DOI: 10.7860/JCDR/2024/66733.19043

Original Article

Physiology Section

Impacts of the Surya Namaskar on Body Composition and Physiological Parameters among Yoga and Non Yoga Professionals: A Quasi-experimental Study

RAMESWAR PAL[1], SOBIKA RAO[2], GURU DEO[3], ISHWAR V BASAVARADDI[4], NEETU SHARMA[5], LALIT MADAAN[6]

ABSTRACT

Introduction: Surya Namaskar (SN) (also known as Sun Salutation) in the Bihar School of Yoga tradition comprises eight different postures completed in twelve steps sequentially. There are different views and schools of SN according to various traditions. Several studies have been conducted to demonstrate the effects of SN on the physiological, physical, and mental aspects of practitioners; however, its comparative effect on Yoga professionals and Non Yoga professionals has not been extensively explored.

Aim: To determine the impacts of SN on body composition and physical and physiological variables among Yoga and Non Yoga professionals.

Materials and Methods: This was a quasi-experimental study conducted at Morarji Desai National Institute of Yoga, New Delhi, India from March 2021 to May 2021. The study involved three groups with 10 subjects each: the Non Yoga Professional Control group (NYPC), the Non Yoga Professional Surya Namaskar group (NYPS), and the Yoga Professional Surya Namaskar group (YPS). The NYPS and YPS groups practiced 12 rounds of SN, totaling 24 minutes daily for 5 days a week over 6 weeks. Height, weight, Body Mass Index (BMI), Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Breathe Holding Time (BHT), Right Hand Grip Strength (RHGS), Left Hand Grip Strength (LHGS), Flexibility, Muscle mass, Percentage Body Fat (PBF%), total Body Fat (BF), Bone Mass (BM), Waist to Hip Ratio (WHR), and Basal Metabolic Rate (BMR) were recorded on the first day and after six weeks. GraphPad Instat Windows-based software, version 3.0, was used to complete the statistical analysis. Intergroup comparison was performed using Repeated Measure Analysis of Variance (ANOVA). Pre- and post-comparisons were made using t-tests. The level of significance was set at $p \leq 0.05$.

Results: A significant reduction was observed in HR ($p \leq 0.05$), SBP ($p \leq 0.01$), Pulse Pressure (PP) ($p \leq 0.05$), Double Product (DoP) ($p \leq 0.05$), and Rate Pressure Product (RPP) ($p \leq 0.05$) following SN in the NYPS group. A significant reduction was observed in SBP ($p \leq 0.01$), DBP ($p \leq 0.05$), and MBP ($p \leq 0.01$) following Surya Namaskar practice in the YPS group. BHT ($p \leq 0.05$), RHGS ($p \leq 0.05$), LHGS ($p \leq 0.05$), and flexibility ($p \leq 0.01$) significantly increased following SN in the NYPS group. Flexibility was significantly increased ($p \leq 0.05$) following SN in the YPS group. PBF and BF decreased significantly ($p \leq 0.001$) following SN in the NYPS group.

Conclusion: The SN has demonstrated effects on the physical, physiological, and therapeutic aspects of practitioners. The present study established that the practice of SN improves body composition and cardiovascular function with increased efficiency, potentially aiding in the prevention of lifestyle-related cardiovascular diseases.

Keywords: Blood pressure, Body composition, Breath holding time, Flexibility, Surya namaskara

