DOI: 10.7860/JCDR/2018/36819.11932

Original Article

Physiology Section

Effect of Yoga on Cardio-Respiratory Health Markers: Physical Fitness Index and Maximum Oxygen Consumption (VO2 Max)

VISHNU D UDHAN[1], SHARADCHANDRA G WANKHEDE[2], SANGITA R PHATALE[3]

ABSTRACT

Introduction: Sedentary lifestyle is one of the major Cardio-vascular risk factor. Although, yoga is used as a mind-body exercise to increase physical fitness, data on effectiveness of long-term training of yoga on cardio-respiratory fitness in healthy adults is least available.

Aim: To find out the effect of Yoga practice on Physical Fitness Index (PFI) and Maximum Oxygen Consumption (VO_2 max) in healthy adults.

Materials and Methods: A pre-post interventional study was conducted on 200 (120 male and 80 female) healthy subjects. An intervention of Yoga (Asanas, Pranayama and Meditation) for six months (one hour per day, six days per week) was given. Weight, Body Mass Index (BMI), Basal Metabolic Rate (BMR), Physical Fitness Index (PFI) and VO_2 max were determined. PFI and VO_2 max were determined by using modified Harvard Step Test (HST) and modified Queen's College Step Test (QST), respectively. Data was collected at baseline and after six months of yoga training. Collected result data was analysed by using paired t-test.

Results: Yoga practice for six months caused significant reduction in weight and BMI ($p<0.0001$) and significant increase in BMR ($p=0.005$), PFI ($p<0.0001$) and VO_2 max ($p<0.0001$).

Conclusion: The findings of this study suggest that yoga is an effective mind-body modality to enhance cardio-respiratory fitness and reduce adiposity in healthy adults.

Keywords: Aerobic capacity, Cardiovascular endurance, Modified harvard step test, Modified queen's college step test

INTRODUCTION

Physical fitness is individual's capability to work with full strength and maximum attention; not succumbing to unjustified tiredness due to continuous work [1]. Some of the vital elements of physical fitness are cardiopulmonary fitness, muscle strength and force of contraction, body fat and muscle contents and flexibility [2]. Cardio-respiratory fitness is heart and lung's collective ability to transport and deliver adequate oxygen and body's ability to utilize maximum oxygen during the work so that work performance could last longer with sustained vigor. Adequate supplement and maximum utilization of supplied oxygen would enable person to work efficiently for long. For better physical work performance, there are numbers of cardio-respiratory adjustments being made by the body such as increase respiratory rate, oxygen uptake, heart rate, cardiac output and importantly marked increase in utilization of available oxygen by the cells [3].

Maximum oxygen consumption or aerobic capacity is abbreviated as VO_2 max. In VO_2 max, 'V' signifies the volume of the O_2 that is being utilized by exercising muscles in the body, whereas; 'max' indicate the maximum amount of O_2 that is utilized during muscular exercise. Generally, there is linear relation between exercise and VO_2 max therefore; it increases as exercise intensity increases. However, at the physiological limit in spite of further increase in exercise intensity, oxygen consumption remains same and attains plateau. This highest rate of oxygen utilization is maximum oxygen consumption (VO_2 Max) or maximum aerobic capacity [4]. Genetics plays a major role in a person's VO_2 max. Nevertheless maintaining very high levels of VO_2 max is possible when one has proper training. VO_2 max is considered as one of the strong indicator or marker for cardio-respiratory fitness or health by World Health Organization (WHO) demonstrating its strong association with better physical performance. Studied epidemiological data reveals that having a proportionally high VO_2 max is a strong sign of health and life expectancy in all age group individuals [3,5,6].

In developing countries like India with the increasing automated work environment, there is marked decline in physical activity at work places. Sedentary life style and eating habits have proven side effects over health conditions. As per the documented surveys and data available, Yoga is one of the most practiced complementary or alternative interventions to achieve best possible physical and mental health [7,8].

