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Investigating the efficacy of cyclic meditation in the management of post-exercise fatigue among law enforcement trainees: a randomized controlled study

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Cyclic meditation (CM), a practice rooted in traditional knowledge, offers a holistic approach to mental and physical well-being, promoting stress reduction, focus, and emotional balance, all of which are essential for enhancing overall health and resilience that can benefit individuals in our fast-paced, often disjointed modern world. To examine the impact of CM on exercise-induced fatigue (EIF), 48 law enforcement trainees (age 28.1±4.4 y, height 1.7±0.06 m, and mass 63.9±8.5 kg) from the Kerala Police Academy in Thrissur, Kerala, India were randomly chosen and were distributed to two even groups. The intervention group (n=24) practiced 30 min of CM after morning physical training session for 30 days, while the control group (n=24) rested in supine. Testosterone, cortisol, and Testosterone-Cortisol ratio (T:C) were assessed for 20 participants in each group on days 1 and 31 after the physical training session. Counter Movement Jump (CMJ) and Rating of Fatigue (ROF) questionnaire were measured for all the participants on days 1, 15, and 31 after the physical training session. The intervention group exhibited significant improvements in CMJ height ($p<0.05$), CMJ flight time ($p<0.05$), and ROF ($p<0.05$), but the control group did not exhibit any significant changes. The control group showed significant decline in testosterone ($p<0.05$) and T:C ($p<0.05$) and a significant rise in cortisol ($p<0.05$) while the intervention group did not reveal any significant changes. The intervention group significantly improved CMJ variables and ROF, restricted the decline in testosterone by over 10%, suppressed the reduction in T:C by more than 50%, compared to the control group and reduced cortisol levels by 27%. These findings suggest that CM could aid in recovering from EIF.

Keywords: Counter movement jump, Cyclic meditation, Exercise induced fatigue, Physical exercise, Recovery, Yoga

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Prolonged endurance activities and excessive exercise often result in exercise-induced fatigue (EIF). Oxidative stress, depletion of energy, inflammation and accumulation of toxic metabolites and are the main contributors to EIF[1]. Researchers have identified biochemical markers as a primary method for exploring the constitutive mechanisms of EIF, with high-intensity exercise increasing cortisol and testosterone levels[2,3]. However, when training intensity surpasses the body's adaptive capacity and exceeds its biological limits, overtraining syndrome can develop, leading to a decline in testosterone secretion[4,5]. The regulation of reproductive system, metabolic function and mental well-being in men are significantly influenced by testosterone[6,7]. When blood testosterone levels fall significantly, it is regarded as hypogonadism, which causes a decline in both physical and mental health[8,9]. Widely-used passive recovery techniques offer several alternatives for athletes and their healthcare providers, offering diverse methods to counteract the negative effects of training, exercise or competition, aiding in quicker recovery and improved performance. To achieve this goal, many modern methods like compression garments, cryotherapy, cold water immersion, etc. are currently being used[10,11].

Practices such as tai-chi, qigong, herbal remedies, fasting, nature therapies, meditation, etc., have been used throughout history to enhance the body's natural resilience and strength[12]. Yoga, with its roots in ancient Indian spirituality, is one such practice has increasingly gained recognition in recent years for its positive effects on health and well-being. Yoga is known to reduce fatigue and burnout, promote the healing process, minimize physical disturbances and enhance the quality of life[13,14]. Meditation, one of the key practices in yoga, is recognized to have a wide range of psychophysiological effects[15]. Research has revealed that different mindfulness based techniques have proven to be efficient in lowering cortisol levels,

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blood pressure, stress, etc.[16]. Although most meditation practices focus on holding a comfortable and still position, some practices also incorporate movement. Cyclic meditation (CM) is one such meditation practice which combines stimulating practices along with calming practices derived from an ancient Indian text, '*Mandukya Upanishad*'[17].

Practicing CM appears to improve cognitive functions and vagal tone, resulting in a 32.1% decrease in energy utilization and oxygen intake compared to a period of resting in a lying down position, as well as a reduction in baseline autonomic arousal and work-induced stress[15,16]. Therefore, this study sought to explore how CM influences post-training fatigue in law enforcement trainees.

