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THE OUTCOME OF SURYA NAMASKAR ON AUTONOMIC NERVOUS SYSTEM REGULATION: A COMPREHENSIVE STUDY

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ABSTRACT

Background: Surya Namaskar is a physically and mentally beneficial practice that can have meditative and relaxing effects when done with mindfulness. Practicing Yoga – Surya Namaskar may improve balance by decreasing sympathetic dominance and raising parasympathetic activity. **Objectives-** Present study was undertaken to understand how Surya Namaskar promotes autonomic balance and contributes to general health by combining physiological tests and subjective measures of well-being.

Material and Methods: After taking clearance from institutional ethical committee, this comprehensive study was conducted on sixty healthy volunteers aged 18-22 years. Considering the exclusion &inclusion criteria, they were randomly selected from the Subharti University Campus. Autonomic function tests, including cardiovascular responses to various stimuli, were conducted pre and post-intervention to Surya Namaskar. A series of tests - BP, HR, HRV, HGT, CPT, LST, Valsalva maneuver, Deep breathing test were performed to assess the physiological and biochemical aspects of autonomic function.

Results & Conclusion: Our study showed that performing Surya Namaskar for three weeks significantly lowers HR, DBP and SBP. In Time domain measures of HRV the SDNN, RMSSD and CV shows significant improvement, while pNN50 and NN50 were insignificant. On the other hand the frequency domain measures of HRV all are insignificant. In case of Sympathetic reactivity measures HGT is highly significant, CPT is simply significant and LST is non-significant. While considering the Parasympathetic reactivity measures only VM is highly significant.

Lastly concluded that Regular practice of Surya Namaskar can be a helpful non-pharmacological intervention for people at risk of hypertension and cardiovascular problems since it improves parasympathetic activity, lowers stress, and decreases sympathetic reactivity when practiced regularl.

Key Words: Surya Namaskar, ANS.

INTRODUCTION

The autonomic nerve system (ANS) is a vital regulator of blood pressure, digestion, respiration rate, heart rate, and other involuntary physiological actions. The parasympathetic nervous system, which encourages the "rest-and-digest" state, and the sympathetic nervous system, which is linked to the "fight-or-flight" response, comprise its two primary parts. Autonomic regulation imbalances are frequently associated with various problems connected to stress, cardiovascular diseases, and other medical conditions.[1]

Stress is unavoidable in contemporary life, frequently developing when people believe their needs are more significant than their means. It is an intrinsic and unavoidable part of modern life. It sets off physiological and psychological reactions.[2] The

stress response, which affects many physiological processes and lasts a person's entire life from childhood into adulthood, is the collective term for the body's adaptive systems in reaction to stress. Persistent or chronic stress affects the body's physiological functions by raising cortisol levels and activating the sympathetic nervous system.[3]

Yoga is an age-old discipline with roots in Indian philosophy that has become well-known for its ability to improve mental and physical health. One of the most efficient ways to relieve tension and encourage relaxation is through yoga's “Surya Namaskar" or Sun Salutation. The 12 postures (asanas) of the Surya Namaskar are traditionally performed in a fluid series. This exercise routine enhances flexibility, balance, and focus while strengthening and stretching the muscles. Surya Namaskar is a physically and mentally beneficial practice that can have meditative and relaxing effects when done with mindfulness.[4]

Surya Namaskara is a dynamic, contemplative activity combining physical exercise with breath control and mindfulness since each movement corresponds to the breath. This workout strengthens and stretches the muscles while improving flexibility, balance, and focus. When performed mindfully, Surya Namaskar can have meditative and calming effects and be healthy for the body and mind.[5]

Yoga is considered a science of self-realization, encompassing ancient beliefs, observations, and guidelines for both body and mind. It is based on moral precepts, ascetic and meditation techniques, and a particular type of physical training that includes the control of posture and respiration. Research is ongoing to explore the health benefits of yoga, including its effects on autonomic functions, cardiovascular efficiency, respiratory efficiency, endurance, energy levels, and immunity.[6]

According to earlier research, practicing yoga regularly—including Surya Namaskar—may improve autonomic balance by decreasing sympathetic dominance and raising parasympathetic activity.

