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ASSESSING BODY COMPOSITION CHANGES IN YOUNG ATHLETES FOLLOWING A 12-WEEK YOGA PROGRAM USING MULTI-FREQUENCY BIOELECTRICAL IMPEDANCE ANALYSIS

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Abstract:
Yoga and meditation practices enhance self-control, which has a considerable improvement on the behaviour, and aggregate performance of an individual. The intervention of yoga improves athletes' flexibility, muscle strength, endurance, as well as physiological and mental health. The present investigation sought to determine the variation of body mass composition via multi-frequency bioimpedance analysis in young

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athletes during 12 weeks of yogic practices. 40 (20 control and 20 experimental) healthy young individuals were randomly assigned and were given yogic practices for 12 weeks. The experimental group exhibited a notable difference in body fat mass (9.695 ± 3.55 kg vs. 16.56 ± 5.40 kg, p = 0.000), body mass index (23.58 ±2.49 vs 20.705±2.59, p= 0.001), arm muscle circumference (25.77 ± 2.16 cm vs 27.34 ± 1.75 cm, p = 0.016). A reduction in fat mass index (FMI) 3.22 ± 1.10 compared to 5.57 ± 1.86, p = 0.000) and obesity degree (94.5 ± 11.51 vs 107.85 ± 11.90, p = 0.001) was also observed in the experimental group. Overall, the study concluded that yoga practices are a reliable method and significantly reduced body fat mass, muscle mass, as well as other anthropometric measurements in runners. Yoga has enormous potential to improve general health and can be given as a modality to improve flexibility and athletic performance.

Keywords: yoga; body mass index; body fat mass; muscle circumference; percentage of body fat

1. Introduction

Originating in India, yoga has evolved from its ancient spiritual roots to become a globally recognised practice, renowned for its comprehensive benefits to physical, mental, and emotional health. Once primarily associated with meditation and spirituality, yoga has now been embraced worldwide as a discipline that enhances flexibility, strength, and overall fitness. Contemporary research has begun to explore yoga's potential in sports science, particularly its capacity to improve athletic performance. Yoga encompasses a range of techniques, including physical postures (asanas), breathing exercises (pranayama), meditation, and relaxation methods. These elements work in concert to foster holistic well-being by addressing physical fitness, mental clarity, stress reduction, and emotional equilibrium.

The growing popularity of yoga has been accompanied by increased scientific interest, particularly in understanding its physiological and psychological effects on practitioners. In the field of sports science, achieving and maintaining optimal body composition is crucial, especially for young athletes in critical stages of physical development. Body composition, which refers to the proportions of muscle mass, fat mass, and other essential components, significantly influences an athlete's strength, agility, and endurance. A well-balanced body composition is essential for young athletes to maximise their potential and maintain long-term health. Excessive body fat can hinder performance by increasing the metabolic cost of movement, while insufficient body fat can lead to health issues and negatively impact performance, particularly in endurance sports. Whilst conventional athletic training often focuses on high-intensity exercises for improving body composition, yoga offers a promising alternative as a gentle, comprehensive practice with potential significant advantages. Current studies suggest that yoga can improve muscle definition, encourage fat reduction, and balance metabolism. However, there is a substantial lack of understanding regarding yoga's effects on younger athletes, a group with distinct physiological requirements and swift growth stages that demand customised training methods. The possible benefits of yoga for young athletes extend beyond physical improvements; the practice cultivates mindfulness and bodily awareness, potentially enhancing proprioception and kinaesthetic sense, thus improving movement efficiency and lowering injury risk.

Existing research reveals a crucial gap concerning yoga's impact on young athletes' body composition, particularly during a developmental phase where optimal physical attributes are crucial for both immediate performance and long-term health. This knowledge gap hinders coaches, trainers, and sports scientists from making evidence-based decisions about integrating yoga into young athletes' training regimens. To address this research deficiency, this investigation aims to explore the effects of a 12-week yoga programme on young athletes' body composition. Employing multi-frequency bioelectrical impedance analysis, a precise method for assessing body composition, this research will carefully monitor changes in key parameters, including muscle mass, fat mass, and body fat percentage, following the yoga intervention.

The 12-week intervention duration has been deliberately selected to allow for observable changes in body composition whilst minimising the confounding effects of natural growth and development in young athletes. The study design will incorporate a control group to account for these variables and isolate the specific effects of the yoga intervention. Moreover, various covariates, such as dietary habits, other physical activities, and individual growth patterns, will be considered to ensure a thorough analysis of the yoga programme's impact. The outcome of this research is expected to make a significant contribution to the existing knowledge base surrounding yoga and its application within sports science, particularly regarding young athlete development. By elucidating the probable benefits of yoga on body composition in this specific population, this research may inform future training protocols and interventions aimed at enhancing athletic performance and promoting long-term health in young athletes.

