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AN COMPARISON OF KETTLEBELL VERSUS BATTLE ROPE EXERCISE ON BALANCE AND GRIP STRENGTH IN RECREATIONAL TABLE-TENNIS PLAYERS: A COMPARATIVE STUDY

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ABSTRACT

Background: Table tennis is a high-intensity, skill-dominant racket sport that demands rapid neuromuscular responses, dynamic postural control, and substantial hand grip strength for effective stroke execution and injury prevention. Recreational players frequently lack structured conditioning programs targeting these physical determinants. Functional resistance modalities such as kettlebell and battle rope training have demonstrated multi-planar neuromuscular benefits; however, comparative evidence regarding their effectiveness in racket sports populations remains limited.

Methodology: A randomized comparative experimental study was conducted involving 44 recreational table tennis players (19–45 years). Participants were allocated into two groups: kettlebell training (n = 22) and battle rope training (n = 22). Both groups underwent structured training protocols for eight weeks. Outcome measures included hand grip strength (assessed via handheld dynamometer) and dynamic postural control (assessed using the Y Balance Test in anterior, posteromedial, and posterolateral directions).

Results: Both groups demonstrated statistically significant improvements in dominant and non-dominant hand grip strength and dynamic balance parameters following the intervention ($p < 0.001$). Between-group analysis revealed significantly greater improvements in dominant hand grip strength ($p = 0.04$) and dynamic balance measures in the battle rope group compared to the kettlebell group.

Conclusion: Both kettlebell and battle rope training significantly enhance grip strength and postural control in recreational table tennis players. However, battle rope training appears comparatively more effective in improving dominant hand grip strength and dynamic balance performance.

Keywords: Table tennis, Kettlebell training, Battle rope training, Grip strength, Dynamic balance, Functional resistance training, Neuromuscular performance

INTRODUCTION

Physical activity and structured exercise are essential for health, fitness, and functional performance throughout life. Any skeletal muscle movement that requires Energy is considered physical activity **[1]**. Regular physical activity greatly benefits musculoskeletal health, heart fitness, neuromotor development, and overall well-being **[2]**. Modern exercise science highlights the importance of training programs that improve strength, endurance, flexibility, postural control, and coordination to enhance performance and lower the risk of injury **[3]**. Rapid ball is a fast-paced racket sport marked by swift ball exchanges, quick reflexes, and complex motor coordination. Players must execute accurate strokes, maintain postural control, and swiftly adjust to unpredictable ball trajectories. Studies show that table tennis involves bursts of high-intensity activity followed by short recovery periods, engaging both aerobic and anaerobic energy systems **[4]**. The technical and tactical skills needed in table tennis have changed significantly over time, making it a sport that requires high physical fitness and skilled movement. Modern play features quick rallies, various spins, and strategic shot placement, demanding well-honed physical and cognitive skills **[5]**.

Taking part in table tennis offers many health and fitness benefits. Regular practice can lead to better cardiovascular endurance, strength, coordination, and body composition **[6]**. To perform well in table tennis, players need a mix of fitness elements, including strength, endurance, agility, postural control, coordination, and reaction time. Analyzing the fitness levels of racket sports players shows that success relies on general fitness and specific skills **[7]**. Balance and control of posture are vital for table tennis due to the sport's fast and dynamic nature. Players need stability while making quick directional changes, lunges, and rotational shots. Good postural control allows players to maintain proper body alignment and make precise strokes. Research on training interventions in table tennis shows significant improvements in postural control and control following well-structured training programs **[8]**. Tools like the Y-Postural control Test are often used to assess dynamic postural control and stability in athletes. These tools are reliable in measuring lower-limb postural control and predicting injury risk **[9]**.

Improvements in dynamic postural control and core stability have been linked to better athletic performance and fewer injuries **[10]**. Core stability training is particularly important for enhancing postural control and movement efficiency **[11]**. Creating effective postural control training programs requires a good grasp of neuromuscular control and dynamic systems theory to improve stability and performance **[12]**. Gripping power is a key part of physical fitness and an important factor in success in racket sports. It represents the strength and endurance of the forearm and hand muscles and is a strong indicator of overall muscle strength and functional ability **[13]**. Gripping power has been identified as a critical measure of health and performance, especially in activities that need manual force and coordination **[14]**. Data on gripping power throughout life emphasize its significance for musculoskeletal health and functional capability **[15]**.

