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The Impact of a 12-Week Structured Yoga Intervention on Flexibility, Balance, and Joint Kinematics in University Athletes: A Quasi-Experimental Study

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Abstract

Objectives. This study aimed to examine the effects of a 12-week structured yoga intervention on flexibility, balance, and joint angles (JA) among university athletes. It was hypothesized that participants undergoing yoga training would show greater improvements across these parameters compared to those following regular sport-specific training alone.

Materials and methods. A quasi-experimental pre–post design was employed, involving 28 male collegiate athletes divided equally into two groups: the Yoga Group (YG, n = 14; handball players) and the Non-Yoga Group (NYG, n = 14; basketball players). The YG underwent bi-weekly 60-minute yoga sessions over 12 weeks in addition to regular training, while the NYG followed only their conventional training. Outcome measures included the Sit-and-Reach (SR) test, Shoulder Flexibility (SF) test, Stork Stand (SS) test for balance, and joint angle (JA) analysis using Dartfish software during three postures: Right Forward Lunge (RFL), Downward Dog (DD), and Chair pose. Normality of the data was confirmed using Shapiro-Wilk tests ($p > 0.05$). Paired t-tests and Welch's t-tests were used for within- and between-group comparisons respectively, with significance set at $p < 0.05$.

Results. The YG showed statistically significant improvements in flexibility and balance: SR increased by +2.1 inches ($p = 0.009$), SF improved by +1.0 inch ($p = 0.025$), and SS time increased by +5.1 seconds ($p = 0.018$). No substantial changes were found in the NYG ($p > 0.05$). Joint angle improvements in the YG included left ankle dorsiflexion during RFL (−7.3°, $p = 0.032$), right hip extension during DD (+11.4°, $p = 0.008$), and right knee flexion during Chair pose (−13.2°, $p = 0.011$). The NYG exhibited either negligible or regressive joint angle adaptations.

Conclusions. The findings demonstrate that structured yoga training significantly enhances flexibility, balance, and biomechanical efficiency in collegiate athletes. Integrating yoga into regular athletic conditioning may serve as a valuable adjunct for performance optimization and injury prevention.

Keywords: yoga intervention, flexibility, balance, joint angle kinematics, university athletes.

Introduction

Engagement in sports and physical activity transcends mere physical conditioning—it acts as a powerful catalyst for holistic development, fostering both physical fitness and psychological well-being (Choudhary & Dubey, 2024; Choudhary et al., 2024). Physical activity is essential for daily well-being (Mario & Das, 2022). Physical activity is a cornerstone of a healthy lifestyle, offering a wide array of benefits for individuals across the lifespan (King & King, 2010). It plays a pivotal role in preventing chronic diseases, enhancing mental well-being, and improving overall quality of life (Kamal & Zulkifli, 2019; Kohl et al., 2013). Flexibility and balance are two critical components that underpin athletic prowess, influencing agility, coordination, and overall performance (Wang et al., 2025). Flexibility, which refers to the range of motion around a joint, enables athletes to execute movements with greater ease and efficiency, thereby reducing the risk of injury (Micheo et al., 2012). Many sports require dynamic movements and quick directional changes, making balance and proprioception essential components of being an athlete (Wang et al., 2025). Yoga is a complex philosophy and methodology that evolved over thousands of years in ancient India. Yoga is becoming recognised for its benefits in enhancing both mental and physical well-being (Ghosh et al., 2024; K.S. et al., 2023; Badve et al., 2025). Over recent decades, yoga has become increasingly popular in the West and is now being integrated into healthcare practices (Nayak & Shankar, 2004; Dubey & Choudhary, 2024). Yoga encompasses many physical, mental, ethical, and spiritual practices designed to promote holistic health, well-being, and heightened consciousness (Impett et al., 2006; Ross & Thomas, 2010). The investigation into the effects of yoga on physical and mental well-being has garnered significant attention, leading to a proliferation of studies aimed at quantifying its benefits (Polsgrove et al., 2016). Yoga, an ancient practice integrating physical postures, breathing techniques, and meditation, is recognized for fostering harmony between mind and body (Binorkar, 2014). Yoga practice has been associated with several positive health outcomes, including reductions in blood pressure (Wolff et al., 2013; McDermott et al., 2014), lower blood lipid levels (Pal et al., 2011), decreased body mass index (McDermott et al., 2014), and improved pulmonary function (Parikh et al., 2018, Yadav & Das, 2001). In the realm of sports and fitness, yoga's emphasis on flexibility and balance complements traditional training regimens, potentially reducing the risk of injuries and promoting faster recovery (Paijwar, 2024). Yoga's profound influence on mental health is increasingly recognized, with evidence suggesting its efficacy in mitigating a spectrum of psychological challenges (Hagen et al., 2023). Yoga's multifaceted benefits extend beyond stress reduction and flexibility, potentially enhancing various attributes crucial for athletic performance (Bucea-Manea-Țoniș et al., 2024; Mane et al., 2014). With stronger evidence and deeper insight into its effects on movement performance, yoga has the potential to become a key element of comprehensive training programs, complementing or even replacing some traditional exercise methods (Broad, 2012). Originally rooted in ancient Indian mind–body practices, modern yoga emphasizes physical postures (asanas), breath control, and mindfulness. In athletic contexts, yoga's integrative approach is believed to enhance flexibility, balance, strength, and recovery (Kaur, 2021; Polsgrove et al., 2016). Yoga, an ancient practice, harmonizes physical and mental well-being through a combination of postures, breathing techniques, and focused concentration (Pal et al., 2023).