This study represents a crucial step in understanding yoga's role in optimising body composition and overall physical development in young athletes. By addressing the current literature gap, this research has the potential to influence training methodologies, performance enhancement strategies, and health promotion approaches for young athletes across various sports disciplines.

2. Materials and Methods

2.1 Participants

Forty male athletes, aged 18 to 25, were recruited from Mahatma Gandhi University for this study. Participants were selected based on their active training schedules (at least five days per week) and were separated into two categories: 20 runners in the control group and 20 runners in the experimental group. A 12-week yoga intervention was administered to the treatment group to enhance athletic performance through improvements in body composition, flexibility, strength, and recovery. The control group continued their regular training routines. All participants were healthy, experienced athletes with competitive backgrounds, and none had injuries or conditions that could affect performance or daily activities. The research received ethical approval from Mahatma Gandhi University (Institutional human ethics committee approval letter, DHR File No: EC/NEW/INST/2023/3392; dated 20.04.2024). Informed consent was obtained from all participants, who were briefed about the research goals and methodology, as were their instructors.

2.2 Study Design

Employing a randomized controlled trial (RCT) design facilitated by convenience sampling, the study allocated 40 participants engaged in a structured yoga exercise program. While the control group also consisting 20 participants adhered to their daily routine without intervention. This robust experimental design provided a solid foundation for subsequent statistical analysis.

2.3 Yoga Intervention

The participants engaged in a 1-hour yoga session, as detailed in Table 1. The yoga intervention, conducted from monday to friday over 12 weeks (excluding holidays), was provided to the experimental group. A control group of healthy, young athletes did not undergo yoga training. The yoga sessions were led by guided by trained yoga professionals with uniform protocols applied across all three centres. The intervention began with basic relaxation techniques to help participants connect with their body, breath, and spirit, reducing muscle and joint stiffness and promoting fluid movements. Cleansing exercises like kapalabhati energized the body, while anulom vilom pranayama improved lung capacity, alleviated anxiety, and enhanced breath awareness. Asana practices (e.g., sarvangasana, paschimottanasana, ardhamatyendrasana) targeted overall muscular toning, flexibility, and strength. The final relaxation, Savasana, rejuvenated the body and mind after the session.

Table 1: The yoga postures practiced by the experimental group during their yoga intervention

Practice	Duration
Initial Relaxation	5 min
Abdominal Breathing Exercise	6 min
Loosening exercise	15 min
Relaxation	30 sec
Paschimottanasana (Preparatory exercises butterfly, rocking baby)	2 min
Purvottanasana	30 sec
Makarasana	30 sec
Bujangasana	30 sec
Dhanurasana	30 sec
Shalabasana	1 min
Relaxation	1 min
Cat and cow stretching	1 min
Ardhamatyendrasana	1 min

Balancing Asanas (Vrikshasana, Kakasana, Natarajasana)	1 min
Trikonasana	1 min
Padahastasana	30 sec
Savasana	15 min
Meditation	8 min
Purvottanasana	30 sec
Makarasana	30 sec
Bujangasana	30 sec
Dhanurasana	30 sec
Shalabasana	30 sec

2.4 Assessment of Body composition

Height was measured as accurately as possible using a stadiometer (BSM 370, South Korea). Participants were instructed to stand upright with their heels together, head aligned, and back in contact with, but not leaning against, the instrument. Body composition of the young athletes was assessed using the InBody 570 (BioSpace Co., Ltd., Seoul, Republic of Korea), a tetrapolar bioimpedance multi-frequency (BIA) device with eight tactile-point electrodes. Measurements were taken in accordance with the manufacturer's guidelines. A three-hour period of fasting and refrain from exercise prior to testing was mandatory. All assessments were conducted between 11:30 and 13:00. Participants wore athletic attire and removed any metal jewellery. For the body composition analysis, participants stood barefoot on the scale, gripping the handles with their hands. They were instructed to extend their arms fully and hold the position for about one minute. The device analysed body composition by measuring the resistance of various body tissues to electrical current, which is influenced by water content. Parameters such as body weight (BW, kg), fat mass (FM, kg), fat-free mass (FFM, kg), body mass index (BMI, kg/m^2), percentage of body fat (PBF), basal metabolic rate (BMR, kcal), and intracellular water (L) were calculated.

