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Effects of yoga on body composition and cardio: Pulmonary functions of 16-18 years healthy female volunteers

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Abstract
The present study was aimed to find out the effects of yoga on body composition and cardio-pulmonary functions on young healthy female volunteers. For this purpose eighty one healthy female volunteers (age 16–18 yrs) were screened randomly from Midnapore District, West Bengal, India. All the volunteers went through a medical examination performed by Physicians. Twenty one volunteers were excluded and the remaining sixty (n = 60) volunteers were randomly divided into two groups: (a) Yoga Group (n = 30) and (b) Control Group (n = 30). Yoga training - 60 min/d, 06 d/wk for 12 wks was followed in yoga group with no yoga training in control group. Significant reduction (P<0.05) in body fat, body mass, BMI, SBP, RHR and RR; and increase (P<0.05) in FVC, FEV1, PEFR, MVV and BHT were noted in the yoga group after 12 weeks of yoga training when compared to baseline data. Further, the control group had significantly (P<0.05) higher body fat, total fat mass, body mass, SBP, RHR and RR; and (P<0.05) lower FVC and MVV when compared to yoga group after 12 weeks of study. It can be suggested that yoga practice may reduce body fat and the chance of cardiovascular and pulmonary diseases.

Keywords: Yoga, body composition, blood pressure, pulmonary function

Introduction

Physical inactivity leads to obesity and increases the risk for cardio-pulmonary diseases (Bharshankar *et al*., 2003; Schunemann *et al*., 2000) [1, 2]. On the other hand, physical activity conveys multiple health benefits including decreased rates of coronary artery disease, hypertension, non-insulin dependent diabetes mellitus, osteoporosis, colon cancer, anxiety and depression, as well as decreased risk of overall mortality (Bharshankar *et al*., 2003; Schunemann *et al*., 2000) [1, 2]. Yoga, with origins in ancient India has several sub-types, and incorporates asana (posture- physical exercise), pranayama (breathing exercise) and meditation (an approach to training the mind or focusing mind on a particular object). Yoga and meditation as adjunctive therapies for promoting and maintaining wellness offer an excellent example of the mind-body connection at work. Yoga creates balance, physically and emotionally, by using postures, or asanas, combined with breathing techniques, or pranayama. Meditation supports the physical and emotional work being done by the postures and breathing, they open the door to self-actualization to create the perfect union of the mind, body, and spirit (Gimbel, 1998) [3]. In addition to low barriers to access, the scientific rationale for yoga effects on the mind are quite strong. The holistic goal of yoga to promote physical and mental health, and also be spiritually and socially conscious, may appeal both to consumers and providers who are concerned about the symptom reduction based focus of psychopharmacology and finding inner peace (Uebelacker *et al*., 2010) [4].
Practicing yoga, with yogic attitude causes several changes in body physiology. In our previous studies it has been noted that regular practice of yoga enhances fitness and co-ordination to brain and muscular activities (Manna *et al*., 2004) [5]. Regular yoga practice helps to maintain normal healthy life style and physical fitness which is indicated by decreasing body fat, blood pressure, heart rate and maintaining lipid profile (Manna, 2017) [6]. Further, it has been observed that yoga exercise improve oxidative stress markers and antioxidant status in healthy participants (Manna, 2018) [7].

The pulmonary functions have been identified as a predictor for overall survival rates as well as a tool in general health assessment (Schunemann *et al*., 2000) [2]. Many studies are available showing the favorable effect of yoga on pulmonary function tests (Doijad & Surdi, 2012; Halder *et al*., 2012) [8, 9]. Stressful environmental conditions and physical inactivity may lead to various diseases like obesity, cardio-pulmonary diseases, diabetes, anxiety, depration and many other problems. Yoga asana (posture- physical exercise), pranayama (breathing exercise) and meditation (an approach to training the mind or focusing mind) may have beneficial role on body and mind. On the basis of the above, the present study was designed to find out the effects of 12 weeks of yoga practice on body composition and cardio-pulmonary functions of 16-18 years female volunteers.

