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EFFECT OF SURYA-NAMASKAR ON ANTHROPOMETRIC PARAMETERS AND SERUM SEROTONIN LEVEL IN APPARENTLY HEALTHY SUBJECTS: A PROSPECTIVE INTERVENTIONAL STUDY

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ABSTRACT **Background:** Surya-Namaskar is a traditional sequence of twelve yogic postures performed with regulated breathing and is valued for its combined physical and mental health effects. Sedentary living and rising psychological stress among young adults adversely affect body composition and serotonin, a neurotransmitter central to mood. Evidence on its effect in apparently healthy people is limited.**Aim:** To assess the effect of three months of Surya-Namaskar on anthropometric parameters, cardiovascular variables, serum serotonin and psychological scores in apparently healthy adults, and to examine the relationship between serotonin and these parameters. **Methods:** This prospective interventional study enrolled 80 apparently healthy adults aged 20-45 years with no addictions and no regular exercise. After baseline assessment of anthropometry, blood pressure, pulse, serum serotonin and DASS-21 scores, participants practised Surya-Namaskar five days a week for three months, after which all measurements were repeated. Paired t-tests and Pearson correlation were used. **Results:** Mean age was 28.54 years and 57.5% were male. Body weight fell from 62.29 to 60.24 kg ($p=0.026$), BMI from 23.11 to 22.54 kg/m² ($p=0.006$) and sagittal abdominal diameter from 25.96 to 24.72 cm ($p<0.001$). Diastolic blood pressure and pulse decreased significantly, while systolic pressure did not. Serum serotonin rose from 0.07 to 0.08 ng/mL ($p=0.002$). Depression, anxiety and stress scores fell significantly. Serotonin correlated negatively with depression ($r=-0.345$, $p=0.002$) and anxiety ($r=-0.330$, $p=0.003$). **Conclusion:** Surya-Namaskar improved body composition, autonomic cardiovascular function, serum serotonin and psychological well-being, supporting its use as a low-cost, non-pharmacological preventive measure in healthy young adults.

KEYWORDS : Surya-namaskar; Yoga; Anthropometric Parameters; Serotonin; Dass-21; Apparently Healthy Adults.

INTRODUCTION

Surya-Namaskar, usually translated as the "sun salutation," is a sequence of twelve dynamic postures performed in a fixed order and coordinated with the breath. Unlike a single static asana, it is practised as a continuous flow that brings together physical movement, breath regulation and mental focus within a short span of time, which is part of why it appeals as a time-efficient form of exercise [1]. Health, as the World Health Organization frames it, is not merely the absence of disease but a state of complete physical, mental and social well-being [2]. Practices that act on more than one of these domains at once are therefore of particular value, especially in people who appear healthy but may be drifting towards future risk.

Daily life has shifted towards lower levels of habitual physical activity because of automation, desk-bound work and longer screen time. These changes have fed a steady rise in overweight and obesity across age groups, both of which are well-recognised risk factors for non-communicable disease [3,4]. A persistent surplus of energy intake drives adipocyte hypertrophy, low-grade inflammation and disturbed adipokine secretion, which can produce insulin resistance and raised cardiometabolic risk long before any overt illness appears [5]. Simple anthropometric measures such as body weight, body mass index (BMI), waist and hip circumference and the waist–hip ratio (WHR) remain inexpensive and clinically useful markers of this risk, and tracking them in healthy people helps detect unfavourable trends early.
Mental health has become an equally pressing concern. Anxiety and depressive symptoms are common in the Indian population, which underlines the need for scalable, non-drug approaches to psychological well-being [6]. Stress arises when perceived demands exceed an individual's coping resources and sets off a cascade of physiological responses [7]. Repeated or chronic stress activates the hypothalamic–pituitary–adrenal (HPA) axis, raising cortisol and disturbing autonomic balance [8]. Over time this can alter appetite, fat distribution and activity patterns, feeding back into poorer body composition [9].

Yoga, which couples physical and mental elements, has gained wide acceptance as a complementary route to better fitness and lower stress [10,11]. Surya-Namaskar in particular involves repeated spinal flexion and extension with coordinated limb movement, and regular practice has been linked with gains in flexibility, muscular endurance and cardiorespiratory fitness [12,13]. Earlier work has reported improvements in pulmonary function, muscle strength and several cardiovascular variables after yoga or Surya-Namaskar training [14,15].

Serotonin (5-hydroxytryptamine) offers a plausible link between physical activity, stress and mood, as it helps regulate mood, sleep, appetite and behaviour [16]. Exercise and mind–body practices may influence serotonergic activity directly, or indirectly by improving sleep, lowering stress reactivity and raising parasympathetic tone [17,18]. Despite a growing literature, few studies have looked at both anthropometric change and an objective biochemical marker of mental health, such as serotonin, in apparently healthy adults — the very group in whom early, preventive intervention may matter most. The present study was carried out to address this gap.