INTRODUCTION

Yoga is one of the ancient sciences, with its origins rooted in the vedic period in ancient India. It is believed that the origin of Yoga can be traced back as early as 3000 B.C., as per archaeological evidence [1]. Over the last few decades, several clinical trials have been conducted on different components of Yoga practices [1,2]. Yoga practices were not developed for treatment, but rather to reach the ultimate level of consciousness. Through various pieces of research, it has been found that regular Yoga practice not only maintains and promotes the healthy state of the body and mind but also prevents the onset of diseases. Studies have reported that a 15-day combined practice of pranayama and meditation brought a significant reduction in resting pulse rate, lowered blood pressure, induced parasympathetic dominance, and reduced mean arterial blood pressure, taking into consideration gender and BMI [1,2]. Another study reported changes in brain waves and blood levels of serum cortisol during Yoga [3]. A systematic meta-analysis of controlled trials assessed the effectiveness of yoga in cardiovascular risk factors and reported its impacts [4]. Additionally, Yoga practice has been found to positively affect BMI, SBP, and HDL cholesterol. Moreover, significant changes were observed in weight, DBP, total cholesterol, triglycerides, HR, and HR variability [5]. A study found the effect of transcendental meditation practice on hormonal levels [6]. After four months of transcendental meditation, the level of cortisol and Thyroid Stimulating Hormone (TSH) decreased, while there was an increase in growth hormone [6]. Researchers investigated the intervention of Santhi kriya to see its effect on psychophysiological parameters; an increased alpha wave activity was found [7]. Another study examined the specific pranayama technique called sukha pranayama, a slow and deep breathing technique, on maternal and fetal cardiovascular parameters, particularly in high blood pressure and pregnant women. It was found to shift the autonomic balance towards the parasympathetic system, increase vagal modulation, and enhance baroreflex sensitivity [8]. In another study, the intervention of Chandra and Surya Nadi pranayamas on cardiovascular parameters and reaction time in the geriatric population found decreased blood pressure, even in individuals with high blood pressure [9]. Additionally, eight weeks of hath Yoga practice significantly improved executive function measures of working memory, shorter reaction time, and greater accuracy [10].

A study on students showed that low-stress students performed better in academic activities than high-stress students, indicating that stress affects students' performance [11]. Finally, 12 weeks of pranayama practice and meditation significantly increased the Left Ventricular Ejection Fraction (LVEF) [12]. Studies suggest that regular Yogic practice for three months decreases blood pressure, HR, and autonomic function, and decreases emotional arousal, leading practitioners towards parasympathetic dominance [5,13]. Yogic science not only helps maintain and improve normal physical and mental health, but it is also a beneficial therapy for some diseases. In every action and movement, the body is aligned with respiration, and the mind needs to be focused on breathing as per instructions while performing [14].

The Surya Namaskar is a complete and perfect blend of bodily movement, breathing, and mental concentration practiced in the Yoga tradition for health, vitality, and spiritual progress [15,16]. The practice is often performed in the traditional Ashram set-up with Beejamanta chanting dedicated to the Sun. The following are postures involved in the twelve steps: Pranamasana (prayers pose), Hasta Utthanasana (raised arms pose), Padahastasana (hand to foot pose), AshwaSanchalanasana (equestrian pose), Parvatasana (mountains pose), Ashtanga Namaskara (salute with eight parts or points), and Bhujangasana (cobra pose), and so on. Postures like Parvatasana, Ashwasanchalanasana, Padahastasana, Hasta Uttanasana, and Pranamasana are repeated to complete the twelve steps [17]. The sequence followed in the study was based on the traditional practices set by the Bihar School of Yoga [17].

An analysis was performed on the kinematics of SN using 3D (3Dimensional) motion capture and concluded that SN alters a wide range of motion by improving extension and flexion. It also enhances the mobility of almost all body joints and stretches anterior and posterior muscles [18]. A study of SN practice concluded that SN is an ideal form of aerobic exercise, involving static and dynamic muscular movements that improve joint mobility and help in better calorie burn. The study reveals that SN consists of all body segment movements and models of whole-body exercise. It improves muscle tone around the joint and strengthens the muscles, improves endurance, and cardiorespiratory fitness compared to a group of people who perform another type of exercise training [19]. The SN also improves mental health, leading to mental quiet, physical relaxation, strength and awareness, and joy, while also enhancing sleep quality and decreasing negative emotion, bodily stress, and worry [20]. Pulmonary function, respiratory pressures, hand grip strength, endurance, and resting cardiovascular parameters in school children were also found to be improved after SN practice [21]. The present study also concluded that fast SN has a similar effect as aerobic exercise, whereas slow SN has similar effects as Yoga [21].