Materials and Methods

Subjects and group

For the present study, eighty one (*n* = 81) healthy female volunteers within the age group of 16–18 years were screened randomly from the Midnapore District, West Bengal, India. Subjects had not been engaged in yoga practice or any physical exercise at least two years preceding the study were considered eligible for this study. Subjects without history of disease and illness were included. This decision was based on the medical examination performed by Physicians. Participants were excluded from the study if they had a history of disease and illness for at least 03 months prior to the commencement of the study. All the volunteers went through a medical examination performed by Physicians. Twenty one [*n* = 21 (Not meeting the inclusion criteria, *n* = 06; decline to participate, *n* = 05; inability to perform yoga, *n* = 5; and unable to follow the schedule, *n* = 5)] volunteers were excluded from the study. The remaining sixty (*n* = 60) volunteers were randomly divided into two groups: (a) Yoga Group (*n* = 30) and (b) Control Group (*n* = 30).

Experimental Design: Yoga training was given by the provided in the yoga group, whereas no yoga training was given to the control group. Yoga training was given by qualified yoga instructor for 60 min/day, 06 days/week for 12-weeks duration following a standard protocol (Chatterjee & Mondal, 2014). The detail of yoga protocol is presented in Table 1. Assessment of body composition and cardio-pulmonary functions were performed in both the groups at 0 week and after 12 weeks.The participant flow during the study is shown in Figure 1.

Table 1: Contents of yogic package practiced by the volunteers during the training schedule

Yogic Training Schedule	Duration of each session (min)
Prayer	02
Om chanting	02
Gayatri Mantra	02
Yogic SukshmVyayam	10
Surya Namaskar	12
Yogasana	10
(i) Shavasana	
(ii) Supt Pawan Muktasana	
(iii) Kandrasana	
(iv) Makarasana	
(v) Shalabhasana	
(vi) Bhujangasana	
(vii) Mandukasana	
(viii)Usharasana	
(ix) Gomukhasana	
Pranayama	15
(i) Kapal Bhati	
(ii) Mahabandh	
(iii) Laybadh Shvas Prashwas	
(iv) Nadi Shodhan	
(v) Ujjayi & Bhramari Pranaya	
Meditation	05
(i) Ajpa Jap	02
(ii) Shanti Mantra	
Total	60

Ethics: The volunteers were informed about the purpose and the possible complications of the study, and written consents were taken from them. The volunteers were asked to refrain from smoking and alcohol throughout the experiment. The yoga group participants were informed not to involve in any other physical activity during the entire period of the study. The participants were asked to maintain their normal diet. The experimental protocol was approved by the Institutional Ethical Committee (Human Studies) (Ref No. MC/IEC (HS)/PHY/FP-02/2016; date: 07.06.2016).

