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Original Article

YOGA EXERCISE INCREASES CHEST WALL EXPANSION AND LUNG VOLUMES IN YOUNG HEALTHY THAIS

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Yoga, a method of breathing and chest expansion exercise, has been reported to improve respiratory function in healthy and respiratory diseases. The present study tested the hypothesis that short-term Yoga exercise increased chest wall expansion and lung volumes in young healthy Thais. Fifty-eight healthy young volunteers (20.1±0.6 years of age) were randomly allocated into Yoga training (n=29) and control (n=29). Five positions of Hatha Yoga (Uttita Kummersana, Ardha Matsyendrasana, Vrikshasana, Yoga Mudra, and Ushtrasana) were assigned because of their dominant effects on chest wall function. The Yoga practice was 20 min/session and 3 sessions/week for 6 weeks. The matching control subjects were designed and stayed free without Yoga exercise in a similar period. Before and after training lung expansion was measured by a standard tape at three levels: upper (sternal angle), middle (rib 5), and lower (rib 8). Lung volumes (tidal volume, FEV_1, $FEV_{25\text{-}75\%}$, and FVC) were measured by a standard spirometer. Compared to pre-training, Yoga exercise significantly increased ($p<0.05$) chest wall expansion in all levels (upper 3.2±0.1 versus 4.4±0.1 cm, middle 5.0±0.1 versus 5.9±0.1 cm, lower 5.9±0.2 versus 6.8±0.1 cm), FEV_1 (2.5±0.1 versus 2.8±0.1 L), $FEV_{25\text{-}75\%}$ (4.1±0.2 versus 4.8±0.2 L/sec), and FVC (2.5±0.1 versus 2.8±0.1 L). The upper chest wall expansion improved better than the other two levels. Resting tidal volume was not altered by Yoga (0.53±0.03 versus 0.55±0.03 L). In contrast, the control subjects did not show any change in all measured parameters through the study. The present data suggest that short-term Yoga exercise improves respiratory breathing capacity by increasing chest wall expansion and forced expiratory lung volumes.

Key words: Yoga, chest wall exercise

Yoga, originated in India thousands years ago, is a method of learning that aims to attain the unity of mind, body, and spirit through three main Yoga structures: exercise, breathing, and meditation (Gilbert, 1999; Halvorson, 2002; Monro, 1997). It is separated into Six Branches. 1. Bhakti Yoga is the path of heart and devotion. 2. Raja Yoga is the path of Yoga that focuses on meditation and contemplation. 3. Jnana Yoga is the path of Yoga that deals with wisdom and knowledge or the Yoga of the mind. 4. Karma Yoga is the path of service; it refers to the energy of action. 5. Tantra Yoga is the path of ritual, it also known as sorcery, witchcraft, magic spell or some mysterious formula. 6. Hatha Yoga is the most popular branch of Yoga. In general, when people mention about Yoga, they refer to Hatha Yoga. It is the physical training part combining postural exercise (“*asana*”), relaxation, and voluntary control of breathing

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("*pranayama*"). Yoga practice consists of the five-principle including proper relaxation, proper exercise, proper breathing, proper diet, and positive thinking and meditation. Yoga respiration consists of very slow, deep breaths with sustained breath hold after each inspiration and expiration. Thus, previous studies considered Yoga as a method of breathing and chest expansion exercise. Breathing and chest wall expansion exercise, the treatment technique for chest physical therapy, have been used to treat various forms of respiratory dysfunction, both acute and chronic abnormalities resulting from medical or surgical conditions, and for health promotion (Brannon et al., 1993; Dean and Ross, 1992; Frownfelter, 1978; Levenson, 1992).

Exercise training has been shown to improve respiratory capacity, airway resistance, exercise tolerance, and to reduce work of breathing (Frownfelter, 1978; Levenson, 1992). Previously, it was reported that Yoga training (asans and pranayams) for 6 months improved lung function, respiratory muscle strength, skeletal muscle strength, and endurance in 12-15 years old Indian (Mandanmohan et al., 2003). However, different Yoga training (three weeks duration) produced different results on the cardiopulmonary function in young Indian (Mandanmohan et al., 2005). At present, Yoga is the popular kind of fashionable exercise that uses for health promotion in all ages in Thailand, but still has few reports about the benefit of Yoga exercise in different techniques on respiration especially lung volumes and chest wall expansion in Thais. This experiment tested the hypothesis that short-term Yoga training improved chest wall expansion and lung volumes in young healthy Thais. Five positions of Hatha Yoga (Uttita Kummersana or cat position, Ardha Matsyendrasana or sitting and twist the trunk position, Vrikshasana or tree position, Yoga Mudra, and Ushtrasana or camel position) were selected for training to simulate a chest expansion exercise position (Frownfelter, 1978).