The shoulder joint is essential for generating strokes and faces considerable mechanical stress due to repeated rotational movements. Research has shown that the shoulder is among the most vulnerable areas for overuse injuries among racket sports players. Weak muscles and poor movement technique can increase stress on the shoulder joint and nearby tissues, leading to injuries and performance issues **[16]**.

Improving strength and coordination in the lower body can enhance movement efficiency and lower the risk of injury. Forehand and backhand strokes in table tennis involve complex interactions between the trunk, upper limbs, and lower limbs. Comparative biomechanical analysis of topspin strokes has emphasized the importance of trunk rotation, shoulder movement, and wrist action in creating power and spin **[17]**. Although table tennis is a non-contact sport, players can suffer from various musculoskeletal injuries due to repetitive movements and stress on their bodies. Studies have shown that overuse injuries are the most common among racket sports players, affecting the shoulder, elbow, wrist, and lower limbs **[18]**.

Common injuries in table tennis include shoulder tendinopathy, wrist strain, elbow overuse injuries, and muscle strains in the lower limbs. Research on injury patterns in racket sports has indicated a high prevalence of upper-limb injuries tied to repetitive gripping and stroke movements **[19]**. Additionally, quick lateral movements and sudden changes in direction can increase the risk of ankle instability and ligament injuries **[20]**. The core muscles help link the upper and lower body, allowing for effective force transfer during strokes **[21]**.

Performance in table tennis depends on various factors, such as physical fitness, technical skills, tactical awareness, and mental readiness. Among these, elements of physical fitness like strength, endurance, postural control, and coordination are key to achieving good performance **[22]**. Profiling the physical fitness of racket sports players has highlighted agility, reaction time, and strength as important for competitive success. Young athletes have exhibited improved motor skills and coordination after following structured training programs **[23]**. Reaction agility has emerged as an important predictor of how effective strokes are, emphasizing the need for neuromuscular training to boost performance **[24]**. Biomechanical studies of footwork have revealed differences in movement efficiency and performance results among players. Efficient footwork and postural control lead to better positioning and stroke execution, helping players maintain performance during intense rallies **[25]**. Training that combines postural control and plyometric exercises has been found to enhance change-of-direction ability and overall athletic performance **[26]**.

These findings highlight the need for well-rounded conditioning programs that target strength, postural control, coordination, and agility. Long-term training has also been shown to improve physical fitness and health aspects among racket sports players. Regular participation in structured training can boost physical fitness, lower injury risks, and enhance performance **[27]**. Therapeutic methods aimed at easing musculoskeletal discomfort and improving functional ability have also benefited racket sports players, stressing the importance of combining rehabilitation and conditioning strategies **[28]**. Kettlebell exercises usually involve dynamic, multi-directional movements like swings, snatches, cleans, and presses. These exercises require coordinated use of the lower limbs, trunk, and upper body, making kettlebell training a full-body workout **[29]**. The explosive nature of many kettlebell actions encourages the development of power, strength, and muscular endurance while improving cardiovascular fitness. Reviews of kettlebell training research show significant gains in strength, power, and endurance with regular training **[30]**. Kettlebell training requires continuous use of stabilizing muscles to maintain control during dynamic movements. This leads to significant improvements in postural coordination and postural control **[12]**. Improved strength and coordination in these muscle groups can make movements more efficient and lower the risk of injury. Gripping power is also significantly involved in kettlebell training, as players must maintain a firm hold on the kettlebell during dynamic movements. Continuous gripping and forearm engagement lead to notable improvements in hand and forearm strength **[31]**.

Combat rope training is another popular method in sports conditioning programs. It includes rhythmic and explosive movements with heavy ropes anchored to a fixed point. This engages multiple muscle groups at once. Combat rope exercises require coordinated activation of the upper limbs, trunk, and lower limbs, providing an effective full-body workout **[32]**. The physical and technical demands of table tennis require a training approach that combines strength, postural control, coordination, and endurance. Performance in table tennis relies not only on skill but also on a player's physical ability to execute movements efficiently and consistently. Studies show that players with better physical fitness perform better and have a lower risk of injury than those with lower fitness levels **[33]**.

