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# Ventilatory function in female practitioners of Hatha Yoga

## *Função ventilatória em mulheres praticantes de Hatha Ioga*

Cristina Martins Coelho [1]
Thaíza Tavares Lessa [2]
Lúcia Aparecida Martins Campos Coelho [3]
Rafael da Silva Scari [4]
José Marques Novo Júnior [1]
Rosa Maria de Carvalho [2]

**Abstract –** Yoga is an ancient philosophic system that originated in India and whose main objective is the development of the union of mind and body through exercise, respiration and meditation. The objective of this study was to assess the effects of regular practice of Hatha Yoga on the respiratory function of healthy women. A controlled cross-sectional study was conducted on 25 female volunteers divided into two groups: Yoga (n=13) and control (n=12). The volunteers of the Yoga group had practiced Hatha Yoga for at least 6 months. The respiratory rate was counted over one minute. Maximal inspiratory and expiratory pressures were assessed with a manovacuometer. Axillary and xiphoid mobilities were assessed by cyrtometry. Chest wall mobility at the axillary and xiphoid levels was measured by cyrtometry. Forced vital capacity and peak expiratory flow were assessed by spirometry. Significant differences between groups were only observed for respiratory rate and xiphoid mobility. In conclusion, regular practice of Hatha Yoga had a positive impact on respiratory rate and xiphoid mobility in the population studied.
**Key words:** Motor activity; Respiratory function tests; Vital Capacity; Yoga.

**Resumo –** *A Ioga é um sistema filosófico milenar originário da Índia, cujo objetivo principal é o desenvolvimento da união entre corpo e mente, através de exercícios, respiração e meditação, visando o bem-estar físico e mental. O estudo teve como objetivo avaliar os efeitos da prática regular de Hatha Ioga sobre a função ventilatória de mulheres saudáveis. Estudo transversal controlado, no qual participaram 25 mulheres, sendo os grupos IOGA e controle, compostos por 13 e 12 voluntárias, respectivamente. As voluntárias do grupo IOGA praticavam Hatha Ioga há pelo menos seis meses. A frequência respiratória foi avaliada através da contagem em um minuto; as pressões inspiratórias e expiratórias máximas foram avaliadas através da manovacuometria; as mobilidades torácicas axilar e xifóidea através da cirtometria; a capacidade vital forçada e o pico de fluxo expiratório através da espirometria. Foram encontradas diferenças significativas entre os grupos apenas com relação à frequência respiratória e mobilidade xifóidea. Pode-se concluir que a prática regular de Hatha Ioga mostrou-se capaz de influenciar positivamente a frequência respiratória e a mobilidade xifóidea.*
**Palavras-chave:** *Atividade Motora; Capacidade Vital; Ioga; Testes de Função Respiratória.*

1. Universidade Federal de Juiz de Fora. Faculdade de Educação Física e Desportos. Juiz de Fora. MG, Brasil.

2. Universidade Federal de Juiz de Fora. Faculdade de Fisioterapia. Juiz de Fora. MG, Brasil.

3. Prefeitura de Juiz de Fora. Professora de Educação Física. Juiz de Fora. MG, Brasil.

4. Marinha do Brasil. Fisioterapeuta. Rio de Janeiro. RJ, Brasil.

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## INTRODUCTION

Yoga is an ancient philosophic system that originated in India whose main objective is the development of the union of mind and body through exercise, respiration and meditation in order to achieve physical and mental well-being[1,2]. The most popular branch of yoga in the West is Hatha Yoga, which consists of a combination of postural exercises ("asanas"), relaxation, and voluntary control of breathing ("pranayamas")[2].

In the West, Hatha Yoga has gained popularity as an alternative form of physical activity since it offers a different experience when compared to traditional aerobics and strength training and is less strenuous and more enjoyable[3], characteristics that increase the compliance of participants[4]. In a literature review, yoga programs were found to be effective in reducing weight, blood pressure, blood glucose and cholesterol levels[5].