The physical aspect of yoga involves assuming and maintaining a series of poses, known as asanas, while consciously regulating the breath (Sherman, 2012). These asanas are not merely static stretches but rather active engagements of specific muscle groups, promoting both strength and flexibility (Suryawanshi et al., 2023). The integration of breathing mechanics with an engaged musculoskeletal system during physical poses presents a comprehensive challenge to the body, optimizing the benefits derived from such practices (Chin & Kales, 2019). This approach acknowledges the interconnectedness of breath and movement, enhancing both physical and mental well-being (Pal et al., 2023). Traditional athletic training is characterized by its targeted approach, where specific exercises and activities are employed to enhance distinct components of physical fitness (Lai, 2014). Through consistent practice, yoga can bring improvements in the alignment of joints involved in kinetic chains, leading to an increased range of motion and enhanced recruitment of muscle fibers (Bucea-Manea-Țoniș et al., 2024). This improved performance is achieved as increased flexibility and reduced muscle tension enhance the stretching of surrounding connective tissues, effectively "loosening" them and decreasing the stress placed on ligaments and joints (Chandler & Brown, 2018). The holistic approach to yoga addresses both physical and mental conditioning, positioning yoga as a powerful modality for athletes aiming to improve their performance (Pal et al., 2023). Its focus on balance, flexibility, strength, endurance, and movement efficiency aligns closely with the multifaceted requirements of athletic training (Pal et al., 2023). Yoga's integration into athletic training regimens has garnered increasing attention due to its potential to augment physical capabilities, particularly in the realms of flexibility and balance, which are foundational elements for success across diverse sports (Polsgrove et al., 2016). Yoga, originating as an ancient discipline, harmonizes the physical, mental, emotional, and spiritual dimensions of practitioners, presenting a holistic approach to wellness that extends beyond mere physical conditioning (Binorkar, 2014; Thangasami & Chandani, 2015). The practice encompasses a variety of components such as physical postures, controlled breathing techniques, relaxation, and meditation (Zhang et al., 2023). A study involving male college athletes demonstrated significant gains in flexibility and balance after a 10-week yoga program. The yoga group showed improvements in sit-reach and shoulder flexibility tests, as well as in balance measured by the stork stand test (Polsgrove et al., 2016). Another study on shooting trainee athletes found similar results, with significant improvements in flexibility and balance after a 6-week yoga intervention. This suggests that even a shorter duration of yoga practice can yield benefits (Iftekher et al., 2017). Yoga's impact on flexibility and balance extends beyond athletes. A study on female college students during the COVID-19 pandemic also reported significant improvements in these areas after a 16-week yoga intervention (Luo & Huang, 2023). College athletes, operating at the peak of their physical prowess, continually seek avenues to enhance their performance and maintain a competitive edge (Polsgrove et al., 2016). Flexibility and balance, crucial components of athletic capability, significantly influence agility, coordination, and injury prevention (Micheo et al., 2012).

This study aims to evaluate the effects of a 10-week yoga intervention on flexibility and balance among college athletes. Flexibility enhances joint mobility and movement efficiency, while balance is essential for postural stability and neuromuscular control during athletic tasks (Wang et al., 2025; Zech et al., 2010). Though various training methods improve these components, yoga's holistic and low-impact nature offers a unique approach that is underexplored in collegiate sports settings. Prior studies suggest stability-focused programs can enhance athletic performance and reduce injury risk (Song et al., 2020). Therefore, this research investigates whether regular yoga practice can elicit measurable improvements in these key performance variables. This study operates on the hypothesis that a 10-week yoga program will significantly improve flexibility and balance in college athletes.

Materials and Methods

Study Participants

This 12-week preliminary study employed a quasi-experimental pre–post design to evaluate the impact of a structured yoga intervention on selected athletic fitness parameters. Two independent groups of college athletes, engaged in different competitive sports, were assessed. Participant recruitment was facilitated through coordination with collegiate coaches from institutions in the southern region of the country. A total of 30 athletes initially volunteered; however, following inclusion criteria screening, the final sample comprised 28 participants (N = 28), with 14 athletes from the handball team (n = 14) and 14 from the basketball team (n = 14). All participants were free from current musculoskeletal injuries, had no prior extensive experience with yoga, and were medically cleared for physical activity. Before enrolment, participants completed a health history questionnaire and provided written informed consent. To maintain the integrity of the results, participants were blinded to the study's hypothesis. All participants were deemed healthy and capable of safely engaging in the exercise regimen. The study was conducted in strict accordance with the guidelines of the Declaration of Helsinki, ensuring ethical standards were maintained throughout the research process. This adherence underscores our commitment to the ethical treatment and well-being of all participants.

