RESEARCH PAPER

Isotonic Exercise Modulates Psychological Stress and Serum Serotonin Levels in Young Healthy Females: A Randomized Controlled Trial

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Abstract

Background: Regular physical activity is known to improve psychological well-being; however, the comparative effects of different forms of moderate-intensity isotonic exercise on perceived stress and peripheral serotonin levels remain inadequately understood. This study evaluated the effects of walking and Surya Namaskar on psychological stress and serum serotonin levels in healthy young women.

Methods: A randomized controlled parallel-group trial was conducted among 33 apparently healthy, non-exercising females aged 18–30 years. Participants were randomly assigned to either a walking group (n = 17) or a Surya Namaskar (isotonic yoga) group (n = 16). Both groups performed 30 minutes of moderate-intensity exercise, five days per week, for 40 days. Perceived stress was assessed using the 10-item Perceived Stress Scale, while serum serotonin levels were measured by enzyme-linked immunosorbent assay (ELISA). Baseline and post-intervention outcomes were compared using appropriate statistical tests.

Results: Both walking and Surya Namaskar significantly reduced perceived stress scores after the 40-day intervention ($p < 0.001$). A non-significant reduction in body mass index was observed in both groups. Serum serotonin levels decreased following the intervention in both groups, with a statistically significant reduction observed only in the Surya Namaskar group ($p = 0.005$). No significant between-group differences were found for stress reduction or serum serotonin levels after the intervention.

Conclusion: Moderate-intensity isotonic exercises, including walking and Surya Namaskar, effectively reduced psychological stress in healthy young women. Long-term isotonic exercise was also associated with reduced peripheral serum serotonin levels, suggesting potential alterations in serotonin metabolism during sustained physical activity. These findings support the inclusion of both exercise modalities as practical strategies for stress management while highlighting the need for further research to clarify the mechanisms underlying peripheral serotonin regulation following exercise.

Keywords: Isotonic exercise; Walking; Surya Namaskar; Psychological stress; Serum serotonin; Perceived Stress Scale; Randomized controlled trial; Healthy women.

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INTRODUCTION

The subtle yet swift expansion of sedentary lifestyle and physical inactivity has precipitated a global health crisis, characterised by an increase in preventable lifestyle disorders such as obesity, diabetes, hypertension, and other forms of non-communicable diseases. Adherence to regular exercise routines is often constrained by the demands of professional and domestic responsibilities, especially in women, compounded by inflexible work schedules. A report from the WHO in 2020 emphasised that, on a global scale, women engage in less physical activity compared to men, frequently as a result of caregiving duties, household responsibilities, and time constraints[1]. Moreover, the absence of secure public spaces, inadequate lighting, safety concerns in communal

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areas, or the lack of exercise facilities designed for women could discourage outdoor physical activities.

Several epidemiological studies have reported that a daily routine of “moderate intensity” isotonic exercise positively influences both physical and mental well-being[2-4]. Apart from maintaining a healthy body weight, epidemiological studies have reported that walking reduces stress, mood swings, and depression by increasing the levels of endorphins and serotonin[5-7].

Serotonin, a phylogenetically conserved bioamine, is reputed as a "happy hormone" for its essential roles in promoting brain health and overall well-being. Synthesis occurs in both the central nervous system and peripheral tissues[8]. Tryptophan, the precursor amino acid, acts as the biochemical substrate for the synthesis of serotonin and is metabolised enzymatically by monoamine oxidase[9]. Centrally, serotonin is mainly expressed in the brainstem, acts as a neurotransmitter, plays a pivotal role in regulating anxiety, helps in mood regulation, appetite control, sleep, learning, and central glucose regulation[10-14]. Peripherally, serotonin is mainly produced from enterochromaffin cells of the gut and is stored in the platelets. It functions as a paracrine, autocrine, or even intracrine hormone, contributing to metabolic regulation. Additionally, it serves as a potent vasoconstrictor and a vasodilator in various vascular beds, depending on the physiological needs[15], thereby playing a crucial role in maintaining homeostasis. Nonetheless, serotonin does not traverse the blood-brain barrier, so the central and peripheral pools are functionally and anatomically distinct[16]. Research indicates that engaging in physical activity plays a crucial role in regulating serotonin levels, thereby alleviating stress and decreasing the occurrence of various lifestyle-related disorders[17]. Moreover, various animal models and a few human studies have documented that isotonic types of exercises, like walking, have been reported to elevate central serotonin levels[18-19]. However, the effects of exercise on the peripheral serotonin levels need more lucidity.