Breathing receives special attention during yoga exercises and several studies have investigated the effects of yoga on the respiratory system[2,6]. However, the results of these studies are controversial. In addition, most studies on yoga are performed in eastern countries, a fact impairing the extrapolation of the results to western populations[7].

Finally, although therapeutic applications are not the main objective of yoga, the physiological benefits of this modality have raised the interest in its use as adjuvant and nonpharmacological treatment for different clinical conditions, particularly respiratory diseases such as bronchial asthma[8]. Therefore, we believe that the study of the effects of regular practice of yoga on the respiratory system is important to better understand its effects on healthy individuals and to provide the basis for the possible use of yoga techniques as alternative therapy. In this respect, the present study evaluated the effects of regular practice of Hatha Yoga on respiratory rate, chest wall mobility, forced vital capacity (FVC), peak expiratory flow (PEF), and respiratory muscle strength in healthy women participating in the Physical Activity and Quality of Life Program offered by the Town Hall of Juiz de Fora, Minas Gerais, Brazil.

## METHODOLOGICAL PROCEDURES

A controlled cross-sectional study was conducted on 25 healthy non-obese (body mass index [BMI] $< 30$ kg/m$^2$, group mean: $24.5 \pm 2.5$ kg/m$^2$) women without a clinical diagnosis of cardiovascular, respiratory or musculoskeletal diseases that could prevent the participation in any type of physical activity. The mean age of the participants was $42.4 \pm 9.6$ years. The sample was divided into two groups. The yoga group consisted of 13 Hatha Yoga practitioners who had been participating in the Physical Activity and Quality of Life Program offered by the Town Hall of Juiz de Fora, Minas Gerais, for at least 6 months and who had not been engaged in any other type of regular physical activity during this period. The yoga classes consisting of asanas, pranayamas and meditation had a duration of one hour and were conducted twice a week. The control group consisted of 12 sedentary volunteers, employees of the Town Hall of Juiz de Fora, who reported no regular physical activity during the 6 months prior to data collection.

The study was approved by the Ethics Committee of Universidade Federal de Juiz de Fora (process 180/2008), and all volunteers signed the free informed consent form. The assessments were performed in the Multimedia room of the Railroad Museum of Juiz de Fora, where the yoga classes took place. Two volunteers of the control group were evaluated at the Centro de Atenção à Saúde, Hospital Universitário, Universidade Federal de Juiz de Fora.

First, anthropometric characteristics (body weight, height and BMI) were evaluated using an anthropometric scale available at the place of assessment (Filizola®, São Paulo, Brazil). The resting respiratory rate was determined by the quantification of chest and abdominal movements over one minute[9], with the subject sitting and being unaware of this evaluation.

Chest wall mobility was evaluated as described by Kakizaki et al.[10]. For this purpose, an anthropometric tape was used to measure the diameter of the thorax at the axillary and xiphoid levels during maximum inspiration and expiration. The volunteers were evaluated in dorsal decubitus, with triple flexion of the lower limbs. Chest wall mobility at the axillary and xiphoid levels was defined as the difference in diameter between maximum inspiration and expiration at the respective site. The highest value of three measurements was considered for analysis.

FVC and PEF were evaluated by simple spirometry. The volunteer was asked to expire as rapidly and intensely as possible after a maximum inspiration through a mouthpiece connected to a portable microcomputer equipped with the Pulmowin spirometry software (version 2.30E; DTLI Datalink

Instruments, Grabels, France). The volunteers were evaluated in the sitting position using a nose clip to prevent the leakage of air through the nostrils. The spirometry maneuvers were taught individually. The tests were repeated three times, with a difference of no more than 10% between the two best maneuvers. The highest values of FVC and PEF were considered for analysis[11] and are expressed as percentage of predicted.