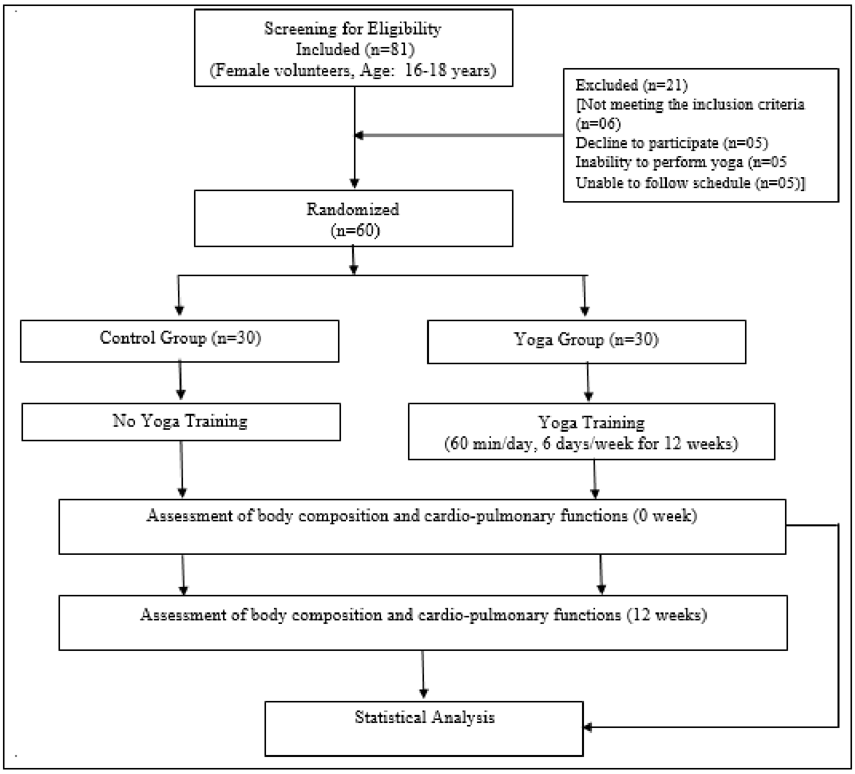

Fig 1: Consort flow chart

Measurements

Measurement of height (stature) and body mass: The height was measured by the stadiometer (Seca 220, UK) with an accuracy recorded to the nearest 0.5 cm. The subject stood barefoot, and erect with heels together and arms hanging naturally by the sides. The heels, buttocks, upper part of the back and usually but not necessarily, the back of the head were in contact with the vertical wall. The subject looked straight ahead and took a deep breath during measurement. The distance from the standing platform, to the highest position of head (vertex) was measured with the help of stadiometer, which indicates the subjects' height (Jonson & Nelson, 1996) [11]. The stature was recorded in centimetres. The body mass was taken on a standard electronic weighing machine (Seca Alpha 770, UK), having an accuracy recorded to the nearest 50 gm. The subject was examined in clothing of known weight in order to record nude weight 12 hours after the last meal. The subject stood at the centre of the weighing machine looking straight. The body mass was recorded in kilograms (Jonson & Nelson, 1996) [11].

Determination of body mass index and body surface area: Body mass index (BMI) and Body surface area (BSA) were derived from the standard equation (Jonson & Nelson, 1996) [11].

BMI = Weight (kg) / Height (m^2)

BSA (sq m) = Weight (kg) $^{0.425}$ × Height (cm) $^{0.725}$ ×71.84/10000

Assessment of percent body fat and lean body mass: A skin fold calliper (Holtain Limited, UK) was used to assess the body fat percentage following standard methodology (Siri, 1956) [12]. The instrument consists of accurately calibrated dial which indicates the thickness of the skin fold in millimetres (mm) when the skin fold is held by the open jaws. The skin fold was taken from four different sites of the body (biceps, triceps, sub-scapular and suprailiac) using the skin fold calliper on the right side of the body. The thickness of the skin and subcutaneous fat was grasped between the thumb and index finger. To estimate the errors, reading was made between three and four seconds when essentially all compressions have taken place and the measurements were established.

Computation of Body density (BD): Body density was calculated by the standard formulae for women (Durnin & Womersley, 1974) [13]. The skin fold thickness at the site of biceps, triceps, sub-scapular and suprailiac was used to calculate the body density.

BD = 1.1549 - 0.0678 log (Biceps + Triceps + Sub scapular + Suprailliac) (for 14-19 yrs)

Computation of Percent Body fat was derived using the standard equation (Siri, 1956) [12].

Body fat (%) = (495 / Body density) – 450

Computation of Lean body mass (LBM) was derived by subtracting fat mass (FM) from total body mass (Siri, 1956) [12] using the following equation.

LBM (kg) = Body mass – Fat mass

FM (kg) = [Body mass (kg) × Body fat (%)] / 100

Assessment of cardiovascular functions: The subject was asked to take rest for 15 minutes resting heart rate (RHR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded using standard procedure (Astrand & Rodhal, 1986) [14].

Assessment of Pulmonary Functions: The forced expiratory volume in 1st second (FEV1); forced vital capacity (FVC); peak expiratory flow rate (PEFR); maximum ventilatory volume (MVV) was measured using an electronic spirometer

(Spirobank II, MIR, USA) following a standard procedure (Mustajbegovic *et al*., 2001) [15]. Respiratory rate (RR) was recorded by observing abdominal wall movement in sitting position after sufficient rest. Breath holding time (BHT) was measured in seconds from the time of holding breath after quit expiration till the breaking point of the held breath by using a stop watch in comfortable sitting position in which subjects were asked to hold breath by closing both nostril voluntarily by pinching nose between his/her thumb and index finger and closed mouth.

Statistical Analysis

To find out whether data were normally distributed, Shapiro–Wilk normality test was performed. All the data of were expressed as mean and standard deviation (SD). Analysis of variance with repeated measures followed by multiple comparison (*post hoc*) tests was performed to find out the significant difference in intragroup and intergroup variables. In each case, the significant level was chosen at 0.05 levels. All the statistical analysis was performed using SSPSS 20 software for Windows (IBM, USA).