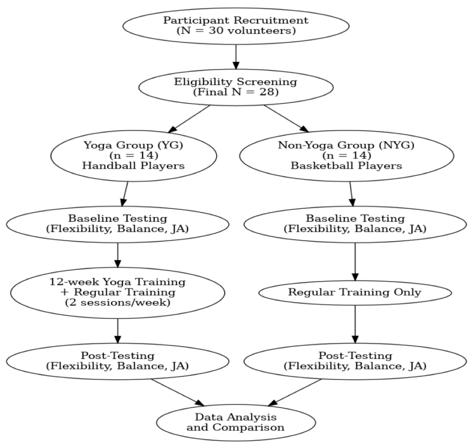

Fig. 1. Flow Diagram

Study Organization

The study involved two groups: the YG (mean age = 19.8 ± 1.05 years) comprised collegiate handball players, while the NYG (mean age = 20.3 ± 1.06 years) included collegiate basketball players. Both groups continued their regular sport-specific training routines, which included common elements like static stretching, resistance training, and aerobic conditioning. Both groups continued to participate in their regular sport-specific training over the 12 weeks. These regular training routines, while largely sport-specific, shared common components such as static stretching, resistance training, and aerobic conditioning (e.g., running). Table 1. Participants' Characteristics (Mean ± SD)

Table 1. Participants' Characteristics (Mean ± SD)

Variable	Yoga Group (YG)	Non-Yoga Group (NYG)
Age (years)	19.8 ± 1.05	20.3 ± 1.06
Height (cm)	176.4 ± 5.2	179.1 ± 4.9
Weight (kg)	69.2 ± 6.3	72.5 ± 5.7
BMI (kg/m²)	22.2 ± 1.4	22.6 ± 1.2

Note: Yoga Group (YG) refers to collegiate handball players who underwent the yoga intervention. The Non-Yoga Group (NYG) refers to collegiate basketball players who followed their regular training regimen. Values represent means ± standard deviations (SD), indicating variability within each group.

Yoga Intervention Protocol

In addition to their usual training, the YG engaged in supervised yoga sessions twice weekly (Tuesdays and Thursdays) before any other physical activity. Each session lasted 60 minutes, comprising warm-up, asana practice, and cool-down. A certified yoga instructor delivered sessions. Each session lasted 60 minutes and included a standardized sequence of yoga postures (asanas), demonstrated by the instructor and performed synchronously by the participants under supervision. Participants in both groups were instructed to refrain from engaging in any additional training outside of their prescribed routines to ensure consistency and minimize confounding variables. Outcome measures—including flexibility, balance, and joint angle (JA)—were assessed for all participants at baseline (pre-intervention) and immediately following the 12-week intervention (post-intervention).

Procedure

Given that flexibility and balance are foundational components in many sports, these variables were selected to quantify the potential contribution of yoga to athletic performance enhancement (Boehde et al., 2005). Additionally, whole-body joint positioning was assessed to examine angular deviations during various movement tasks, enabling a kinetic analysis of posture and movement through joint angle (JA) evaluations (Latash, 1998). The aim was to determine whether consistent yoga practice could improve biomechanical alignment and functional movement patterns associated with athletic fitness.

Assessments were conducted separately for each group. Baseline testing for the yoga group (YG) was performed two days before the initiation of the intervention, while the non-yoga group (NYG) underwent the same testing protocol one day afterward. Following the completion of the 12-week intervention period, post-testing was conducted one day after the final yoga session for the YG, and subsequently the next day for the NYG. All tests were conducted without a prior warm-up to ensure uniformity across trials.

The assessment battery included six components: (1) Shoulder Flexibility (SF) test, (2) Sit-and-Reach (SR) test, (3) Stork Stand (SS) test for static balance, (4) Right Forward Lunge (RFL), (5) Downward Dog (DD), and (6) Chair pose.

Flexibility was assessed using standardized SF (Bryant, 2010), and SR (Baechle & Earle, 2008) protocols, while

Table 2. Yoga Training Protocol for the Experimental Group (YG)

Week(s)	Session Frequency	Duration	Components	Focus Area
1–2	2/week	60 min	Warm-up: Pranayama, joint mobilityAsanas: Tadasana, Vrikshasana, Bhujangasana, Balasana, Adho Mukha SvanasanaCool-down: Shavasana, guided relaxation	Foundational poses, alignment, breathing
3–4	2/week	60 min	Warm-up: Nadi Shodhana, shoulder rollsAsanas: Utkatasana, Trikonasana, Virabhadrasana I & II, Setu BandhasanaCool-down: Supine twists, Shavasana	Lower limb activation, static balance
5–6	2/week	60 min	Warm-up: Kapalabhati, shoulder mobilityAsanas: Downward Dog, Plank, Cobra, Child's Pose, Warrior FlowCool-down: Forward bends, Anulom-Vilom	Core control, dynamic transitions
7–8	2/week	60 min	Warm-up: Joint looseningAsanas: Chair Pose, Lunge Series, Forward Fold, BridgeCool-down: Spinal twists, meditation	Flexibility, muscle elongation
9–10	2/week	60 min	Warm-up: Light VinyasaAsanas: Eagle, Tree, Supine Leg Raises, Bow PoseCool-down: Breath-hold techniques	Balance, coordination
11–12	2/week	60 min	Warm-up: Meditation, shoulder mobilityAsanas: Integrated flow (Sun Salutations, Warrior, Triangle)Cool-down: Yoga Nidra	Postural integration, mind-body awareness