Materials and Methods

Subjects

This study involved 48 male law enforcement trainees (age 28.1±4.4 y, height 1.7±0.06 m, and mass 63.9±8.5 kg) from the Kerala Police Academy, Thrissur, Kerala, India. Using G*Power software (Version 3.1.9.4), the sample size was determined with alpha set at 0.05 and power at 0.8. Based on an effect size of 0.92 from a previous study[18], 20 participants were recommended per group, amounting to 40 samples. To ensure sufficient sample size, we opted to have 24 participants per group, leading to a total of 48 samples. Informed consent, including a description of all the methods and techniques, possible pros and cons was obtained from every individual who participated in the current experimental trial. The subjects underwent 3 to 5 h physical training per day (excluding Sundays) including running, physical exercises, parade, etc. The subjects were able to speak and understand both English and Malayalam languages. None of the subjects were under any kind of medication during the study period. Subjects with hyperthyroidism, diabetes, insomnia or any other serious or chronic disorders that can lead to fatigue were excluded from the study. The subjects were not users of cigarettes, alcohol or any other recreational drug and were also instructed to avoid consumption of any such substances within the study time frame. All subjects were informed to adhere to their standard training and diet and were also instructed to refrain from drinking coffee but were allowed to drink a maximum of two teas per day.

Study design

The day before the commencement of the study, participants were selected at random using simple random sampling method and provided with detailed explanations and were familiarized regarding the intervention and measurement procedures of the study. On this day, physical characteristics including weight, height, body mass index and age were measured and documented. After the pre data collection on day 1, subjects were randomly designated to intervention group (CM) (n=24) or control group (Supine Rest) (n=24) using simple random sampling method. The intervention group attended CM for a period of 30 min for 30 days under the guidance of a trained yoga teacher while the control group rested in supine. The pre, intermediate and post assessments were taken on day 1 (pre measurement), day 15 (intermediate measurement) and on day 31 (post measurement) respectively after the physical training sessions for Counter Movement Jump (CMJ) and Rating of Fatigue (ROF) for all the subjects. On day 1 and day 31 at 8:30 AM, saliva samples were taken to measure testosterone (T), cortisol (C), and T: C levels. (Fig. 1). To maintain the accuracy of results, only twenty participants were taken from each group for saliva analysis as the saliva collection time was different for the other four excluded participants.

Methodology

On day 1, day 15 and on day 31, after the physical training session, subjects performed three CMJs for the measurement trial. Best of the three jumps were used for the analysis.

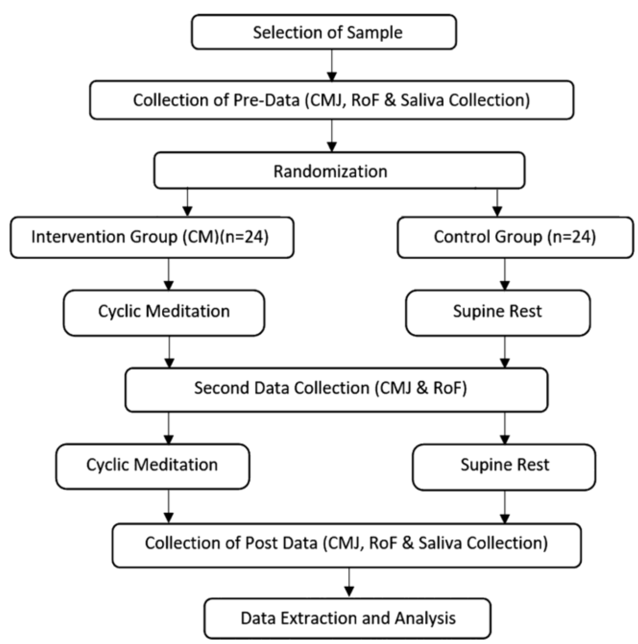

Fig. 1 — Illustrates the layout and structure of the study design

Participants also completed the ROF questionnaire, which is an 11-point numerical scale from 0 to 10, designed to assess the intensity of fatigue across various situations. The scale includes five diagrams and five descriptors to assist users in interpreting the scale and providing accurate ratings. A score of 0 signifies the absence of fatigue, whereas 10 stands for total fatigue and exhaustion[19]. Previous studies[19] have shown to have good reliability with other measures of fatigue like blood lactate concentration (r=0.825) and heart rate (r= 0.839). On day1 and on day 31, the CMJ was followed by collection of a 1-min unstimulated saliva for the analysis of Testosterone, cortisol, and T:C. Saliva samples were obtained by passively drooling saliva directly into a sterile Eppendorf tube. Concentrations of cortisol and testosterone are not dependent on the rate of flow of saliva[20]. All the subjects were instructed to consume only water and avoid all other substances for an hour before giving their saliva sample. Saliva tubes were preserved at a temperature of − 80°C until they underwent analysis. Cortisol (pg/mL) and testosterone (pg/mL) were calculated in duplicate by using enzyme-linked immunosorbent assay kits (ELISA) (Salimetrics, PA, USA) and a Perkin Elmer EnSpire 2300 multimode plate reader (PerkinElmer, Inc., MA, USA).

