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BRIEF COMMUNICATION

Increased Maximal Expiratory Pressure, Abdominal and Thoracic Respiratory Expansibility in Healthy Yoga Practitioners Compared to Healthy Sedentary Individuals

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Abstract

Background: Increasing thoracic expansion is effective at reducing blood pressure in hypertensive subjects. Yoga prescribes many respiratory techniques with a growing number of practitioners. However, very little is known whether sedentary or yoga practitioners show measurable differences in their respiratory patterns.

Objective: This study aims to demonstrate differences between healthy sedentary individuals and healthy yoga practitioners regarding maximal respiratory pressures and thoracic and abdominal respiratory expansibility.

Methods: Maximal inspiratory and expiratory pressures (MIP and MEP, respectively) were evaluated by manovacuometry, while respiratory expansion was assessed by the cirtometry of abdominal (CA), thoracic xiphoidal (CTX), and thoracic axillary (CTA) circumferences at rest (end expiratory moment) and at full inspiration in healthy sedentary individuals (SED) and yoga practitioners (YOGA). A *delta* derived from rest and full inspiration measures (ΔCA, ΔCTX, and ΔCTA, respectively), followed by a percentage of each item (ΔCA/CA, ΔCTX/CTX, and ΔCTA/CTA) was then calculated**.** Groups were compared by means of an unpaired Student's t-test, with a significance level $p < 0.05$.

Results: All respiratory expansion measures were significantly higher in in the YOGA group. A significantly higher MEP (cmH_2O) was also detected in yoga practitioners: SED 89.3 ± 19.3 and YOGA 114.7 ± 24.8 ($p = 0.007$), along with decreased heart rate at rest (bpm): SED 84±6 and YOGA 74±15 ($p = 0.001$).

Conclusions: Yoga practitioners have shown greater thoracic and abdominal expansion and increased MEP, when compared to healthy sedentary individuals, as well as significantly lower heart rates at rest and body mass index (BMI). However, whether or not these findings are related to respiratory patterns is uncertain.

Keywords: Yoga; Breathing Exercises; Sedentarism; Maximal Respiratory Pressures; Heart Rate; Blood Pressure.

Background

Respiratory exercises have proven to be an effective non-pharmacologic intervention for the treatment and prevention of hypertension[1] and psychological states, such as anxiety and depression.[2] However, not much has been demonstrated concerning respiratory patterns that could be considered critical parameters for health issues.

Most respiratory evaluations are related to pulmonary function (spirometry) or respiratory muscle strength (maximal inspiratory and expiratory pressure) and made by means of a mouth device that could interfere with most people's natural breathing.[3] Abdominal cavity and rib cage movements involved in respiration have the potential to be evaluated (piezoelectric belts), but

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there is no scientific consensus as to acceptable values, on the variation of respiratory movements at rest and in an orthostatic position, or in differences between healthy individuals and those presenting pathologies or comorbidities.

Rib cage expansion assessed by cirtometry has been used to evaluate responses to a one-month respiratory exercise program involving hypertensive subjects and has demonstrated not only enhanced thoracic expansion, but also lower blood pressure and increased heart rate variability, a reliable index of vagal modulation.[4]

Yoga is an ancient philosophy based on physical and non-physical techniques to reach an elevated state of consciousness. Among the physical components, respiratory exercises, or *pranayamas*, are known to influence both physiological and psychological states, and are widely practiced by its adherents.[5]

Therefore, the aim of this study was to investigate whether differences in abdominal and rib cage expansion and maximal inspiratory and expiratory pressures could be found between yoga practitioners and healthy sedentary individuals.

Methods

Study Design

A cross sectional study approved by the local ethics committee (UP 4802/12) took place at the Clinical Investigation Laboratory of Instituto de Cardiologia do Rio Grande do Sul, in Porto Alegre, Brazil, from July to October 2014. Healthy yoga practitioners, constituting the Yoga group (YOGA), and healthy sedentary individuals, constituting the Sedentary group (SED), were recruited from the social media network. They were to be between 20 and 47 years of age, non-smokers, and non-obese (BMI ≤ 29.9). Additionally, they were to have practiced yoga at least twice a week for at least one year (YOGA) or not engaged in any form of exercise at all (SED). If they met the inclusion/exclusion criteria, they were sent information on the study and invited to participate. All participants signed an informed consent and were assessed between 2:00pm and 4:00pm on weekdays.