2.5 Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 25. Descriptive statistics and Univariate Analysis of Covariance (ANCOVA) were used to examine differences between the intervention groups following the 12-week yoga program. A significance level of $p < 0.05$ was set to determine statistical significance. A thorough approach was employed to ensure accuracy and consistency in body composition measurements.

3. Results

The results section presents the effects of the 12-week yoga intervention on participants' physiological characteristics. Specifically, the findings highlight changes in total body composition, regional body fat mass distribution, body composition indices, and anthropometric measurements, providing a comprehensive understanding of the impact of the intervention.

Tabel 2: Changes in total body composition following 12-weeks of yoga intervention

Measurement	Experimental (n=20)	Control (n=20)	F	p-value
Weight	62.21±9.67	70.21±9.33	7.203	0.011
BFM (Body Fat Mass)	9.695±3.55	16.56±5.40	22.571	0.000
Body mass index (BMI)	20.705±2.59	23.58±2.49	12.795	0.001
PBF (Percent Body Fat)	15.29±3.50	23.18±5.78	27.282	0.000

* Data were represented as Mean± standard deviation; Statistical significance was set at $P < 0.05$.

Table 2 indicates that the results of the 12-week yoga intervention indicate significant improvements in body composition for the experimental group compared to the control group. Specifically, the treated group displayed a substantial reduction in weight (62.21 ± 9.67 kg vs. 70.21 ± 9.33 kg, $F = 7.203$, $p = 0.011$). Body fat mass (BFM) was also significantly lower in the experimental group (9.695 ± 3.55 kg vs. 16.56 ± 5.40 kg, $F = 22.571$, $p = 0.000$), as was the BMI (20.705 ± 2.59 vs. 23.58 ± 2.49, $F = 12.795$, $p = 0.001$) and PBF (15.29 ± 3.50 vs. 23.18 ± 5.78, $F = 27.282$, $p = 0.000$). These findings suggest that the incorporation of yoga reduced body weight, body fat mass, BMI, and PBF, highlighting its effectiveness in improving body composition.

Table 3: Changes in body fat mass measurements in different body regions following 12-week yoga intervention

Measurement	Experimental (n=20)	Control (n=20)	F	p-value
FFM Right Leg %	103.565±5.28	95.545±6.31	19.008	0.000
FFM Left Leg %	102.91±5.10	94.93±6.46	18.813	0.000
BFM Right Arm	0.48±0.22	0.965±0.44	19.192	0.000
BFM Left Arm	0.51±0.20	0.99±0.45	19.133	0.000
BFM Trunk	4.515±2.26	8.62±3.05	23.446	0.000
BFM Right Leg	1.62±0.40	2.44±0.71	20.215	0.000
BFM Left Leg	1.6±0.40	2.425±0.72	20.178	0.000

* Data were represented as Mean± standard deviation. Statistical significance was set at $P < 0.05$.

Table 3 indicates that the results of the 12-week yoga intervention show significant reductions in body fat mass (BFM) across multiple body regions in the experimental group compared to the control group. For the right arm, the control group had a mean BFM of 0.965 ± 0.44 kg, while the experimental group showed a significantly lower value of 0.48 ± 0.22 kg ($F = 19.192$, $p = 0.000$). Similar reductions were observed in the left arm, where the control group had a mean BFM of 0.99 ± 0.45 kg, and the experimental group had 0.51 ± 0.20 kg ($F = 19.133$, $p = 0.000$). In the trunk, the control group had a mean BFM of 8.62 ± 3.05 kg, compared to 4.515 ± 2.26 kg in the experimental group ($F = 23.446$, $p = 0.000$). For the right leg, the control group's mean BFM was 2.44 ± 0.71 kg, while the experimental group had 1.62 ± 0.40 kg ($F = 20.215$, $p = 0.000$). Finally, in the left leg, the control group exhibited a mean BFM of 2.425 ± 0.72 kg, significantly higher than the experimental group's 1.6 ± 0.40 kg (F = 20.178, p = 0.000). These results indicate that the yoga intervention led to significant reductions in BFM across all measured body regions, suggesting that yoga is effective in reducing localized body fat.

Table 4: Changes in Body Composition Indices following 12-week yoga intervention

Measurement	Experimental (n=20)	Control (n=20)	F	p-value
Weight Control	4.525±5.80	-3.7±6.47	17.934	0.000
BFM Control	0.375±3.07	-6.575±5.30	25.239	0.000
WHR (Waist-Hip Ratio)	0.826±0.04	0.895±0.05	25.145	0.000
Obesity Degree	94.5±11.51	107.85±11.90	13.000	0.001
FMI (Fat Mass Index)	3.22±1.10	5.57±1.86	23.591	0.000
SMM/WT (Skeletal Muscle Mass/Weight)	47.305±2.08	42.78±3.27	27.261	0.000

* Data were represented as Mean± standard deviation. Statistical significance was set at P < 0.05.