Materials and Methods

Subjects

Fifty-eight healthy volunteers, 18-25 years of age, were recruited from the undergraduate students of Khon Kaen University and separated into two groups: Yoga training (20 females and 9 males) and control group (21 females and 8 males). All subjects were free of any acute and chronic diseases. This study was reviewed and approved by the Institute Ethics Committee, based on the declaration of Helsinki, and written consensus was obtained from all subjects.

Experimental protocol

General characteristics (age, body weight, height, and body mass index: BMI) were collected from all subjects and matched between groups. All subjects were assigned to learn the whole protocol and explained in detail by the investigator. At the first day of study, both groups came to the training room and their chest expansion and lung volumes were measured as pretest data. The chest wall expansion was measured by a standard tape at three levels: upper (sternal angle), middle (rib 5), and lower (rib 8) levels. The lung volumes including tidal volume (V_T), forced expiratory volume in one second (FEV_1), forced expiratory volume between 25-75% ($FEF_{25-75\%}$), and forced vital capacity (FVC) were measured by a standard spirometer. Then the Yoga group was trained to perform Yoga exercise for 20 minutes while the control group was stay free in the same room. Both were allowed to live freely at their homes without other heavy exercise, drinking, and smoking. The Yoga group was asked to come to the study room three days a week for six weeks to perform 20-min Yoga exercise. At the end of 6 weeks period, all studied parameters were measured as posttest data with the same methods.

The Yoga group performed five yoga postures (Figure 1): Uttita Kummersana (cat position), Ardha Matsyendrasana (sitting and twist the trunk), Vrikshasana (tree position), Yoga Mudra and Ushtrasana (camel position) for 20 minutes a day, one time a day, and 3 days a week until 6 weeks.