Note- Sessions occurred every Tuesday and Thursday morning throughout the 12 weeks

balance was measured via the Stork Stand test (Coulson & Archer, 2009). For each of these measures, the best of three attempts was recorded to ensure reliability. Video analysis was employed to evaluate JA during the RFL, DD, and chair positions. Participants were instructed to face laterally (with their right side toward the camera) and hold each posture for 10–15 seconds (Latash, 1998; Polsgrove, 2008). Joint angles for the ankle, knee, hip, and shoulder were derived using Dartfish motion analysis software. For unilateral movements like the RFL, joint angles were measured bilaterally. For symmetrical postures such as the DD and chair pose, right-side joint angles were recorded to represent bilateral alignment. These composite measures aimed to provide both quantitative and visual evidence of potential improvements in flexibility, balance, and joint articulation attributable to yoga training. Collectively, the findings from these assessments are expected to inform how yoga may influence key physical performance metrics in collegiate athletes.

Statistical Analysis

Descriptive and inferential statistical analyses were conducted to evaluate changes in flexibility, balance, and joint angle (JA) measures within each group. Due to the use of participants from two distinct sport disciplines, between-group comparisons were limited; therefore, the primary focus was placed on within-group comparisons. Pre- and post-intervention mean values were calculated for all measured variables. Change scores (post–pre) were derived to quantify improvements following the 12-week intervention. To assess the significance of these changes, paired sample t-tests were applied within each group. Additionally, Welch's two-sample t-test was used to compare the change scores between the yoga and non-yoga groups, accounting for unequal variances. All statistical analyses were performed using IBM SPSS Statistics version 26 (SPSS Inc., Chicago, IL, USA), ensuring robust and precise data handling. Statistical significance was set at $p < 0.05$ for all tests.

Results

The 12-week quasi-experimental study included two assessments—pre- and post-intervention—conducted around 24 structured yoga sessions delivered to the experimental group. A total of 28 male collegiate athletes participated, divided equally between two sports teams: handball (Yoga Group, YG) and basketball (Non-Yoga Group, NYG). The primary outcomes centered on flexibility (sit-and-reach and shoulder flexibility tests), balance (stork stand test), and joint angle measurements during three yoga postures (Right Forward Lunge, Downward Dog, and Chair pose). The Yoga Group exhibited statistically significant improvements across all key variables following the intervention. Specifically, sit-and-reach scores increased by 2.1 inches ($p = 0.009$), shoulder flexibility improved by 1.0 inch ($p = 0.025$), and stork stand balance time increased by 5.1 seconds ($p = 0.018$). In contrast, the Non-Yoga Group did not show meaningful changes in these domains, with slight declines noted across all three tests.

Normality of the data was assessed using the Shapiro-Wilk test. All variables showed p-values greater than 0.05, indicating that the data were normally distributed and suitable for parametric testing (Table 3).

This confirms the assumption of normality required for conducting paired and independent t-tests. The consistency in normal distribution across both Yoga and Non-Yoga groups enhances the reliability of comparative analysis. Therefore, subsequent statistical procedures were deemed appropriate for evaluating intervention effects.

Statistically significant improvements in flexibility—measured through the Sit-and-Reach (SR) and Shoulder Flexibility (SF) tests—and balance—measured through the Stork Stand (SS) test—were observed in the Yoga Group

Table 3. Shapiro-Wilk Normality Test Results

Variable	W-Statistic	p
Sit-and-Reach (YG)	0.939	0.411
Sit-and-Reach (NYG)	0.957	0.668
Stork Stand (YG)	0.982	0.983
Stork Stand (NYG)	0.947	0.517
Shoulder Flexibility (YG)	0.953	0.614
Shoulder Flexibility (NYG)	0.904	0.131

(YG) over the 10-week intervention period [Table 4]. The SR performance for the YG increased from a baseline mean of 21.6 inches (SD = 3.7) to 23.7 inches (SD = 2.4), with a mean improvement of 2.1 inches (p = 0.009). Similarly, SF scores improved from −0.2 inches (SD = 2.9) to 0.8 inches (SD = 2.7), reflecting a 1.0-inch gain (p = 0.025). The stork stand time also increased significantly, from 13.4 seconds (SD = 6.9) to 18.5 seconds (SD = 7.8), showing a 5.1-second improvement (p = 0.018).