Despite the growing interest in the therapeutic effects of yoga on the autonomic nervous system, more comprehensive studies need to be conducted focused explicitly on Surya Namaskar and its potential to modulate autonomic function.

The present study aimed to investigate the acute and long-term effects of Surya Namaskar on various parameters such as HRV and other autonomic functions. HRV, which represents the beat-to-beat variation in HR under resting conditions, is influenced by circadian rhythm, environmental factors, and exercise. It is considered a sensitive indicator of the autonomic system. During stress, there is an increase in LF HRV power, reflecting an increase in sympathetic stimulation.[7] Stress affects the hypothalamus through the limbic system and leads to changes in HRV through the autonomic nervous system. HRV, which represents the heart's ability to respond to various physiological and environmental stimuli, serves as a sensitive tool for evaluating the autonomic nervous system's influence on the myocardium.[8]

This study aims to bridge this gap by examining the outcome of regular Surya Namaskar practice on autonomic nervous system regulation, focusing on "Heart Rate Variability (HRV)” as an indicator of Autonomic Nervous system balance.

This study aims to provide a comprehensive understanding of how Surya Namaskar promotes autonomic balance and contributes to general health by combining physiological tests and subjective measures of well-being. The findings may significantly impact the development of non-pharmacological treatments to improve autonomic function and treat disorders linked to stress. Additionally, this research may encourage including yoga in routine healthcare and wellness initiatives as a holistic strategy for improving autonomic function and promoting well-being.

MATERIALS AND METHODS

The present comprehensive study was conducted in the Department of Physiology at Subharti Medical College, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh, India. The study was conducted after due approval from the Institutional Ethical Committee (IEC). Sixty healthy volunteers were selected for the study. Volunteers aged 18-22 years were screened, and detailed medical history was taken to exclude any disorder that can interfere with autonomic functions and any contraindication for exercise training, like smoking, obesity, hypertension, COPD, etc.

Autonomic functions were tested by a battery of five tests developed by Ewing and Clark in 1981 in Edinburgh and later validated by the American Diabetes Association[9.10].

Autonomic function tests, including cardiovascular responses to various stimuli, were conducted pre and post-intervention. Detailed procedures for data collection, including BP measurement, heart rate variability analysis, and isometric exercise tests, were outlined. The Institutional Ethics Committee approved the study protocol.

A series of tests assessed the physiological and biochemical aspects of autonomic function.

All the subjects were explained about the procedures to be undertaken, and written informed consent was obtained. All subjects underwent the following tests before and after the Surya Namaskar (Yoga) to assess Autonomic functions.

1. Autonomic Function Test

Autonomic function tests were performed at the Research Lab, Department of Physiology Subharti Medical College, Meerut.

The subjects were informed beforehand that the following should not be done:

1. Take any medication 24 hours before recording.

2. They should refrain from eating large meals, tea, coffee, or caffeinated drinks at least two hours before the recording.

Before the test began, the volunteers were given instructions regarding the exam and the recording process and were given some time to settle in and feel comfortable.

Basal BP and Heart Rate (HR)

The Accusure TD-3127 system made in Taiwan was used for BP recording. BP was recorded after an adequate five-minute rest in a sitting position. The machine's display screen noted Systolic BP, Diastolic BP, and Basal heart rate.

Heart Rate Variability (HRV)

Lead II ECG recording was done in a lying posture at 25 mm/sec speed and 10 mm/MV voltage for 330 seconds to obtain HRV using the data acquisition system RMS- Polyrite AD version 2.2. The data was analyzed in both the frequency and time domains.

In frequency domain analysis, the entire spectrum of frequencies is divided into three major frequency bands. Each bandwidth's area under the curve was calculated and expressed in arbitrary units.