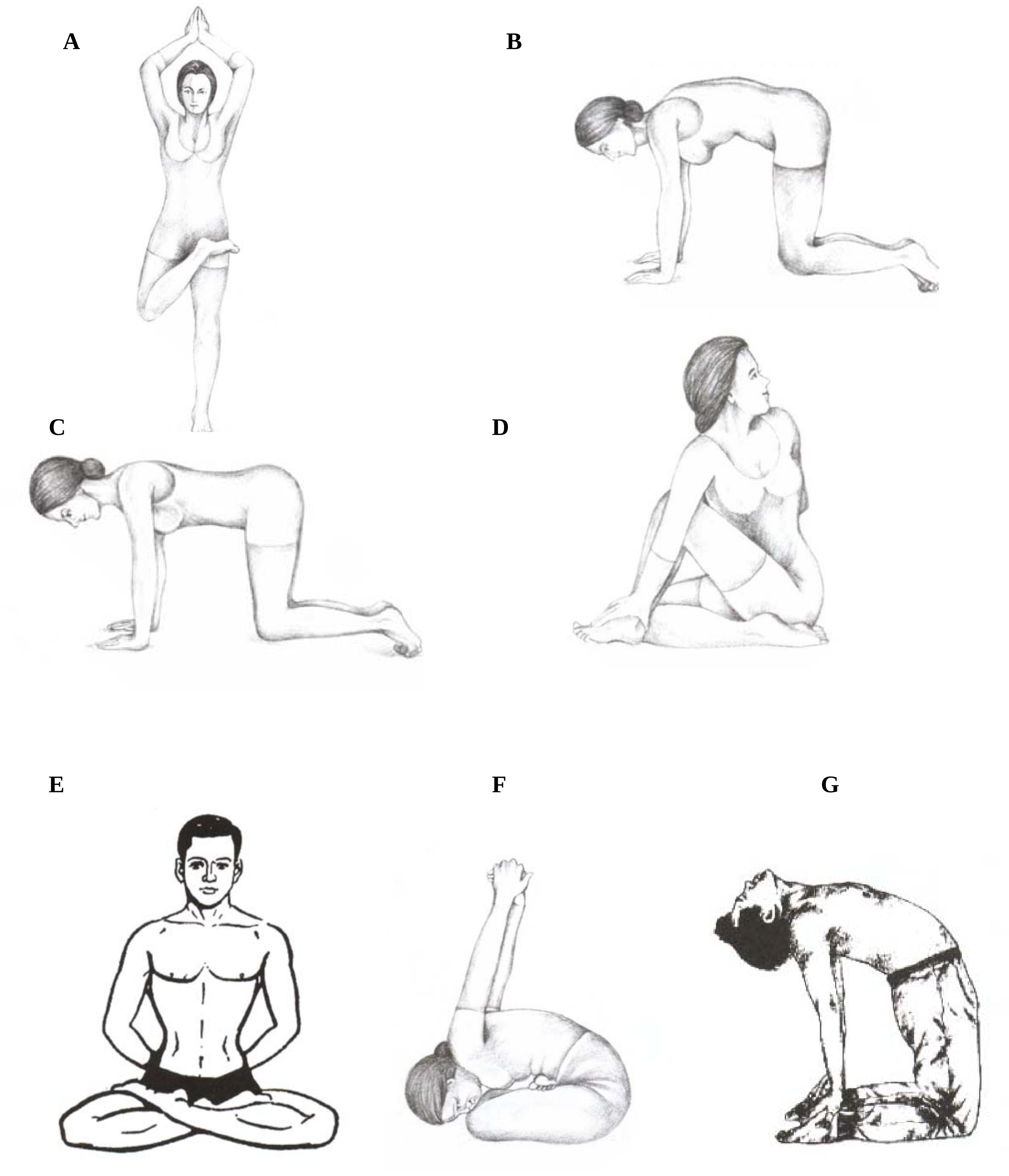

Figure 1. A, Vrikshasana or tree position; B, Starting position of Uttita Kummersana or cat position; C, Uttita Kummersana or cat position; D, Ardha Matsyendrasana or sitting and twist the trunk; E, Starting position of Yoga Mudra; F, Yoga Mudra position; G, Ushtrasana or camel position (Krongkwan, 2003).

Data analyses

All data were expressed as mean ± SEM and were statistically analyzed by using the Statmost software (DataMost, USA). One-way ANOVA and appropriate post hoc tests (Duncan's Multi-Range) were used to determine the statistical difference among parameters. P-values of less than 0.05 indicated a significant difference.

Table 1. General characteristics of control and Yoga groups

Parameters	Control (n=29)	Yoga (n=29)
Age (years)	20.1 ± 0.6	20.1 ± 1.3
Body height (cm)	162.1 ± 7.5	161.1 ± 9.0
Body weight (kg)	54.4 ± 8.8	49.3 ± 6.0
BMI (kg/m^2)	20.7 ± 2.4	19.1 ± 1.0

Data were mean ± SE. BMI: body mass index.

Results

General characteristics

The general characteristics of both control and Yoga groups were not significantly different both before and after experimental studies (Table 1). Body weight, height, and BMI were all within the normal range of healthy person.

Lung volumes

At the beginning of the study (before or pretest), all measured lung volumes were not significantly different between groups (Table 2). Yoga exercise significantly increased FVC, FEV_1, and $FEF_{25-75\%}$ ($p < 0.05$) without any effect on tidal volume. However, only the posttest $FEF_{25-75\%}$ of Yoga significantly increased when compared to control. No lung volumes of the control were significantly different when compared between before and after values.

Table 2. Lung volumes of control and Yoga groups

Lung volume	Before		After	
	Control	Yoga	Control	Yoga
V_T (L)	0.55 ± 0.03	0.53 ± 0.03	0.57 ± 0.03	0.55 ± 0.03
FEV_1 (L)	2.54 ± 0.13	2.46 ± 0.10	2.46 ± 0.14	2.78 ± 0.11 *
$FEV_{25-75\%}$ (L/sec)	3.83 ± 0.21	4.10 ± 0.23	3.72 ± 0.20	4.77 ± 0.24 $^{*\beta\alpha}$
FVC (L)	2.53 ± 0.13	2.49 ± 0.12	2.51 ± 0.14	2.82 ± 0.12 *

Data were mean ± SEM. *: significance between before and after Yoga, $^{\beta}$: significance between before control and after Yoga, $^{\alpha}$: significance between after control and after Yoga, $p<0.05$.

Table 3. Chest wall expansion of control and Yoga groups.

Chest expansion (cm)	Before		After	
	Control	Yoga	Control	Yoga
Upper	3.00 ± 0.09	3.19 ± 0.07	3.02 ± 0.10	4.40 ± 0.14 $^{*\beta\alpha}$
Middle	4.64 ± 0.11	4.97 ± 0.13	4.68 ± 0.10	5.92 ± 0.13 $^{*\beta\alpha}$
Lower	5.40 ± 0.14	5.91 ± 0.18	5.44 ± 0.14	6.77 ± 0.14 $^{*\beta\alpha}$

Data were mean ±. SEM. *: significance between before and after Yoga, $^{\beta}$: significance between before control and after Yoga, $^{\alpha}$: significance between after control and after Yoga, p<0.05.

Chest wall expansion

As general characteristics and lung volumes, baseline chest wall expansion was not significantly differently between groups (Table 3). At the end of 6 weeks Yoga training, chest wall expansion significantly increased ($p < 0.05$) in all three levels when compared to their pretest values and posttest control. The improvement was highest at the upper (38%) compared to middle (19%) and lower (15%) levels.