Table 4. Comparative Changes in Flexibility and Balance Measures Between Yoga and Non-Yoga Groups

Group	Measure	Change	p	Between-Group, p
YG	Sit-and-Reach (inches)	+2.1	0.009*	0.04*
NYG	Sit-and-Reach (inches)	−0.5	0.27	
YG	Shoulder Flexibility (inches)	+1.0	0.025*	0.14
NYG	Shoulder Flexibility (inches)	−0.9	0.21	
YG	Stork Stand (seconds)	+5.1	0.018*	0.04*
NYG	Stork Stand (seconds)	−3.9	0.14	

Note: YG = Yoga Group; NYG = Non-Yoga Group; $p < 0.05$ indicates statistical significance.

In contrast, the Non-Yoga Group (NYG) showed reductions across all measures. SR scores decreased slightly from 21.2 inches (SD = 2.8) to 20.7 inches (SD = 3.4), a −0.5-inch change (p = 0.27). SF performance declined from −1.0 inches (SD = 3.7) to −1.9 inches (SD = 2.8), a −0.9-inch difference (p = 0.21). Balance performance, as assessed by the stork stand, also dropped from 21.9 seconds (SD = 8.6) to 18.0 seconds (SD = 9.3), representing a −3.9-second change (p = 0.14). Between-group comparisons (YG vs. NYG) revealed statistically significant differences in SR (p = 0.04) and SS (p = 0.04), indicating that the YG experienced superior gains compared to the NYG by the end of the 10-week intervention.

Whole Body Measures

Within-group comparisons of pre- and post-intervention joint angle (JA) measurements were conducted across three key postures—Right Forward Lunge (RFL), Downward Dog (DD), and Chair Pose—for both the Yoga Group (YG) and Non-Yoga Group (NYG3. In the YG, statistically significant improvements were found across multiple joints. During the RFL, a significant increase in left ankle dorsiflexion was observed with a mean change of −7.3° (SD = 10.9; p = 0.032). In the DD posture, improvements were recorded in right knee extension (+4.2°, SD = 6.1; p = 0.039), right hip extension (+11.4°, SD = 12.5; p = 0.008), and shoulder flexion (−6.9°, SD = 9.1; p = 0.012). The Chair Pose revealed significant gains in right knee flexion (+13.2°, SD = 8.4; p = 0.011), indicative of increased lower limb mobility and control.In contrast, the NYG displayed significant but regressive changes, predominantly reflecting compensatory or restricted movement patterns. In the DD position, there was a significant increase in right knee flexion (−10.7°, SD = 11.1; p = 0.047), hip flexion (−10.2°, SD = 16.8; p = 0.049), and shoulder flexion (−14.9°, SD = 21.5; p = 0.035). The Chair Pose showed increased knee flexion (−8.4°, SD = 8.9; p = 0.018) and shoulder extension (+5.7°, SD = 8.8; p = 0.048), suggesting reduced mobility or compensatory shifting during posture maintenance. In table 5 it illustrates the pre–post joint angle improvements in the Yoga Group (YG), with significant gains observed in left ankle dorsiflexion during the R-foot lunge (p = 0.032), right knee and hip extension in the Downward Dog pose (p = 0.039, p = 0.008), and right knee flexion in the Chair pose (p = 0.011). These results suggest enhanced lower-limb mobility and functional posture control following yoga intervention.

Table 5. Summary of Pre–Post Joint Angle Changes in the Yoga Group (YG)

Position	Joint	Diff (Â°)	Movement	T-test, p
R-foot lunge	Right knee	-4.8	Flexion	0.12
R-foot lunge	Right hip	-0.9	Flexion	0.48
R-foot lunge	Right shoulder	4.1	Extension	0.23
R-foot lunge	Left knee	-2.3	Flexion	0.53
R-foot lunge	Left ankle	-7.3	Dorsiflexion	0.032
Downward dog	Right ankle	-1.4	Dorsiflexion	0.47
Downward dog	Right knee	4.2	Extension	0.039
Downward dog	Right hip	11.4	Extension	0.008
Downward dog	Right shoulder	-6.9	Flexion	0.012
Chair	Right ankle	-5	Dorsiflexion	0.11
Chair	Right knee	-13.2	Flexion	0.011
Chair	Right hip	-2.1	Flexion	0.44
Chair	Right shoulder	-4.9	Flexion	0.18

Table 6 presents the pre–post intervention changes in joint angles for the Non-Yoga Group (NYG). Unlike the YG, the NYG demonstrated limited or regressive adaptations in joint mobility, many of which may reflect compensatory movement patterns rather than true improvements in flexibility or control. Notably, during the Downward Dog (DD) position, significant increases in right knee flexion (−10.7°, p = 0.047) and hip flexion (−10.2°, p = 0.049) were observed, suggesting restricted posterior chain mobility, possibly due to tight hamstrings and limited hip extension capability.

