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Relaxation Breathing Improves Human Glycemic Response

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Abstract

Objectives: This study evaluated a simple relaxation breathing exercise for acute improvement of postprandial glycemic and insulinemic status.
Design: Healthy human subjects were randomized to control breathing (CB; $n=13$) or a relaxation breathing exercise (RB; $n=13$) that was repeated every 10 minutes for the 30 minutes before and 90 minutes after consuming a glucose challenge (oral glucose tolerance test; OGTT; 75 g/240 mL). Blood samples were collected before, and 30, 60, and 90 minutes post OGTT for glucose and insulin analysis.
Results: Blood glucose at 0 minutes (pre-OGTT), and 30, 60, and 90 minutes post-OGTT with continued RB was 93.7 ± 1.9, 136.5 ± 8.1, 165.7 ± 8.1, and 130.2 ± 6.9 mg/dL, and 97.1 ± 2.4, 173.1 ± 8.4, 158.7 ± 11.1, and 137.1 ± 10.1 with CB, respectively. RB blood glucose was significantly lower at 30 minutes than CB. Glucose area under the curve (AUC) for CB and RB were not significantly different. Plasma insulin for both CB and RB was significantly increased relative to baseline at 30, 60, and 90 minutes. Insulin values for RB tended to be higher than CB at 30 and 60 minutes, although the difference was not statistically significant. Insulin AUC for CB and RB was not significantly different.
Conclusions: Relaxation breathing acutely improves the glycemic response of healthy subjects, and breathing pattern could be important for interpretation of glycemic index measurements.

Introduction

Yoga is an exercise regimen that generally includes a wide range of relaxation breathing exercises, ranging from varied breathing depth to alternate nostril breathing, which have the capability of altering human physiology. The practice of yoga includes physical activities, postures, and breathing patterns that may improve glycemic status in persons with type 2 diabetes.[1,2] Yogic pranayama breathing has been shown to reduce sympathetic nervous system output, increase parasympathetic output, reduce stress, and improve cardiovascular function.[3–5] Iyengar yoga has been suggested to improve mood and anxiety by increasing thalamic γ-aminobutyric acid levels.[6] Additionally, psychologic stress can alter gastrointestinal transit time and impair glucose handling.[7] Psychologic stress management regimens have also been shown to improve long-term glycemic control.[8] The varied components of yoga represent confounding variables that make evaluation of the effect of only the respiratory breathing pattern difficult to obtain and reproduce experimentally.

Glucose tolerance in humans is known to be impaired by hypoxia, and sleep apnea is a hypoxia condition that is highly correlated with type 2 diabetes.[9–11] Administration of hyperbaric oxygenation improves oxygenation and appears to improve glycemic status in those with type 2 diabetes.[12] While a 3-week intervention with meditation and relaxation breathing has been suggested to improve postprandial glycemic status,[13] the acute effects of relaxation breathing on postprandial glycemic response remain unclear. The present study sought to determine the effect of a simple and clinically reproducible relaxation breathing exercise on the glycemic and insulinemic response to an oral glucose tolerance test (OGTT; 75 g dextrose/240 mL) in healthy college-aged subjects.

Methods and Materials

Participants and study design

This study was approved by the Winona State University Human Subjects Committee with health exclusions including diabetes, smoking, asthma, or sleep apnea. Healthy subjects (21 female and 5 male; 20.1 ± 0.2 years old; and a body mass

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index of 22.8 ± 2.5**)** were randomized to two separate rooms (21°C) for control breathing (CB; no breathing intervention; $n = 13$) or relaxation breathing (RB; $n = 13$). The RB involved cycles of deep inhalations with slow exhalation durations that progressively lengthen on each succeeding inhalation from 1 second to 10 seconds, before returning to a 1-second exhalation period (Fig. 1). A RB exercise was developed and recorded that was played continuously as a self-repeating loop at 35 decibels starting every 10 minutes (http://www.youtube.com/watch?v=UEXEVnp5GFc). The intent of this RB was to create a simple respiratory exercise that could be exactly replicated by other investigators.

Following an overnight fast (9 hours) with exclusion of all food and beverages except water, subjects arrived at between 5:00 AM and 7:00 AM, then sat quietly in their assigned room for a 30-minute acclimation period of CB or RB repeated once every 10 minutes. After the 30-minute control period (and repeating the RB three times or undergoing no assigned breathing exercise), subjects consumed a commercial OGTT (Lemon-Lime Trutol 75, NERL Diagnostics, East Providence, RI; 75 g dextrose/240 mL) within 4 minutes. Blood was collected by finger prick just before OGTT administration (pre-OGTT was considered 0 minutes). Additional blood samples were collected 30, 60, and 90 minutes following OGTT consumption with continued RB every 10 minutes, or no breathing intervention (CB). Blood glucose was measured with Comfort-curve test strips and calibrated Accuchek analyzers (Roche Diagnostics Inc., Indianapolis, IN), and plasma insulin was measured by enzyme-linked immunosorbent assay (Alpco Diagnostics Inc., Salem, NH) as described previously.[14]