Positive health benefits of regular physical exercise on cardiopulmonary fitness by improving aerobic capacity are well documented in scientific literature [9]. However, data on effectiveness of long-term training of yoga on cardio-respiratory fitness in healthy adults with large sample is least available. Therefore, the present study was aimed to assess the efficacy of long-term yogic exercise on cardio-respiratory health markers in healthy adults. The part of study has been already published which had the same samples and weekly yoga exercise schedule [10].

MATERIALS AND METHODS

In this pre- and post yoga interventional study, minimum sample size (n) was determined by using formula in [11] and minimum sample size =188. Therefore 200 healthy individuals (120 male and 80 female) with age ranging between 30 to 50 years with mean age of 39±0.95 years were selected. Written consent was obtained from study subjects. Individuals with any systemic disease, mental disorders, pregnant women and practicing any type of physical exercise or yoga were excluded from study. Healthy individuals willing to practice yoga continuously for six months (one hour per day, weekly six days) were included in the present study. The study was approved by institutional ethical committee (Registration No. ECR/581/INST/MH/2014) and conducted at Department of Physiology, MGM Medical College Aurangabad, India, during period of February 2016 to February 2018. Yoga was practiced under the supervision of qualified yoga teacher. Weekly yoga exercise schedule is shown in [Table/Fig-1] [10].

Day	Yogic Exercise with Timing
Monday and Thursday	Prayer (4 min); Joint Movements (6 min); Suryanamaskar (12 min); Tadasan, Trikonasan, Virbhadrasan, Vrukshasan, Shavasana (21 min); Pranayama (15 min): Yogshwasan, Anulom-Vilom, Kapalbhati, Bhastrika; Prayer (2 min).
Tuesday and Friday	Prayer (3 min); Joint Movements (6 min); Suryanamaskar (12 min); Naukasan, Dhanurasan, Setubandhasan, Sarpasan, Shalbhasan, Shavasana (21 min), Pranayama (15 min): Yogshwasan, Anulom-Vilom, Kapalbhati, Bhramari; Prayer (2 min).
Wednesday	Prayer (3 min); Joint Movements (6 min); Suryanamaskar (10 min); Pachimottanasan, Sarvangasan, Halasan, Pawanmuktasan, Gomukhasan, Vakrasan, Shavasana (21 min); Pranayama (15 min): Yogshwasan, Anulom-Vilom, Kapalbhati, Bhramari; Prayer (2 min).
Saturday	Prayer (3 min); Joint Movements (6 min); Suryanamaskar (15 min); Meditation (32 min); Prayer (4 min)
Sunday	Holiday

[Table/Fig-1]: Weekly schedule for yoga exercise at Yoga centre.

Data was collected at baseline (pre-yoga) and after six months of yoga training (post-yoga). Weight, BMI, BMR, PFI and VO_2max were determined. BMI was calculated by using formula: BMI=weight (kg)/ height (m^2); BMR was determined by using Harris-Benedict equation [12]. PFI and VO_2 Max were estimated by using modified HST [13-15] and modified QST [16,17], respectively.

Physical Fitness Index (PFI): PFI was measured by using HST. In this modified step test 18 inches step was used. The subjects were asked to step up and step down in up-up and down-down fashion at the rate of 30 steps per minute keeping time on metronome for the duration of 5 minutes unless subject stops from exhaustion. The recovery pulse rate was counted at 1 to 1.5; 2 to 2.5 and 3 to 3.5 minutes recovery. PFI was calculated by using formula as PFI = (Duration of exercise in sec x 100) / {2 x (sum of 1 to 1.5, 2 to 2.5, 3 to 3.5 minutes recovery)}.