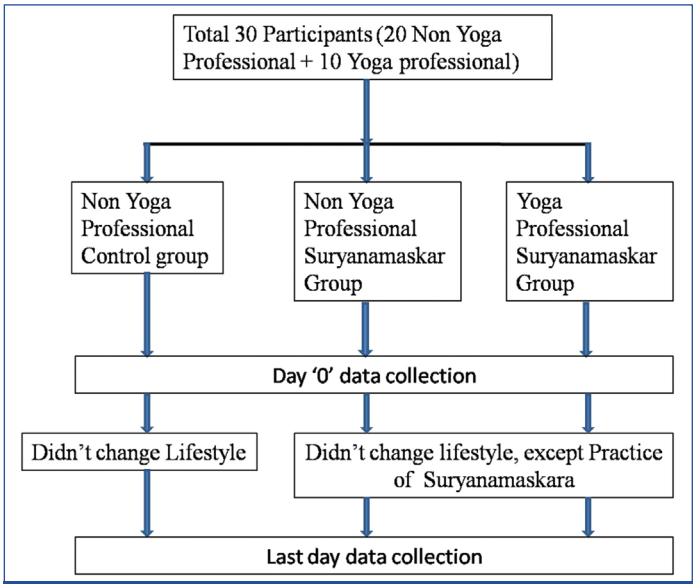
Many studies have illustrated the effects of Yogic practices on populations of different age groups, with various benefits such as uplifting body composition, cardiovascular endurance, stress reduction, brain health, and oxidative stress [18-21]. Comparative effects of Yoga and other physical and mental activities on physiological and physical parameters [19-21] have also been studied. However, a comparative study of the impacts of SN on body composition, muscle strength, and flexibility of Yoga professionals and Non Yoga professionals has not been explored much. The present study was planned with the aim of finding the impact of SN on body composition, physical, and physiological parameters among Yoga and Non Yoga professionals. Therefore, the current study was proposed to test the hypothesis of wheather the practice of SN has an impact on body composition and specific physiological parameters of Yoga and Non Yoga professionals.

MATERIALS AND METHODS

The present quasi-experimental study (pre-test-post-test design) was conducted at Morarji Desai National Institute of Yoga, Ministry of Ayush, Government of India, New Delhi, India, for a total duration of one and a half months from March 2021 to May 2021. The study was approved by the Institutional Ethical Committee (IEC) of Morarji Desai National Institute of Yoga (MDNIY) File No. MDNIY/2020-21/RES/IR/EC/001. Written consent was obtained from each participant.

Sample size calculation: The investigator informed the staff and all the members of MDNIY about the study and requested them to join voluntarily. The sample size was not calculated, and random sampling was done based on the convenience of the participants and the investigator.

Inclusion and Exclusion criteria: Both males and females aged between 18-35 years, who were physically and mentally healthy, were included in the study. Yoga therapists, Yoga Instructors, and Yoga Teachers of MDNIY who had been practicing Yoga professionally for five years (in the Yoga professional group). Non Yoga professionals were chosen from the Administration Office, Accounts office of MDNIY, and other staff who were not practicing Yoga. A schematic representation of participant selection and data collection is mentioned in [Table/Fig-1].



[Table/Fig-1]: Schematic representation of participant distribution and data collection.

Subjects with any physical and mental disorders, chronic diseases or disorders like hypertension, obesity, diabetes, depression, prolapsed intervertebral disc, etc.,; subjects on medications or steroids, and those with smoking and drinking habits, or engaged in fitness training like pilates, strength training, or any other fitness program were excluded from the study.

Study Procedure

The study comprised a total of 30 subjects who were divided into 03 groups with 10 subjects in each as: Non Yoga Professional Control group (NYPC); Non Yoga Professional Surya Namaskar group (NYPS); and Yoga Professional Surya Namaskar group (YPS).

Surya Namaskar groups (NYPS and YPS) practiced 12 rounds of SN, 24 minutes daily, for 05 days a week and for 06 weeks. Data was collected on the 1st day and the last day of the study. Participants were requested not to alter their lifestyle except for the practice of SN during the study period. Control groups were requested not to change their lifestyle. Diet was not controlled in any group.

The first 02 weeks were a demonstration and preparation session conducted by the certified instructors of MDNIY who have completed a Diploma course in Yoga and cleared Masters level Yoga certification from the Yoga Certification Board, Ministry of Ayush, Government of India. The next four weeks were practice sessions. SN was practiced as per [Table/Fig-2]. Suryanamaskar was practiced at a controlled room temperature of 24°C-28°C.

