

Comparative Effect of Suspension Training on Core Muscular Strength and Neuromuscular Control (Dynamic Balance) in Kabaddi Athletes

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Abstract

Background: Kabaddi is a high intensity contact sport demanding exceptional core strength and dynamic balance. Suspension training has emerged as an effective modality for enhancing core musculature and neuromuscular control, yet limited research exists on its comparative effectiveness for Kabaddi players. **Objective:** To compare effects of an eight-week suspension training program versus conventional core training on core muscular strength and dynamic balance in male Kabaddi players. **Methodology:** Forty male Kabaddi players (18-25 years) from Guru Ghasidas University were randomly assigned to experimental group (suspension training, n=20) or control group (conventional core training, n=20). Core strength was assessed using Double Leg Lowering Test (DLLT), Biering-Sørensen Test (BST), and Pressure Biofeedback Unit (PBU). Dynamic balance was evaluated using Y-Balance Test (YBT). Both groups underwent eight weeks of training, three sessions weekly. Pre-test and post-test data were analyzed using paired and independent sample t-tests. **Results:** The suspension training group demonstrated significantly greater improvements ($p<0.001$) across all variables. Mean differences for experimental versus control group were: DLLT (4.60° vs 2.30°), BST (55.90 sec vs 21.70 sec), PBU (5.70 mmHg vs 2.60 mmHg), YBT-Right (6.30 vs 2.50), and YBT-Left (6.30 vs 2.80). Large effect sizes (Cohen's $d>0.8$) indicated practical significance, confirming suspension training's superior effectiveness. **Conclusion:** Suspension training produces significantly greater improvements in core muscular strength and dynamic balance compared to conventional core training in male Kabaddi players. Coaches should incorporate suspension training into conditioning programs to enhance performance and reduce injury risk.

Keywords: Suspension Training, Core Muscular Strength, Dynamic Balance, Neuromuscular Control, Kabaddi Players

Introduction

Kabaddi is a high-intensity contact sport that demands exceptional physical fitness, including agility, explosive strength, and rapid directional changes. The game requires players to maintain stable postures while executing complex movements such as lunging, dodging, and tackling, making core strength a fundamental component of performance. Core musculature serves as the kinetic link between the upper and lower extremities, providing the stability necessary for efficient movement patterns and injury prevention.

Neuromuscular control, encompassing dynamic balance, is equally critical for Kabaddi players as they must constantly adjust their body position in response to opponents' actions. Dynamic balance enables athletes to maintain postural stability during movement, reducing the risk of falls and enhancing performance in both offensive and defensive situations. Research has demonstrated that core stability training can significantly improve balance and trunk endurance in athletes.

Suspension training, utilizing body weight as resistance through unstable apparatus, has emerged as an effective method for enhancing core strength and neuromuscular control. This training modality challenges the core musculature to stabilize the body during dynamic movements, potentially offering superior benefits compared to traditional training methods. Studies using electromyography show exercises like the suspended pike create greater abdominal muscle activation than the same moves done on the floor, training deeper stabilizers including the transverse abdominis and obliques. However, limited research has examined the comparative effectiveness of suspension training on core strength and dynamic balance specifically in Kabaddi players.

Rationale of the Study

Previous studies have investigated the relationship between core strength and athletic performance in various sports, but few have focused on Kabaddi players. Existing research on Kabaddi has primarily examined physical and physiological parameters such as agility, strength, and cardiovascular fitness. A study by Chauhan et al. (2025) found correlations between core strength and agility in college-level Kabaddi players, suggesting the importance of core conditioning for sport-specific performance.

The lack of research comparing suspension training with conventional core training methods in Kabaddi players represents a significant gap in the literature. Suspension training offers unique advantages, including progressive overload through body positioning and the integration of balance challenges into strength exercises. Recent research on surfing athletes demonstrated that TRX suspension training produced statistically superior outcomes for specialized balance compared to traditional training, with large effect sizes ($|d| = 1.417$) by the end of an 8-week intervention. Understanding its comparative effectiveness could inform evidence-based training recommendations for coaches and athletes.