Maximum Oxygen Consumption (VO_2max): In this modified step test 16.25 inches step was used. The subjects were asked to step up and down in up-up and down-down fashion at the rate of 24 steps per minute for male and 22 steps per minutes for female keeping time on metronome for 3 minutes unless subject stops from exhaustion. The recovery pulse was counted from 5 to 20 seconds after stoppage of exercise. VO_2 Max was calculated by using formulae for male subject, VO_2 Max = 111.33–0.42 (Pulse count in 15 sec x 4); and for female subject, VO_2 Max = 65.81 – 0.1847 (Pulse count in 15 sec x 4).

Basal Metabolic Rate (BMR): BMR was calculated by using Harris-Benedict equation [12], as- for men, BMR=66+ (13.7 x weight (kg)) + (5 x height (cm)) – (6.8 x age (years)); and for female, BMR=655+ (9.6 x weight (kg)) + (1.8 x height (cm)) – (4.7 x age (years)).

STATISTICAL ANALYSIS

Collected result data was statistically analysed by using data SPSS (Version 24th). Pre and post-yogic values were compared applying paired t-test. In the statistical analysis, p-value was established at 5% level of significance.

RESULTS

Pre-yogic exercise and post-yogic exercise mean weight, BMI and BMR were measured and summarized in [Table/Fig-2]. It shows a significant reduction in mean weight by 1.87kg (p<0.0001) mean BMI by 0.67kg/m^2 (p<0.0001). While BMR was significantly higher by 20.44 calories per day (p=0.005).

Mean PFI and VO_2 max at baseline and after six months of yoga practice is summarized in [Table/Fig-3]. It shows, after six months of regular yoga practice, PFI was significantly increased by 19.83 (56.15%) (p<0.0001) and VO_2 max by 6.30 ml/kg/min 14.43% (p<0.0001).

Variables	Measurements	Mean±SD (n=200)	Mean Difference	t-value	p-value
Weight (kg)	Pre-Yogic Exercise	69.19±10.95	1.87	8.22	p<0.0001***
	Post-Yogic Exercise	67.32±8.82			
BMI (kg/m^2)	Pre-Yogic Exercise	25.30±3.46	0.67	7.01	p<0.0001***
	Post-Yogic Exercise	24.63±2.65			
BMR	Pre-Yogic Exercise	1490.74±194.48	20.44	2.83	p=0.005**
	Post-Yogic Exercise	1511.18±172.67			

[Table/Fig-2]: Comparison of Pre and Post-yogic exercise Weight, Body Mass Index (BMI), Basal Metabolic Rate (BMR).
SD: Standard Deviation; ***p<0.0001; **p=0.005; statistical test: paired t-test

Variables	Measurements	Mean±SD (n=200)	Mean Difference	t-value	p-value
PFI	Pre-Yogic Exercise	35.31±16.89	19.83	24.20	p<0.0001***
	Post-Yogic Exercise	55.13±19.67			
VO_2 Max (ml/kg/min)	Pre-Yogic Exercise	43.73±6.28	6.30	18.02	p<0.0001***
	Post-Yogic Exercise	50.04±6.95			

[Table/Fig-3]: Comparison of Pre and Post-yogic exercise PFI and VO_2 max.
SD: Standard Deviation; S: Significant; ***p<0.0001, statistical test: paired t-test

DISCUSSION

This study was aimed to find the effect of long-term training of yoga for six months on cardio-respiratory fitness by determining the PFI, and VO_2 max profile along with the anthropologic parameters in healthy adults.

We found a highly significant reduction (p<0.0001) in body weight and BMI (p<0.0001) following yoga training for six months. However, a significant increase in post-yogic BMR was noticed (p=0.005) [Table/Fig-2]. Post-yogic values for PFI and VO_2max were significantly higher (p<0.0001) than its pre-yogic values [Table/Fig-3]. These findings indicate positive effects of yoga on the cardio-respiratory fitness.

The outcomes of this study i.e., reduction in weight and BMI after yoga practice were consistent with the findings of other studies [18,19]. Few other studies have also reported the reduction in BMI after yoga regimen [20,21]. Further, Parmar D et al., have reported that, overweight individuals were having less physical fitness in comparison to normal BMI individuals [22]. In the context of the findings of Parmar D et al., the present study reports an improvement in BMI after yoga practice [22]. Hence, we presume that the enhancement in physical fitness might be due to improvement in BMI.