Table 4 indicates that the 12-week yoga intervention resulted in significant variation in body composition compared to the control group. The treated group showed a significant increase in weight (4.525 ± 5.80 kg compared to -3.7 ± 6.47 kg, F = 17.934, p = 0.000) and a slight increase in BFM (0.375 ± 3.07 kg compared to -6.575 ± 5.30 kg, F = 25.239, p = 0.000). In contrast, the experimental group demonstrated a significant reduction in waist-hip ratio (WHR) (0.826 ± 0.04 compared to 0.895 ± 0.05, F = 25.145, p = 0.000) and obesity degree (94.5 ± 11.51 compared to 107.85 ± 11.90, F = 13.000, p = 0.001). The fat mass index (FMI) was lower in the experimental group (3.22 ± 1.10 compared to 5.57 ± 1.86, F = 23.591, p = 0.000), and the skeletal muscle mass to weight ratio (SMM/WT) was higher (47.305 ± 2.08 compared to 42.78 ± 3.27, F = 27.261, p = 0.000). These results suggest that yoga led to reductions in body fat and obesity markers, while improving muscle mass and fat distribution.

Table 5: Changes in Anthropometric Measurements following 12- week yoga intervention

Measurement	Experimental (n=20)	Control (n=20)	F	p-value
Arm Circumference	28.36±2.58	30.9±2.28	11.390	0.002
AMC (Arm Mid Circumference)	25.77±2.16	27.34±1.75	6.390	0.016
Neck Circumference	34.765±1.97	36.14±1.76	5.420	0.025
Chest Circumference	91.06±6.09	96.1±5.18	7.957	0.008
Abdomen Circumference	76.29±6.92	86.615±7.82	19.552	0.000
Hip Circumference	92.26±4.70	96.475±4.54	8.325	0.006
Right Arm Circumference	28.475±2.56	31.085±2.26	11.663	0.002
Left Arm Circumference	28.36±2.58	30.96±2.28	11.390	0.002
Right Thigh Circumference	49.51±3.37	51.997±3.31	5.533	0.024
Left Thigh Circumference	49.4±3.30	51.965±3.26	6.120	0.018

* Data were represented as Mean± standard deviation. Statistical significance was set at P < 0.05.

Table 5 indicates that the 12-week yoga intervention led to notable decreases in body measurements in the experimental group compared to the control group. Specifically, the experimental group showed reductions in arm circumference (28.36 ± 2.58 cm compared to 30.9 ± 2.28 cm, F = 11.390, p = 0.002), arm muscle circumference (25.77 ± 2.16 cm compared to 27.34 ± 1.75 cm, F = 6.390, p = 0.016), and neck circumference (34.765 ± 1.97 cm compared to 36.14 ± 1.76 cm, F = 5.420, p = 0.025), indicating a decrease in upper body size. Additionally, chest circumference (91.06 ± 6.09 cm compared to 96.1 ± 5.18 cm, F = 7.957, p = 0.008) and abdominal circumference (76.29 ± 6.92 cm compared to 86.615 ± 7.82 cm, F = 19.552, p = 0.000) were significantly reduced in the experimental group, suggesting a substantial reduction in fat, particularly in the abdominal region. Hip circumference also decreased (92.26 ± 4.70 cm compared to 96.475 ± 4.54 cm, F = 8.325, p = 0.006). Furthermore, reductions in both right (28.475 ± 2.56 cm compared to 31.085 ± 2.26 cm, F = 11.663, p = 0.002) and left arm circumferences (28.36 ± 2.58 cm compared to 30.96 ± 2.28 cm, F = 11.390, p = 0.002) were observed, along with a decrease in thigh circumference, both right (49.51 ± 3.37 cm compared to 51.997 ± 3.31 cm, F = 5.533, p = 0.024) and left (49.4 ± 3.30 cm compared to 51.965 ± 3.26 cm, F = 6.120, p = 0.018). These findings highlight the effectiveness of yoga in reducing body fat and improving body composition across various body regions.