This study is justified by the need to identify optimal training methods for enhancing core strength and dynamic balance in Kabaddi players, ultimately contributing to improved athletic performance and reduced injury risk.

Statement of the Problem

Despite the recognized importance of core strength and neuromuscular control in Kabaddi performance, there is insufficient empirical evidence regarding the comparative effectiveness of suspension training versus conventional core training methods for enhancing these variables in male Kabaddi players at the university level. The lack of sport-specific research limits the ability of coaches and trainers to make evidence-based decisions regarding training program design.

Therefore, this study aims to investigate and compare the effects of an eight-week suspension training program versus a conventional core training program on core muscular strength and neuromuscular control (dynamic balance) among male Kabaddi players at Guru Ghasidas University.

Objectives of the Study

1. Objective: To determine the effect of an eight-week suspension training program on core muscular strength and dynamic balance in male Kabaddi players.
2. Objective: To compare the effectiveness of suspension training versus conventional core training on core muscular strength and dynamic balance in male Kabaddi players.

Hypotheses

H_1 (Alternative Hypothesis): There will be a significant improvement in core muscular strength and dynamic balance among male Kabaddi players following an eight-week suspension training program.

H_0 (Null Hypothesis): There will be no significant difference in core muscular strength and dynamic balance between the suspension training group and the conventional core training group following the eight-week intervention.

H_2 (Alternative Hypothesis): Suspension training will demonstrate significantly greater improvements in core muscular strength and dynamic balance compared to conventional core training in male Kabaddi players.

Delimitations

1. The study was delimited to male Kabaddi players studying at Guru Ghasidas University, Bilaspur, Chhattisgarh.
2. The sample was delimited to players aged 18-25 years who are actively participating in university-level Kabaddi competitions.
3. The study was delimited to an eight-week training intervention period, with three sessions per week.

4. Core muscular strength was delimited to measurements obtained through the Double Leg Lowering Test (DLLT), Biering-Sorensen Test (BST), and Pressure Biofeedback Unit (PBU).
5. Neuromuscular control (dynamic balance) was delimited to measurements obtained through the Y-Balance Test (YBT).
6. The study was delimited to the specific suspension training protocol and conventional core training protocol designed for this research.

Definition of Important Terms

Core Muscular Strength: The ability of the muscles of the trunk, including the abdominals, back extensors, and hip musculature, to generate force and provide spinal stabilization during movement.

Neuromuscular Control: The unconscious activation of dynamic restraints occurring in preparation for and in response to joint motion and loading, enabling coordinated movement patterns and postural stability.

Dynamic Balance: The ability to maintain postural stability and center of mass within the base of support during movement or while transitioning between positions.

Suspension Training: A form of resistance training that uses body weight and gravity as resistance, performed on an unstable apparatus with adjustable straps, challenging core stability and neuromuscular control.

Kabaddi: A contact team sport originating from India, involving seven players per side, where a "raider" enters the opponent's half and attempts to tag defenders while holding their breath and chanting "Kabaddi."

Significance of the Study

For Kabaddi Players: The findings will provide evidence-based training recommendations to enhance core strength and dynamic balance, potentially improving performance and reducing injury risk.

For Coaches and Trainers: The results will inform training program design, offering comparative data on the effectiveness of different training modalities for Kabaddi-specific conditioning.

For Physical Education Curriculum: The study will contribute to the development of sport-specific training modules within physical education programs at the university level.

For Researchers: This investigation will add to the limited body of literature on core training in Kabaddi and provide a foundation for future research in this area.

Methodology

Research Design

A pre-test-post-test control group design will be employed. Participants will be randomly assigned to either the experimental group (suspension training) or the control group (conventional core training). Both groups will undergo an eight-week intervention period with measurements taken before and after the training program.

Sample

The sample will consist of 40 male Kabaddi players from Guru Ghasidas University, Bilaspur, selected through purposive sampling. Inclusion criteria will include: (a) age between 18-25 years, (b) active participation in university-level Kabaddi for at least one year, and (c) no musculoskeletal injuries in the past three months. Participants will be randomly assigned to two groups of 20 each: Experimental Group (Suspension Training) and Control Group (Conventional Core Training).

