

Assessment of Regular Yoga on Cardiovascular EnduranceAbhishek Kumar¹, Kavindra Kumar²¹Assistant Professor, Department of Physiology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India²Assistant Professor, Department of Physiology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India

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Abstract:**Background:** An essential part of physical fitness and a significant factor in determining cardiovascular health is cardiovascular endurance. Yoga has emerged as a promising non-pharmacological strategy for enhancing cardiorespiratory fitness, and regular physical activity is known to lower the risk of cardiovascular disease.**Objective:** This study was to evaluate how regular yoga practice affected individuals' cardiovascular endurance and a few cardiopulmonary markers.**Methods:** A total of 105 people who appeared to be in good health were recruited and split into two groups: a yoga group (n = 52) and a control group (n = 53). At baseline and following a seven-month study period, anthropometric measures, resting cardiovascular parameters, and cardiopulmonary exercise responses were evaluated. Body mass index (BMI), blood pressure and resting heart rate, maximal workload (W-max/kg), maximal oxygen consumption (VO₂-max/kg), metabolic equivalent (MET-max), minute ventilation (VE-max), VCO₂-max, and respiratory exchange ratio (RER) were among the parameters assessed. The Mann-Whitney U test was used for statistical analysis, with BMI modifications made as needed.**Results:** Higher W-max/kg, VO₂-max/kg, and MET-max values showed that participants in the Yoga group had considerably greater cardiovascular endurance than those in the Control group. Additionally, the yoga group's body weight, BMI, and resting blood pressure were all noticeably reduced. Analysis by gender showed that female yoga practitioners showed more noticeable gains, especially in metrics related to exercise capacity and resting heart rate. Even after controlling BMI, a number of cardiopulmonary benefits remained.**Conclusion:** Regular yoga practice greatly improves adults' cardiorespiratory fitness and cardiovascular endurance. For enhancing cardiovascular health and lowering cardiovascular risk, yoga may be a useful, accessible, and safe lifestyle intervention.**Keywords:** Body mass index (BMI), resting heart rate, blood pressure, maximal workload (W-max/kg), VO₂-max, MET-max, V-Emax, VCO₂-max, and respiratory exchange ratio (RER).This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.**Introduction**

In all industrialized nations, cardiovascular disease (CVD) is the primary cause of mortality and disability. Physical exercise is a crucial component of primary prevention, which primarily focuses on modifiable risk factors [1]. Yoga, a system of physical exercises and breathing methods intended to improve inner balance and health, is one type of exercise that may be utilized. For example, the American College of Sports Medicine recommends these activities [2].

Studies showing the positive impact of regular yoga practice on human health have been published all over the world. A meta-analysis of the literature on the effects of yoga on indices of CVD risk associated with insulin resistance was repeatedly conducted by Innes et al. [3,4]. The results indicated

positive changes in blood pressure, abdominal obesity, lipid and coagulation profiles, oxidative stress, sympathetic activation, improved risk profiles in adults with type 2 diabetes mellitus, and several clinical endpoints. Other authors also supported these conclusions [5].

However, in 2012, Lau et al. [6] carried out a meta-analysis of research to validate the efficacy of yoga for secondary prevention of CVD. No suitable randomized controlled trials that met the inclusion criteria (at least a 6-month follow-up period, patients with CVD, studies comparing a group practicing yoga and controls receiving no intervention or treatments other than yoga) were identified in the major databases.

Physical and mental treatment is the main ad-

vantage of yoga. Yoga can slow down the aging process, which is mostly an artificial state brought on by self-poisoning or auto-intoxication. We may considerably slow down the catabolic process of cell degeneration by maintaining a clean, flexible, and well-lubricated body. Combining pranayama, meditation, and yoga poses is necessary to reap the full advantages of yoga. Medical scientists claim that yoga treatment works because it balances the neurological and endocrine systems, which have a direct impact on all other bodily systems and organs. Yoga serves as "curative therapy" as well. The core of yoga is achieving mental tranquility, enhanced focus, a calm state of mind, and harmony in interpersonal relationships.