Results

Effect of yoga on body composition of young female volunteers

The body composition variables showed that there was significant reduction ($P<0.05$) in percentage of body fat, total fat mass, body mass and BMI in the yoga group after 12 weeks of yoga training when compared to baseline data (0 week). However, there was no significant difference in height, BSA and LBM in the yoga group after 12 weeks of training when compared to baseline data. In the control group no such changes were noticed after 12 weeks of study. Further, it was observed that the control group had significantly ($P<0.05$) higher body fat, total fat mass, body mass and BMI when compared to yoga group after 12 weeks of study (Table 2).

Table 2: Effect of yoga on body composition of yoga and control group female volunteers

Groups	Yoga Group		Control Group	
Parameters	**0 Week**	**12 Weeks**	**0 Week**	**12 Weeks**
Height (cm)	156.7 ± 4.5	156.7 ^{NS} ± 4.5	155.2 ± 4.1	155.2^{NS} ± 4.1
Body mass (kg)	48.8 ± 2.3	46.0$^{*\#}$ ± 2.0	47.3 ± 2.4	48.0 ^{NS} ± 2.1
BMI (kg m^{-2})	19.9 ± 1.1	18.3$^{*\#}$ ± 1.0	19.6 ± 1.1	19.9 ^{NS} ± 1.2
BSA (m^2)	1.46 ± 0.45	1.41^{NS} ± 0.41	1.43 ± 0.43	1.44 ^{NS} ± 0.47
Body Fat (%)	19.3 ± 3.4	15.6$^{*\#}$ ± 3.1	18.5 ± 3.4	19.1 ^{NS} ± 2.8
Fat mass (kg)	9.42 ± 0.81	7.02$^{*\#}$ ± 0.84	8.75 ± 0.85	9.17 ^{NS} ± 0.81
LBM (kg)	39.38 ± 2.3	38.82 ^{NS} ± 2.1	38.55 ± 2.7	38.83 ± 2.4

[All the data were expressed as mean ± SD; ANOVA with repeated measured followed by multiple comparison (*post hoc*) tests were performed; n= 30. When compared to baseline data (0 week) *$P<0.05$; when compared to control group # $P<0.05$; NS= not significant, BMI= body mass index, BSA= body surface area, LBM= lean body mass, ANOVA= analysis of variance, SD= standard deviation.]

Effect of yoga on cardiovascular functions of young female volunteers

A significant reduction ($P<0.05$) in systolic blood pressure (SBP), and resting heart rate (RHR) were noted in the yoga group after 12 weeks of yoga training when compared to baseline data (0 week). However, there was no significant change in diastolic blood pressure (DBP) in the yoga group after 12 weeks of training when compared to baseline data. In the control group no such changes were noticed after 12 weeks of study. Further, the control group had significantly ($P<0.05$) higher SBP and RHR when compared to yoga group after 12 weeks of study (Table 3).

Table 3: Effect of yoga on cardiovascular functions of yoga and control group female volunteers

Groups	Yoga Group		Control Group	
Parameters	**0 Week**	**12 Weeks**	**0 Week**	**12 Weeks**
SBP (mmHg)	124.0 ± 4.1	117.0$^{*\#}$ ± 4.3	122.3 ± 3.8	121.1^{NS} ± 4.0
DBP (mmHg)	79.1 ± 3.2	78.1 ^{NS} ± 3.0	77.6 ± 3.2	76.6 ^{NS} ± 3.0
RHR (beats/min)	82.1 ± 3.7	78.4$^{*\#}$ ± 2.8	84.4 ± 3.0	83.1 ^{NS} ± 3.2

[All the data were expressed as mean ± SD; ANOVA with repeated measured followed by multiple comparison (*post hoc*) tests were performed; n= 30. When compared to baseline data (0 week) *$P<0.05$; when compared to control group # $P<0.05$; NS= not significant, SBP= systolic blood pressure, DBP= diastolic blood pressure, RHR= resting heart rate, ANOVA= analysis of variance, SD= standard deviation.]

Effect of yoga on pulmonary functions of young female volunteers

It has noted that there was significant increase ($P<0.05$) in FVC, FEV1, PEFR, MVV and BHT among the yoga group subjects after 12 weeks of yoga training when compared to baseline data (0 week). However, there was significant reduction ($P<0.05$) in RR among the yoga group subjects after 12 weeks of yoga training when compared to baseline data. In the control group no such changes were noticed after 12 weeks of study. Further, the control group had significantly ($P<0.05$) lower FVC and MVV; and higher ($P<0.05$) RR when compared to yoga group subjects after 12 weeks of study (Table 4).