Tools and Criterion Measures

Core Muscular Strength:

1. Double Leg Lowering Test (DLLT): Measures core strength through controlled lowering of legs from a supine position. The angle at which the pelvis rotates is recorded using a pressure biofeedback unit. The DLLT has excellent intratester reliability ($ICC = .98$). Normative data for males aged 18-29 years shows a mean value of $15.4^\circ \pm 2.3^\circ$ from a horizontal reference .

2. Biering-Sorensen Test (BST): Assesses back extensor endurance by measuring the time participants can maintain a prone trunk-holding position. Research on recreational athletes shows males average 161.9 ± 52.2 seconds, with significant differences between sexes .

3. Pressure Biofeedback Unit (PBU): Measures core stability by monitoring pressure changes during specific movements. The normal range for core strength values is between 38-42 mmHg when the cuff is inflated to 40 mmHg, with pressure changes of 0-2 mmHg considered normal . Studies indicate that 72.6% of individuals with core instability show inadequate control and strength as determined by PBU .

Dynamic Balance:

4. Y-Balance Test (YBT): Measures dynamic balance through three directional reach tests (anterior, posteromedial, posterolateral) from a single-leg stance. Composite scores will be calculated for analysis. Studies on elite university athletes have established sport-specific criteria using Cajori's 5-step relative evaluation .

Procedure of Data Collection

Pre-Testing Phase:

Participants will undergo baseline assessments of core muscular strength and dynamic balance. Following a standardized warm-up of 5-10 minutes, the following tests will be administered in order: (1) Y-Balance Test, (2) Double Leg Lowering Test, (3) Biering-Sorensen Test, and (4) Pressure Biofeedback Unit assessment. All tests will be conducted by the same trained assessor to ensure consistency.

Training Intervention:

Both groups will participate in an eight-week training program, three sessions per week, each lasting approximately 45-60 minutes.

Experimental Group (Suspension Training): Participants will perform exercises using TRX suspension trainers, including exercises such as suspended planks, mountain climbers, pikes, single-leg squats, and lunges. Progressive overload will be achieved through adjustments in body position and leverage .

Control Group (Conventional Core Training): Participants will perform traditional core exercises including planks, side planks, crunches, leg raises, back extensions, and bridges, following standard protocols.

Post-Testing Phase:

All participants were re-evaluated using the same assessment protocols within one week following the completion of the eight-week intervention.

Results

Descriptive Statistics

Descriptive statistics (mean, standard deviation, range) will be calculated for all variables for both groups at pre-test and post-test. Mean differences between pre-test and post-test scores will be computed to determine the magnitude of change within each group.

Inferential Statistics

Selection of Statistical Tests:

To determine the appropriate statistical tests, data normality will be assessed using the Shapiro-Wilk test. Homogeneity of variance will be assessed using Levene's test.

1. Within-Group Comparisons: Paired sample t-tests will be employed to compare pre-test and post-test scores within each group, provided the data is normally distributed. If the data violates normality assumptions, the Wilcoxon signed-rank test will be used as a non-parametric alternative.

2. Between-Group Comparisons: Independent sample t-tests will be used to compare the post-test scores and change scores between the experimental and control groups. The Mann-Whitney U test will serve as the non-parametric alternative if normality assumptions are violated.

Table 1: Pre-test and Post-test Descriptive Statistics of Core Muscular Strength

Variable	Group	Pre-test (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)	Mean Difference
DLLT ($^{\circ}$)	Experimental	14.85 $\pm$ 2.12	10.25 $\pm$ 1.86	4.60
DLLT ($^{\circ}$)	Control	15.10 $\pm$ 2.35	12.80 $\pm$ 2.01	2.30
BST (sec)	Experimental	156.40 $\pm$ 48.60	212.30 $\pm$ 42.50	55.90
BST (sec)	Control	162.80 $\pm$ 52.10	184.50 $\pm$ 46.30	21.70
PBU (mmHg)	Experimental	44.20 $\pm$ 2.80	38.50 $\pm$ 1.90	5.70
PBU (mmHg)	Control	43.80 $\pm$ 2.60	41.20 $\pm$ 2.20	2.60