Position 1:	Pranamasana (prayers pose)
Position 2:	Hasta Utthanasana (raised arms pose)
Position 3:	Padahastasana (hand and foot pose)
Position 4:	AshwaSanchalanasana (equestrian pose)
Position 5:	Parvatasana (mountains pose)
Position 6:	Ashtanga Namaskara (salute with eight parts or points)
Position 7:	Bhujangasana (cobra pose)
Position 8:	Parvatasana (mountains pose)
Position 9:	Ashwasanchalanasana (equestrian pose)
Position 10:	Padahastasana (hand and foot pose)
Position 11:	Hasta Utthanasana (raised arms pose)
Position 12:	Pranamasana (prayers pose)

[Table/Fig-2]: Surya Namaskar practice sequence of postures.

Parameters

Age: The participant's age was collected from any proof of birth certificate or any other document mentioning the date of birth.

Height, Body Weight, and Body Mass Index (BMI): The Body Weight (BW) was measured in kilograms and height in centimeter using an electronic stadiometer model number BYH01, made by Beryl, Guangdong, China. The BMI was calculated as the ratio of weight to height in meters squared (i.e., kg/meter^2) [5].

Resting Heart Rate (HR) and blood pressure: HEM- 7113 (Omron Healthcare Singapore PTE LTD. Singapore, Japan) automatic blood pressure monitor was used to record HR and BP. A total of three readings of SBP, DBP, and HR were recorded. The average value of three readings was considered in the study as the final one. The PP was assessed as the difference between SBP values and DBP. The Mean Blood Pressure was assessed as DP+1/3PP. The RPP was calculated as ((SP×HR)/100). Double product (DoP) was evaluated as MP×HR, where the values of DoP and RPP were expressed as mmHg, BPM and mmHg Bpm, respectively [22].

Right Hand Grip Strength (RHGS) and Left Hand Grip Strength (LHGS): The handgrip strength of the participants was assessed using a hand grip strength dynamometer with a model hydraulic hand dynamometer, SH5001, made by SAEHAN, South Korea. Two readings (in kg) for the hand grip strength were taken, and the better one was noted [23].

Flexibility: The flexibility parameter was assessed by measuring the flexibility of the low back or the flexibility of the participants' hip and trunk (H and T) using the standard sit-and-reach test. Before the actual measurement, a demonstration was given on how to carry out the test. The volunteers were asked to sit on the floor with legs fully extended, their back and head against a wall, and the bottom of their feet against the sit-and-reach box. They were instructed to place their hands on each other, stretching their arms forward while keeping their back and head against the wall support and knees straight. The distance was measured from the fingertips to the box edge with a measuring scale (in feet). Volunteers were then requested to slowly bend and reach forward as much as possible (head and back moved away from the wall), sliding the fingers along with a measuring scale. A minimum of three trials were performed, and the average measurement was taken as the final value [23].

Breath-hold Time (BHT): Volunteers were asked to sit erect, holding their breath as long as possible with their nose clipped, immediately following maximal inspiration using both nostrils. During this period, they were restrained from inhalation and exhalation strictly. The period for which the breath was held was noted in seconds (s) using an electronic stopwatch. Due surveillance was maintained to avoid intermediate breathing by the volunteers [24].

Body composition: The data collection for body composition was done using Bodivis, BCA-1C Body composition analyser of Tongfang Health Technology Co. Ltd, Beijing, China. The direct segmental Multi-frequency bioelectric Impedance Analysis method (DSM-BIA) was used to collect body composition data. The parameters assessed were muscle mass, PBF%, total BF, BM, WHR, and BMR were analysed through this instrument.

STATISTICAL ANALYSIS

GraphPad Instat Windows-based software, version 3.0, was used to complete the statistical analysis. Values were expressed as mean±Standard Deviation (SD). The intergroup comparison of baseline values was done by repeated measure ANOVA. When significant differences were found, Tukey-kramer Post-hoc tests were conducted. Two-tailed Student's t-test for paired samples was used to test the significance of the difference between the means for intragroup pre and post values. The computed t was then compared with the critical t scores for different levels of significance to accept or reject H0. The level for significance was set as p≤0.05.

RESULTS

There was no significant difference in the baseline values of physiological parameters, body composition, and physical parameters in all the three groups [Table/Fig-3,4]. Physiological responses following Yogic practices are depicted in [Table/Fig-3].

