Relaxation Breathing Improves Human Glycemic Response

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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 before and after an oral glucose tolerance test (OGTT; 75g/240mL). Blood samples were collected before, and 30, 60 and 90 minutes post OGTT for glucose and insulin analysis.

Results: Blood glucose at 0 min (pre-OGTT), and 30, 60, and 90 min 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 min than CB. Glucose 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 improves the glycemic response of healthy subjects and breathing pattern could be important for interpretation of glycemic index measurements.
Relaxation Breathing Improves Human Glycemic Response

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Abstract

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Running Title: Relaxation Breathing and Glycemic Response

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 that have the capability of altering human physiology. The practice of yoga includes physical activities, postures, and breathing patterns that may improve glycemic status in type 2 diabetics.1,2 Yogic pranayama breathing has been shown to reduce sympathetic nervous systems output, increase parasympathetic output, reduced stress, and improved cardiovascular function.3-5 Lyengar yoga has been suggested to improve mood and anxiety by increasing thalamic GABA levels.5 Additionally, psychological stress can alter gastrointestinal transit time and impair glucose handling.7 Psychological 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, in fact, sleep apnea is a hypoxia condition that is highly correlated with type 2 diabetes. Administration of hyperbaric oxygenation improves oxygenation and appears to improve glycemic status in type 2 diabetics. While a three-week intervention with meditation and relaxation breathing has been suggested to improve post-prandial glycemic status, the acute effects of relation 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 insulineic response to an oral glucose tolerance test (OGTT; 75g dextrose/240mL) in healthy college-aged subjects.

Methods

Subjects 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 (female=21, male=5; age= 20.1 ± 0.2; BMI= 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 (Figure 1). A pre-recorded RB exercise played continuously as a self-repeating loop at 35 decibels starting every 10 minutes (http://www.youtube.com/watch?v=UEXEVnp5GFc). The intent of our RB was to create a simple respiratory exercise that could be exactly replicated by future investigators.

Following an overnight fast (nine hours) with exclusion of all food and beverages except water subjects arrived at between 5:00 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 oral glucose tolerance test (OGTT; Lemon-Lime Trutol 75, NERL Diagnostics, East Providence, R.I.; 75g dextrose/240mL) 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 ELISA (Alpco Diagnostics Inc. Salem, N.H.) as described previously.

Data analysis

Values are reported as mean ± standard deviation. Following ANOVA and a repeated measures analysis 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. AUC values were calculated using the trapezoidal method and statistically analyzed using a Students 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 non-compliance. Of 31 healthy college-aged subjects who started the study, 26 subjects completed the study with three leaving for reasons of nausea after consuming the OGTT beverage and two leaving due to fainting during blood collection. The glycemic response to RB is shifted down and to the right relative to CB (Figure 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 vs 13,832 ± 595 mg/dL-90 min), demonstrating a trend towards 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 associated with an altered 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 practice of yoga is associated with physical stretching, meditative, and other physical activities that could also influence response to an OGTT. We limited the effect of these confounding factors and created an experiment wherein only respiratory pattern was altered. Our RB exercise limited the effect to just breathing pattern on human glycemic and insulinemic response to an OGTT.

Relaxation breathing 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 towards significance (P=0.091). In contrast at 60 minutes, RB was associated with a blood glucose that was slightly, and non-significantly higher than CB. This observation may have been due to improved insulin sensitivity, increased insulin secretion or delayed gastric emptying while performing RB. In our 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. Other studies examining similarly aged healthy populations have been observed a 75 g OGTT response that was similar to the present study. 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 in response to a 75 gram OGTT at around 30 minutes. Relaxation breathing could have caused these effects by slowing the rate of gastric emptying, however to our
Relaxation breathing dependent improvements in glycemic response to the OGTT might 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 non-diabetics.\(^{18}\) Yoga breathing has been suggested to improve arterial oxygenation in persons with chronic obstructive pulmonary disease.\(^{19}\) Given that our subjects were healthy volunteers 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

Relaxation breathing exercises improve the glycemic response in healthy college-aged persons and could provide an inexpensive non-pharmacological 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.

References


Figures and Tables

Figure 1. Relaxation breathing pattern repeated every 10 minutes of study. Each arrow represents a slow deep inspiration 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.

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

Table 1. Effect of repeating a relaxation breathing exercise before and following administration of an oral glucose tolerance test (75g dextrose/240mL) on the glycemic and insulinemic response of healthy humans.
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<table>
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<th>Breathing</th>
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<th>60-minutes</th>
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<td>Glucose (mg/dL)</td>
<td>Glucose (mg/dL)</td>
<td>Glucose (mg/dL)</td>
<td>Glucose (mg/dL-90min)</td>
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<td>Insulin (µIU/mL)</td>
<td>Insulin (µIU/mL)</td>
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<td>78.7 ± 17.0#</td>
<td>43.1 ± 8.9#</td>
<td>5481 ± 909</td>
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</table>

Data expressed as mean ± standard deviation.
Statistical Significance: difference from baseline (0-min) indicated by #, differences between treatments at same time indicated by differing letters.
Relaxation breathing pattern repeated every 10 minutes of study. Each arrow represents a slow deep inspiration 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.

215x279mm (200 x 200 DPI)
Changes in blood glucose in response to an oral glucose tolerance test (75g dextrose/240mL). Relaxation breathing was associated with significantly lower blood glucose at 30 minutes than persons using control breathing.

215x279mm (200 x 200 DPI)