Table 4: Effect of yoga on pulmonary functions of yoga and control group female volunteers

Groups	Yoga Group		Control Group	
Parameters	0 Week	12 Weeks	0 Week	12 Weeks
FVC (L)	1.89 ± 0.07	$2.11^{*\#}$ ± 0.09	1.91 ± 0.05	1.93^{NS} ± 0.09
FEV1 %	83.8 ± 4.2	87.1^{*} ± 3.4	84.2 ± 3.4	85.6^{NS} ± 3.7
PEFR (L/Sec.)	3.7 + 0.34	4.1^{*} + 0.61	3.8 + 0.41	3.9^{NS} + 0.45
MVV (L/min)	72.5 ± 2.5	$77.8^{*\#}$ ± 3.1	73.5 ± 2.8	74.7^{NS} ± 2.2
BHT (sec.)	24.6 ± 2.3	27.2^{*} ± 2.0	25.6 ± 2.4	26.4^{NS} ± 2.1
RR (breath/min)	18.3 ± 1.8	$16.1^{*\#}$ ± 1.2	18.0 ± 1.1	17.5^{NS} ± 1.3

[All the data were expressed as mean ± SD; ANOVA with repeated measured followed by multiple comparison (*post hoc*) tests were performed; n= 30. When compared to baseline data (0 week) *$P<0.05$; when compared to control group # $P<0.05$; NS= not significant, FVC= Forced vital capacity, FEV1 = Forced expiratory volume during the 1st second, PEFR= Peak expiratory flow rate. MVV= Maximum Ventilatory Volume, BHT= Breath Holding Time, RR= Respiratory rate, ANOVA= analysis of variance, SD= standard deviation.]

Discussion

Yoga has a role in maintaining good health and physical fitness. In the present study, significant reduction in body fat was noted after 12 week of yoga exercise. The reduction in body fat might be due to the fact that the volunteers underwent a high level of yogic exercise over a period of time, which resulted in lowering of body fat percentage. Yoga involves deep nostril breathing, flexibility of limbs and stretching of different body parts, which might be the cause of reduction of body fat of the volunteers practicing yoga. The reduction of body fat might influence the body mass and hence in the present study significant reduction of body mass was noted among the volunteers practicing yoga. Similar observations were noted by many authors where reduction in body fat was noted after yoga training (Manna, 2017; George & Ludvik, 2000; Himashree, Mohan & Singh, 2016; Zorofi, Hojjati & Elmiyeh, 2013) [16, 17, 18]. On the other hand, no significant difference was observed in LBM among the subjects after 12 weeks of yoga training programme. This might be due to improper optimization of the training load and/or short duration of the yoga training. Increase in body fat can elevate the risk factors for obesity, cardiovascular disease, diabetes and many other complications (Manna, 2017; George & Ludvik, 2000; Himashree, Mohan & Singh, 2016; Zorofi, Hojjati & Elmiyeh, 2013) [16, 17, 18]. Regular yoga practice may reduce body fat, which is essential for disease free life.

Heart rate and blood pressure are essential for assessing cardiovascular fitness. The cardiovascular response in yoga was studied in the present experiment and it has been seen that there was significant reduction in systolic blood pressure and resting heart rate among the yoga group after 12 weeks of yoga training when compared to baseline data. However, there was no significant change in diastolic blood pressure among the experimental group after yoga training. Similar observations were noted by many researchers where reduction in blood pressure and heart rate was noted after yoga training (Bharshankar *et al*., 2003; Manna, 2017; Mehta, Mehta & Pai, 2017; Nivethitha, Mooventhan & Manjunath, 2016) [1, 5, 19, 20]. It can be stated that yoga involves deep nostril breathing, flexibility of limbs and stretching of different body parts which might be the cause of reduction of systolic blood pressure and heart rate of the subjects. Reduction in heart rate and blood pressure indicate a shift in the balancing components of autonomic nervous system towards the parasympathetic activity (Manna, 2017; Mehta, Mehta & Pai, 2017; Nivethitha, Mooventhan & Manjunath, 2016) [5, 19, 20]. This modulation of autonomic nervous system activity might have been brought about through the conditioning effect of yoga on autonomic functions and mediated through the limbic system and higher areas of central nervous system (Selvamurthy *et al*., 1983) [21]. Regular practice of yoga increases the baroreflex sensitivity and decreases the sympathetic tone; thereby restoring blood pressure to normal level in patients of essential hypertension (Vijayalakshmi *et al*., 2004) [22]. Meditation by modifying the state of anxiety reduces stress-induced sympathetic over activity thereby decreasing arterial tone and peripheral resistance, and resulting in decreased diastolic blood pressure and heart rate, this ensures better peripheral circulation (Bhargava, Gogate & Macarenhas, 1988) [23] and blood flow to the tissues (Gopal *et al*., 1973) [24]. Elevation in heart rate and blood pressure variables indicate the risk factors for cardiovascular disease. Regular yoga practice may restore normal heart rate and blood pressure which are essential to maintain disease free life.