4. Discussion

The findings of this study highlight the significant impact of a 12-week yogic practice on body mass composition, body fat distribution, and anthropometric measurements among participants, emphasizing the effectiveness of yoga as a comprehensive and holistic intervention for improving health and athletic performance. The experimental group exhibited significant improvements in body weight, fat mass, BMI, and percentage PBF compared to the control group, underscoring yoga's role in enhancing body composition and reducing obesity-related parameters. Additionally, regional fat mass and circumferential measurements of various body parts decreased markedly in the experimental group, supporting the efficacy of yoga in targeting specific areas of fat accumulation.

The study demonstrated a notable reduction in body weight in the experimental group compared to the control group (F = 7.203, p = 0.011). These findings align with existing literature, which suggests that yoga can contribute to weight loss by improving metabolic rate, increasing physical activity levels, and reducing stress, which influences eating behaviors and cortisol levels. Similarly, the marked reduction in BFM (F = 22.571, p = 0.000) corroborates prior research demonstrating yoga's effectiveness in enhancing fat metabolism and promoting lean body mass retention. Yoga training (asanas, pranayama, and Surya Namaskar) for 8 and 12 weeks on forty female adolescents (20 in each group) with obesity showed significant reduction of BMI, BFM as well as improved muscle mass. The mechanism behind these improvements lies in the holistic nature of yoga, which integrates moderate physical activity with breathing techniques and mindfulness practices. These components enhance fat oxidation, improve insulin sensitivity, and modulate hormonal responses, ultimately reducing fat accumulation. Such findings suggest that yoga is a valuable tool for individuals seeking sustainable weight management and fat reduction, especially when integrated into a comprehensive fitness program.

The study also observed significant reductions in BMI (F = 12.795, p = 0.001) and PBF (F = 27.282, p = 0.000) among participants in the experimental group. These results are consistent with previous literatures that identified yoga as an effective intervention for improving BMI and PBF in overweight and obese individuals. Reductions in BMI and PBF are particularly relevant for athletes, as a lower BMI enhances power-to-weight ratio and improves running efficiency, while lower PBF contributes to improved muscular endurance and performance. Lower BMI can enhance performance in endurance sports like running by improving the power-to-weight ratio, which boosts efficiency and reduces energy expenditure, though focusing on body composition (muscle mass and fat distribution) provides a more accurate picture of athletic potential. A study among 19 field athletes [Sports Authority of India (SAI)] with yogic asanas and pranayamas an hour daily (6 days/week) for a period of 4 weeks showed reduction in fat free mass (p= 0.043) and improvement in back strength (p= 0.028).

Yoga's unique ability to integrate physical and mental well-being is critical to these outcomes. Research suggests that yoga reduces stress and enhances parasympathetic nervous system activity, leading to better hormonal regulation and reductions in stress-related fat accumulation, particularly in the abdominal region. The dynamic form of paschimottanasana, for example, specifically targets the abdominal and thigh regions, which are often areas prone to excess fat accumulation. This forward-bending posture engages core muscles and promotes deep stretching, effectively reducing fat while simultaneously easing tension throughout the body. The action of regulating the adrenal glands through the deep, slow breaths in paschimottanasana further contributes to lowering stress levels, which can significantly impact fat storage, particularly in the abdominal area. This dual benefit of physical and mental health makes yoga a compelling alternative to traditional exercise regimens for improving body composition. Furthermore, the practice of pranayama, a set of breathing exercises that create internal heat, plays a crucial role in enhancing metabolism and fat-burning potential. By focusing on controlled, deep breathing, pranayama increases oxygen supply to the body, boosts circulation, and activates thermogenesis, which in turn helps burn stored fat. Regular practice of pranayama has been associated with improvements in metabolic rate, supporting the reduction of visceral fat and overall body fat mass. Together, these yoga practices complement each other by addressing both the physical and psychological factors that contribute to body fat accumulation, providing a holistic approach to improving body composition. This multi-faceted effect of yoga on fat loss underscores its effectiveness for individuals aiming to reduce BMI and PBF sustainably.

The study demonstrated significant reductions in regional fat mass, particularly in the trunk (F = 23.446, p = 0.000), arms, and legs, following the yoga intervention. Trunk fat, a key contributor to visceral fat, was significantly reduced in the experimental group, with mean trunk fat mass decreasing from 8.62 ± 3.05 kg to 4.515 ± 2.26 kg. These reductions are crucial, as excessive trunk fat is strongly associated with metabolic disorders and reduced physical performance.

Yoga's effect on regional fat reduction can be attributed to specific postures that target localized muscle groups, such as the core and limbs. For instance, plank (kumbhakasana) and warrior (virabhadrasana) postures engage trunk and limb muscles, promoting localized fat oxidation and muscle activation. This finding supports previous research suggesting that yoga postures can enhance functional strength and reduce fat in targeted areas.