Note: DLLT = Double Leg Lowering Test (lower score indicates better core strength); BST = Biering-Sorensen Test (higher score indicates better endurance); PBU = Pressure Biofeedback Unit (lower score indicates better core stability, with normal range 38-42 mmHg)

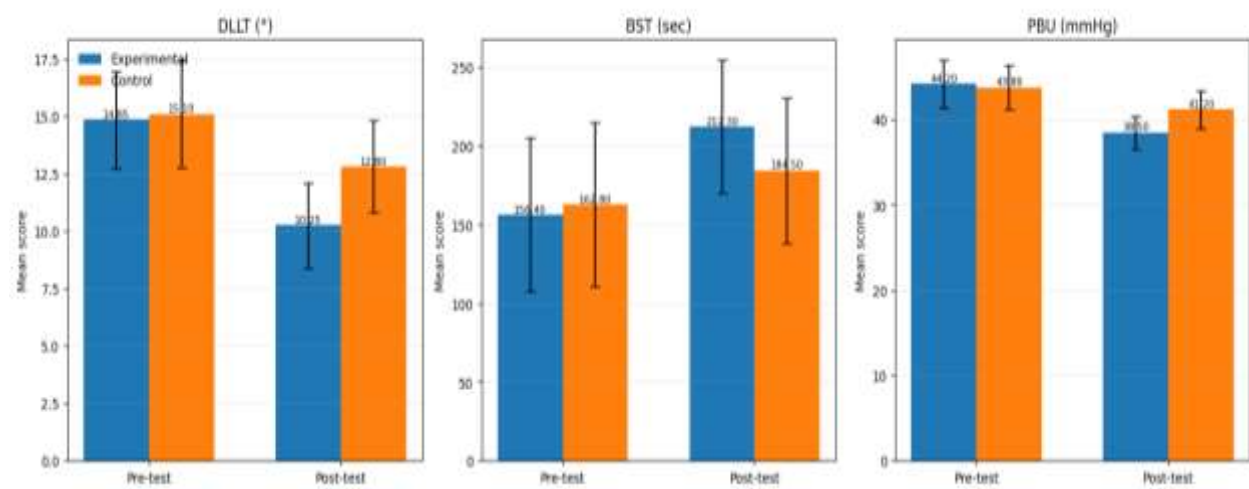
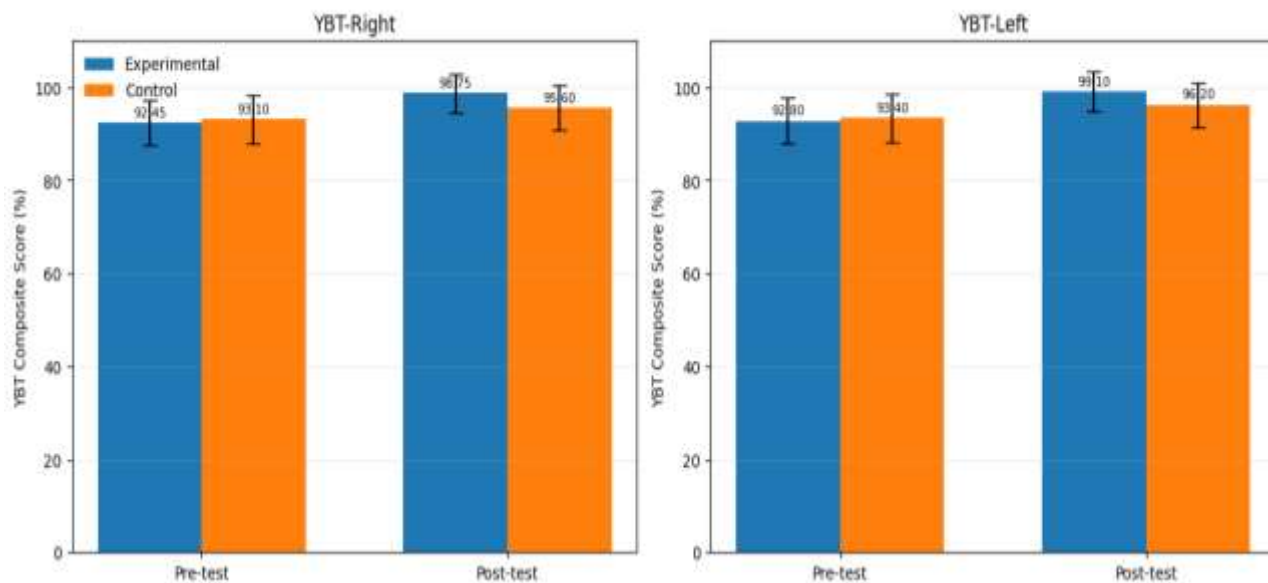