Thuse MP in his study found the improvement in BMI and physical fitness efficiency following 14 weeks of yoga intervention [23]. Significant increase in maximum oxygen consumption (VO_2 max) post-yogic exercise in our study matches with the findings of Tran MD et al., [24]. According to him, increase in VO_2max may be attributed to increased muscular endurance resulting from the yoga practice. Our findings related to increase in PFI and VO_2max were in accordance with findings of Balasubramanian B et al., [25]. They have reported significant rise in cardiopulmonary fitness after six months of yoga training. In their treatise, they made it clear that increase in VO_2 max is due to increased oxygen consumption by the muscle as a result of yogic exercise which in turn suggests an increase in muscle blood flow. Further, Gharote MC, reiterates this effect is due to generalized decrease in vascular tone resulting from stimulation of parasympathetic activity during the yogic training [26].

So, significant improvement in BMI, PFI and VO2 max by yogic exercises in healthy individuals adds extra fitness to cardiorespiratory health.

LIMITATION

The present study was conducted on yoga group only. There was no control group considered. Measurement and comparison of PFI and VO_2 max in yoga and control group would have given much more clear idea about the effect of yoga on cardiorespiratory fitness. Male and female subjects were included in the study but considered whole cohort as a single unit so, no separate analysis was done. In future, the study may be conducted with- i) yoga group along with control group; and ii) comparative analysis of data for male and female subjects, separately.

CONCLUSION

The outcomes of the present study may encourage implementing yoga exercise as cardio-respiratory fitness regimen. Regular yoga exercise may also be adopted as BMI improving workout.

Declaration: The present study was the part of PhD research work. Principal Researcher: Vishnu D Udhan; Guide: Dr. Sharadchandra G Wankhede.

ACKNOWLEDGEMENTS

Special Thanks to Dr. Jayant P Baride, Dr. Pravin Kalyankar, Dr. Shrikant L Patil, Dr. Narayan Khurde, Dr. Pramod Shinde, Shri. Balasaheb Joshi, Mr. Suraj Thete and all the study participants.