The study found a significant (p≤0.05) reduction in body weight and BMI following SN in a NYPS. A significant reduction was noticed in HR (p≤0.05), SBP (p≤0.01), PP (p≤0.05), DoP (p≤0.05), and RPP (p≤0.05) following SN practice in the NYPS group. Additionally, a significant reduction was noticed in SBP (p≤0.01), DBP (p≤0.05), and MBP (p≤0.01) following SN practice in the YPS group. No significant change was seen in any of the components of

	NYPC		NYPS		YPS	
Parameters	Pre	Post	Pre	Post	Pre	Post
Height (cm)	163.1±7.69	-	164.9±9.20	-	165.5±6.52	-
Weight (kg)	65.6±14.69	64.7±13.86	66.71±14.54	64.2±14.1*	67.4±9.01	66.8±8.75
BMI (kg/m^2)	24.6±4.20	24.2±3.89	24.4±4.08	23.4±3.89*	24.6±3.3	24.4±3.27
HR (bpm)	85.6±8.63	80.8±6.99	84.8±9.80	76.81±7.56*	76.1±11.9	76.6±8.38
SBP (mmHg)	116.5±5.79	115.1±7.46	119±5.98	113.5±6.39**	118.8±5.59	112.8±10.71*
DBP (mmHg)	75.0±6.67	77.3±7.06	77.3±5.42	77.1±5.87	76.0±6.44	72.0±6.32**
PP (mmHg)	41.5±3.74	37.81±6.98	41.7±3.59	36.4±5.93*	42.8±4.10	40.8±8.33
MBP (mmHg)	88.8±6.19	89.9±8.96	91.2±5.35	89.2±5.38	90.3±5.86	85.6±7.03**
DoP (mmHg bpm)	7627.17±1114.6	7259.1±822.4	7743.2±1110.7	6851.1±780.8*	6894.1±1403.1	6546.8±846.6
RPP (mmHg bpm)	9996.5±1319.6	9298.0±1001.2	10113.8±1513.9	8706.3±900.9*	9501.2±1623.5	8606.8±970.3

[Table/Fig-3]: Physiological response following Surya Namaskar practices. (n=10 in each group).
Values are expressed as Mean±SD. No significant difference was noted in the pre of all groups. *indicates the comparison between the pre and post of the same group. *indicates p≤0.05, **indicates p ≤0.01, ***Indicates p≤0.001. NYPC: Non yoga professional control group; NYPS: Non yoga professional surya namaskar group; YPC: Yoga professional control group; YPS: Yoga professional surya namaskar group; BMI: Body mass index; HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; PP: Pulse pressure; MBP: Mean blood pressure; DoP: Double product; RPP: Rate pressure product

Parameters	NYPC		NYPS		YPS	
	Pre	Post	Pre	Post	Pre	Post
BHT (second)	35.0±13.89	35.7±23.18	33.3±14.59	39.1±13.05*	42.0±6.5	49.3±13.59
RHGS (kg)	27.5±8.37	26.9±8.44	32.1±10.52	36.4±10.15*	29.1±7.46	31.4±10.17
LHGS (kg)	26.6±7.89	27.3±7.59	29.8±10.09	33.3±16.67*	29.9±8.62	31.0±9.48
Flexibility (cm)	23.6±8.66	24.2±7.73	25.6±11.31	31.5±8.65***	34.8±12.54	33.7±10.53*
Muscle mass (kg)	45.3±8.57	44.9±7.93	48.6±13.44	48.3±13.01	44.1±6.6	44.8±7.3
PBF (%)	25.5±7.08	24.9±6.47	25.0±5.01	23.0±4.74**	27.9±8.57	27.1±8.76
BF (kg)	17.1±7.26	16.55±6.78	16.8±6.06	15.7±5.28**	20.4±7.04	19.1±7.00
Bone Mass (kg)	3.14±0.48	3.1±0.45	3.2±0.5	3.2±0.5	3.1±0.37	3.1±0.4
WHR	0.91±0.05	0.94±0.05	0.89±0.06	0.89±0.05	0.91±0.07	0.91±0.07
BMR (Kcal)	1535.8±262.48	1550.4±246.6	1591.8±260.7	1603.8±276.5	1467.2±125.2	1532.2±216.2