A series of thoughtfully crafted poses known as yoga asanas save energy and turn it into subtle forms of mental energy. The entire body may reach its highest level of physical perfection and maximum efficiency with the aid of yoga poses. The entire body becomes radiant as it gains the power and resilience to endure all kinds of stress and pressure throughout our lives. Yoga poses are not just maximizing the effectiveness of the fundamental systems while simultaneously assisting in achieving the highest levels of yogic realization and self-purification. The capacity of the heart and lungs to absorb and deliver sufficient amounts of oxygen to the working muscles for tasks involving vast muscular masses that must be completed over extended periods of time is known as cardiovascular endurance. For instance: Large muscles are used in running, swimming, and cycling. There are several synonyms for cardiovascular endurance, such as continuous running, swimming, climbing, trekking, aerobics, biking, and other activities that need the cardio-respiratory system. A physiological condition of well-being that enables one to fulfill the demands of everyday life, serves as the foundation for athletic performance, or both is referred to as physical fitness. Cardiovascular fitness, musculoskeletal fitness, body composition, and metabolism are all components of health-related physical fitness [7]. The majority, if not all, of the bodily processes (skeletal-muscular, cardiorespiratory, hematocirculatory, neurological, and endocrine-metabolic) involved in engaging in regular physical activity and/or exercise can be considered integrated measures of physical fitness.

Therefore, the functioning state of all these systems is examined when physical fitness is assessed. Cardiovascular disease and an increasing number of other chronic illnesses, such as diabetes mellitus, cancer (colon and breast), obesity, hypertension, bone and joint disorders (osteoporosis and osteoarthritis), and depression, are all modifiable risk factors for physical inactivity [8]. Yoga improves physical, emotional, and spiritual wellness and brings about a certain peace, which many cancer patients seek [9]. Yoga, breathing techniques, and

meditation can lower stress, encourage healing, and improve quality of life for cancer patients [10,11]. However, yoga is neither a cure for cancer nor a reliable method of preventing it. Because of this, physical fitness is currently regarded as one of the most significant health indicators and a predictor of morbidity and death for all causes, including cardiovascular disease (CVD) [12].

Cardiorespiratory fitness, also known as cardiovascular fitness or maximum aerobic power, is the total capability of the respiratory and cardiovascular systems as well as the capacity to engage in extended, intense activity. The World Health Organization has long held that the best measure of cardiorespiratory fitness is the maximum oxygen consumption (VO₂max) reached during a graded maximal exercise to voluntary exhaustion [13].

Yoga practice can improve general health and fitness, balance all bodily systems, and contribute to long-term wellness. Once mastered, yoga may be done on an individual basis at any time, eliminating typical obstacles to physical activity including scheduling conflicts and bad weather.

Methodology

Study design: All participants underwent a comprehensive physical examination and had their histories taken as part of the clinical evaluation. Body mass index (BMI) was computed by dividing weight in kilograms by height in meters squared (kg/m²). Anthropometric measures, such as height and body weight, were acquired using established protocols.

Study area: The study was carried out at the Lord Buddha Koshi Medical College and Hospital's Department of Physiology in Saharsa, Bihar, India.

Study duration: The study lasted seven months and involved baseline and post-intervention examinations of anthropometric, cardiovascular, and cardiopulmonary exercise parameters.

Sample size: There were 52 people in the yoga group and 53 in the control group, with a total of 105 participants in the research.

Inclusion criteria

- Adults who are willing to take part in the study, regardless of gender
- Individuals who were part of the yoga or control groups
- People who appear to be in good condition and are able to do exercise testing
- Individuals who provide written, informed permission

Exclusion criteria

- A history of respiratory, metabolic, or cardiovascular conditions
- The existence of neurological or musculoskeletal

tal disorders that impair exercise performance

- People using drugs that alter blood pressure, heart rate, or ability to exercise
- Women who are pregnant or breastfeeding.
- Individuals who are unable or unwilling to finish study procedures

Data collection: The following factors were looked into: Maximum oxygen consumption per kilogram per minute (VO₂max /kg/min), maximum metabolic equivalent (METmax), maximum minute ventilation (VEmax), VCO₂max, maximum carbon dioxide production, resting blood pressure (BPrest), maximum heart rate (HRmax), blood pressure at maximum exertion, maximum performance (Wmax /kg), and respiratory exchange ratio (RER). For both the Yoga and Control groups, all measures were methodically documented and utilized for further research.