Discussion

Yoga has its ancient roots in India, where it is both a spiritual and physical practice-integrating mind and body. Contemporary Americans lean toward its fitness aspects. Since 1998, Yoga has become standard fare at health clubs and community recreation programs in Thailand. The difference between Yoga and other exercise is the predominant focus on sensations in the body (Halvorson, 2002). Like other forms of exercise, the present data indicate that six-week Yoga training improves respiratory capacity especially chest wall expansion and lung volumes. This study agrees with previous reports in Indian children (Mandanmohan et al., 2003) and supports the benefit of Yoga as an alternative exercise for health and treatment of some abnormalities.

Respiratory function depends on many factors including nervous system, respiratory muscle strength, and lung dimension. Mandanmohan et al. (2003) demonstrated that short-term Yoga practice increased skeletal muscle strength and lung volumes in children. Yoga training also improves muscle strength and flexibility (Raub, 2002) and increased respiratory sensation (Villien et al., 2005), maximum expiratory pressure and flow rate (Joshi et al., 1992; Stanescu et al., 1981; Yadav and Das, 2001). It is likely that the improvement of respiratory function and increased chest wall expansion in the present study were resulted from the increased respiratory muscle strength. Psychological effects may not concern in this case since both control and Yoga groups were studied in the same place and with the same investigators, and were all the students of Khon Kaen University of the same age. Like other types of exercise, Yoga practice decreased reaction time, indicating improvement of neuromuscular system (Bhavanani et al., 2003). Increased nerve conduction velocity was reported in dynamic exercise (Masuda et al., 2001; Ross et al., 2001), but not yet in the Yoga training. Although the chemoreceptor reflex adaptation and blood gases has been widely studied (Forster and Pan, 1995; Pianosi and Khoo, 1995), the possible role of nervous system on improved lung function in Yoga exercise especially in a short-term training period needs further experiments..

The main purpose of the lung is to maintain gas exchange and transport to match the need of cellular respiration. The pulmonary gas exchange depends mainly on the ventilation-perfusion ratio. Although the present study indicated increased chest wall expansion in all three levels, the most improvement is at the upper part (Table 2). This area usually ventilates in excess of blood flow and the ventilation-perfusion ratio is highest (Ganong, 1995). Thus, the increased chest wall at the upper part may not result in good gas exchange. In contrast, the increased chest wall dimension at the lower part indicates the possible increased ventilation-perfusion ratio and improved gas exchange capacity. Blood flow to this part is usually high in excess of ventilation. However, regional blood flow distribution in Yoga practice has to be clarified in the future.

Five positions of Hatha-Yoga used in this study has been reported to predominantly effect on prime mover and accessory respiratory muscle such as external and internal intercostal muscle, pectoral, latisimus dorsi, erector spinae, rectus abdominis, serratus anterior and diaphragm (Frownfelter, 1978; Levenson, 1992). Performing Yoga stretching and balancing movement can lead to improvements of muscle strength and flexibility of all these muscles (Halvorson, 2002). In addition, general principles of yogic breathing can change breath habitually from chest breathing to abdominal breathing pattern. Abdominal breathing uses the diaphragm primarily, and is congruent with the shape of the lungs and the capacities of the breathing muscles. It performs respiration with the least effort and is associated with mental stability and calmness. In contrast, chest breathing utilizes primarily intercostal muscle plus accessory breathing muscles: trapizius, scalenes, pectoral, and sternomastoid (Chaitow and Bradley, 2002; Frownfelter, 1978; Levenson, 1992). It is less efficient, aerates less of the lung, fatigues the neck and upper chest if used habitually, and is associated with urgency and anxiety (Gilbert, 1999). However, why the upper part of chest expands more by Yoga exercise needs further studies.

A type of Yoga, the *Asanas,* involves a variety of effects including (1) relaxation, stretching, and balancing of muscles; (2) mobilization of joints; 3) improvement of posture; (4) action on pressure points; (5) improvement of breathing; (6) calming of the nervous system; and (7) promotion of homeostasis in cardiovascular, digestive, endocrine and other systems (Monro, 1997). The *Asanas* relaxes muscles through holding them in gently stretched positions (Monro, 1997). As another benefit, Yoga improves posture. Appropriate posture improves breathing because the chest is opened up (Halvorson, 2002).

In summary, the present study suggests that short-term Yoga exercise improves respiratory breathing capacity by increasing chest wall expansion and forced expiratory lung volumes. These data provide more scientific evidence to support the beneficial effect of Yoga practice on respiration and muscle strength.

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