METHODS

This prospective interventional study was carried out over one year in the Department of Physiology, Moti Lal Nehru Medical College, Prayagraj, after approval from the institutional ethics committee. Written informed consent was obtained from every participant before enrolment. The sample size was calculated for the comparison of two paired means, assuming an expected reduction in BMI of about 1.0 kg/m² with a standard deviation of the difference of 2.5 kg/m², at a 95% confidence level and 80% power; this gave a minimum of 49 participants. After allowing for non-compliance and to provide adequate power for the biochemical outcome, 80 apparently healthy adults were enrolled.

Apparently healthy adults aged 20 to 45 years of either sex, free of tobacco and alcohol addiction and not engaged in any regular exercise, were included. Individuals with co-morbid conditions such as asthma, renal impairment or arthritis, those unable to perform the postures for any reason, women with a known gynaecological neoplasm requiring surgery, and pregnant women were excluded.

At enrolment, demographic details were recorded and anthropometric parameters — height, weight, waist circumference, hip circumference and sagittal abdominal diameter — were measured using standard techniques. BMI and WHR were then derived. Resting blood pressure, pulse rate and respiratory rate were noted, and a venous blood sample was drawn for the estimation of serum serotonin by enzyme-linked immunosorbent assay (ELISA). Psychological status was assessed using the DASS-21 inventory, which contains seven items each for depression, anxiety and stress, scored from 0 to 3 on a Likert scale; the section totals were doubled to obtain the final scores.

Participants then practised Surya-Namaskar under supervision, five days a week, for three months. At the end of the intervention all anthropometric, cardiovascular, biochemical and psychological measurements were repeated. Data were analysed using SPSS. Paired t-tests were used to compare pre- and post-intervention values, and the Pearson correlation coefficient was used to examine the relationship between the change in serotonin and changes in the other parameters. A p-value below 0.05 was taken as statistically significant.

RESULTS

Table 1: Baseline demographic characteristics of the study participants (n = 80)

Characteristic	Value	
Age (years), mean ± SD	28.54 ± 5.44	Range 20–39
Male, n (%)	46 (57.5)	
Female, n (%)	34 (42.5)	

The study group comprised 80 apparently healthy adults with a mean age of 28.54 ± 5.44 years (range 20–39 years), reflecting a largely young-adult population. Of these, 46 (57.5%) were male and 34 (42.5%) were female, giving a modest male majority and a mixed-sex sample suitable for an unbiased assessment of the intervention.

Table 2: Anthropometric parameters before and after Surya-Namaskar practice

Parameter	Before (Mean ± SD)	After (Mean ± SD)	t	p-value
Weight (kg)	62.29 ± 6.13	60.24 ± 6.18	2.28	0.026
Waist circumference (cm)	86.21 ± 5.08	86.01 ± 5.09	0.22	0.823
Hip circumference (cm)	100.27 ± 4.54	100.61 ± 4.34	0.50	0.620
BMI (kg/m²)	23.11 ± 1.28	22.54 ± 1.46	2.80	0.006
Sagittal abdominal diameter (cm)	25.96 ± 1.70	24.72 ± 1.27	7.78	<0.001
Waist–hip ratio	0.87 ± 0.05	0.86 ± 0.05	1.74	0.084

Body weight fell significantly from 62.29 kg to 60.24 kg ($p = 0.026$) and BMI from 23.11 to 22.54 kg/m² ($p = 0.006$). The most marked change was in sagittal abdominal diameter, which dropped from 25.96 to 24.72 cm ($p < 0.001$). Waist circumference, hip circumference and WHR showed only minor changes that did not reach statistical significance, indicating that the practice acted mainly on overall and central body composition rather than on peripheral fat distribution.

Table 3: Cardiovascular parameters before and after Surya-Namaskar practice

Parameter	Before (Mean ± SD)	After (Mean ± SD)	t	p-value
Systolic BP (mmHg)	123.18 ± 6.94	121.51 ± 8.92	1.44	0.154
Diastolic BP (mmHg)	79.81 ± 4.38	77.75 ± 5.01	2.60	0.011
Pulse rate (beats/min)	81.91 ± 7.06	78.39 ± 5.89	3.61	0.001

Diastolic blood pressure fell significantly from 79.81 to 77.75 mmHg ($p = 0.011$) and pulse rate from 81.91 to 78.39 beats/min ($p = 0.001$). Systolic blood pressure showed a downward trend (123.18 to 121.51 mmHg) that did not reach significance ($p = 0.154$), most likely because the cohort was already normotensive. The pattern points to improved autonomic balance and cardiovascular efficiency after the intervention.