CMJ serves as a major tool in evaluating the neuromuscular function[21]. The CMJ is a reliable tool for measurement of flight time (r=0.934) and jump height (r=0.932) in neuro-muscular fatigue[22]. The ‘My Jump’ smart phone application was employed to calculate the CMJ flight time by identifying the frames of take-off and landing in the video, followed by calculation of jump height with an equation ($h = t^2 \times 1.22625$). In this equation, the variable h refers to the height of the jump quantified in meters, and t indicates the duration of the time spent in air while jumping in seconds[23]. To capture the CMJ, the researcher lay flat on the floor in prone position with an iPhone 11 positioned 1.5 meters away from the participant, directed towards their feet in the frontal plane. After the jump, the 'My Jump' app was used to identify the first frame where both feet were airborne while going up and the first frame where at least one foot touching the floor while reaching down to calculate jump height and flight duration[24]. The iPhone 11 used for the study was equipped with a 240 Hz camera, delivering 1080p video quality.

Jump height was recorded in centimetres, flight time was recorded in seconds, power was recorded in watts, force was recorded in newtons and velocity was recorded in metre per second.

Intervention

Following their training, the subjects in the intervention group participated in a 30-min CM session for 30 days while the control group relaxed in supine rest (SR). Before commencing the CM training, the instructor highlighted the need to practice slowly, with focus and relaxation. The following are the steps followed in CM[17];

1. Chanting of opening prayer (a verse taken from *Mandukya Upanishad*) (0:40 min)
2. A series of sequential isometric contractions of muscles, finishing with SR (1:00 min)
3. Gently standing up by shifting the body towards the left and assuming a standing position (*Tadasana*)
4. Distributing your body weight evenly on both feet, (2:00 min) a method called ‘centring’
5. The first lateral bending position in standing posture, (*Ardhakattichakrasana*) slowly bending to the right side. (1:20 min)
6. Slowly coming back to *Tadasana* along with guidance emphasizing on awareness and calming the body and mind. (1:10 min)
7. The second lateral bending position in standing posture, (*Ardhakattichakrasana*) slowly bending to the left side. (1:20 min)
8. *Tadasana* (1:10 min); slowly bending forward (*Padahasthasana*) (1:20 min)
9. *Tadasana* (1:10 min); slowly bending back (*Ardhachakrasana*) (1:20 min)
10. Gently lie on your back (*Savasana*), then follow the sequence of instructions to progressively relax each part of your body (10:00 min).

Trial registration

This research was registered with the ‘CTRI (Clinical Trials Registry-India)’ (Registration number: CTRI/2023/07/054839). The registration was completed on July 6, 2023.

Results

After being entered into an Excel sheet, the collected data were analyzed and evaluated using JASP version 0.13.1.

CMJ variables

CMJ variables pre- versus intermediate

In the intervention group, CMJ height increased 5.42% from 26.075 to 27.490 while it increased 1.1%

from 25.658 to 25.940 in the control group. The intervention group exhibited a 1.72% increase in CMJ flight time, rising from 0.466 to 0.474, compared to a 1.53% increase in the control group, from 0.456 to 0.463. The intervention group had a 1.93% increase in CMJ velocity, rising from 1.141 to 1.163, while the control group showed a 1.25% increase, from 1.120 to 1.134. CMJ force increased by 1.82% from 1256.19 to 1279.078 in the intervention group while it increased 1.59% from 1229.30 to 1248.916 in the control group. CMJ power increased in the intervention group by 3.02% from 1453.904 to 1497.781 while in the control group, it increased 2.79% from 1401.129 to 1440.323 (Table 1).