[Table/Fig-4]: Response in body composition and physical parameters following Surya Namaskar practices (n=10 in each group).
Values are expressed as Mean±SD. No significant difference was noted in the pre of all groups. *indicates the comparison between the pre and post of the same group. *Indicates p≤0.05, **Indicates p≤0.01, ***Indicates p≤0.001. NYPC: Non yoga professional control group; NYPS: Non yoga professional surya namaskar group; YPC: Yoga professional control group; YPS: Yoga professional surya namaskar group; BHT: Breath holding time; RHGS: Right hand grip strength; LHGS: Left hand grip strength; PBF: Percent body fat; BF: Total body fat; WHR: Waist to hip ratio; BMR: Basal metabolic rate

physiological parameters, body composition, and physical parameters in the control group. The responses in body composition and physical parameters are depicted in [Table/Fig-4]. A significant (p≤0.05) improvement was noticed in BHT following SN in the NYPS group. RHGS and LHGS increased significantly (p≤0.05) following SN practice in the NYPS group. Flexibility also increased significantly (p≤0.001) following SN practice in the NYPS group. Flexibility improved considerably (p≤0.05) following SN practice in the YPS group. PBF and BF decreased significantly (p≤0.001) following SN practice in the NYPS group. The study didn't find any significant change in muscle mass, BM, WHR, and BMR.

DISCUSSION

The present study aimed to evaluate the effects of SN on body composition, physical, and physiological parameters among Yoga and Non-Yoga Professionals. A significant reduction in body weight, BMI, HR, SBP, PP, DoP, and RPP following SN practice was found in the NYPS group. A significant reduction was noticed in SBP, DBP, and MBP following SN practice in the YPS group, and significant enhancement was noticed in BHT, RHGS, LHGS, and flexibility following SN practice in the NYPS group. PBF and BF decreased significantly following SN practice in the NYPS group, and flexibility was improved significantly following SN practice in the YPS group.

In the current study, body weight and BMI were significantly reduced following SN in the NYPS group. This may be due to extra energy consumption in the NYPS group. A previous study of a Yoga module found that regular Yogic practice decreases body weight and BMI [5]. PBF and BF decreased significantly following SN practice in the NYPS group. This may be due to increased energy expenditure and reduction in fat deposition in the body. Previous studies also support this fact [21].

Blood pressure decreased significantly in the NYPS group and YPS group. It could be stated that SN could control the blood pressure of the practitioner. Regular SN practices shifted the equilibrium towards parasympathodominance, which could reduce blood pressure. Earlier studies also support this fact [19-21].

A decrease in BP may be due to reduced stress, norepinephrine, and epinephrine after Yoga practice. Yogic practices, if adopted regularly, may decrease sodium and potassium concentration and renin activity in the blood. This resultantly lowers BP towards normalcy in hypertensive patients. Earlier studies showed that Yogic practices have an influential role in reducing cortisol levels. These practices are inclined to induce relaxation, which may lower blood pressure [5,25,26]. Moreover, decreased body weight and BMI may improve lipid profiles, which would have a beneficial role in lowering blood pressure by reducing total cholesterol and low-density lipoprotein cholesterol. Previous studies support this fact [5]. DoP, an index of load on the heart, and RPP, an index of myocardial oxygen consumption, were decreased following SN practice due to the improvements in blood pressure. This data has been supported by previous studies on SN and yoga modules containing SN [5,19,20,21]. The persistence of the change as mentioned above in the Yoga practitioner may be due to long-term changes in the autonomic nervous system and metabolism. Also, it may predict that Yoga participants may move towards parasympathodominance and decrease stress levels [20].

A decreased PBF and BF in NYPS following Yogic practice may be due to increased energy expenditure by practicing SN. Regular SN practice improved hand grip strength. This may be due to enhancement in the motor system of the practitioner. Improvement in flexibility may be due to progress in the range of motion. A study in this context has already concluded that SN alters a wide range of motion by improving extension and flexion. A previous study also observed that the practice of SN enhances the mobility of almost all body joints, stretching anterior and posterior muscles [18]. SN also increased BHT in NYPS; it may be due to improved lung volumes and capacity. The earlier study supports this fact [21].

Moreover, the major significant effects were found in physical, physiological, and body composition in the NYPS group following SN. It was mentioned that NYPS population was selected from administrative office, accounts office, and other Non Yoga populations. Most of the NYPS participants were sedentary people and participated in this study. Regular SN practice improved the quality of life of the participants. Also, participating in the SN practice may increase the energy expenditure, participants may move towards parasympathodominance and may reduce stress of the participants showed the remarkable results as described above in the NYPS group [5,19-21].