Table 4: Serum serotonin and DASS-21 scores before and after Surya-Namaskar practice

Parameter	Before (Mean ± SD)	After (Mean ± SD)	t	p-value
Serum serotonin (ng/mL)	0.07 ± 0.01	0.08 ± 0.01	-3.14	0.002
Depression score	13.43 ± 2.22	10.64 ± 2.31	7.24	<0.001
Anxiety score	9.85 ± 1.58	9.24 ± 1.66	2.09	0.040
Stress score	16.05 ± 1.30	12.85 ± 1.61	12.97	<0.001

Serum serotonin rose significantly from 0.07 to 0.08 ng/mL ($p = 0.002$). All three DASS-21 domains improved: depression scores fell from 13.43 to 10.64 ($p < 0.001$), stress scores from 16.05 to 12.85 ($p < 0.001$) and anxiety scores from 9.85 to 9.24 ($p = 0.040$). Using DASS-21 severity bands, the changes in depression and stress represented a shift from the moderate towards the mild range, suggesting a clinically meaningful gain in psychological well-being.

Table 5: Correlation of change in serum serotonin with changes in anthropometric and physiological parameters

Parameter	Pearson r	p-value
Weight	-0.031	0.785
Waist circumference	0.091	0.422
Hip circumference	-0.078	0.492
BMI	-0.096	0.396
Sagittal abdominal diameter	0.058	0.609
Waist–hip ratio	-0.074	0.514
Systolic BP	0.109	0.337
Diastolic BP	-0.072	0.527
Pulse rate	-0.039	0.732

The change in serotonin showed only weak, non-significant correlations with the changes in every anthropometric and cardiovascular parameter (all $p > 0.05$). In other words, although Surya-Namaskar raised serotonin, this rise was not statistically linked to the improvements seen in body measurements, blood pressure or pulse, suggesting that the physical and neurochemical benefits followed largely independent pathways.

Table 6: Correlation of serum serotonin with depression, anxiety and stress scores

Psychological parameter	Pearson r	p-value
Depression	-0.345	0.002
Anxiety	-0.330	0.003
Stress	-0.065	0.564

Serum serotonin correlated negatively and significantly with depression ($r = -0.345$, $p = 0.002$) and anxiety ($r = -0.330$, $p = 0.003$): as serotonin increased, depression and anxiety scores tended to fall. The correlation with stress was weak and non-significant ($r = -0.065$, $p = 0.564$). This indicates that the mood-related benefits of the intervention were more closely tied to serotonin than its effects on perceived stress.

DISCUSSION

The mean age of our participants was 28.54 ± 5.44 years, with most being young adults of both sexes (57.5% male). This profile is close to that of comparable Surya-Namaskar studies. More et al. reported a very similar mean age of 28.89 years and a comparable sex distribution in an apparently healthy cohort, which supports the comparability of our findings on anthropometry, serotonin and psychological scores [19]. Suwannakul et al. found Surya-Namaskar to be feasible and well-accepted among young university students [20], and earlier work by Bhutkar et al. and Singh et al. likewise showed physiological and fitness benefits in young populations [13,14]. Reports from Godse et al., Shakeela and Sugumar and Joshi et al. similarly describe

favourable responses to yoga-based practice among students and young professionals [21,22,23].

Body weight fell significantly after the intervention, from 62.29 to 60.24 kg ($p = 0.026$), suggesting that regular practice can support modest weight reduction even in people who are not obese. More et al. observed a comparable fall of about 1.68 kg after six months of practice [19]. Jakhotia et al. reported weight loss in obese women that matched circuit training and treadmill walking after eight weeks of Surya-Namaskar [24], and Bhutkar et al. found reductions in weight and BMI alongside gains in strength and endurance, pointing to genuine fitness adaptation [13].

Waist circumference and WHR changed little in our cohort and neither reached significance ($p = 0.823$ and $p = 0.084$). A similar absence of change has been described by Suwannakul et al. in young female students with shorter, less frequent sessions [20]. By contrast, studies in people with greater abdominal adiposity, or with longer interventions, have shown clear reductions: More et al. reported a significant fall in waist circumference after six months [19], and Cramer et al. found a marked decrease in abdominal circumference in women with central obesity after a 12-week yoga programme [25]. This suggests that a longer or more intense practice may be needed to shift waist-related measures in lean individuals.