Hand grip test (HGT)

The isometric exercise test used a light, small handgrip Dynamometer. First, the baseline BP was recorded in sitting postures, and then the subjects were instructed to press the Dynamometer with their dominant hand with the maximum possible force to record maximum voluntary contraction (MVC). The 30% of the MVC was calculated, and then the subjects were instructed to press the Dynamometer continuously at 30% of their MVC for 4 minutes by their dominant hand. BP was recorded at the 1^{st}, 2^{nd}, and 4^{th} minute of isometric contraction, and the 5^{th}-minute value was measured as recovery after the termination of isometric contraction. The systolic and diastolic BP differences from resting values were calculated at the 1^{st}, 2^{nd}, and 4^{th} minute. The difference in diastolic blood pressure differences gave information about sympathetic reactivity. The difference in systolic pressure was considered a mixed response (i.e., due to both sympathetic and parasympathetic stimuli).

Cold pressor test (CPT)

Before the test, baseline BP was recorded. The subjects were asked to immerse their hand to the wrist in 4.5 C cold water for 2 min. BP was recorded from the other arm at the 1^{st} and 2^{nd} min. of immersion, and the 5th-minute value was recorded as recovery. Diastolic and systolic pressure changes were calculated at 1^{st} and 2^{nd} minutes from the resting value.

Lying to standing test (LST)

The subjects were asked to stand from the prone position and then stand steady. Blood pressure was measured at 0.5^{th}, 1^{st}, and 2 min. The systolic and diastolic pressure changes were calculated at 0.5^{th}, 1^{st}, and 2^{nd} min of measurement after standing up.

Valsalva maneuver (Valsalva ratio)

Valsalva maneuver was performed on a mercury manometer, which was locally assembled in our laboratory. It consists of a U-shaped graduated glass tube with a bulb on one arm filled with mercury. The other end of the glass tube was connected to a mouthpiece through the rubber tube. Using a mouthpiece attached to a mercury manometer, the test volunteers were instructed to increase their intra-thoracic pressure to 40 mmHg and hold it there for 15 seconds while wearing a nose clip.

Continuous EKG recording was done on BPL electrocardiograph – Cardiart 108T-DIGI for 1 min before straining, for 15 seconds during straining, and 45 seconds after the release of strain.

The Valsalva ratio was an index of heart rate changes during a Valsalvamanoeuvre. The Valsalva ratio was taken as the maximum R-R interval in the 15s following expiration divided by the minimum R-R interval. It is a measure of parasympathetic reactivity.

Deep breathing test (E: I ratio)

The subjects were given continuous signals corresponding to inspiration and expiration to their total capacity without breaking the breath during inhalation and exhalation. The frequency of the cycle was six breaths /min for 1 minute. Phases of respiration were matched manually on ECG. The average of the six most comprehensive R-R intervals was measured during the expiratory phase, and similarly, the six shortest R-R intervals were measured during the inspiratory phase. The averaged value of the expiratory R-R interval and inspiratory R-R interval was taken to calculate the E: I ratio.

Surya Namaskar

After warming up, the subjects were instructed to perform ten cycles of Suryanamaskar in approximately 20 minutes, six days a week, and continued for three weeks. Each cycle consists of 12 asanas, each complementary to the next. A complete Suryanamaskar round consists of two sets of the twelve poses, but the second set differs in that the opposing leg is moved through the series.

Statistical Analysis

Continuous data were summarised as mean±SD, while discrete data were presented as frequency (n) and percentage (%). Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software version 23.0. A p-value of 0.05 was considered non-significant at a 95% confidence interval.