CMJ variables pre- versus post

In the intervention group, CMJ height increased 15.36% from 26.075 to 30.082 while it increased 2.01% from 25.658 to 26.174 in the control group. The intervention group showed a 2.8% rise in CMJ flight time, from 0.466 to 0.494, whereas the control group had a 0.87% increase, from 0.456 to 0.460. The intervention group experienced a 6.22% increase in CMJ velocity, from 1.141 to 1.212, while the control group showed a 1.34% rise, from 1.120 to 1.135. The intervention group exhibited a 6.92% increase in CMJ force, from 1256.19 to 1343.109, whereas the control group showed a 0.55% rise, from 1229.30 to 1236.16. The intervention group exhibited a 12.60% increase in CMJ power, from 1453.904 to 1637.134, whereas the control group showed a 0.46% rise, from 1401.129 to 1407.602 (Table 1).

Hormonal variables pre- versus post

In the intervention group, testosterone decreased 21.19% from 232.913 to 183.54 which was not significant while it decreased significantly (Table 2) 31.5% from 228.63 to 156.62 in the control group. The intervention group saw a 27.34% decrease in cortisol, from 4929.21 to 3581.34, while the control group experienced a 28.3% rise, from 2981.74 to 3824.61. T:C decreased by 21.4% in the intervention group, from 0.070 to 0.055, while the control group saw a 44.2% decrease, from 0.095 to 0.053 (Table 1).

Rating of fatigue scale

Rating of fatigue scale pre- versus intermediate

The intervention group experienced a 43.13% decrease in fatigue, from 6.375 to 3.625, while the control group saw an increase of 7.03%, from 5.917 to 6.333 (Table 1).

Rating of fatigue scale pre- versus post

The intervention group had a 64.04% decrease in fatigue, from 6.375 to 2.292, while in the control group, fatigue increased by 12.67%, from 5.917 to 6.667 (Table 1).

Discussion

Multiple studies have previously explored the impact of various recovery techniques such as water immersion, compression garments, mechanical bed massage etc. post exercise or physical training[18,25,26]. To the best of our understanding, this is the first time that CM was incorporated into the training module in

Table 1 — the mean ± standard deviation for the pre, intermediate, and post measurements

	Intervention			Control		
Variables	Pre	Intermediate	Post	Pre	Intermediate	Post
Testosterone (pg/mL)	232.913 ±113.353	-	183.54 ±72.119	228.63 ±94.19	-	156.62 ±60.73
Cortisol (pg/mL)	4929.21 ±4695.29	-	3581.34 ±1490.46	2981.74 ±1572.45	-	3824.61 ±2205.28
T:C (pg/mL)	0.070 ±0.04	-	0.055 ±0.02	0.095 ±0.07	-	0.053 ±0.03
CMJ Height (cm)	26.075 ±4.199	27.490 ±4.243	30.082 ±4.268	25.658 ±6.402	25.940 ±6.169	26.174 ±4.662
CMJ Flight Time (seconds)	0.466 ±0.049	0.474 ±0.036	0.494 ±0.034	0.456 ±0.058	0.463 ±0.053	0.460 ±0.040
CMJ Velocity (m/s)	1.141 ±0.121	1.163 ±0.088	1.212 ±0.085	1.120 ±0.144	1.134 ±0.131	1.135 ±0.106
CMJ Force (Newtons)	1256.19 ±160.05	1279.078 ±116.504	1343.109 ±116.798	1229.30 ±187.94	1248.916 ±173.52	1236.16 ±127.574
CMJ Power (Watts)	1453.904 ±352.753	1497.781 ±255.278	1637.134 ±262.841	1401.129 ±412.541	1440.323 ±383.107	1407.602 ±274.551
ROF	6.375 ±1.689	3.625 ±1.345	2.292 ±1.083	5.917 ±1.248	6.333 ±1.239	6.667 ±1.373