Evaluations and Measurements

Systolic and diastolic blood pressure (SBP and DBP, respectively) and resting heart rate (HR) were assessed in accordance with Brazilian Hypertension Guidelines (OMROM Automatic Blood Pressure Monitor Model HEM-711).

Respiratory rates were assessed by three consecutive measures at rest in the supine position, using the visual method. The mean of three values was considered for analysis. Maximal inspiratory and expiratory pressure (MIP and MEP, respectively), as performed by manovacuometry (Globalmed MDI Model MVD 300) with five measurements of each variable and then taking the mean of the values, was also considered for analysis.

Based on the method applied by Pinheiro, et al.[4], measurements of circumferences at rest, including respiratory maneuvers, were used to detect respiratory expansion at three different levels of the abdomen and thorax. Abdominal expansion was taken at the mean distance between the iliac crest and the last rib, and thoracic expansion was measured in the xiphoidal process and at the axillary level. Measurements were taken in the orthostatic position after full exhalation and at maximal inspiratory retention. Three consecutive measures have been taken and the mean of these has been considered for analysis. A delta was derived from the resting and full inspiration measurements (ΔCA, ΔCTX, and ΔCTA, respectively) to standardize measurements as a percentage of expansion, and a percentage of each item (ΔCA/CA, ΔCTX/CTX, and ΔCTA/CTA) was then calculated.

All measurements were taken by the same trained investigator.

Statistical Analysis

As a novel approach to investigative study, this study has gathered a convenience sample of subjects. Collected data have been processed by the SPSS 25.0 for Windows. Normality of data have been tested by the Kolmogorov–Smirnov test, and all variables fulfilled normality criteria. Groups were compared by means of an unpaired Student´s t-test. Data are presented as the mean (M) ± standard deviation (SD) for a significance level of $p < 0.05$.

Results

Twenty-six individuals were enrolled in YOGA (n = 15) and SED (n=11). No significant differences were observed between the two groups in terms of age, systolic and diastolic pressure, and respiratory rate. However, the BMI was significantly lower in YOGA than SED: 22.5 ± 2.0

versus 25.3 ± 2.2 (p = 0.031). The waist-height ratio proved to be higher in SED than in YOGA (0.5 ± 0.05 versus 0.4 ± 0.03 p = 0.004). The resting heart rate was lower in YOGA than in SED (74±15 beats per minute versus 84±6 beats per minute, p = 0.031). No significant differences were found in respiratory variables between the groups for MIP, but YOGA presented a significantly higher MEP than in SED: 114.7 ± 24.8 cmH_2O versus 89.3 ± 19.3 cmH_2O (p = 0.009). All values for abdominal and thoracic expansion were significantly higher in YOGA than in SED. Results are summarized in Table 1.

Discussion

This study demonstrated that the MEP was significantly higher in YOGA than in SED, although there were no differences in the MIP and respiratory rate between the two groups, which is in accordance to another study that showed no changes in respiratory rates among healthy individuals after eleven months of yoga.[6]

The main finding of this study was that all respiratory movements of the abdominal cavity and rib cage assessed by cirtometry were significantly greater in YOGA than in SED. This calls attention to the fact that the inspiratory abdominal values of the SED group were lower than at rest, suggesting a squeezing displacement of the abdominal cavity to attend inspiratory demands. Electromyographic analysis demonstrated greater demands of the abdominal muscles during respiration in the orthostatic position, when compared to the supine position, which suggests that this "maneuver" of squeezing the abdominal cavity as a synergistic action of these muscle and diaphragm is supposed to happen in healthy individuals.[7] The respiratory muscle pump for venous return is well described in the literature,[8] which could be related to the lower resting heart rate found in