RESULTS

Table 1 shows that the mean SBP, DBP, and HR were 117.8 ± 2.741 mmHg, 77.42 ± 4.661 mmHg, and 71.9 ± 3.784b/min, respectively, before the exercise. After three weeks of exercise, mean SBP, DBP, and HR were reduced to 115.8 ± 2.201 mmHg, 73.3 ± 3.799 mmHg, and 68.2 ±1.476b/min, respectively. This reduction was statistically significant when the post-intervention value of SBP, DBP, and HR was compared with the pre-

intervention value. (p = 0.0418 for SBP), (p=0.0294 for DBP), (p=0.0169 for HR).

Table 2- On comparison of pre and post-intervention values, there was a significant increase (p=0.0059) in SDNN, RMSSD (p=0.0059), and CV Variance (p=0.0273) from 361.964± 143.059, 528.11 ± 196.773 and 267437.5 ±82426.93 respectively to 566.932 ± 36.773, 688.64 ± 134.157 and 323992.9 ± 49989.21. On the other hand, insignificant changes were observed in the variables NN50 and pNN50 (p > 0.05).

Table 3 shows no significant change (p >0.05) in LF%, HF%, LF/HF %, LFnu, and HFnu was observed when pre-exercise values were compared with post-exercise values.

Table 4 : Hand grip test (HGT). The delta values of SBP and DBP, which were 26.2 ± 7.62 mmHg and 26 ± 5.44 mmHg before the exercise, reduced to 18.8 ± 7.67 mmHg and 20.2 ± 6.42 mmHg, respectively, after three weeks of exercise. This post-exercise reduction was statistically significant (SBP p=0.0025) (DBP p=0.0004).

Cold Pressor test (CPT). The delta values of SBP and DBP, which were 22 ± 5.811 mmHg and 22.2 ± 6.42 mmHg before the exercise, reduced to 16.8 ± 5.43 mmHg and 17.6 ± 4.19 mmHg, respectively, after three weeks of exercise. The post-exercise reduction of the delta value of SBP was statistically significant (p=0.0176) and highly significant for DBP (p=0.0004).

Lying to standing test (LST). The delta values of SBP and DBP were 7.6 ± 3.74 mmHg and 11.2 ± 3.55 mmHg, respectively, before the exercise. After three weeks of exercise, delta values of SBP and DBP were reduced to 5.8 ± 2.39 mmHg and 9.8 ± 3.19 mmHg, respectively. This reduction was statistically insignificant when the post-exercise delta value of SBP and DBP was compared with the pre-exercise value (p >0.05).

Table 5 shows that the post-exercise value of VR is 1.917 ± 0.26, Compared with the pre-exercise value of 1.633 ± 0.37, which showed a highly significant change (p=0.0068).

While the post-exercise value of E: I 1.409 ± 0.1804 did not show any significant change (p>0.05) from their pre-exercise value.

Table 1: Effect of Surya Namaskar exercise on sympathetic activity

Variables	Suryanamaskar		P value
	Pre-exercise Mean ± SD	Post-exercise Mean ± SD	
SBP (mmHg)	117.8 ± 2.741	115.8 ± 2.201	0.0418
DBP (mmHg)	77.2 ± 2.860	75.4 ± 3.134	0.0294
HR (b/min)	71.9 ± 3.784	68.2 ± 1.476	0.0169

SBP- Systolic Blood Pressure, DBP- Diastolic Blood Pressure, and HR- Heart Rate

Table 2: Effect of Surya Namaskar on Time Domain Measures of HRV

Variables	Pre-exercise Mean ± SD	Post-exercise Mean ± SD	P value
SDNN (ms)	361.964± 143.059	566.932 ± 36.773	0.0059
RMSSD (ms)	528.11 ± 196.773	688.64 ± 134.157	0.0059
NN50 (count)	758.1 ± 110.256	786.7 ± 74.127	>0.05
pNN 50 (%)	21.45 ± 4.80	21.61 ± 5.349	>0.05
CV (ms^2)	267437.5 ±82426.93	323992.9 ± 49989.21	0.0273

SDNN- Standard deviation of NN interval, RMSSD-square root of the mean squared differences of successive Mean, NN intervals deviation from arithmetic mean, NN50 - the number of consecutive RR interval differing more than 50ms, pNN 50 - The percentage of NN 50 intervals and Variance - Variance is a measure of Statistical dispersion indicating how far from the expected values its values are.