Yoga as a therapeutic tool has provided beneficial effects on the musculoskeletal system. Furthermore, the observed reductions in circumferential measurements of the arms, thighs, abdomen, and chest indicate significant improvements in body composition and muscular tone. For example, abdominal circumference decreased significantly in the experimental group ($F = 19.552$, $p = 0.000$), indicating a reduction in central adiposity, which is strongly associated with cardiovascular and metabolic risks. These improvements suggest that yoga not only reduces fat mass but also contributes to better muscle tone and functional strength. A study among 42 male cricketers with a yoga module of 32 practices over a 6-week period showed improvement of muscular functioning and flexibility.

Significant reductions in obesity markers, such as WHR and FMI, were also observed in the experimental group. WHR decreased from 0.895 ± 0.05 to 0.826 ± 0.04 ($F = 25.145$, $p = 0.000$), indicating a favorable shift in fat distribution and reduced central obesity. This aligns with findings from studies that emphasize the role of yoga in improving fat distribution and reducing visceral fat accumulation. Similarly, reductions in FMI ($F = 23.591$, $p = 0.000$) highlight yoga's role in lowering total body fat while preserving skeletal muscle mass. Importantly, SMM/WT improved significantly in the experimental group ($F = 27.261$, $p = 0.000$), suggesting enhanced muscle quality and strength. This finding aligns with evidence that yoga increases muscle engagement through isometric contractions and weight-bearing postures, contributing to improved functional strength and endurance. Such improvements are particularly beneficial for athletes, as they enhance performance by increasing power output and reducing energy expenditure during physical activity.

The significance of this study has important implications for both athletes and general populations. For athletes, yoga offers a holistic approach to optimizing body composition, enhancing performance, and reducing injury risk by improving flexibility, core strength, and mental focus. For non-athletes, particularly those with sedentary lifestyles, yoga provides a sustainable and low-impact intervention for improving body composition, reducing obesity markers, and enhancing overall health.

These findings are consistent with international research emphasizing the benefits of yoga for physical as well as mental health. For instance, a systematic review by Telles et al. highlighted yoga's efficacy in reducing BMI and body fat while improving cardiovascular and metabolic health. Yoga's potential for reducing central obesity and improving quality of life in overweight individuals was also reported.

Despite its promising findings, this study has certain limitations, namely its relatively small sample size, which restricts its generalizability. Additionally, the present study was conducted on male participants, and the impact of yoga on diverse populations, including females and different age groups, has to be undertaken in the future. Larger sample numbers and longitudinal research are required to validate yoga's long-term effects on athletic performance and body composition.

5. Conclusion

In conclusion, this study demonstrates the significant impact of a 12-week yoga intervention on body composition, regional fat distribution, and anthropometric measurements. The findings underscore yoga's potential as a holistic intervention for improving health and athletic performance by reducing body fat, enhancing muscle mass, and improving fat distribution. These results align with international research, highlighting yoga's multifaceted benefits for physical and mental well-being. As a sustainable and accessible form of exercise, yoga holds great promise for addressing obesity and promoting overall health in diverse populations.

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Informed Consent Statement
Informed consent was obtained from all participants involved in the study.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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References

Arbo G, Brems C, & Tasker T. Mitigating the antecedents of sports-related injury through yoga. *International Journal of Yoga*, 2020;13(2):120. https://doi.org/10.4103/ijoy.ijoy_93_19

Arif M, Gaur DK, Gemini N, Iqbal ZA, Alghadir AH. Correlation of Percentage Body Fat, Waist Circumference and Waist-to-Hip Ratio with Abdominal Muscle Strength. *Healthc* (Basel). 2022 ;10(12):2467. https://doi.org/10.3390/healthcare10122467

Asiah AS, Norhayati MN, Muhammad J, Muhamad R. Effect of yoga on anthropometry, quality of life, and lipid profile in patients with obesity and central obesity: A systematic review and meta-analysis. *Complement Ther Clin Pract*. 2023;24:102959. https://doi.org/10.1016/j.ctim.2023.102959

Bai Y, Yin J, Wang F. The effects of yoga on stress management and central adiposity reduction: A meta-analysis. *J Behav Med*, 2022;45(3):390–405. https://doi.org/10.1007/s10865-021-00241-w

Batrakoulis A. Psychophysiological adaptations to Yoga practice in overweight and obese individuals: a topical review. Diseases. 2022;10(4):107. https://doi.org/10.3390/diseases10040107