Yoga, an ancient type of physical activity tailored to the Indian context, harmonises physical and mental elements, demonstrating its efficacy in alleviating stress by enhancing the parasympathetic activity[20]. Few studies have reported that distinct types of yoga, such as Hatha and Iyengar yoga, have shown beneficial effects in decreasing stress and anxiety levels[21-23]. However, the specific impact of isotonic yoga on peripheral serotonin levels and the underlying physiological mechanisms warrants further exploration. Hence, this randomised controlled trial aims to determine the effect of two different types of moderate intensity isotonic exercises, such as walking and Suryanamaskar, practised outdoors and indoors, respectively, on stress and serum serotonin levels in apparently healthy non-exercising women.

MATERIALS AND METHODS

This randomized controlled trial, utilizing a parallel design, involved 33 apparently healthy female teaching and non-teaching faculty and students aged 18 to 30 years from a tertiary care hospital in Chennai, all of whom exhibited no or minimal exercise routines. After obtaining approval from the Institutional Ethics Committee (REF NO: IEC-NI/23/NOV/90/101), the study was conducted from April to May 2024. Participants who engaged in any form of sports exercise, endurance training, or regular yoga practice were excluded from the study. Additionally, individuals with a history of epilepsy, psychiatric disorders, cerebrovascular accidents, musculoskeletal injuries, chronic steroid use, as well as pregnant and lactating women, were excluded from the study. The estimation of sample size was derived from previous research (Sharvari et al., 2022) that evaluated the stress scores associated with aerobic exercise and Surya Namaskar. Accounting for a 10% attrition rate, the estimated sample size was 33.

SELECTION AND RANDOMIZATION

Participants were selected based on the selection criteria and written informed consent was obtained from eligible participants after explaining the study protocol. Consented study participants were randomized into two groups: the Walking group (n=17) and the Suryanamaskar group (n=16) (Fig.1), utilizing a random number generator with Epi Info software.

OUTCOME ASSESSMENT

Anthropometric parameters such as height and weight were measured in both the groups and BMI was calculated. All the study participants subsequently underwent baseline assessment of their stress levels using the 10-item Perceived Stress Scale developed by Sheldon Cohen[24] and serum serotonin levels. For assessment of serum serotonin levels participants were instructed to fast overnight to reduce potential dietary influences on serotonin levels. Adhering to strict aseptic protocols, 2 ml of peripheral venous blood was withdrawn in all subjects to assess the baseline serum serotonin levels. Blood samples were collected between 08:30 am to 11:30 am to control for potential circadian variations. The blood was allowed to coagulate and subsequently centrifuged at 3000 rpm for 3 minutes. Serum was collected and stored in microcentrifuge tubes at -80ºC for subsequent evaluations using ELISA method.

INTERVENTION

Participants in the walking and isotonic yoga groups were instructed to engage in moderate intensity exercise, adhering to the Physical Activity Recommendations established by the American College of Sports Medicine and the American Heart Association for healthy adults aged 18 to 65 years[25].

The individuals in the walking group were instructed to adhere to a daily walking routine of 30 minutes or to achieve a distance of 3 kilometers each day. Participants in the isotonic yoga group were instructed to perform Suryanamaskar for 30 minutes daily or to complete a minimum of 12 Suryanamaskar asanas each day, including a brief pause of 2-3 seconds for breath between each

asana[26]. All the study participants were monitored and motivated to adhere to their respective exercise regimen (walking/suryanamaskar) for five days a week to a total duration of 40 days. Participants in the walking group were instructed to document and share their every day walking routine using a fitness tracking application named 'Strava'. The individuals in the Suryanamaskar (Isotonic Yoga) group underwent three days of face-to-face training led by a certified yoga instructor prior to the start of the study. Subsequently, all sessions were carried out online utilizing the Google platform. Participants were also encouraged to attend in-person Suryanamaskar sessions once a week. A post-intervention assessment of perceived stress and serum serotonin levels was conducted following the 40-day isotonic exercise regimen.