Table 3: Effect of Surya Namaskar on Frequency Domain Measures of HRV

Variables	Pre Mean ± SD	Post Mean ± SD	p-value
LF (%)	50.02 ± 16.48	47.34 ± 12.62	>0.05
HF (%)	41.27 ± 17.58	43.10 ± 14.08	>0.05
LF: HF ratio (%)	1.554 ± 0.935	1.272 ± 0.642	>0.05
LF nu	62.89 ± 24.614	59.62 ± 23.582	>0.05
HF nu	37.09 ± 24.629	41.07 ± 21.471	>0.05

LF- Low-frequency power percentage, HF- High-frequency power percentage, LF/HF- Low frequency and High-frequency ratio, LFnu- Low frequency in normalized units, and HF nu- High frequency in normalized units.

Table 4: Effect of Surya Namaskar on sympathetic reactivity (HGT, CPT, and LST)

Variables		Pre Mean ± SD mmHg	Post Mean ± SD mmHg	p-value
HGT	SBP	26.2 ± 7.62	18.8 ± 7.67	0.0025
	DBP	26 ± 5.44	20.2 ± 6.42	0.0004
CPT	SBP	22 ± 5.811	16.8 ± 5.43	0.0176
	DBP	22.2 ± 6.42	17.6 ± 4.19	0.0004
LST	SBP	7.6 ± 3.747	5.8 ± 2.39	>0.05
	DBP	11.2 ± 3.552	9.8 ± 3.19	>0.05

HGT-hand grip test, CPT-cold pressor test, and LST-lying to standing test. The data represents the delta values for SBP and DBP for the reactivity tests performed.

Table 5: Effect of Surya Namaskar on Parasympathetic Reactivity (DBT & VM)

Test	variables	Pre Mean ± SD	Post Mean ± SD	p-value
DBT	E: I	1.373 ± 0.143	1.409 ± 0.1804	>0.05
VM	VR	1.633 ± 0.37	1.917 ± 0.26	0.0068

Deep Breathing Test (DBT), Valsalva maneuver (VM), Valsalva Ratio (VR) & Expiratory Inspiratory Ratio (E: I).

DISCUSSION

The study's findings show that performing Surya Namaskar for three weeks significantly lowers HR, DBP, and SBP. This suggests that the practice has a beneficial effect on cardiovascular health and lowers sympathetic nervous system activity.

The reduction in SBP and DBP observed in the present study aligns with existing literature that suggests yoga-based exercises, including Surya Namaskar, can enhance cardiovascular health by improving autonomic regulation. Similar drops in blood pressure and heart rate were observed by Chhabra et al. after consistent yoga practice; these results were attributed to enhanced vagal tone and decreased sympathetic activity.[11] These findings also echo the results of research conducted by Sivasankaran et al., who demonstrated that yoga exercises reduced arterial pressure and promoted relaxation, likely due to a reduction in stress hormone levels and increased parasympathetic activity.[12]

The reduction in the HR observed in this study is consistent with findings from previous studies that have reported yoga practices lower HR by improving cardiovascular efficiency and reducing myocardial oxygen consumption. Patel and North first highlighted the role of yoga in reducing heart rate, which they suggested was the result of enhanced parasympathetic dominance and lower basal sympathetic tone.[13]

The mechanism underlying these benefits is likely multifactorial. Yoga, including Surya Namaskar, has been shown to promote physical relaxation and reduce stress. Suryanamskar may result in lower heart rate and blood pressure, which is a direct result due to the reduction in the activation of the sympathetic nervous system. Furthermore, Surya Namaskar's rhythmic breathing techniques may increase vagal activity, improve baroreflex sensitivity, and lessen heart rate variability. Telles et al. also supported these findings by discovering that yoga's regulated breathing techniques positively impact autonomic function.[14]

Furthermore, the significant improvements in SBP and DBP can be partially attributed to the isometric and isotonic muscle work involved in Surya Namaskar. This exercise combines static and dynamic movements, enhancing circulation and promoting cardiovascular endurance, which may improve arterial function and reduce peripheral resistance.