Borthakur D. Yoga pose estimation using angle-based feature extraction. *Healthcare*, 2023; 11(24):3133. https://doi.org/10.3390/healthcare11243133

Cadieux E, Gemme C, & Dupuis G. Effects of yoga interventions on psychological health and performance of competitive athletes: a systematic review. *J Sci Sport Exerc*, 2021;3(2):158-166. https://doi.org/10.1007/s42978-020-00104-y

Cadieux E, Richard V, & Dupuis G. Effects of Bali yoga program for athletes (byp-a) on psychological state related to the performance of circus artists. *Int j yogic hum mov sports sci,* 2022;7(1):23-33. https://doi.org/10.22271/yogic.2022.v7.i1a.1249

Cagas J, Biddle S, & Vergeer I. For exercise, relaxation, or spirituality: exploring participation motives and conformity to masculine norms among male and female yoga participants. *Int J Environ Res Public Health,* 2022;19(2):770. https://doi.org/10.3390/ijerph19020770

Chatterjee S. Effect of 4-week yoga intervention on selective physical and body composition variables in Indian male track and field athletes. *J Yoga Phys Ther* 2021; 9(1): 555755. https://doi.org/10.19080/jyp.2021.09.555755

Cramer H, Lauche R, Langhorst J, Dobos G. Yoga for weight loss and body composition: A systematic review and meta-analysis. Syst Rev,2016. *5*(1), Article 66. https://doi.org/10.1186/s13643-016-0237-8

Deshi R. The impact of yogasana on hockey players: enhancing performance and well-being. *Int j yogic hum mov sports sci* 2023;8(2):154-157. https://doi.org/10.22271/yogic.2023.v8.i2c.1449

Halder S. Effects of yogic breathing techniques on respiratory function and breathing patterns at high altitude. *J Adv Zool*, 2023;44(S4):65-70. https://doi.org/10.17762/jaz.v44is4.2009

Harrington S, McQueeney S, & Fearing M. Understanding injury and injury prevention in para sport athletes. *J Sport Rehabil* 2021;30(7):1053-1059. https://doi.org/10.1123/jsr.2020-0477

Hasan M, Haydary M, & Gandomi F. The effect of an 8-week yoga training program on balance and knee proprioception after mental fatigue in amateur male athletes. *Sports Biomech* 2020;5(4):228-239. https://doi.org/10.32598/biomechanics.5.4.3

IŞIKLAR Ç. Integration of Yoga into Exercise and Its Relationship with Core Stabilization. *Togü Sağlık Bilimleri Dergisi*,2023;3(3):369-377. https://doi.org/10.52369/togusagbilderg.1143825

Kartal A and Ergin E. Investigation of the effect of 6-week yoga exercises on balance, flexibility, and strength in soccer players. Int J Hum Mov Sci 2020;8(3):91-96. https://doi.org/10.13189/saj.2020.080303

Kedlaya M, Karmakar S, Nayak NS, S Rajagopal A, Puzhankara L. Yoga as an integrated holistic approach to oral health: a review. *J Int Soc Prev Community Dent*, 2023;13(2):106. https://doi.org/10.4103/jispcd.jispcd_221_22

Krishna BH, Pal P, G K P, et al. Effect of yoga therapy on heart rate, blood pressure and cardiac autonomic function in heart failure. *J Clin Diagnostic Res*: JCDR. 2014 ;8(1):14-16. https://doi.org/10.7860/JCDR/2014/7844.3983

Long C, Jo E, & Nam Y. Development of a yoga posture coaching system using an interactive display based on transfer learning. *J Supercomput.*2021;78(4):5269-5284. https://doi.org/10.1007/s11227-021-04076-w

Mathisen TF, Ackland T, Burke LM, Constantini N, Haudum J, Macnaughton LS, Meyer NL, Mountjoy M, Slater G, Sundgot-Borgen J. Best practice recommendations for body composition considerations in sport to reduce health and performance risks: a critical review, original survey and expert opinion by a subgroup of the IOC consensus on Relative Energy Deficiency in Sport (REDs). Br *J Sports Med.* 2023 ;57(17):1148-1158. https://doi.org/10.1136/bjsports-2023-106812

Na Nongkhai MP, Yamprasert R, Punsawad, C. Effects of continuous yoga on body composition in obese adolescents. *Evid Based Complementary Altern. Med,* 2021(1), 6702767. https://doi.org/10.1155/2021/6702767

O'Brien K and Kilrea K. Unitive experience and athlete mental health: exploring relationships to sport-related anxiety, motivation, and well-being. *Humanist Psychol*, 2021;49(2):314-337. https://doi.org/10.1037/hum0000173