Limitation(s)

Due to the small sample size, a significant result might not have been observed in most of the parameters in the study. There was no diet restriction from the researchers for volunteers, which also could have been one of the factors in no change of parameter value following SN in groups. It is not a randomised blind trial, so all groups were familiar with the practices. Future research may focus on including a control group from a completely non familiar area to compare the results. Intervention of SN may be provided to a population of different age groups and genders with a very large sample, which may provide a better conclusion.

CONCLUSION(S)

The present study exhibited reduced blood pressure, heart load, myocardial oxygen consumption, improvement in body composition, and enhancement in breath-holding time and hand grip strength. Therefore, the practice of SN improves body composition and

cardiovascular function with increased efficiency and may help to prevent lifestyle-related cardiovascular complications.

Acknowledgement

The authors acknowledge the support of Shree Ravi Kant Tyagi, Medical Laboratory Technologist, and Mrs. Parul Chaudhury, Laboratory Assistant of Morarji Desai National Institute of Yoga, for their help in data collection. Support of the Administration of MDNIY is also acknowledged. Overall, the support of the volunteers is acknowledged.

REFERENCES

[1] Anakad RB, Herur A, Patil S, Shashikala GV, Chinagudi S. Effect of short-term pranayama and meditation on cardiovascular functions in healthy individuals. Heart Views. 2011;12(2):58-62.
[2] Telles S, Nagarathana R, Nagendra HR, Desiraju T. Physiological changes in sports teacher following 3 months of training in Yoga. Indian J Med Sci. 1993;47(10):235-38.
[3] Kamei T. Decrease in serum cortisol during Yoga exercise is correlated with alpha wave activation. Percept Mt Ski. 2000;90(3 Pt 1):1027-32.
[4] Chu P, Gotink RA, Yeh GY, Goldie SJ, Hunkink MM. The effectiveness of Yoga in modifying risk factors for cardiovascular disease and metabolic syndrome: A systematic review and meta-analysis of randomised control trials. Eur J Prev Cardiol. 2016;23(3):291-307.
[5] Pal R, Singh SN, Chatterjee A, Saha M. Age-related changes in cardiovascular system autonomic functions and levels of BDNF of healthy active males: Role of Yogic practice. Age (Dordr). 2014;36(4):9683. Doi: 10.1007/s11357-014-9683-7.
[6] MacLean CRK, Walton KG, Wenneberg SR, Levitsky DK, P Mandarino JP, Waziri R. Effect of the transcendental meditation program on adaptive mechanism: changes in hormone levels and responses to stress after 4 months of practice. Psycho Neuro Endocrinology. 1997;22(4):277-95.
[7] Satyanarayana M. Effect of Santhi kriya on certain psychophysiological parameters: A preliminary study. Indian J Physio Pharmacol.1992;36(2):88.
[8] Bhavanani AB, Ramanathan M, Dayanidy G. Immediate effect of sukha pranayama: A slow and deep breathing technique on maternal and fetal cardiovascular parameters. Yoga Mimamsa. 2018;50(2):48-52.
[9] Ramanathan M, Bhavanani AB. Immediate effect of Chandra and suryanadi pranayamas on cardiovascular parameters and reaction time in a geriatric population. Int J Physiol. 2014;2(1):59-63. Doi: 5958/J.2320-608X2.1.013.
[10] Gothe NP, Auley E Mc. Yoga and cognition: A meta-analysis of chronic and acute effects. Psychosom Med. 2015;77(7):784-97.
[11] Kautz A, Sharma N. Effect of Yoga on academic performance in relation to stress. Int J Yoga. 2009;2(1):39-43. Doi: 10-4103/0973-6131.53860.
[12] Krishna BH, Pal P, Pal GK, Balachander J, Jayasettiaseelon E, Sreekanth Y, et al. A randomised controlled trial to study the effect of Yoga therapy on cardiac function and N terminal pro BNP in Heart failure. Integr Med Insights. 2014;9:01-06.
[13] Madanmohan, Udupa K, Bhavanani AB, Shatapathy CC, Sahai A. Modulation of cardiovascular response to exercise by yoga training. Indian J Physiol Pharmacol. 2004;48(4):461-65.