The results presented in Table 2 indicate that regular practice of Surya Namaskar significantly improves key time-domain measures of heart rate variability (HRV), specifically the standard deviation of NN intervals (SDNN), root mean square of successive differences (RMSSD), and coefficient of variance (CV). These parameters are commonly used to assess autonomic function and the balance between sympathetic and parasympathetic activity. A significant increase in these measures suggests enhanced parasympathetic (vagal) modulation and improved autonomic function.

The significant increase in SDNN (p=0.0059) after three weeks of Surya Namaskar practice demonstrates improved overall heart rate variability, reflecting greater adaptability of the cardiovascular system to changing physiological conditions. SDNN is regarded as a global marker of autonomic function, and increases in this measure are often associated with improved parasympathetic activity and reduced sympathetic dominance. Similar findings were reported by Cohen et al., who found that yoga-based practices significantly increased SDNN, indicating enhanced cardiac vagal modulation in practitioners.[15]

RMSSD, which reflects parasympathetic activity, also significantly increased (p=0.0059). This finding is consistent with other studies, such as the work of

Javorka et al.[16] Which highlighted that regular physical exercise, including yoga, can improve vagal tone and thus enhance RMSSD. The increase in RMSSD in this study points to greater heart resilience to stress and an enhanced capacity for recovery, which is particularly important for overall cardiovascular health.

In contrast, the variables NN50 and pNN50, representing the number and percentage of successive NN intervals differing by more than 50 ms, did not show significant changes ($p > 0.05$). This may suggest that while Surya Namaskar influences global measures of HRV (such as SDNN and RMSSD), its impact on certain specific indices of parasympathetic modulation, like NN50 and pNN50, may not be as pronounced. These findings are similar to research by Thayer et al,[17] which showed that some HRV parameters are more sensitive to the effects of physical activity than others.

The significant increase in CV ($p=0.0273$) suggests more excellent statistical dispersion of heart rate intervals, which could indicate a healthier autonomic nervous system. Increased variability in heart rate can be a sign of better autonomic control, as it reflects the ability of the cardiovascular system to adjust to environmental and physiological changes. This increase in variance aligns with studies such as those by Singh et al,[18] which found that yoga-based interventions enhance HRV and promote better autonomic balance.

The results presented in Table 3 show that Surya Namaskar's practice did not lead to significant changes in the frequency domain measures of heart rate variability (HRV), specifically low-frequency power percentage (LF%), high-frequency power percentage (HF%), LF/HF ratio, low frequency in normalized units (LFnu), and high frequency in normalized units (HFnu) ($p > 0.05$ for all). These findings suggest that while Surya Namaskar significantly impacts time-domain measures of HRV, its influence on frequency-domain measures may be more limited or require a longer duration of practice to produce measurable effects.

LF% reflects a combination of sympathetic and parasympathetic activity, though it is often interpreted as an index of sympathetic modulation. In this study, LF% showed a slight decrease from 50.02% ± 16.48% to 47.34% ± 12.62%, but this change was not statistically significant. Similarly, LFnu, which represents the normalized low-frequency component and is more closely associated with sympathetic modulation, also showed a non-significant decrease. These results indicate that Surya Namaskar did not produce a significant reduction in sympathetic activity, which contrasts with the findings of some other yoga studies. For example, research by Bernardi et al,[19] reported a significant decrease in LF after yoga practice, suggesting a shift towards parasympathetic dominance. The lack of significance in the current study may be due to the short intervention duration (three weeks), as other studies often observe significant effects after more extended periods of yoga practice.