Table 2 — The within group analysis of all the variables

Variables	Group	Assessment	t	p	Effect size
CMJ Height	Intervention	Pre-Intermediate	2.867	0.009	0.585
		Intermediate- Post	4.721	< .001	0.964
		Pre- Post	5.084	< .001	1.038
	Control	Pre-Intermediate	0.859	0.399	0.175
		Intermediate- Post	0.260	0.798	0.053
		Pre- Post	0.578	0.569	0.118
CMJ Flight Time	Intervention	Pre-Intermediate	1.469	0.155	0.300
		Intermediate- Post	3.618	0.001	0.739
		Pre- Post	3.926	< .001	0.801
	Control	Pre-Intermediate	1.823	0.081	0.372
		Intermediate- Post	-0.347	0.731	-0.071
		Pre- Post	0.509	0.616	0.104
CMJ Velocity	Intervention	Pre-Intermediate	1.540	0.137	0.314
		Intermediate- Post	3.579	0.002	0.731
		Pre- Post	3.914	< .001	0.799
	Control	Pre-Intermediate	1.591	0.125	0.325
		Intermediate- Post	0.057	0.955	0.012
		Pre- Post	0.704	0.488	0.144
CMJ Force	Intervention	Pre-Intermediate	1.301	0.206	0.265
		Intermediate- Post	3.606	0.001	0.736
		Pre- Post	3.818	< .001	0.779
	Control	Pre-Intermediate	1.817	0.082	0.371
		Intermediate- Post	-0.482	0.634	-0.098
		Pre- Post	0.258	0.799	0.053
CMJ Power	Intervention	Pre-Intermediate	1.158	0.259	0.236
		Intermediate- Post	3.587	0.002	0.732
		Pre- Post	3.732	0.001	0.762
	Control	Pre-Intermediate	1.775	0.089	0.362
		Intermediate- Post	-0.550	0.588	-0.112
		Pre- Post	0	0.915	0.022
ROF	Intervention	Pre-Intermediate	-8.307	< .001	-1.696
		Intermediate- Post	-4.553	< .001	-0.929
		Pre- Post	-10.605	< .001	-2.165
	Control	Pre-Intermediate	1.514	0.144	0.309
		Intermediate- Post	0.848	0.405	0.173
		Pre- Post	2.265	0.033	0.462
Testosterone	Intervention	Pre- Post	-2.008	0.059	-0.449
	Control	Pre- Post	-4.158	<0.001	-0.930
Cortisol	Intervention	Pre- Post	-1.619	0.122	-0.362
	Control	Pre- Post	2.128	0.047	0.476
T/C	Intervention	Pre- Post	-1.344	0.195	-0.301
	Control	Pre- Post	-3.700	0.002	-0.827

an attempt to reduce EIF. The "awakening phase" in CM is marked by the practice of yoga asanas or postures, while the "calming phase" occurs when lying down in supine position. A core aspect of CM is the conscious awareness of the sensations experienced throughout the body during the practice. This indicates that integrating stimulating practices and soothing techniques, alongside relaxation and mindfulness, might be better at reducing both psychological and physiological arousal compared to lying down in supine for an equivalent amount of time[16].

On day 15 and day 31, the intervention group experienced a significantly larger increase in CMJ jump height compared to the control group (Table 2). In a similar study, foam rolling was done following eccentric exercise training as a recovery method. Compared with pre-measurements, the intervention group demonstrated a higher CMJ height than the control group ($p<0.05$) at 72 h (8.6%, $p<0.05$), with moderate effects observed at both 48 and 72 h[27].

In the current study, the control group experienced a 1.53% increase in CMJ flight time from pre to intermediate and a 0.88% increase from pre to post, whereas the intervention group showed a 1.72% rise from pre to intermediate and a 2.8% increase from pre to post (Table 1). In a similar study, 3 different recovery techniques namely cold water immersion (CWI), contrast water immersion (CWT) technique and passive recovery (PAS) were compared on elite professional football players after a football match[28]. From pre to post, the CWI group improved flight time by 1.72% and the CWT group reduced flight time by 1.75% while the PAS group stayed at baseline. After 24 h, both the CWI and CWT groups stayed at post values while the PAS group reduced flight time by 3.51%. At 48 h, both the CWI and CWT groups returned to baseline while the PAS group reduced flight time by 1.75%[28].

In the present study, the intervention group exhibited a 21.19% decrease in testosterone, a 27.34% reduction in cortisol, and a 21.4% decrease in T:C, while the control group showed a 31.5% drop in testosterone, a 28.3% rise in cortisol, and a 44.2% decrease in T:C. In a similar study, the effect of infrared heat on recovery was observed in athletes after a training session. In the intervention group, testosterone decreased by 3.94% from day 1 to day 2, testosterone stayed reduced by 3.94% from day 1 to day 3 and testosterone increased by 5.9% from day 1 to day 5. The control group exhibited a 4.3% drop in testosterone from day 1 to day 2, a 1.43% decrease from day 1 to day 3, and a 0.95% rise from day 1 to day 5. In the intervention group, cortisol decreased by 5.9% from day 1 to day 2, cortisol returned to baseline from day 1 to day 3 and cortisol decreased by 2.97% from day 1 to day 5. In the control group, cortisol increased by 7.96% from day 1 to day 2, cortisol stayed increased by 7.96% from day 1 to day 3 and cortisol increased by 8.6% from day 1 to day 5. In the intervention group, T:C increased by 7.9% from day 1 to day 2, T:C stayed increased at 7.9% from day 1 to day 3 and T:C increased by 10.52% from day 1 to day 5. From day 1 to day 2, T:C in the control group reduced by 9.1%, and this 9.1% reduction persisted through day 3, while cortisol stayed reduced by 9.1% up to day 5[29].