Pulmonary functions are essential for assessing the respiratory status of the subject. The pulmonary functions in response to yoga was studied in the present experiment and it has been seen that there was significant increase in FVC, FEV1, PEFR, MVV and BHT and significant reduction in RR among the yoga group subjects after 12 weeks of yoga training when compared to baseline data. It can be stated that yoga involves Asana (posture- physical exercise), Pranayama (breathing exercise) and meditation (an approach to training the mind or focusing mind on a particular object) which might be the cause of increase in FVC, FEV1, PEFR, MVV and BHT and reduction in RR after yoga training. Yoga exercise and postures involve isometric contraction which might increase strength of respiratory muscles including diaphragm, intercostals muscles, and abdominal muscles and hence the increase in FVC, FEV1, PEFR, MVV and BHT and reduction in RR was observed after yoga training. Similar observations have been reported by many researchers (Doijad & Surdi, 2012; Halder *et al*., 2012; Gopal *et al*., 1973) [8, 9, 24]. An earlier study reported that regular Yoga practice resulted in decrease in resting respiratory rate (Patil, 2012) [25], improvement in BHT and MVV (Jiwtode & Mahajan, 2016) [26]. Kapalbhati in which forceful exhalation was performed by contracting the abdominal muscles, without any undue movements in the chest and shoulder region, and the inhalation is passive. This produces short powerful strokes of exhalation in quick succession with contraction of abdominal and diaphragm muscles which trains the subject to make full use of diaphragm and abdominal muscles in breathing (Makwana, Khirwadkar & Gupta, 1988) [27]. Thus yoga training might improves the strength of respiratory muscles performance which may in turn increased FEV1 in yoga group subjects. Anulom-vilom (Nadi Shodhan) alternate nostril breathing technique a part of pranayama increases the resistance of respiratory muscles which may increase peak expiratory flow rates and FEV1 due to strengthening of respiratory muscles in yoga group subjects. During yoga practice different breathing techniques may cause the respiratory apparatus to empty and fill quickly, completely and efficiently which may intern increased forced vital capacity (FVC) (Makwana, Khirwadkar & Gupta, 1988; Mehrotra *et al*., 1998) [28]. During pranayama all the maneuvers i.e. deep inspiration up to TLC and prolonged expiration up to residual volume, are done through nostrils which offer resistance by means of decreased cross sectional area and turbulence. Yoga with its calming effect on the mind can reduce and release emotional stresses, hereby withdrawing the broncho-constrictor effect (Jiwtode & Mahajan, 2016; Makwana, Khirwadkar & Gupta, 1988) [26, 28]. By practicing pranayama, the various reflex mechanisms that control respiratory center in bulbopontine area may be altered or modified by producing a strong cortical force thereby increasing the breath holding time or decreasing the resting respiratory rate (Jiwtode & Mahajan, 2016; Makwana, Khirwadkar & Gupta, 1988; Mehrotra *et al*., 1998) [16, 28]. Thus regular yoga practice may improve the pulmonary functions which are essential to maintain disease free lifestyle.

Conclusions

Regular practice of yoga helps to maintain normal healthy life style and physical fitness which is indicated by improving body composition, cardiovascular and pulmonary functions. The findings of the study demonstrate the efficacy of yoga on body composition, cardiovascular and pulmonary functions in healthy subjects. The findings of the present study suggest that yoga can be used as an effective life-style modality to reduce the chance of CVD and pulmonary diseases. Thus regular practice of yoga may be helpful to maintain disease free lifestyle.

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