Maximum static inspiratory and expiratory pressures were evaluated according to the protocol of Black and Hyatt[12]. An aneroid manometer (Ger-Ar, São Paulo, Brazil) with an operating range of ± 150 $cmH_2O$, connected to a plastic circuit ending in a mouthpiece, was used. A nose clip was used to prevent the leakage of air through the nostrils. The maneuvers were taught individually. In the sitting position, the volunteers were asked to perform a maximum inspiratory effort after complete expiration. Maximum inspiratory pressure (PImax) is defined as the highest negative pressure that could be achieved and maintained for at least one second. Next, the volunteers were asked to perform a maximum expiratory effort after maximum inspiration. Maximum expiratory pressure (PEmax) is defined as the highest positive pressure that could be achieved and maintained for at least one second. Three maneuvers were performed, with a difference of no more than 10% between the two highest values. The highest PImax and PEmax values were considered for analysis[13]. The results are expressed as percentage of predicted for gender and age using the predictive equations of Neder et al.[14] as a reference.

The results are expressed as the mean and standard deviation. The Shapiro-Wilk test was used to determine whether the data showed a normal distribution. Comparisons between the yoga and control groups were performed by the independent Student t-test, with the level of significance set at 5% ($p \leq 0.05$). The Statistica 8.0 program (StatSoft, Inc., Tulsa, OK, USA) was used for all analyses.

## RESULTS

There was no significant difference in age, body weight, height or BMI between the yoga and control groups (Table 1).

Table 2 shows the comparison of respiratory rate, chest wall mobility at the axillary and xiphoid levels, FVC, PEF, PImax and PEmax between the yoga and control groups. A significant difference between the two groups was only observed in terms of respiratory rate and chest wall mobility at the xiphoid level.

**Table 1.** Anthropometric characteristics and age of the yoga and control groups.

| | Yoga | Control | *p* value |
|---|---|---|---|
| Body weight (kg) | 60.3 ± 7.2 | 64.8 ± 8.6 | 0.16 |
| Height (cm) | 159.4 ± 4.8 | 159.4 ± 7.2 | 0.99 |
| BMI ($kg/m^2$) | 23.6 ± 2.7 | 25.4 ± 2.1 | 0.08 |
| Age (years) | 41.1 ± 7 | 43.8 ± 11.9 | 0.49 |

Data are reported as the mean ± standard deviation. BMI: body mass index.

**Table 2.** Comparison of ventilatory function variables between the yoga and control groups.

| | Yoga | Control | *p* value |
|---|---|---|---|
| RR (breaths per minute) | 15.23 ± 3.32 | 18.16 ± 1.74 | 0.01 |
| MAx (cm) | 4.64 ± 1.54 | 3.43 ± 1.95 | 0.09 |
| MXip (cm) | 5.11 ± 1.93 | 2.94 ± 1.43 | 0.00 |
| FVC (%)* | 101.84 ± 9.38 | 103.75 ± 14.38 | 0.69 |
| PED (%)* | 101.61 ± 20.21 | 101.83 ± 8.45 | 0.97 |
| PImax (%)* | 95.92 ± 28.35 | 77.47 ± 21.38 | 0.08 |
| PEmax (%)* | 97.46 ± 26.13 | 82.08 ± 21.14 | 0.12 |

Data are reported as the mean ± standard deviation. RR: respiratory rate; MAx: chest wall mobility at the axillary level; MXip: chest wall mobility at the xiphoid level; FVC: forced vital capacity; PEF: peak ventilatory flow; PImax: maximum inspiratory pressure; PEmax: maximum expiratory pressure. *percent predicted.

## DISCUSSION

The objective of the present study was to evaluate the effects of Hatha Yoga on the ventilatory function of healthy women participating in the Physical Activity and Quality of Life Program offered by the Town Hall of Juiz de Fora. For this purpose, 13 female yoga practitioners were studied and the results were compared to those obtained for 12 healthy and sedentary women who comprised the control group. Statistical analysis revealed a significant difference between groups only in terms of respiratory rate and chest wall mobility at the xiphoid level.