The major finding was that the intervention group was able to significantly improve all CMJ variables and ROF scores in comparison with the control group (Table 2). Even though only CMJ height and CMJ flight time are the only CMJ parameters associated with fatigue, the intervention group also significantly improved CMJ velocity, CMJ force and CMJ power. It was also observed that the magnitude of change is more for CMJ variables in the last 15 days in the intervention group. This could mean that as the period of practicing CM increases, the positive effect of CM on fatigue also increases.

The decrease in testosterone post intervention could have occurred as a result of overtraining. It has been reported in earlier studies that men engaging in rigorous exercise training may have disruptions in the hypothalamic-pituitary-gonadal (HPG) axis, lower resting testosterone levels and may have hypogonadism[30,31]. But it is evident from this study that the intervention group which practiced cyclic meditation has less percentage decrease in testosterone levels (21.19%) compared to the control group (31.5%). Therefore it can be said that CM was able to inhibit the steep decline of testosterone by more than 10% compared to SR. The drop in testosterone levels which may have caused due to overtraining has also contributed to the decrease in T:C. The intervention group has less than half the decrease in T:C (21.6%) compared to the control group (44.2%). The group which practiced CM were able to restrict the decline of T:C by more than 50% compared to SR.

These differences demonstrates that CM could be incorporated along with regular physical training as an effective tool to bring down the EIF levels. The observed changes following CM may have occurred due to the reduced oxygen consumption, improved sleep quality and an increased dominance of the vagal system in autonomic regulation as seen in previous studies[16].

The insights gained from this research are likely to hold important implications in exercise training sessions or applied sports settings where fatiguing exercise sessions can cause burnout, muscle damage, injury or illness etc. particularly when there is insufficient time for recovery due to the competition and training schedules.

Limitations of the study

More sample size, gender-diverse sampling and more assessment points are required to accurately identify the changes caused by CM.

Conclusion

The implementation of CM after exhausting exercise yielded potentially favourable effects. CM has significantly improved all CMJ parameters and ROF. CM was able to scale down the decline in testosterone by more than 10% in comparison with the SR and was able to reduce cortisol levels by

27.34%. CM was able to suppress the reduction in T:C by more than 50% compared to SR. Therefore, it can be concluded from this study that CM could be used as an effective tool to recover from EIF.

Future Directions

In this study, CM was compared with SR to identify the effects on EIF. SR involves only relaxation while CM involves repeated stimulating and relaxing practices. Future studies can compare CM with other practices more similar to CM that involves stimulating and calming practices.

Future studies can identify the long-term effects of CM on EIF and could also include a follow-up investigation where we stop the training for a few days and see the changes in testosterone and cortisol after three or four days.

Future research can also be done in other populations and settings to validate the findings and explore their applicability in different contexts.

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Conflict of Interest

The authors declare they have no commercial or financial interests that could potentially pose as a conflict of interest in this research.

Author Contributions

The idea was conceived and developed by SB along with VR who verified the analytical methods. RMN contributed in planning, designing and supervising throughout the experiment. The trial was performed by SB who was assisted by SZHZ in data collection and data analysis. All the authors contributed in result interpretation and findings of the experiment. The manuscript was drafted by SB, with all the authors providing essential critiques and aiding in the refinement of the document.

Ethics Approval

The research was authorized by the 'Institutional Ethics Committee of Swami Vivekananda Yoga Anusandhana Samsthana University' on 18th March 2023, reference number: RES/IEC-SVYASA/283/2023.

Informed Consent

Before the research commenced, participants gave their consent by signing a form that explained the procedures, risks, and benefits.

Data Availability

The authors declare that the article includes all data that validate the conclusions of the study, and the data will be made available by the authors upon reasonable request.

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