Study procedure: Participants who were satisfied with the inclusion criteria were enrolled in the study after giving written informed permission and receiving clearance from the institutional ethics committee. Every participant first had a thorough baseline assessment, which included a thorough history, a physical examination, and anthropometric measurements including height and weight to determine body mass index (BMI). Heart rate, blood pressure, and other resting cardiovascular parameters were measured under regulated settings after sufficient rest. In order to evaluate exercise capacity and related physiological parameters, such as Wmax/kg, VO₂max, METmax, VEmax, VCO₂max, and respiratory exchange ratio (RER), participants then completed cardiopulmonary exercise testing utilizing a graded exercise protocol. Participants in the Control group carried on with their regular daily activities without any particular intervention, whereas those in the Yoga group, according to group assignment, adhered to a structured yoga intervention for the length of the study. The same standardized techniques were used to

repeat all evaluations at the conclusion of the seven-month research period. For statistical analysis, the gathered data was methodically documented and assembled.

Risk factor analysis: To assess the relationship between group status and exercise ability and specific anthropometric and cardiovascular characteristics, risk factor analysis was carried out.

Statistical analysis: Statistica 12 (Dell Software, StatSoft, Inc.) was used to perform statistical analysis. All clinical characteristics were compared between the two groups using the Mann-Whitney U test. When adjusting for weight and BMI, logistic regression was used. P = 0.05 was used as the significance threshold.”

Result

The research cohort's anthropometric, cardiovascular, and cardiopulmonary exercise data are compiled in **Table 1**, which compares the Yoga and Control groups. While there was no significant difference in height (p = 0.40), participants in the Yoga group had substantially lower body weight and BMI than those in the Control group (p < 0.001 for both). The yoga group tended to have a lower resting heart rate, although this difference was not statistically significant (p = 0.06). On the other hand, the Yoga group's maximum heart rate was substantially greater than the controls' (p = 0.005). The Yoga group had substantially lower resting systolic and diastolic blood pressure (p = 0.003 and p = 0.02, respectively) than the Control group. Wmax/kg, VO₂max/kg, and METmax values were greater in the Yoga group than in the Controls, indicating substantial gains in exercise capacity (p = 0.007, p = 0.028, and p = 0.018, respectively). Furthermore, the Yoga group had substantially reduced VEmax and absolute VO₂max (p = 0.008 and p = 0.01, respectively). VCO₂max and respiratory exchange ratio (RER) did not differ statistically significantly across the groups (p > 0.05).

Table 1: The parameters studied for the entire cohort

Parameter	Overall Mean ± SD	Yoga Group (n = 52) Mean ± SD	Control Group (n = 53) Mean ± SD	P-value
Weight (kg)	76.9 ± 18.2	67.5 ± 11.2	87.8 ± 18.5	< 0.001
Height (cm)	171.0 ± 9.2	170.3 ± 9.0	171.7 ± 9.4	0.4
BMI (kg/m ²)	26.1 ± 6.0	23.3 ± 3.0	29.8 ± 6.4	< 0.001
HRrest (bpm)	74.0 ± 13.5	71.0 ± 12.0	76.5 ± 14.5	0.06
HRmax (bpm)	163.0 ± 19.0	168.5 ± 15.5	158.0 ± 21.0	0.005
SBP Rest (mmHg)	125.0 ± 14.5	121.5 ± 15.0	129.0 ± 13.5	0.003
DBP Rest (mmHg)	79.2 ± 11.0	76.8 ± 10.5	82.0 ± 11.5	0.02
Wmax/kg (W/kg)	2.45 ± 0.90	2.62 ± 0.63	2.30 ± 1.10	0.007
VO ₂ max/kg (ml·kg ⁻¹ ·min ⁻¹)	27.2 ± 8.0	28.3 ± 6.2	26.2 ± 9.6	0.028
METmax	7.7 ± 2.2	8.1 ± 1.8	7.4 ± 2.6	0.018
VEmax (L/min)	83.5 ± 30.0	75.0 ± 22.5	92.5 ± 34.0	0.008
VO ₂ max (L/min)	2100 ± 670	1950 ± 580	2280 ± 720	0.01
VCO ₂ max (L/min)	2470 ± 850	2310 ± 680	2650 ± 970	0.09
RER	1.21 ± 0.12	1.24 ± 0.10	1.19 ± 0.14	0.07