On the other hand, HF%, generally considered an index of parasympathetic (vagal) activity, showed a non-significant increase from 41.27% ± 17.58% to 43.10% ± 14.08%. Similarly, HFnu, another measure of parasympathetic activity, showed a slight non-significant rise. These changes suggest a potential trend towards increased parasympathetic modulation, although the lack of statistical significance means no firm conclusions can be drawn. Other studies, such as those by Telles et al,[20] have reported significant increases in HF following yoga practices, indicating greater parasympathetic activation. However, this study's small sample size or short intervention period may have contributed to the non-significant results.

The LF/HF ratio, which reflects the balance between sympathetic and parasympathetic activity, decreased from 1.554 ± 0.935 to 1.272 ± 0.642. While this reduction suggests a shift towards greater parasympathetic dominance and lower sympathetic influence, the change was insignificant. The LF/HF ratio is a commonly used marker of autonomic balance, with a lower ratio indicating a healthier balance between sympathetic and parasympathetic activity. The trend toward a lower LF/HF ratio is consistent with the improvements in time-domain HRV measures. Still, the lack of significance implies that longer-term or more frequent Surya Namaskar practice may be necessary to achieve significant changes in autonomic balance as measured by frequency domain parameters.

The findings in Table 4 indicate that Surya Namaskar significantly reduces sympathetic reactivity, particularly in response to the Hand Grip Test (HGT) and Cold Pressor Test (CPT), but has no significant effect on the Lying to Standing Test (LST). Sympathetic reactivity, measured through these tests, provides insights into how the sympathetic nervous system responds to stress and regulates blood pressure.

The results for the HGT show a significant reduction in systolic blood pressure (SBP) and diastolic blood pressure (DBP) after three weeks of Surya Namaskar practice. The delta SBP decreased from 26.2 ± 7.62 mmHg to 18.8 ± 7.67 mmHg ($p=0.0025$), and the delta DBP decreased from 26 ± 5.44 mmHg to 20.2 ± 6.42 mmHg ($p=0.0004$). These findings suggest a substantial reduction in sympathetic reactivity to isometric exercise, consistent with previous research highlighting the beneficial effects of yoga-based interventions on autonomic function. Pramanik et al,[21] demonstrated similar reductions in blood pressure and heart rate following yoga practice, attributed to enhanced parasympathetic activity and decreased sympathetic tone. The improvement in the HGT values indicates that Surya Namaskar may help lower cardiovascular reactivity during physical stress.

The CPT results also showed a significant reduction in sympathetic reactivity. The delta SBP decreased from 22 ± 5.81 mmHg to 16.8 ± 5.43 mmHg (p=0.0176), and the delta DBP decreased from 22.2 ± 6.42 mmHg to 17.6 ± 4.19 mmHg (p=0.0004). The cold pressor test measures cardiovascular response to cold exposure, which activates the sympathetic nervous system. The significant reductions in SBP and DBP suggest that Surya Namaskar may attenuate the body's stress response to cold stimuli by enhancing vagal activity and dampening sympathetic outflow. These results agree with research by Sharma et. Al,[22] who reported improved cardiovascular responses to cold stress following regular yoga practice.

In contrast to the significant changes observed in the HGT and CPT, the Lying to Standing Test (LST) did not show significant reductions in SBP or DBP. The delta SBP decreased from 7.6 ± 3.74 mmHg to 5.8 ± 2.39 mmHg (p > 0.05), and the delta DBP decreased from 11.2 ± 3.55 mmHg to 9.8 ± 3.19 mmHg (p > 0.05). The LST assesses baroreceptor sensitivity and autonomic adjustment to postural changes, emphasizing evaluating orthostatic tolerance. The lack of significant findings in the LST may indicate that Surya Namaskar has less influence on the autonomic responses associated with postural changes or that a more extended intervention period may be required to elicit measurable improvements in this domain.