Data analysis

Values are reported as mean ± standard deviation. Following analysis of variance, a repeated-measures analysis

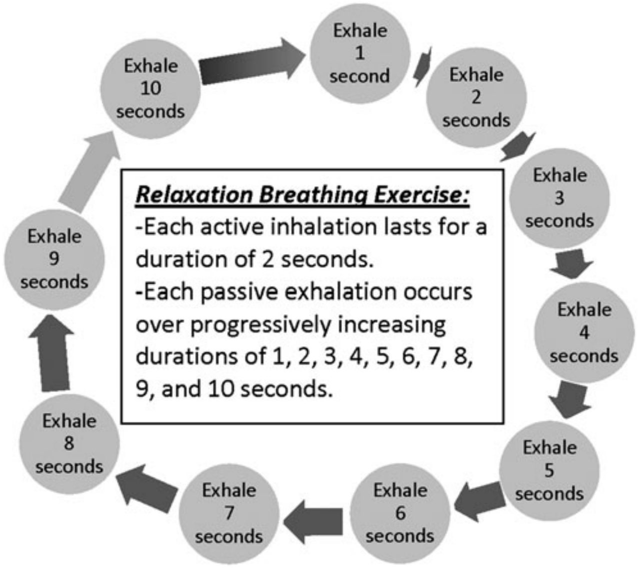

FIG. 1. Relaxation breathing pattern repeated every 10 minutes of study. Each arrow represents a slow deep inhalation lasting 2 seconds, followed by an expiration of the duration listed in the circle starting at 1 second and was increasing with each expiration until a 10-second expiration was reached.

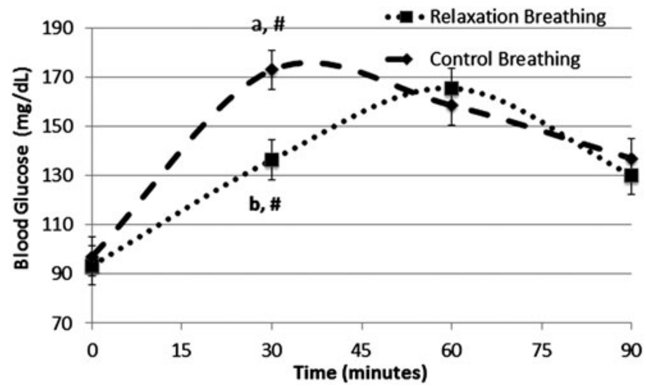

FIG. 2. Changes in blood glucose in response to an oral glucose tolerance test (75 g dextrose/240 mL). Relaxation breathing was associated with significantly lower blood glucose at 30 minutes than persons using control breathing.

was completed using SAS Version 9.0 to examine time and treatment as independent variables using repeated measures, least mean squares, and a Tukey adjustment for multiple comparisons. Area under the curve (AUC) values were calculated using the trapezoidal method and statistically analyzed using a Student's t-test. Statistical significance was assumed when $p < 0.05$.

Results

The RB exercise was found to be acceptable by all subjects, with no subjects stopping study participation because of respiratory pattern noncompliance. A total of 31 healthy college-aged subjects started the study; 3 subjects left the study because of nausea after consuming the OGTT beverage, and 2 left due to fainting during blood collection, with 26 persons completing the study. The glycemic response to RB is shifted down and to the right relative to CB (Fig. 2). The 30-minute postprandial glucose concentration (Table 1) of both treatment groups was significantly increased relative to baseline, but the peak blood glucose was significantly lower for those performing RB (136.5 ± 8.1 mg/dL) relative to CB (173.1 ± 8.4 mg/dL). Blood glucose for both RB and CB remained significantly elevated relative to baseline at 60 minutes, although the difference between RB and CB was no longer significant. Glucose AUC (Table 1) was slightly lower for RB than CB (12,717 ± 567 versus 13,832 ± 595 mg/dL-90 minutes), demonstrating a trend toward significance ($p = 0.091$). Plasma insulin was significantly increased following OGTT administration for both CB and RB relative to baseline at 30, 60, and 90 minutes, with the peak being reached at 60 minutes (Table 1). While insulin tended to be higher in the RB group, no statistically significant differences between the two treatment groups were observed, nor was the insulin AUC for CB and RB significantly different (Table 1).