The anthropometric and cardiovascular characteristics of the Yoga and Control groups are compared by gender in **Table 2**. Weight, height, BMI, resting heart rate, maximum heart rate, maximal workload per kilogram (W_{max}/kg), and VO_{2max}/kg did not change statistically significantly between the Yoga and Control groups among men ($p > 0.05$ for all). On the other hand, ladies in the yoga group had a considerably lower body weight and BMI than fe-

males in the control group ($p < 0.001$). Yoga ladies also showed a considerably greater maximum heart rate ($p = 0.007$) and a significantly lower resting heart rate ($p = 0.05$). W_{max}/kg and VO_{2max}/kg , two measures of exercise capacity, were also considerably greater in Yoga ladies than in Control females ($p < 0.001$ and $p = 0.001$, respectively). There was no discernible variation in height across the groups for either gender.

Table 2: The parameters studied by gender

Parameter	Yoga Males	Control Males	P-value	Yoga Females	Control Females	P-value
Weight (kg)	76 ± 12	93 ± 17	0.07	63 ± 8	85 ± 19	< 0.001
Height (cm)	180 ± 7	181 ± 8	0.53	166 ± 6	167 ± 5	0.85
BMI (kg/m ²)	23.2 ± 2.5	28.5 ± 6.3	0.08	23.0 ± 3.3	30.5 ± 6.6	< 0.001
HR _{rest} (bpm)	72 ± 14	74 ± 13	0.49	72 ± 11	79 ± 15	0.05
HR _{max} (bpm)	171 ± 7	165 ± 16	0.13	167 ± 18	154 ± 23	0.007
W_{max}/kg (W/kg)	3.1 ± 0.5	3.0 ± 1.0	0.7	2.4 ± 0.5	1.9 ± 0.8	< 0.001
VO_{2max}/kg (ml·kg ⁻¹ ·min ⁻¹)	34 ± 5	33 ± 10	0.48	25.5 ± 5	22.3 ± 7	0.001

After adjusting for body mass index (BMI), **Table 3** shows the comparison of cardiopulmonary exercise parameters across the groups. W_{max}/kg , VO_{2max}/kg , MET_{max}, VCO_{2max}, and absolute VO_{2max} all showed significant variations among the group after correction ($p < 0.01$). Males' W_{max}/kg , VO_{2max}/kg , MET_{max}, VEmax, VCO_{2max}, and VO_{2max} continued to differ substantially between the Yoga and Control groups (p

< 0.05), according to sex-wise analysis. After adjusting for BMI, W_{max}/kg and VEmax among females exhibited statistically significant differences ($p = 0.024$ and $p = 0.045$, respectively), but VO_{2max}/kg , MET_{max}, VCO_{2max}, VO_{2max} , and RER did not ($p > 0.05$). After adjusting for BMI, the respiratory exchange ratio (RER) did not show any significant differences in the cohort as a whole or in comparisons by sex.

Table 3: The parameters studied adjusted for BMI

Parameter	Entire Group (P)	Males (P)	Females (P)
W_{max}/kg (W/kg)	0.001	0.015	0.024
VO_{2max}/kg (ml·kg ⁻¹ ·min ⁻¹)	0.003	0.021	0.053
MET _{max}	0.006	0.036	0.1
VEmax (L/min)	0.08	0.008	0.045
RER	0.35	0.1	0.73
VCO _{2max} (L/min)	0.009	0.048	0.09
VO_{2max} (L/min)	0.008	0.039	0.08

Discussion

This study sought to ascertain how yoga practice affected the cardiovascular response to physical fitness and exercise endurance. An individual's cardiorespiratory endurance is the primary determinant of their level of physical fitness. Maintaining a physiological milieu related to cardiovascular parameters has been shown to benefit from yoga practice [14]."