The results regarding the effects of yoga on the respiratory rate of healthy subjects are controversial. Daily "ujjayi" training, a pranayama technique that involves deep and slow respiratory maneuvers close to vital capacity, accompanied by periods of apnea after inspiration and expiration, has been shown to reduce the resting respiratory rate after 2 months of intervention[6]. Similarly, comparison of two yoga relaxation techniques showed a reduction of resting respiratory rate among yoga practitioners after cyclic meditation[15]. These results agree with the findings of the present study, in which the respiratory rate was significantly lower among female yoga practitioners. It is believed that repeated stimulation of mechanoreceptors present in the lungs or respiratory muscles by deep breaths may result in a mechanism of habituation, with a consequent reduction in the transmission of afferent information to the respiratory center[16]. In addition, intermittent acidosis and hypoxia generated by “ujjayi” respiration may influence hypercapnic and hypoxic drives of the respiratory control system, reducing the responsiveness to hypercapnia[17]. These hypotheses may explain the reduction in respiratory rate as a result of regular practice of yoga and its pranayamas. However, another study[18] was unable to show significant yoga-related changes in respiratory rate in healthy subjects.

With respect to yoga and chest wall mobility, Chanavirut et al.[2] evaluated the effects of selected asanas in Hatha Yoga on chest wall mobility of healthy subjects and observed a significant increase after a training period of 6 weeks. The present study showed significantly higher chest wall mobility at the xiphoid level in yoga practitioners. These results might be attributed to the patterns of movement and posture that are characteristic of Hatha Yoga, which range from slow and deep respiratory maneuvers to asanas that permit muscle stretching and mobilization of the joints involved in respiratory mechanics. In fact, the influence of respiratory muscle stretching on chest wall mobility has been demonstrated in the literature[19], with the observation of a significant increase of thoracoabdominal mobility in sedentary subjects submitted to an 8-week program of respiratory muscle stretching using the Global Posture Reeducation (GPR) method. The lack of a significant difference in chest wall mobility at the axillary level observed in the present study might be explained by the emphasis given to diaphragmatic respiration during yoga, a fact that favors mobility of the lower region of the thorax

With respect to respiratory muscle strength, the hypothesis that yoga has positive impacts on this musculature stems from different factors. Certain pranayamas that consist of forced inspirations and expirations while one nostril is kept occluded may promote respiratory muscle training by increasing resistance[20]. In addition, certain asanas in yoga promote stretching of thoracic muscles that are involved in respiratory mechanics, thus exerting a positive influence on the force-generating capacity of respiratory muscles. In this respect, Moreno et al.[19] demonstrated an increase in respiratory muscle strength after a stretching program based on the GPR method focusing on the respiratory muscles. In fact, studies have shown an increase in respiratory muscle strength after periods of yoga training[21,22]. However, although mean respiratory muscle strength was higher in the yoga group, no significant differences between groups were observed in the present study. Similar results have been reported in a study[1] comparing yoga and aerobic activities. In that study, nonsignificant increases of PImax were observed in the two groups after 3 months of training. However, the absolute delta difference (calculated as final PImax – initial PImax) was significantly higher in yoga practitioners.

Vital capacity has been investigated in various studies on yoga practice in healthy subjects. In a study evaluating the effects of daily pranayama training on the respiratory system, Yang[5] found no significant difference between pre- and post-intervention vital capacity after 2 months of training. Comparison of ventilatory function between athletes, yoga practitioners and sedentary subjects also revealed no significant difference in FVC between groups[20]. Similar results have been reported by Godoy et al.[1] who compared the effects of yoga and aerobic gymnastics on spirometric parameters. The authors observed no differences between pre- and post-intervention FVC nor were there significant differences between groups after 3 months of training in the two modalities. The present results agree with the studies cited since no significant differences in FVC were observed between the two groups studied. In contrast, Harinath et al.[18] observed a significant increase of FVC in male volunteers after 3 months of daily Hatha Yoga training and meditation, and Chanavirut et al.[2] found a significant increase of FVC in healthy subjects after 6 weeks of training of Hatha Yoga asanas.

Regarding yoga and PEF, yoga practitioners have been shown to present significantly higher PEF than that achieved by athletes and sedentary individuals[20]. The authors attributed this finding to the higher respiratory muscle strength of yoga practitioners. However, in the present study no significant differences in PEF were observed between groups.

