional oxygen. At rest, if this amount of oxygen were to enter the system all at once (which it doesn't, since the water is absorbed over a period of time), it would provide about 10% of the bodies oxygen needs for one min. At maximal levels of exertion, the 24 mL of additional oxygen would provide less than 1% of the oxygen needed to exercise for one min. This in contrast to *breathing* 100% oxygen during exercise, whereby an additional 70 mL of oxygen is supplied to tissues every minute (8).

The amount of oxygen that is in oxygenated beverages in comparison to the manufacturer's claim also seems to be exaggerated. Our analysis found that the oxygenated water contained only three times as much oxygen as tap water (versus ten times as much, as claimed). This translates to only 6.7 mL of additional O_2 per one-half liter bottle. It is possible that some of the extra oxygen reportedly contained in the oxygenated beverage diffused out while the product was on the shelf, or the oxygen could have diffused out of solution when the bottle was opened. However, all three bottles were analyzed immediately after opening, and in a practical sense, the bottles would have to be opened before consumption. Another possibility is that there may be some other molecule in the water that binds additional oxygen, making it immeasurable by traditional methods. Since the mechanism by which the additional water is infused into the water is defined by the manufacturer, stating proprietary technology, this area remains speculative.

Conclusion

Based on the results of this study, there appears to be no evidence to support the claims that drinking super oxygenated water enhances performance or enhances recovery from exhaustive exercise. Additionally, manufacturer claims that these products contain 7-10 times more oxygen than tap water may be exaggerated.

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