The significant reductions in blood pressure responses during the HGT and CPT tests indicate that Surya Namaskar effectively reduces sympathetic reactivity to physical and cold stressors. The attenuation of these stress responses could be due to several factors, including improved parasympathetic tone, reduced levels of stress hormones such as cortisol, and enhanced cardiovascular efficiency. Surya Namaskar, which combines physical postures, controlled breathing, and relaxation, has promoted a shift toward parasympathetic dominance, reducing stress reactivity and improving autonomic balance.[23] However, the insignificant changes in the LST suggest that the effect of Surya Namaskar on autonomic regulation of postural responses may be less pronounced or require a more extended practice duration.

Table 5 examines the effects of Surya Namaskar on parasympathetic reactivity, specifically through the Deep Breathing Test (DBT) and Valsalva Maneuver (VM). These tests assess the function of the parasympathetic nervous system, which is responsible for maintaining resting states and promoting recovery from stress by controlling activities like heart rate and digestion.

The DBT evaluates parasympathetic reactivity by measuring the Expiratory-Inspiratory Ratio (E: I), which reflects heart rate variability during deep breathing. The E: I ratio in this study increased slightly from 1.373 ± 0.143 to 1.409 ± 0.1804 after three weeks of Surya Namaskar practice, but the change was not statistically significant (p > 0.05). These results suggest that although there may be a trend toward improved parasympathetic function, the three-week intervention was not long enough to change this parameter significantly. Previous studies have shown that longer-term yoga can improve the E: I ratio, signifying enhanced vagal tone.20 The lack of significant change in the E: I ratio may indicate that Surya Namaskar's impact on heart rate variability during breathing exercises is modest in the short term.

The Valsalva Maneuver (VM), a test of parasympathetic reactivity, measures the Valsalva Ratio (VR), which represents the heart rate response to a forced exhalation against resistance. In this study, the VR increased significantly from 1.633 ± 0.37 to 1.917 ± 0.26 (p=0.0068), indicating a substantial improvement in parasympathetic reactivity after Surya Namaskar practice. The significant increase in VR suggests that Surya Namaskar enhances the body's ability to regulate heart rate via parasympathetic pathways. A higher VR indicates better cardiac vagal control, which is associated with improved autonomic balance and resilience to stress.[24] This finding aligns with previous studies demonstrating that yoga-based interventions, including pranayama and other breathing techniques, can enhance parasympathetic function and improve cardiovascular health.

The overall findings from the VM and DBT indicate that Surya Namaskar has a more pronounced effect on parasympathetic reactivity measured by VR than by the E: I ratio. The significant improvement in VR suggests that Surya Namaskar positively influences cardiac autonomic regulation, mainly through enhanced vagal tone, which is critical for maintaining cardiovascular health and reducing the risk of stress-related disorders. The improvement in VR may be attributed to the combination of physical postures and controlled breathing exercises involved in Surya Namaskar, which stimulate the parasympathetic nervous system and reduce sympathetic activation.

However, the lack of a significant change in the E: I ratio suggests that the benefits of Surya Namaskar on parasympathetic reactivity may be more detectable in dynamic autonomic challenges, such as the VM, rather than in simple respiratory-driven autonomic measures like the DBT. This also implies that more extended practice periods may be necessary to observe significant changes across various parasympathetic reactivity tests.

CONCLUSION

This study underscores the positive impact of Surya Namaskar on cardiovascular health, mainly through improvements in heart rate variability (HRV) and autonomic function. Regular practice of Surya Namaskar can be a helpful non-pharmacological intervention for people at risk of hypertension and

cardiovascular problems since it improves parasympathetic activity, lowers stress, and decreases sympathetic reactivity when practiced regularly. While significant improvements were observed in time-domain HRV measures, changes in frequency-domain measures were less pronounced, indicating that longer or more intense practice may be needed. Further research with larger sample sizes and extended intervention periods is recommended to fully explore its effects on parasympathetic modulation and overall cardiovascular health.

Conflict of Interest

The authors have no conflict of interest to declare.

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