Table 1 – Characterization of participants

	SED (n=11)	YOGA (n=15)	p
Age (years)	33.2 ± 8.7	36.8 ± 7.4	0.315
SBP (mmHg)	117.8 ± 7.7	113.1 ±7.4	0.185
DBP (mmHg)	75.3 ± 8.9	72.3 ±5.5	0.297
HR (bpm)	84 ± 6	74 ± 15	0,031*
RR (cpm)	11.9 ± 6.5	11.0 ± 3.9	0.658
BMI (kg/m^2)	25.3 ± 2.2	22.5 ± 2.0	0.031*
W-H ratio	0.5 ± 0.05	0.44 ± 0.03	0.004*
Δ CA (cm)	-0.67 ± 1.4	1.3 ± 1.8	0.007*
ΔCA/CA	-0.09 ± 0.02	0.02 ± 0.03	0.008*
ΔCTX (cm)	1.3 ± 1.1	4.0 ± 1.7	0.002*
ΔCTX/ CTX	0.02 ± 0.01	0.06 ± 0.04	0.002*
ΔCTA (cm)	2.08 ± 1.08	3.23 ± 1.74	0.028*
ΔCTA/CTA	0.02 ± 0.01	0.04 ± 0.01	0.012*
MIP (cmH_2O)	78.3 ± 18.8	91.2 ± 29.9	0.161
MEP (cmH_2O)	89.3 ± 19.3	114.7 ± 24.8	0.009*

SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, HR: Heart rate at rest, bpm: beats per minute, RR: Respiratory rate at rest, cpm: cycles per minute, BMI: Body Mass index, W-H ratio: Waist-Height ratio, Δ CA: Delta value from rest and full inspiration measures for abdominal circumference ΔCA/CA percentage value of expansion of abdominal circumference, ΔCTX: Delta value from rest and full inspiration measures for xiphoidal circumference, ΔCTX/ CTX: percentage value of expansion of xiphoidal circumference, ΔCTA: Delta value from rest and full inspiration measures for axillary level thoracic circumference, ΔCTA/CTA: percentage value of expansion of axillary level thoracic circumference, MIP: Maximal Inspiratory pressure, MEP: Maximal expiratory pressure.

** Significant differences between groups after Student´s t-test ($p < 0.05$)*

YOGA as compared to SED.[9] To what extend HR can be modified by yoga respiratory techniques warrants further investigation.

No differences between the groups was detected in SBP or DBP. Nevertheless, the waist-height ratio, as a marker of abdominal fat and cardiovascular risk[10] and BMI, were significantly lower in YOGA. Whether or not these differences have been determining factors for differences found in other outcomes demands further elucidation, and whether or not these findings are related to respiratory pattern is still uncertain.

Furthermore, it is unclear whether the cirtometry of respiratory movements may be considered an accurate method to analyze breathing patterns and contribute to the early detection of improper respiratory patterns. Hence, more studies are needed to explain the effects of yoga and its respiratory exercises on healthy individuals.

As a limitation, this study has not tested the reproducibility and reliability of cirtometry evaluations.

Conclusion

MEP, abdominal and thoracic expansion were significantly enhanced in yoga practitioners as compared to sedentary individuals. The resting heart rate and BMI were also significantly lower in the former group. As no significant differences were detected in the respiratory rate, it is plausible to question whether or not the respiratory pattern rather than the respiratory rate may be modified by yoga.

Author contributions

Literature search: Fetter C, Souza LA and Schein A. Conception and design of the research: Fetter C, Dartora DR, Casali K and Irigoyen MC. Acquisition of data: Fetter C, Souza LA, Schein A and Casali K. Analysis and interpretation of the data: Fetter C, Dartora DR and Eibel B. Writing of the manuscript: Fetter C, Eibel B and Souza LA. Critical revision of the manuscript for intellectual content: Dartora DR, Casali K and Irigoyen MC.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Ethics approval and consent to participate

This study was approved by the Ethics Committee of the IC/FUC under the protocol number 4802/12. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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