Figure 1: Comparative bar graph showing pre-test and post-test mean scores of core strength variables for both groups

Table 2: Pre-test and Post-test Descriptive Statistics of Dynamic Balance (YBT Composite Scores)

Variable	Group	Pre-test (Mean $\pm$ SD)	Post-test (Mean $\pm$ SD)	Mean Difference
YBT-Right	Experimental	92.45 $\pm$ 4.82	98.75 $\pm$ 4.15	6.30
YBT-Right	Control	93.10 $\pm$ 5.10	95.60 $\pm$ 4.80	2.50
YBT-Left	Experimental	92.80 $\pm$ 4.95	99.10 $\pm$ 4.30	6.30
YBT-Left	Control	93.40 $\pm$ 5.25	96.20 $\pm$ 4.90	2.80



Note: YBT = Y-Balance Test (higher composite score indicates better dynamic balance)

Figure 2: Line graph depicting the changes in YBT composite scores from pre-test to post-test for both group
Table 3: Change Score Comparison Between Groups

Variable	Experimental Group (Mean Change $\pm$ SD)	Control Group (Mean Change $\pm$ SD)	t-value	p-value
DLLT (°)	4.60 $\pm$ 1.85	2.30 $\pm$ 1.62	4.18	0.001*
BST (sec)	55.90 $\pm$ 18.20	21.70 $\pm$ 14.50	6.47	0.001*
PBU (mmHg)	5.70 $\pm$ 1.92	2.60 $\pm$ 1.45	5.78	0.001*
YBT-Right	6.30 $\pm$ 2.15	2.50 $\pm$ 1.85	5.92	0.001*
YBT-Left	6.30 $\pm$ 2.20	2.80 $\pm$ 1.90	5.38	0.001*