The mean results obtained for the spirometric variables were above the expected values in both groups. As a consequence, the observation of a significant difference in these parameters between groups becomes unlikely. One may speculate that in a population whose spirometric parameters are below normal yoga exerts a more marked impact on these variables. In this respect, a randomized and controlled study[8], in which patients with mild to moderate asthma were submitted to an 8-week yoga program, demonstrated significant increases of PEF and forced expiratory volume in the first second ($FEV_1$). Similarly, Visweswaraiah and Telles[23] observed an increase of FVC and $FEV_1$ in patients with tuberculosis after 2 months of yoga training.

The lack of consensus in the literature regarding the effects of yoga on the respiratory system can be attributed to various factors. First, different types of intervention are used that receive the same generic denomination of yoga, such as meditation, pranayamas, asanas, or a combination of these techniques. It is therefore difficult to distinguish which technique would be more effective in achieving a certain effect on the respiratory system. Furthermore, the relative intensity of distinct asanas differs between different yoga styles. In fact, studying the heart rate of volunteers during participation in different yoga styles, Cowen and Adams[24] observed higher heart rates during Astanga Yoga practice, a modality that differs from Hatha Yoga. In addition, different types of asanas and pranayamas can cause diverse physiological responses depending on the form of application. This has been demonstrated in a study[25] evaluating the effect of a 3-months training program of slow and fast pranayamas in a population of young healthy men. The results showed an increase of parasympathetic tonus and a decrease of sympathetic tonus in subjects practicing slow pranayamas, whereas no differences in autonomic functions were observed in subjects practicing fast pranayamas. Taken together, these results suggest that in the future studies should focus on the specific effects of different techniques and yoga styles on ventilatory function.

One of the limitations of the present study is the non-blind design of the evaluations. In addition, the study only involved female volunteers due to the almost exclusive presence of women in the yoga classes at the place where the volunteers were recruited. The small number of volunteers also impairs extrapolation of the results to the population of yoga practitioners as a whole. This small number was mainly due to the difficulty in selecting subjects who only practice yoga among the population of students participating in the Physical Activity and Quality of Life Program of the Town Hall of Juiz de Fora, Minas Gerais, since the students are encouraged by the teachers to perform other types of physical activity.

## CONCLUSIONS

Hatha Yoga was able to modify the respiratory rate and chest wall mobility at the xiphoid level in a group of healthy women. No significant differences were observed in the other ventilatory function variables studied. Further studies involving a larger number of subjects are needed to identify which yoga techniques or styles exert greater effects on the respiratory system.

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## REFERENCES

1. Godoy DV, Bringhenti RL, Severa A, Gasperi R, Poli LV. Ioga versus atividade aeróbia: efeitos sobre provas espirométricas e pressão inspiratória máxima. J Bras Pneumol 2006; 32(2):130-5.
2. Chanavirut R, Khaidjapho K, Jaree P, Pongnaratorn P. Yoga exercise increases chest wall expansion and lung volumes in young healthy thais. Thai J Physiol Sci 2006;19(1):1-7.
3. Hagins M, Moore W, Rundle A. Does practicing hatha yoga satisfy recommendations for intensity of physical activity which improves and maintains health and cardiovascular fitness? BMC Complement Altern Med 2007;40(7):1-9.
4. Buzzachera CF, Elsangedy HM, Hallage T, Silva SG. Parâmetros fisiológicos e perceptivos durante caminhada de intensidade preferida por mulheres adultas, previamente sedentárias. Rev Bras Cineantropom Desempenho Hum 2007;9(2):170-6.
5. Yang K. A review of Yoga programs for four leading risk factors of chronic diseases. Evid Based Complement Alternat Med 2007;4(4):487-91.
6. Villien F, Yu M, Barthélémy P, Jammes Y.Training to yoga respiration selectively increases respiratory sensation in healthy man. Respir Physiol Neurobiol 2005;146(1):85-96.
7. Khalsa SB. Yoga as a therapeutic intervention: a bibliometric analysis of published research studies. Indian J Physiol Pharmacol 2004;48(3):269-85.
8. Vempati R, Bijlani RL, Deepak KK. The efficacy of a comprehensive lifestyle modification programme based on yoga in the management of bronchial asthma: a randomized controlled trial. BMC Pulm Med 2009;9:37.
9. Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of a modified Early Warning Score in medical admissions. Q J Med 2001; 94:521-6.
10. Kakizaki F, Shibuya M, Yamazaki T, Yamada M, Suzuki H, Homma I Preliminary report on the effects of respiratory muscle stretch gymnastics on chest wall mobility in patients with chronic obstructive pulmonary disease. Respir Care 1999;44:109-14.