REFERENCES

[1] Clarke HH. Basic understanding of physical fitness, Physical Fitness. Research Digest Series. 1971;1(2):1-10.
[2] Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise and physical fitness: definitions and distinctions for health related research. Journal Health Rep. 1985;100(2):126-31.
[3] de Araujo CGS, Heardy AH, Stein R. Maximum oxygen consumption measurement: Valuable biological marker in health and sickness. Arq Bras Cardiol. 2013;100(4):Le51–e53.
[4] Turnley J. VO_2 max : How can an Endurance Athlete use it to obtain Peak Performance? [Internet] Available from: http://henryortho.com/pdf/VO2max.pdf. Accessed on March 15, 2018.
[5] Shreehari P, Khan MI, Sreemala P, Khan TT, Mudassir M. VO_2 max estimation in medical students. J Cont Med A Dent. 2013;1(1):26-29.
[6] Shephard RJ, Allen C, Benade AJ, Davies CT, Di Prampero PE, Hedman R, et al. The maximum oxygen intake: An international reference standard of cardio-respiratory fitness. Bull World Health Organ. 1968;38:757-64.
[7] Salmon PG, Bayley-Velose R. Clinical yoga research: current status and recent developments. J Yoga Phys Ther. 2016;6:254.
[8] Salmon P, Lush E, Jablonski M, Sephton SE. Yoga and Mindfulness: Clinical aspect of an Ancient Mind/Body Practice. Cognitive and Behavioral Practice. 2009;16:59-72.
[9] Shashikala L, Geetanjali H T, Banner R, Sanjeev kumar, Natraj SM. Efficiency of recovery pulse rate as an index of physical fitness. Indian Journal of Fundamental and Applied Life Sciences. 2014;4(2):216-19.
[10] Udhan VD, Wankhede SG, Shinde P. Effectiveness of yoga as mind-body exercise on memory, perceived stress and mental health. Int J Adv Res. 2018;6(4):147-51.
[11] Bhalwar R (ed). Textbook of Public Health and Community Medicine. 1st ed. New Delhi: Published in Collaboration with WHO; 2009.
[12] Harris J, Benedict J. A Biometric Study of Human Basal Metabolism. PNAS. 1918;4(12): 370-73.
[13] Brouha, L. The step test: A simple method of measuring physical fitness for muscular work in young men. Research Quarterly. 1943;14:31-35.
[14] Ryhming I. A modified Harvard step test for the evaluation of physical fitness. Arbeits Physiologie. 1953;15(3):235-50.
[15] Gallagher JR, Brouha L. A Simple method of evaluating fitness in boys: the step test. Yale J Biol Med. 1943;15(6):769-79.
[16] McArdle WD, Katch FI, Pechar GS, Jacobson L, Ruck S. Reliability and interrelationships between maximal oxygen uptake, physical work capacity and step test scores in college women. Med Sci Sports. 1972;4(4):182-86.
[17] Queen's College Step Test. [Internet] Available from: https://www.kinnect.com.au/wp- content/uploads/2014/09/Queens-College-Step-Test.pdf. Accessed on March 15, 2018.
[18] Chauhan A, Semwal DK, Mishra SP, Semwal RB. Yoga practice improve the body mass index and blood pressure: A randomized controlled trial. Int J Yoga. 2017;10(2):103-06.
[19] Sucheta Kumari N, Damodara Gowda KM, Sukesh N, Madhu LN, Kathyayani. Effect of yoga therapy on body mass index and oxidative status. Nitte University Journal of Health Science. 2011;1(1-3):10-14.
[20] Rshikesan PB, Subramanya P. Nidhi R. Yoga practice for reducing male obesity & weight related psychological difficulties: a randomized control trial. J Clin Diagn Res. 2016;10(11):OC22-OC28.
[21] Yadav R, Yadav RK, Pande RM, Kochar KP. Effect of Short-term yoga based lifestyle intervention on health related quality of life in overweight and obese subjects. J Altern Compliment Med. 2016;22(6):443-49.
[22] Parmar D, Vaghela V. Study of physical fitness index using modified harvard step test in relation with body mass index in physiotherapy students. International Journal of Recent Advances in Multidisciplinary Research. 2015;2(12):1075-77.
[23] Thuse MP. The effect of Yoga on health related to physical fitness programme on the female of Amravati town. Internat J Phy Edu. 2011;4(1):155-57.
[24] Tran MD, Holly RG, Lashbrook J, Amsterdam EA. Effect of hatha yoga practice on the health-related aspects of physical fitness. Prev Cardiol. 2001;4(4):165-70.
[25] Balasubramanian B, Pansare MS. Effect of yoga on aerobic power on muscles. Indian J Physiol Phamacol. 1991;35(4):281-82.
[26] Gharote MC. A psychological study of the effect of short term yogic training on adolescent high school boys. Yoga Mimansa. 1971;14(1-2):92-99.

PARTICULARS OF CONTRIBUTORS:
1. PhD Scholar, Department of Physiology, MGM Medical College, Aurangabad, Maharashtra, India.
2. Professor, Department of Physiology, MGM Medical College, Aurangabad, Maharashtra, India.
3. Professor, Department of Physiology, MGM Medical College, Aurangabad, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Mr. Vishnu D Udhan,
Department of Physiology, MGM Medical College, N-6, Aurangabad-431003, Maharashtra, India.
E-mail: vishnu.udhan@gmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Apr 16, 2018**
Date of Peer Review: **Jun 04, 2018**
Date of Acceptance: **Jul 02, 2018**
Date of Publishing: **Aug 01, 2018**