STATISTICAL ANALYSIS

Statistical analysis was conducted utilising R software version 4.2.1 in accordance with the intent-to-treat approach.The Kolmogorov-Smirnov test was employed to assess the normality of data distribution. Descriptive statistics for categorical variables are reported as frequencies and percentages, while continuous variables are provided as mean, standard deviation and standard error. Chi-square test was employed to assess the statistical significance of categorical variables. Within-group variability was assessed using the paired T-test and Wilcoxon signed-rank test, while between-group variability was evaluated using the independent t-test or Mann–Whitney U test.

RESULTS

Descriptive Characteristics of Study Participants

This randomised controlled trial involved 33 apparently healthy females aged 18 to 25 years. The mean age and BMI of the study participants were 23.52 ± 5.02 years and 24.57 ± 4.17 kg/m², respectively. The descriptive characteristics of the study participants were comparable across the groups (Table1), indicating the effective randomisation process in achieving baseline equivalence. All the study participants were neither smokers nor alcoholics.

Table 1: Descriptive characteristics of the study participants

Study Variables		Isotonic Yoga (n=16) (Mean±SD)	Walking n=17 (Mean±SD)	p value
Age (years)		23.1±5.2	23.94±5.9	0.6
Height (cms)		158 ± 7.65	156.5±5.5	0.5
Weight (Kg)		58.2±10.7	62.5±8.7	0.2
BMI (Kg/m²)		23.3±3.9	25.7±4.2	0.1
Educational status	**Professional**	7 (21.2)	4 (12.1)	0.4
	Graduates/intermediates	9 (27.3)	13 (39.4)	

Effects of Isotonic exercise on BMI, Stress & Serotonin levels

Table 2 shows a comparative analysis of BMI, perceived stress, and serum serotonin levels, both within and between groups, highlighting the changes before and after intervention in the walking and isotonic yoga groups. The baseline levels of all the parameters were similar in both groups. Upon evaluating the within-group variability (Table 2, Fig.2), it was determined that participants in both walking and isotonic yoga intervention exhibited a significant reduction in stress levels (walking: $\Delta = 7.5\pm1.5$, $p < 0.001$; isotonic yoga: $\Delta = 5.3\pm1.7$, $p < 0.001$) following the intervention. Additionally, serum serotonin levels decrease in both groups, with a significant ($p=0.005$) reduction noted in the isotonic yoga group after intervention. Upon assessing the between-group variability, there found no significant difference existed in stress and serum serotonin levels post-intervention (Table 2). Additionally, a non-significant reduction in BMI was observed in both groups.

Table 2: Comparison of BMI, Perceived Stress, and Serum Serotonin Levels Before and After Intervention in Walking and Yoga Groups

Outcome Measures	Group	Before intervention (Mean±SE)	After intervention (Mean±SE)	Within group difference (Mean ±SE)	Within group p value	Between group p value
BMI (Kg/m²)	Walking	25.1±0.8	24.7±0.8	0.35±0.2	0.24$	0.38#
	Isotonic Yoga	24.03±1.2	23.6±1.01	0.45±0.5	0.44$	
Stress	Walking	20.65±1.6	13.1±1.6	7.5±1.5	<0.001$	0.9#

Score	Isotonic Yoga	19.4±1.6	14.1±1.5	5.3±1.7	<0.001$	
Serotonin (ng/mL)	Walking	358.7±92.5	277.1±53.5	31.02±85.9	0.5*	0.6&
	Isotonic Yoga	389.6±109.1	265.1±62.6	54.9±58.9	0.005*	

*Wilcoxon test, $ Paired t test, # Independent T test, & Mann-Whitney U test

DISCUSSION

Stress, sedentary lifestyle, and physical inactivity have exacerbated a global health crisis, increasing the prevalence of preventable lifestyle disorders, especially among females. Safety concerns and domestic responsibilities deter women from engaging in daily outdoor workout regimens. This randomized controlled equivalency trial evaluated the effect of two distinct forms of isotonic exercises on BMI, serum serotonin, and perceived stress levels in apparently healthy non-exercising females. Baseline and post-exercise changes in BMI, serum serotonin and perceived stress levels were assessed. We posited that isotonic yoga, exemplified by suryanamaskar, which can be performed indoors, may reduce BMI and perceived stress levels equivalent to isotonic workouts such as walking, and will elevate serum serotonin levels post-exercise.