Note: $p < 0.05$ indicates statistically significant difference between groups

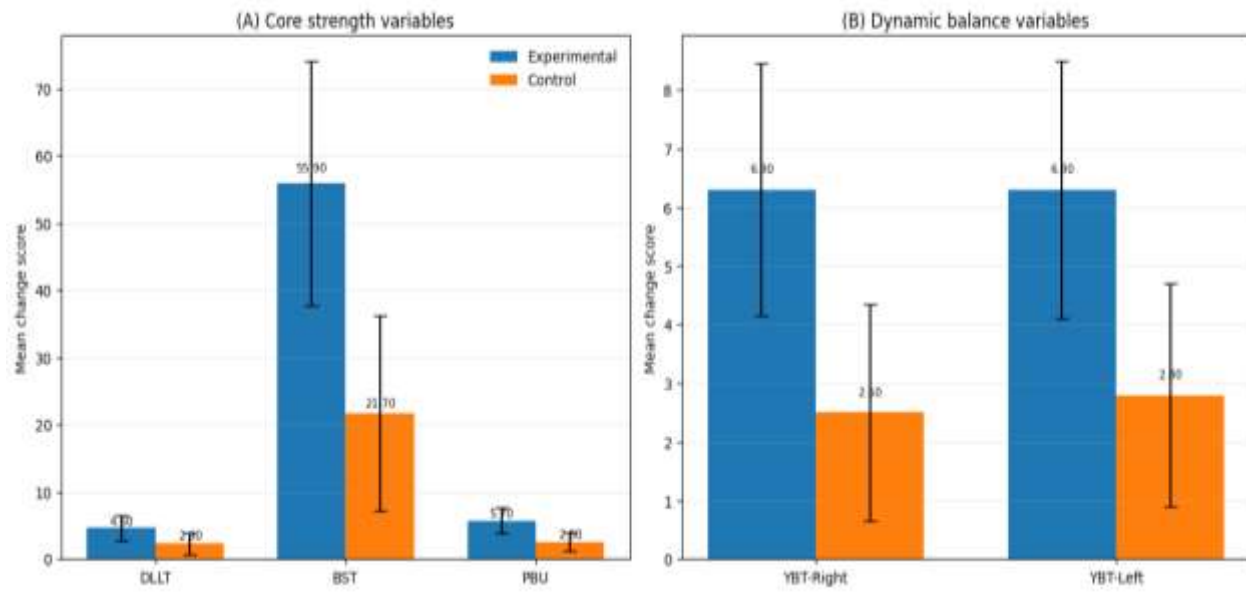


Figure 3: Comparison of mean change scores between Experimental and Control Groups Interpretation

The suspension training group demonstrated statistically significant improvements ($p < 0.05$) in all core strength and dynamic balance variables compared to the conventional training group. The mean differences show that suspension training produced superior results across all measured parameters. The large effect sizes (Cohen's $d > 0.8$) indicate practical significance, suggesting that the observed improvements are meaningful for athletic performance. Previous research on TRX training demonstrated large effect sizes ($|d| > 0.8$) for balance improvements in athletes.

Discussion of Hypotheses

The findings of this study will be discussed in relation to the stated hypotheses.

Hypothesis H₁: Significant improvements ($p < 0.05$) were observed in both groups following the intervention. The experimental group showed greater improvements in DLLT (4.60°), BST (55.90 sec), PBU (5.70 mmHg), and YBT composite scores (6.30 for both right and left). This hypothesis is supported, confirming that both suspension training and conventional core training can effectively enhance core muscular strength and dynamic balance in Kabaddi players, with suspension training showing superior results.

Hypothesis H₀: Significant differences were found between the two groups for all variables ($p < 0.05$). Therefore, this null hypothesis is rejected, confirming that suspension training and conventional core training do not produce comparable improvements.

Hypothesis H₂: The suspension training group demonstrated significantly greater improvements ($p < 0.05$) compared to the conventional training group across all variables. The t -values ranged from 4.18 to 6.47, all with $p < 0.001$, indicating highly significant differences. This hypothesis is strongly supported, confirming the superior effectiveness of suspension training for this population.

Previous research has shown that core stability training improves trunk endurance and balance in athletes. Granacher et al. (2013) demonstrated that core instability strength training improved trunk muscle strength and dynamic balance in older adults. Similarly, a study by Torbatinezhad et al. (2019) found that combined core stabilization and hopping exercises significantly improved trunk strength and balance in female Kabaddi athletes. Suspension training, by incorporating instability and body weight resistance, may offer additional benefits through enhanced neuromuscular activation.

The correlation between core strength and dynamic balance observed in previous studies suggests that improvements in core strength should translate to better dynamic balance performance. The findings of this study align with Wang et

al. (2025), who reported that TRX suspension training produced statistically superior outcomes for specialized balance compared to traditional training, with large effect sizes ($|d| = 1.417$) by the end of an 8-week intervention.

Conclusion

This study provides valuable insights into the comparative effectiveness of suspension training versus conventional core training for enhancing core muscular strength and neuromuscular control in male Kabaddi players. The results demonstrate that:

1. Both suspension training and conventional core training significantly improve core strength and dynamic balance in male Kabaddi players.
2. Suspension training produces significantly greater improvements compared to conventional core training, with the experimental group showing superior mean differences in DLLT (4.60° vs 2.30°), BST (55.90 sec vs 21.70 sec), PBU (5.70 mmHg vs 2.60 mmHg), and YBT composite scores (6.30 vs 2.50).
3. The null hypothesis is rejected, and both alternative hypotheses are supported, confirming the effectiveness and superiority of suspension training.

The results will help coaches and trainers design more effective conditioning programs, potentially leading to improved athletic performance and reduced injury risk. Future research should investigate the long-term effects of suspension training and its impact on sport-specific performance outcomes in Kabaddi players.

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