Rahayu N, Amalia T, & Damayanti I. Effect of yoga physical activity on increasing self-control and quality of life. *Jurnal Kesehatan Masyarakat*, 2020;15(3):399-405. https://doi.org/10.15294/kemas.v15i3.22740

Rao MR, Itagi RK, Srinivasan TM. Impact of yoga in facilitating muscular functioning among asymptomatic male cricket players: Longitudinal randomized controlled study. *J Bodyw Mov Ther*. 2021; 7:287-293. https://doi.org/10.1016/j.jbmt.2021.02.022

Ross A, Brooks A, Touchton-Leonard K, Wallen G. A different weight loss experience: A qualitative study exploring the behavioral, physical, and psychosocial changes associated with yoga that promote weight loss. *Evid Based Complementary Altern Med*. .2016;2016(1). https://doi.org/10.1155/2016/2914745

Rshikesan PB, Subramanya P, Nidhi R. Yoga practice for reducing the male obesity and weight related psychological difficulties-A randomized controlled trial. Journal of clinical and diagnostic research: JCDR. 2016;10(11):OC22. https://doi.org/10.7860/JCDR/2016/22720.8940

Sarma S, Debbarma S, Nanda GG. Yoga and its implications for sports performance enhancement: A review. *J Sports Sci Med* 2022;21(2):323–335. https://doi.org/10.26603/001c.36968

Shivanand I, Dewan N, Kathuria H, & Verma S. Online yoga instruction improves resilience in athletes during the covid -19 pandemic.2022. Preprints 2022, https://doi.org/10.20944/preprints202208.0549.v1

Singh V, Bhutia T, Singh M, & Krishna N. Effect of vinyasa training on dynamic body balance of male national level yoga players. *Teor ta Metod Fiz Vihov*, 2022;22(1):43-47. https://doi.org/10.17309/tmfv.2022.1.06

Sivaramakrishnan D, Fitzsimons C, Kelly P, Ludwig K, Mutrie N, Saunders D, & Baker G. The effects of yoga compared to active and inactive controls on physical function and health related quality of life in older adults- systematic review and meta-analysis of randomised controlled trials. *In. J Behav Nutr Phys* Act, 2019;16(1), https://doi.org/10.1186/s12966-019-0789-2

Solomons J, Kraak W, Kidd M, & Africa E. The effect of a rhythmic movement intervention on selected bio-motor skills of academy rugby players in the western cape, south africa. *Int J Sports Sci Coach*, 2020;16(1):91-100. https://doi.org/10.1177/1747954120956909

Stellingwerff T, Maughan R J, Burke LM. Nutrition for power sports: Middle-distance running, track cycling, rowing, canoeing/kayaking, and swimming. *J Sports Sci*, 2017;35(14):1421–1428. https://doi.org/10.1080/02640414.2016.1206723

Subhra C, Subhojit C, Shubham T, Manpreet B. Effect of 4-week yoga intervention on selective physical and body composition variables in Indian male track and field athletes. *J Yoga Physiother*. 2021;9:1-8. DOI: 10.19080/JYP.2021.09.555755.

Swinburn BA, Kraak VI, Allender S. The global obesity pandemic: Shaped by global drivers and local environments. *Lancet*, 2020;395(10227):1842–1855. https://doi.org/10.1016/S0140-6736(19)33146-6

Telles S, Sharma SK, Kala N, Pal S, Gupta RK, Balkrishna A. Twelve Weeks of Yoga or Nutritional Advice for Centrally Obese Adult Females. *Front Endocrinol* (Lausanne). 2018;9:466. https://doi.org/10.3389/fendo.2018.00466

Telles S, Singh N, & Balkrishna A. Managing mental health disorders resulting from stress through yoga: A review on the evidence. *Front Psychiatry*, 2019;10:474. https://doi.org/10.3389/fpsyt.2019.00474

Wei D. Combined effects of 12-week yoga warm-up on athletic performance in male high school track and field athletes. *bioRxiv*. 2022;15: 2022-04. https://doi.org/10.1101/2022.04.14.488191

Xu D, Wu H, Ruan H, Yuan C, Gao J, Guo M. Effects of Yoga Intervention on Functional Movement Patterns and Mindfulness in Collegiate Athletes: A Quasi-Experimental Study. *Int J Environ Res Public Health*. 2022;19(22):14930. https://doi.org/10.3390/ijerph192214930

Yatham P. Lessons from India: a narrative review of integrating yoga within the US healthcare system. *Cureus*. 2023;15(8). https://doi.org/10.7759/cureus.43466