Additionally, a significant increase in shoulder flexion (−14.9°, p = 0.035) may reflect compensatory overuse of the upper body to offset lower-body stiffness. In the Chair pose, increased knee flexion (−8.4°, p = 0.018) and shoulder extension (+5.7°, p = 0.048) were observed, which may

Table 6. Summary of Pre–Post Joint Angle Changes in the Non-Yoga Group (NYG)

Position	Joint	Diff (Â°)	Movement	T-test, p
R-foot lunge	Right knee	-2.1	Flexion	0.61
R-foot lunge	Right hip	-0.8	Flexion	0.7
R-foot lunge	Right shoulder	8.7	Extension	0.18
R-foot lunge	Left knee	-5.5	Flexion	0.28
R-foot lunge	Left ankle	1.9	Plantar flexion	0.3
Downward dog	Right ankle	-0.6	Dorsiflexion	0.91
Downward dog	Right knee	-10.7	Flexion	0.047
Downward dog	Right hip	-10.2	Flexion	0.049
Downward dog	Right shoulder	-14.9	Flexion	0.035
Chair	Right ankle	-3	Dorsiflexion	0.09
Chair	Right knee	-8.4	Flexion	0.018
Chair	Right hip	-6.9	Flexion	0.06
Chair	Right shoulder	5.7	Extension	0.048

Table 7. Between-Group Differences in Joint Angles at Post-Intervention (Yoga Group vs. Non-Yoga Group)

Position	Joint	Difference (Â°)	T-test, p
R-foot lunge	Right knee	3.2	0.29
R-foot lunge	Right hip	0.7	0.46
R-foot lunge	Right shoulder	6.4	0.21
R-foot lunge	Left knee	2.9	0.33
R-foot lunge	Left ankle	9.8	0.012
Downward dog	Right ankle	1.3	0.39
Downward dog	Right knee	14.9	0.009
Downward dog	Right hip	22.3	0.006
Downward dog	Right shoulder	8.1	0.11
Chair	Right ankle	2.2	0.27
Chair	Right knee	4.1	0.13
Chair	Right hip	6	0.09
Chair	Right shoulder	10.9	0.018

indicate instability or reliance on altered mechanics for posture maintenance. These findings suggest that athletes not participating in yoga may adopt biomechanically less efficient strategies during static or semi-dynamic poses, potentially increasing susceptibility to overuse or imbalance-related injuries.

Table 7 displays the post-intervention comparative joint angle differences between the Yoga Group (YG) and Non-Yoga Group (NYG). Significant between-group differences were observed in several key areas, highlighting the superior biomechanical adaptations in the YG following the 10-week yoga intervention. In the R-foot lunge, a significant difference in left ankle dorsiflexion (9.8°, p = 0.012) was noted, suggesting enhanced lower-limb flexibility and weight-bearing mobility in the YG. In the Downward Dog, the YG exhibited significantly greater right knee extension (14.9°, p = 0.009) and hip extension (22.3°, p = 0.006) compared to the NYG, reflecting improved posterior chain length and control. These postural improvements may translate into better movement efficiency and force distribution during athletic tasks.

Furthermore, in the Chair pose, a significant difference in right shoulder flexion (10.9°, p = 0.018) was observed, indicating the YG's superior ability to maintain scapular and upper-body alignment during a complex bilateral task. Overall, the results in Table 4 provide robust evidence that yoga training contributes meaningfully to enhanced joint mobility, symmetry, and functional posture—improvements not seen in the control group.Table 4: Between-Group Joint Angle Differences (YG vs. NYG)

Discussion

This study investigated the impact of a 12-week structured yoga intervention on flexibility, balance, and joint kinematics among collegiate athletes. The findings demonstrated that the inclusion of yoga training significantly enhanced physical performance parameters in the Yoga Group (YG) compared to the Non-Yoga Group (NYG), who engaged solely in conventional athletic training.