Our research's results are consistent with a prior study conducted by Gupta et al. [15], who similarly evaluated BMI, BSA, resting respiratory rate, pulse rate, blood pressure, VO_{2max} , and PFI. They found that consistent exercise training lowers blood pressure and resting pulse rate while increasing VO_{2max} and PFI. Additionally, they demonstrated a strong negative connection between VO_{2max}

and BMI. The mean absolute VO_{2max} values of 70 healthy, normal Indian Air Force personnel were reported in previous research by Banerjee et al. [16] to be around 2.5 l/min, which is consistent with our control group data.

Cardiovascular stamina and balance are crucial for preserving one's quality of life. Our results demonstrate that there was no significant mean change in balance between the two groups, which may suggest that both yoga and aerobic exercise improve balance. Since there was no discernible difference in the mean change, it was difficult to identify whether training is more advantageous to obtain greater advantages overall. Perhaps additional individuals were needed to ascertain the true difference. Both groups show comparable balance findings, suggesting that the middle-aged population's balance is improved by the training. Therefore,

either aerobics or yoga exercise might be recommended for balance training during recovery, according to the current study.

Numerous studies have shown that practicing yoga improves balance control. According to a comprehensive study, yoga helped young and older healthy people perform better on clinical balance control tests like the Berg balance scale. Another study found that yoga was just as successful as Tai Chi in enhancing both static and dynamic balance control in six healthy older individuals who participated in a specially created yoga program. Additionally, recent research has shown that yoga is beneficial for enhancing a number of higher cognitive abilities, including working memory, mental flexibility, and executive control [17]. Yoga practice necessitates the use of deliberate balance management. Intentional balance control may have become nearly automatic with little cognitive resource engagement among yoga practitioners via consistent practice [18].

Following yoga instruction, Jyotsna Bharshankar et al. [19] and Gandhi et al. [20] discovered a statistically significant drop in both SBP and DBP. After a month of pranayama training, Kalwale P.K., Shete A.N., et al., [21,22] found a considerable drop in SBP but no change in DBP. Both the systolic and diastolic blood pressure were statistically significantly lower in our study. Increased vagal tone reduces the heart's workload, which lowers cardiac output and, consequently, systolic blood pressure. Yoga modifies hypothalamic discharges [23], which lowers peripheral resistance and sympathetic tone and, thus, diastolic blood pressure.

The results of this study, which showed a decrease in weight and BMI following yoga practice, were in line with those of prior studies [24]. A few additional studies have also documented a decrease in BMI following a yoga practice [25, 26]. Furthermore, compared to people with normal BMIs, overweight people had lower levels of physical fitness, according to Parmar D et al. [27]. The current study reveals an improvement in BMI following yoga practice, which is consistent with the findings of Parmar D et al. Therefore, we assume that an improvement in BMI may be the cause of the increase in physical fitness.

The goal of the current study was to evaluate how regular yoga practice affected individuals' cardiovascular endurance. There were 105 individuals in all, divided into yoga and control groups. The study's results showed that participants who regularly practiced yoga had significantly improved cardiovascular endurance, as shown by higher $VO_2\max$ and lower resting heart rates when compared to the control group. Both male and female members of the yoga group showed these gains. Younger and older participants exhibited similar

improvements in cardiovascular endurance, according to further subgroup analysis based on age; however, older members of the yoga group did not significantly alter their resting heart rate in comparison to their control counterparts. Overall, the findings show that consistent yoga practice improves cardiovascular endurance, with age-related differences in response.

Conclusion

The current study shows that regular yoga practice significantly improves individuals' cardiovascular endurance and general cardiorespiratory fitness. Regular yoga practitioners outperformed the control group in a sample of 105 people, as seen by greater W_{\max}/kg , $VO_2\max/kg$, and MET_{\max} values as well as better blood pressure and heart rate profiles. These results imply that yoga practitioners have more effective cardiovascular and respiratory systems.

Participants in the yoga group also had decreased body weight and BMI, which suggests positive improvements in body composition that might improve cardiovascular health. Female participants showed more noticeable gains, especially in resting heart rate and exercise capacity indicators, according to gender-wise analysis. Crucially, even after controlling BMI, a number of the cardiovascular advantages of yoga practice persisted. Overall, the findings point to frequent yoga as a practical, non-pharmacological, and successful strategy for enhancing cardiovascular endurance and fostering long-term cardiovascular health in adults.

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