Discussion

The practice of yoga in a general sense is often associated with intentional alteration of one's breathing pattern. However, there are many versions and interpretations of yoga; therefore, clinical assessment of breathing pattern on glycemic and insulinemic response to an OGTT is difficult. The

Table 1. Effect of Repeating a Relaxation Breathing Exercise Before and Immediately Following Administration of an Oral Glucose Tolerance Test (75 g Dextrose/240 mL) on the Glycemic and Insulinemic Response of Healthy Humans

Breathing	*0 minutes Glucose (mg/dL)*	*30 minutes Glucose (mg/dL)*	*60 minutes Glucose (mg/dL)*	*90 minutes Glucose (mg/dL)*	*Area under curve Glucose (mg/dL-90 min)*
Control	97.1 ± 2.4	173.1 ± 8.4[#,a]	158.7 ± 11.1[#]	137.1 ± 10.1[#]	13832 ± 595
Relaxation	93.5 ± 1.9	136.5 ± 8.1[#,b]	165.7 ± 9.6[#]	130.2 ± 6.9[#]	12718 ± 567
	Insulin (μIU/mL)	*Insulin (μIU/mL)*	*Insulin (μIU/mL)*	*Insulin (μIU/mL)*	*Insulin (μIU/mL-90 min)*
Control	7.5 ± 1.6	53.7 ± 11.5[#]	63.9 ± 18.4[#]	45.0 ± 9.3[#]	4855 ± 1187
Relaxation	8.4 ± 2.2	66.6 ± 12.2[#]	78.7 ± 17.0[#]	43.1 ± 8.9[#]	5481 ± 909

Data expressed as mean ± standard deviation.

Statistical significance: difference from baseline (0 minutes) indicated by #, differences between treatments at same time indicated by letters.

practice of yoga is associated with physical stretching, meditative, and other physical activities that could also influence response to an OGTT. The current study limited the effect of these confounding factors and created an experiment wherein respiratory pattern was the primary condition that was altered. The RB exercise limited the effect to just breathing pattern on human glycemic and insulinemic response to an OGTT.

RB before and during an OGTT was associated with an improved glycemic response. Blood glucose at 30 minutes for those practicing a RB exercise was 36.6 mg/dL lower than CB. In addition, the glucose AUC was lower with a trend toward significance ($p = 0.091$). In contrast, at 60 minutes, RB was associated with blood glucose that was slightly, and nonsignificantly higher than with CB. This observation may have been due to improved insulin sensitivity, increased insulin secretion, or delayed gastric emptying while performing RB. In the authors' previous glycemic and insulinemic response trial examining healthy college-aged populations, a smaller 140-calorie challenge resulted in a peak glucose within 30 minutes of consumption.[14] Other studies examining similarly aged healthy populations have been observed a 75-g OGTT response that was similar to the present study.[15–17] In the present study, RB was associated with a blunted appearance of the glycemic peak (60 minutes) in contrast to these prior studies where the blood glucose peak was in response to a 75-g OGTT at around 30 minutes. RB breathing could have caused these effects by slowing the rate of gastric emptying; however, to the authors' knowledge, there are no published reports that RB can alter gastric emptying time. Future studies may wish to examine this possibility more closely, especially in persons with known insulin resistance (i.e., type 2 diabetes).

RB-dependent improvements in glycemic response to the OGTT could have been more robust in a population whose arterial oxygenation is already known to be impaired. Hypoxia is induced by severe pneumonia, and hyperglycemia is used as a marker of pneumonia severity in nondiabetics.[18] Yoga breathing has been suggested to improve arterial oxygenation in persons with chronic obstructive pulmonary disease.[19] Given that the subjects in the current study were healthy, it is unlikely that this difference could have been statistically detected using finger-pulse oximetry without very large study population sizes; therefore, oximetry measurements were not attempted in our study regimen. Future studies of RB in populations known to experience hypoxia, such as those with chronic obstructive pulmonary disease or pneumonia, could provide a useful assessment of the potential benefits of RB.

Indexing foods to a standard glycemic index helps consumers choose foods with a more favorable glycemic response for improved nutritional health.[20] Clinical glycemic index (GI) reference values exist for nearly all foods, and these values are central to many nutrition counseling regimens, especially for those applied to persons with metabolic syndrome and diabetes. The present study suggests that subject breathing pattern at the time of food GI evaluation may influence the measurements used to calculate a food's GI value. Future GI measurement guidelines may wish to describe the use of a standardized breathing pattern.

Conclusions

RB exercises improve the glycemic response in healthy college-aged persons and could provide an inexpensive nonpharmacological way to improve postprandial glycemic control in a manner independent of exercise or other activities central to yoga. Establishment of a standardized breathing pattern during GI calculation could be clinically important for improving the accuracy of GI measurements. Persons with type 2 diabetes or chronic obstructive pulmonary disease may also benefit from RB.

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Disclosure Statement

No competing financial interests exist.

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