The improvements observed in flexibility, specifically in the Sit-and-Reach (SR) and Shoulder Flexibility (SF) tests, indicate that yoga provides additional benefits beyond standard warm-up stretching routines. Although both groups participated in regular static stretching during their respective sports practices, only the YG showed statistically significant gains. These results are consistent with prior literature, which has shown that yoga enhances flexibility through prolonged static holds, mindful breathing, and progressive muscle elongation (McHugh & Cosgrave, 2009; Amin & Goodman, 2014). In contrast, the NYG either showed negligible changes or slight regressions, highlighting the limited efficacy of routine pre-exercise stretching when not supplemented with targeted mobility training. Balance, assessed via the Stork Stand test, also improved significantly in the YG, supporting existing evidence that yoga enhances proprioceptive control and neuromuscular coordination (Zech et al., 2010; Boehde et al., 2005). The lack of significant changes in the NYG, despite participation in skill-based sport-specific drills, suggests that traditional athletic training alone may not sufficiently challenge static balance in a structured or systematic manner. The superior outcomes in the YG underscore yoga's potential as a neuromuscular enhancer capable of stimulating the sensorimotor system through controlled, isometric contractions and dynamic balance postures. Joint angle (JA) analyses provided further biomechanical insights into how yoga contributes to movement efficiency. In the Right Forward Lunge (RFL), YG participants demonstrated significantly increased dorsiflexion of the left ankle, suggesting improved posterior chain mobility and eccentric strength. Conversely, the NYG athletes exhibited no such changes, often adopting more plantar-flexed positions to compensate for limited range of motion. These findings align with previous observations that yoga training fosters improved alignment and muscular balance through full-range joint activation (Clark, 2013; Verkhoshansky, 2009). During the Downward Dog (DD) posture, the YG showed increases in hip and knee extension and shoulder flexion, reflecting improved hamstring, lumbar, and deltoid flexibility. In contrast, the NYG displayed regressions in these areas, potentially due to compensatory tightness or fatigue accumulation. These divergent adaptations further affirm the corrective and restorative potential of yoga in addressing movement asymmetries and muscular imbalances common in sport-specific training. The divergence in flexibility adaptations observed during the Downward Dog posture between the Yoga Group and the Non-Yoga Group underscores the nuanced impact of yoga on musculoskeletal function (Polsgrove et al., 2016). In the Chair Pose, the YG achieved greater knee flexion while maintaining upright shoulder positioning, suggesting improved core engagement and postural control. In contrast, NYG athletes demonstrated increased shoulder extension, likely as a counterbalancing mechanism to stabilize the center of mass, indicative of weaker lower-limb engagement. This distinction highlights yoga's efficacy in promoting integrated body movement and kinetic chain synergy—attributes essential for athletic performance. The results of the present study align well with previous findings in the literature. For instance, Polsgrove et al. (2016) reported that a 10-week yoga intervention significantly improved flexibility and balance among male college athletes. Their yoga group demonstrated gains in sit-reach ($P = 0.01$), shoulder flexibility ($P = 0.03$), and stork stand balance ($P = 0.05$), along with enhanced joint angles during dynamic yoga positions such as the right foot lunge, downward dog, and chair pose. These improvements mirror the current findings where the yoga group showed significant increases in joint mobility and postural control following 12 weeks of structured yoga training. Similarly, Luo and Huang (2023) found that a 16-week yoga program significantly enhanced flexibility and balance in female college students, particularly during the pandemic when access to conventional training facilities was limited. Participants showed measurable gains in balance (e.g., single-limb stance and Romberg test) and flexibility (e.g., sit-and-reach and groin mobility), whereas the control group saw no change. This supports the broader generalizability of yoga's benefits across different genders and contexts, reinforcing its relevance as a holistic training modality. Furthermore, the findings of Iftekher and Rahaman (2017) provide additional support, demonstrating that even a short-term, 6-week yoga intervention significantly improved flexibility ($P = 0.017$) and balance ($P = 0.004$) in shooting trainees. The consistent improvements across different populations, durations, and sporting backgrounds emphasize yoga's potential to enhance core physical parameters essential for athletic performance. The increases in hip and knee extension alongside shoulder flexion within the Yoga Group suggest enhanced flexibility in the hamstrings, lumbar region, and deltoid muscles, potentially stemming from the sustained stretching and postural alignment inherent in regular yoga practice (Zhang et al., 2023). Regular yoga practice may promote a more balanced musculoskeletal system, mitigating the risk of injury and optimizing athletic performance (Holtzman & Beggs, 2013).The results of the present study align with the findings of Dubey and Choudhary (2024), who reported significant improvements in back flexibility ($\Delta = 3.20 \pm 0.95$ cm) and lumbar flexion ($\Delta = 1.50 \pm 0.75$ cm) among female college students following a six-week Surya Namaskar intervention, further supporting the positive role of yoga-based practices in enhancing musculoskeletal flexibility and spinal mobility. The findings of the present study are further supported by Choudhary et al. (2025), who demonstrated that a six-week perturbation-based balance training program significantly improved dynamic stability in university basketball players, highlighting the value of neuromuscular training in enhancing balance and postural control. Similar to our yoga-based intervention, their results confirm the efficacy of structured training protocols in promoting athletic balance and reducing performance-related asymmetries. The study by Balaji et al. (2024) supports the present findings by demonstrating that a six-week Surya Namaskar intervention significantly improved back flexibility and lumbar flexion in male college students, thereby reinforcing the role of structured yoga practices in enhancing musculoskeletal function and overall physical well-being. Although yoga is widely recognized for its positive effects on flexibility and balance, similar improvements can also be achieved through other exercise modalities such as traditional stretching and strengthening programs. Further, a study by Waza and Deol (2025) complements the current findings by emphasizing yoga's positive role in influencing musculoskeletal parameters. Their comparative analysis revealed that yoga practitioners demonstrated moderate improvements in bone mineral density and body composition, reinforcing the current study's evidence that structured yoga interventions contribute to flexibility, posture, and overall physical health. Research by Gothe and McAuley (2016) demonstrated that both yoga and conventional exercise routines are equally effective in enhancing functional fitness parameters like balance and flexibility in older adults. This highlights that while yoga is a valuable approach, it is among several effective strategies available for improving these physical capacities.

Together, these studies substantiate the observed improvements in the present investigation and suggest that regular integration of yoga into athletic training regimens can meaningfully augment flexibility, balance, and joint functionality, particularly in sports demanding precision and mobility. Collectively, the results of this study provide compelling evidence that yoga can serve as a potent adjunct to conventional athletic training by improving flexibility, balance, and neuromuscular coordination. The integration of yoga into collegiate sport programs may offer a holistic training modality that addresses both physical and mental dimensions of athlete performance.