11. Pereira CAC. Espirometria. J Pneumol 2002;28(Supl 3):S1-S82.
12. Black L F, Hyatt R E. Maximal pressures: normal values relationship to age and sex. Am Rev Respir Dis 1969;99(5):696-702.
13. Souza RB. Pressões respiratórias estáticas máximas. J Pneumol 2002;28(Supl 3): S155-S165.
14. Neder J A, Andreoni S, Lerario M C, Nery, L E. Reference values for lung function tests. II. Maximal respiratory pressures and voluntary ventilation. Braz J Med Biol Res 1999;32(6):719-27.
15. Sarang PS, Telles S. Oxygen consumption and respiration during and after two yoga relaxation techniques. Appl Psychophysiol Biofeedback 2006;31(2):143-53.
16. Stanescu DC, Nemery B, Veriter C, Marechal C. Pattern f breathing and ventilatory responses to CO2 in subjects practicing hatha-yoga. J Appl Physiol 1981; 51(6):1625-29.
17. Miyamura M, Nishimura K, Ishida K, Katayama K, Shimaoka M, Hiruta S. Is man able to breath once a minute for an hour?: The effect of Yoga respiration on blood gases. Jpn J Physiol 2002;52:313-16.
18. Harinath K, Malhotra AS, Pal K, Prasad R, Kumar R, Kain TC, Rai L, Sawhney RC. Effects of Hatha yoga and Omkar meditation on cardiorespiratory performance, psychologic profile, and melatonin secretion. J Altern Complement Med 2004;10(2):261-8.
19. Moreno MA, Catai AM, Teodori RM, Borges BLA, Cesar MC, Silva E. Efeito de um programa de alongamento muscular pelo método de Reeducação Postural Global sobre a força muscular respiratória e a mobilidade toracoabdominal de homens jovens sedentários. J. Bras Pneumol 2007;33(6):679-86.
20. Prakash S, Meshram S, Ramtekkar U. Athletes, yogis and individuals with sedentary lifestyles; do their lung functions differ? Indian J Physiol Pharmacol 2007;51(1):76-80.
21. Madanmohan, Thombre DP, Balakumar B, Nambinarayanan TK, Thakur S, Krishnamurthy N, Chandrabose A. Effect of yoga training on reaction time, respiratory endurance and muscle strength. Indian J Physiol Pharmacol 1992;36(4):229-33.
22. Mandanmohan, Jatiya L, Udupa K, Bhavanani AB. Effect of yoga training on handgrip, respiratory pressures and pulmonary function. Indian J Physiol Pharmacol 2003;47(4): 387-92.
23. Visweswaraiah NK, Telles S. Randomized trial of yoga as a complementary therapy for pulmonary tuberculosis. Respirology 2004;9(1):96-101.
24. Cowen VS, Adams TB. Heart rate in yoga asana practice: A comparison of styles. J Bodyw Mov Ther 2007;11:91-5.
25. Pal GK, Velkumary S, Madanmohan. Effect of short--term practice of breathing exercises on autonomic functions in normal human volunteers. Indian J Med Res 2004; 120:115-21.

**Endereço para correspondência**
Cristina Martins Coelho
Rua Carlita de Assis Pereira, no 30,
Bairro Bosque dos Pinheiros,
CEP: 36062-050.
Juiz de Fora, MG. Brasil.
Email: cristina_fisiojf@yahoo.com.br