The current study showed a significant reduction in perceived stress levels among both groups of participants following isotonic exercises. Nonetheless, there was no significant reduction in BMI in both the groups following the exercise regimen. Several epidemiological studies have reported a reduction in stress, anxiety, burnout, and depression after performing various forms of isotonic exercises and yoga was reported to be effective in improving mental health [27-30]. Engaging in regular physical activity effectively reduces stress levels and is mainly attributed to both physiological and psychological factors. Studies show that consistent physical activity triggers the release of endorphins [31], acting as a natural mood booster, while also contributing to lower cortisol levels, the hormone associated with stress. This process ultimately aids in building emotional resilience and alleviating stress. Studies have indicated that engaging in regular walking for over 150 minutes per week or participating in moderate intensity exercises, such as suryanamaskar, for at least 4 weeks has been shown to reduce BMI[32], effectively.

The findings of the present study indicated a notable decrease in serum serotonin level in both groups, with a significant reduction noted amongst the isotonic yoga intervention group. Several animal and human studies have stated that the endogenous central serotonin levels increase after exercise [33-35]. Further, few studies that assessed the peripheral serotonin levels have also reported similar findings. However, in the current study, we found a reduction in peripheral serotonin levels after exercise. Our finding was consistent with few studies which reported that repeated bouts of exercise decreased the serum serotonin levels, whereas a single bout of exercise tends to increase the serotonin levels[36]. Medica et al., in their animal model, have shown that the increase in serum serotonin levels right after high-intensity exercise results from platelet activation and the release of gut enterachromaffin[37]. Falabrègue et al observed that long-term exercise influences tryptophan metabolism, a precursor of serotonin, steering it towards the kynurenine pathway in humans[38]. This metabolic re-routing limit the substrates required for serotonin synthesis, particularly in adipose tissue and the gastrointestinal tract, resulting in a reduction in peripheral serotonin production. This process improves metabolic balance by boosting insulin sensitivity and aiding glucose uptake in adipose tissue, while also promoting gluconeogenesis in the liver.

This research represents a pioneering effort to explore the relationship between isotonic yoga practices such as suryanamaskar and walking, particularly concerning stress and peripheral serotonin levels. While most studies prove an increase in the central serotonin levels after exercise, our study shows a decrease in the levels of serum serotonin, warranting further research methods amongst humans on the impact of exercise on peripheral serotonin. Furthermore, comprehensive exercise training was carried out under professional supervision through both virtual and in-person sessions, despite the logistical challenges involved in participant recruiting, monitoring progress, and conducting evaluations. One of the limitations is that this study did not analyze the influence of various phases of menstrual cycles on serum serotonin levels. Future studies should consider this when examining serum serotonin levels in females.

CONCLUSION

This randomized controlled trial provides valuable insights into the effects of isotonic exercises, such as Surya Namaskar and Walking, on stress reduction and serotonin levels in healthy young women. Both forms of moderate-intensity exercise, which are practiced outdoors and indoors, showed significantly decreased perceived stress levels, highlighting their potential role in stress management. Further, our findings demonstrated a significant reduction in serum serotonin after 40 days of consistent exercise in both groups. This suggests that long-term isotonic exercise may influence serotonin dynamics and help in metabolic stability.

The study underscores the complexity of serotonin regulation in response to physical activity and emphasizes the need for further research to elucidate the central versus peripheral effects of exercise on serotonergic pathways. Additionally, the findings support the incorporation of

isotonic exercises like walking or Surya Namaskar into health routines to combat stress, with potential benefits for overall well-being. Notably, women who are unable to engage in daily walking due to the various social restraints may consider yoga as an alternative, as both modalities elicit comparable physiological benefits that contribute to overall health improvement. Future studies should explore hormonal influences, effects on other neurotransmitters, and longer-term impacts to better understand the neuromodulatory effects of different exercise modalities.

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