Conclusion

This 12-week quasi-experimental study demonstrated that integrating a structured yoga intervention into the training routines of collegiate athletes significantly enhanced key physical performance parameters, particularly flexibility, balance, and joint mobility. The Yoga Group (YG), composed of handball players, exhibited notable improvements across all measured variables, including sit-and-reach, shoulder flexibility, stork stand balance, and joint angles in functional postures such as the right foot lunge, downward dog, and chair pose. In contrast, the Non-Yoga Group (NYG), comprised of basketball players engaged in regular sport-specific training without yoga, showed negligible or regressive changes, underscoring the added value of yoga beyond conventional athletic routines. These findings affirm that yoga, when consistently practiced under structured guidance, can serve as a powerful adjunct to traditional training regimens, addressing biomechanical alignment, neuromuscular coordination, and functional mobility. By promoting muscular balance, postural symmetry, and enhanced proprioceptive control, yoga contributes to more efficient movement patterns that are vital for both performance enhancement and injury prevention. The study's results align with and extend the current literature on yoga's efficacy, highlighting its versatility and applicability across diverse sporting contexts. The observed gains, particularly in joint angle control and static balance, suggest that yoga can help athletes develop the foundational movement quality necessary for optimal performance in dynamic sports. Future investigations should aim to explore long-term adaptations, delve into sport-specific performance metrics, and include physiological measures such as VO_2max, muscle activation patterns, or stress biomarkers (e.g., cortisol) to comprehensively understand yoga's multidimensional impact. Given the positive outcomes observed, athletic programs at the collegiate level should consider incorporating yoga into their training protocols to foster well-rounded physical development.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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Вплив 12-тижневої інтервенції зі структурованої йоги на гнучкість, рівновагу та кінематику суглобів університетських спортсменів: Квазіекспериментальне дослідження

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 11 с., 7 табл., 1 рис., 57 джерела.

Мета дослідження. Мета цього дослідження полягала у вивченні впливу 12-тижневої інтервенції зі структурованої йоги на гнучкість, рівновагу та суглобові кути (СК) серед університетських спортсменів. Було висунуто гіпотезу, що учасники, які виконують тренування з йоги, продемонструють кращі результати за зазначеними параметрами порівняно з тими, хто займається виключно регулярними тренуваннями, специфічними для певного виду спорту.

Матеріали та методи. Застосовано квазіекспериментальний пре-пост дизайн дослідження, до якого було залучено 28 студентів-спортсменів чоловічої статі, розподілених порівно на дві групи: група, що займалася йогою (YG, n = 14; гандболісти), та група, що не практикувала йогу (NYG, n = 14; баскетболісти). Група YG протягом 12 тижнів двічі на тиждень додатково до звичайних тренувань відвідувала 60-хвилинні заняття з йоги, тоді як група NYG дотримувалася виключно свого звичайного режиму тренувань. Критерії оцінювання показників включали тест на вимірювання загальної гнучкості тіла при згинанні тулуба вперед, сидячи на підлозі з витягнутими вперед руками (“Sit-and-Reach test”, SR), тест на гнучкість плечей (SF), тест на рівновагу у позиції «Лелека» (“Stork Stand test”, SS) та аналіз суглобових кутів (СК) з використанням програмного забезпечення Dartfish у трьох положеннях: випад вперед правою ногою (RFL), поза «Собаки мордою вниз» (“Downward Dog”, DD) та поза «Стільця». Нормальність даних було підтверджено за допомогою критеріїв Шапіро-Вілка ($p > 0.05$). З метою порівняння внутрішньогрупових та міжгрупових показників використовувалися парні t-критерії та t-критерії Велча відповідно, з рівнем значущості $p < 0.05$.

Результати. Група YG продемонструвала статистично значуще поліпшення гнучкості та рівноваги: SR збільшився на +2.1 дюйма ($p = 0.009$), показник гнучкості плечей покращився на +1.0 дюйма ($p = 0.025$), а час виконання тесту на рівновагу у позиції «Лелека» збільшився на +5.1 секунди ($p = 0.018$). У групі NYG істотних змін встановлено не було ($p > 0.05$). Поліпшення показників суглобових кутів у групі YG включали дорсифлексію лівої гомілки під час виконання випаду вперед правою ногою (−7.3°, $p = 0.032$), розгинання правого стегна під час виконання пози «Собаки мордою вниз» (+11.4°, $p = 0.008$) та згинання правого коліна під час виконання пози «Стільця» (−13.2°, $p = 0.011$). У групі NYG спостерігалися незначні або регресивні адаптації суглобових кутів.

Висновки. Результати дослідження показують, що структуровані тренування з йоги сприяють значному покращенню гнучкості, рівноваги та біомеханічної ефективності у студентів-спортсменів. Інтеграція йоги до регулярних спортивних тренувань може слугувати цінним доповненням для оптимізації результативності та запобігання травматизму.

Ключові слова: інтервенція з йоги, гнучкість, рівновага, кінематика суглобових кутів, університетські спортсмени.

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