MATERIAL

Pen, Pencil, Paper, Eraser, Kettlebell, Combat rope, Handheld dynamometer, Markers, Proforma, Consent form, Patient information sheet, Time, Measure tape, Weight scale.

METHODOLOGY

- SOURCE OF DATA: Table tennis academy at Ahmedabad
- STUDY DESIGN: A comparative study
- SAMPLE SIZE: The sample size at 80% power analysis was found to be 18 participants in one group; a total of 36 individuals would be considered for both groups. For the current study, 44 subjects in total will be included in order to counteract the dropout impact. Groups A and B, each consisting of 22 individuals
- STUDY DURATION: During the academic year
- DURATION OF INTERVENTION: For eight weeks, do combat rope workouts 3 times a week[41] and

kettlebell workouts 2 times each week for 30-45 minutes **[37]**.

OUTCOME MEASUREMENT

- First, the technique mentioned here will be demonstrated, and then players will perform the components.
  1) **Handheld dynamometer [36]**
  2) **Check for postural control: [39]**

PROCEDURE:

Each participant was informed about the study methodology, and a written consent form was filled out by all the participants. A detailed assessment was then taken, the procedure was explained properly than was filled out by the participants, and confidentiality of the data was assured.

STATISTICAL ANALYSIS

- Normalative data was found using Shapiro-Wilk test.
- Paired t-test was used to analyse intra-group differences.
- Independent t-test compared inter-group differences.
- Mann whitnney and wilcoxen test were done where data was not normally distributed.
- Version 26.0 of SPSS software was used for the statistical analysis. $P<0.05$ was considered significant for all measurements. $P>0.05$ was considered non-significant.
- Value of confidence interval was set at 95%.
- $P< 0.001$ was considered highly significant.
- $P<0.001$ was considered highly significant.

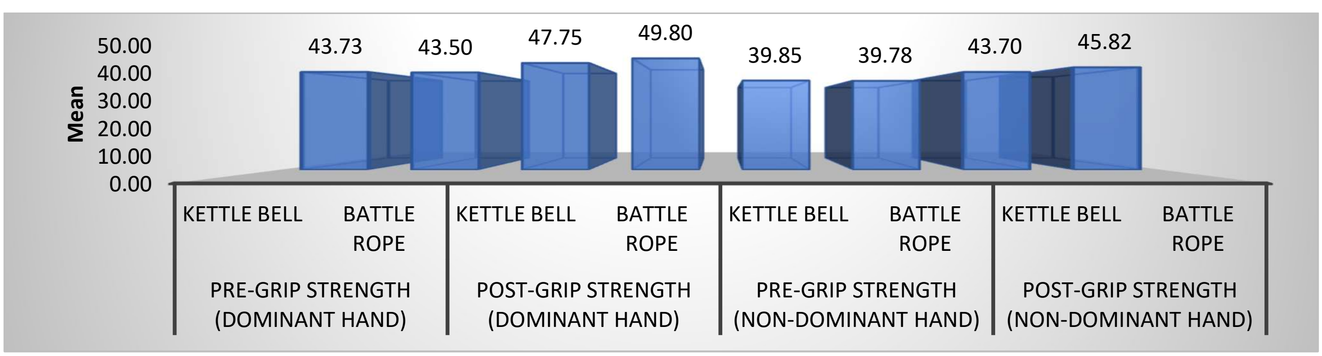
RESULTS

As shown in **Graph 1**, there was no significant difference between the kettlebell and battle rope groups in dominant hand grip strength, indicating both groups were comparable before the intervention. After the training period, a significant difference was observed, with the battle rope group showing greater improvement than the kettlebell group. Similarly, the pre-test comparison of non-dominant hand grip strength showed no significant difference between the groups. However, post-test results indicated greater improvement in the battle rope group compared to the kettlebell group. Overall, battle rope training was more effective in improving grip strength in both hands.