BMI fell significantly from 23.11 to 22.54 kg/m² ($p = 0.006$), and the sagittal abdominal diameter showed the largest response of all, dropping from 25.96 to 24.72 cm ($p < 0.001$). As sagittal diameter is a sensitive marker of central and visceral fat, this points to a real improvement in core body composition. These results echo More et al., who reported a significant BMI reduction and a 4.2% fall in sagittal diameter [19]. Reductions in BMI after Surya-Namaskar have also been documented by Bhutkar et al. and Shakeela and Sugumar [13,22], while Na Nongkhai et al. recorded falls in both BMI and body-fat mass in overweight adolescents after a 12-week yoga programme [26]. The repeated forward and backward bending of Surya-Namaskar, with continuous core activation, plausibly strengthens abdominal muscles and mobilises central fat, which would explain why sagittal diameter responded more than waist circumference [25].

Diastolic blood pressure (79.81 to 77.75 mmHg, $p = 0.011$) and pulse rate (81.91 to 78.39 beats/min, $p = 0.001$) both fell significantly, whereas systolic pressure showed only a non-significant downward trend ($p = 0.154$). The limited systolic response is consistent with Suwannakul et al., who found no significant systolic change in normotensive students [20], while Joshi et al. reported greater reductions in both systolic and diastolic pressure with Surya-Namaskar than with treadmill walking in a higher-stress group [23]. The fall in diastolic pressure and pulse most likely reflects greater parasympathetic tone and reduced sympathetic drive, in keeping with reports by More et al., Sinha and Sinha, and Kodidala et al. of lower resting heart rate and improved autonomic balance after sustained practice [19,27,28].

Serum serotonin increased significantly, from 0.07 to 0.08 ng/mL ($p = 0.002$). Because serotonin governs mood, emotional balance and stress handling, even a small rise is mechanistically meaningful. Our result aligns closely with More et al., who reported an approximately 10% rise in serum serotonin after six months of practice [19]. Direct serotonin data for Surya-Namaskar are scarce, but Lee et al. found that yoga preserved or raised serotonin in premenopausal women while it fell in controls [18], and Streeter et al. showed that yoga produced greater mood and anxiety benefits than metabolically matched walking, consistent with an effect on central neurotransmitter systems [17]. A likely mechanism is that the rhythmic movement, controlled breathing and meditative focus of the practice lower HPA-axis activity and cortisol while raising parasympathetic tone, all of which favour serotonin synthesis and release. Peripheral serotonin does not directly mirror central activity, but the consistent rise across studies argues for a real effect on serotonergic pathways.

All three DASS-21 domains improved. Depression fell from 13.43 to 10.64 ($p < 0.001$) and stress from 16.05 to 12.85 ($p < 0.001$), each representing a shift from the moderate towards the mild band, while anxiety fell more modestly from 9.85 to 9.24 ($p = 0.040$). More et al. reported almost identical reductions in depression and stress [19]. Comparable improvements in depressive and stress symptoms after yoga or Surya-Namaskar have been reported by Shohani et al., Godse et al., Deorari et al. and Suresh and Preetha [29,21,30,31], and reductions in anxiety and perceived stress have been described by Suwannakul et al. and Joshi et al. [20,23], with Streeter et al. again noting larger anxiety benefits from yoga than from walking [17]. The mood gains seen here are best explained by the combined physical, neurochemical and psychological actions of the practice — lower cortisol and sympathetic activity, higher serotonin, and the emotional regulation that comes with mindful, breath-linked movement. This is also reflected in the significant negative correlations between serotonin and both depression and anxiety, even though serotonin did not track changes in body measurements or blood pressure.

LIMITATIONS

The before-after design without a control group limits causal inference and cannot fully exclude temporal or lifestyle confounders. The sample was relatively small and confined to apparently healthy young adults, which limits generalisability to older people or those with chronic illness. Diet, sleep and physical activity outside Surya-Namaskar were not tightly controlled and may have influenced the outcomes. Peripheral serum serotonin was measured rather than central nervous system serotonin, so it may not fully reflect brain serotonergic activity. A single, uniform practice duration and frequency were used, so the effects of different intensities or durations could not be compared.

CONCLUSION

Three months of regular Surya-Namaskar led to significant improvements in body composition, with reductions in body weight, BMI, and sagittal abdominal diameter, though waist circumference and WHR remained unchanged. Diastolic blood pressure and pulse rate decreased, indicating enhanced cardiovascular function, while systolic pressure was stable. Notably, serum serotonin levels increased, correlating with reduced depression, anxiety, and stress; however, these psychological benefits were largely independent of physical measures. The findings advocate for Surya-Namaskar as a non-pharmacological approach to enhance physical fitness and emotional well-being in young adults, suggesting its inclusion in preventive health programs, while recommending larger controlled trials for further validation.

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