[14] Choudhary R. Effect of dynamic suryanamaskar on vital capacity of physical education students capacity of physical education students. Indian J Phys Educ Sports Med Exerc Sci. 2008;8(2):01-20.
[15] Prasanna VL, Vandhana S. Insights on Surya namaskar from its origin to application towards health. J Ayurveda Integr Med. 2022;13(2):100530. https://doi.org/10.1016/j.jaim.2021.10.002.
[16] Choudhary R, Stec K. The effects of dynamic suryanamaskar on flexibility of university students. J Adv Dev Res. 2010;1(1):45-48.
[17] Bhaumik U, Chatterjee S, Singh KK. Suryanamaskar pose identification and estimation using no code computer vision. In: Bajpai MK, Kumar Singh K, Giakos G. (eds) Machine Vision and Augmented Intelligence—Theory and Applications. Lecture Notes in Electrical Engineering. Singapore: Springer; 2021;796:85-90. https://doi.org/10.1007/978-981-16-5078-9_7.
[18] Mullerpatan RP, Agarwal BM, Shetty T, Nehete GR, Narasipura OS. Kinematics of Suryanamaskar using three-dimensional motion capture. Int J Yoga. 2019;12(2):124-31. Doi: 10.4103/ijoy.IJOY_26_18. PMID: 31143020; PMCID: PMC6521759.
[19] Jakhotia KA, Shimpi AP, Rairikar SA, Mhendale P, Hatekar R, Shyam A, et al. Suryanamaskar: An equivalent approach towards management of physical fitness in obese females. Int J Yoga. 2015;8(1):27-36. Doi: 10.4103/0973-6131.146053.
[20] Godse AS, Shejwal BR, Godse AA. Effects of suryanamaskar on relaxation among college students with high stress in Pune, India. Int J Yoga. 2015;8(1):15-21. Doi: 10.4103/0973-6131.146049.
[21] Bhavanani AB, Udupa K, Madanmohan, Ravindra P. A comparative study of slow and fast suryanamaskar on physiological function. Int J Yoga. 2011;4(2):71-76. Doi: 10.4103/0973-6131.85489.
[22] Gobel FL, Nordstrom LA, Nelson RR, Jorgenson CR, Wang Y. The rate-pressure product as an index of myocardial oxygen consumption during exercise in patients with angina pectoris. Circulation. 1978;57(3):549-55.
[23] Halder K, Chatterjee A, Pal R, Tomer OS, Saha M. Age related differences of selected Hatha yoga practices on anthropometric characteristics, muscular strength and flexibility of healthy individuals. Int J Yoga. 2015;8(1):37-46.
[24] Pal R, Saha M, Chatterjee A, Halder K, Tomer OS, Pathak A, et al. Anaerobic power, muscle strength and physiological changes in physically active men following yogic practice. Biomed Hum Kinet. 2013;5(1):113-20.
[25] Selvamurthy W, Sridharan K, Ray US, Tiwary RS, Hegde KS, Radhakrishan U, et al. A new physiological approach to control essential hypertension. Indian J Physiol Pharmacol. 1998;42(2):205-13.
[26] Telles S, Nagarathna R, Nagendra HR. Autonomic changes during "OM" meditation. Indian J Physiol Pharmacol. 1995;39(4):418-20.

PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Human Physiology, Morarji Desai National Institute of Yoga, New Delhi, India.
2. Assistant Professor, Department of Human Anatomy, Morarji Desai National Institute of Yoga, New Delhi, India.
3. Assistant Professor, Department of Yoga Therapy, Morarji Desai National Institute of Yoga, New Delhi, India.
4. Director (Retd.), Morarji Desai National Institute of Yoga, New Delhi, India.
5. Consultant, Department of Yoga Therapy, Morarji Desai National Institute of Yoga, New Delhi, India.
6. Yoga Therapist, Department of Yoga Therapy, Morarji Desai National Institute of Yoga, New Delhi, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Rameswar Pal,
Morarji Desai National Institute of Yoga, Ministry of Ayush,
Government of India, 68, Ashoka Road, New Delhi-110001, India.
E-mail: physioramupal@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 26, 2023
- Manual Googling: Oct 18, 2023
- iThenticate Software: Dec 27, 2023 (13%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jul 26, 2023**
Date of Peer Review: **Oct 05, 2023**
Date of Acceptance: **Dec 20, 2023**
Date of Publishing: **Feb 01, 2024**