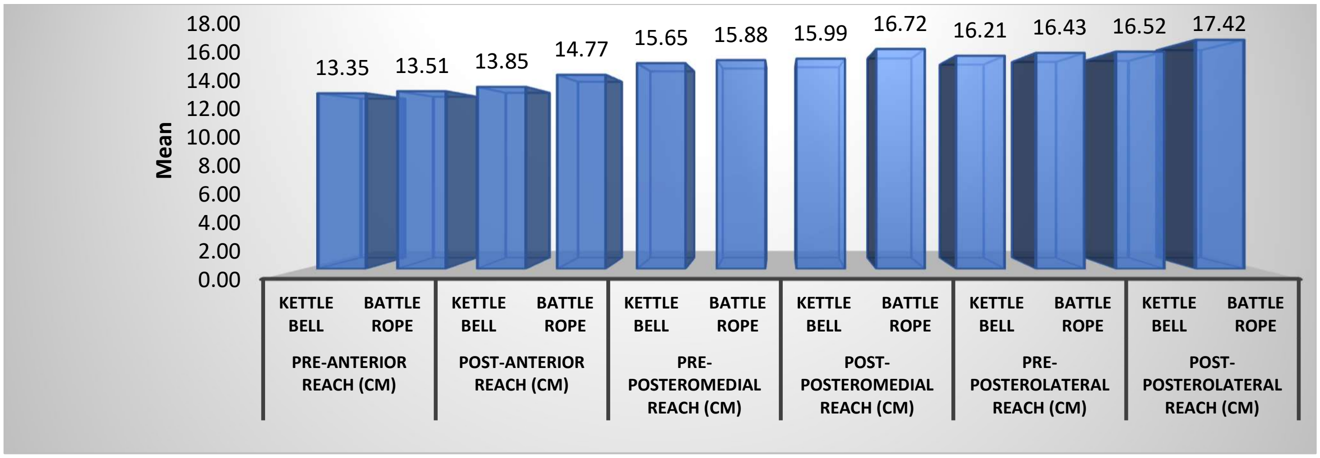
As shown in **Graph 2**, there were no significant differences between the kettlebell and battle rope groups in anterior, posteromedial, and posterolateral reach distances, indicating both groups were comparable before the intervention. After the training period, significant improvements were observed between the groups in all three reach directions. The battle rope group demonstrated greater improvement in anterior reach distance compared to the kettlebell group. Similarly, the battle rope group showed better improvement in both posteromedial and posterolateral reach distances. Overall, battle rope training was more effective in enhancing dynamic balance.

Table 1: Between-Group analysis of grip strength and dynamic balance

GP		Mean	Std. Deviation	t Test	P value
Pre-Grip Strength (Dominant Hand)	Kettle Bell	43.73	3.08	0.214	0.831
	Combat rope	43.50	3.78		
Post-Grip Strength (Dominant Hand)	Kettle Bell	47.75	3.03	2.122	0.04
	Combat rope	49.80	3.37		
GP		Mean	Std. Deviation	Mann Whitney Test	P value
Pre-Grip Strength (Non-Dominant Hand)	Kettle Bell	39.85	3.12	241.50	0.991
	Combat rope	39.78	3.66		
Post-Grip Strength (Non-Dominant Hand)	Kettle Bell	43.70	3.09	149.00	0.029
	Combat rope	45.82	3.34		
GP		Mean	Std. Deviation	t Test	P value
Pre-Anterior Reach (cm)	Kettle Bell	13.35	1.17	0.394	0.696
	Combat rope	13.51	1.49		
GP		Mean	Std. Deviation	Mann Whitney Test	P value
Post-Anterior Reach (cm)	Kettle Bell	13.85	1.31	157.00	0.046
	Combat rope	14.77	1.57		
GP		Mean	Std. Deviation	t Test	P value
Pre-Posteromedial Reach (cm)	Kettle Bell	15.65	1.01	0.686	0.497
	Combat rope	15.88	1.26		
Post-Posteromedial Reach (cm)	Kettle Bell	15.99	1.05	2.076	0.044
	Combat rope	16.72	1.29		
Pre-Posterolateral Reach (cm)	Kettle Bell	16.21	1.28	0.511	0.612
	Combat rope	16.43	1.54		
Post-Posterolateral Reach (cm)	Kettle Bell	16.52	1.30	2.086	0.043
	Combat rope	17.42	1.55		



Graph 1: Comparison of dominant and non-dominant hand grip strength between groups



Graph 2: Comparison of dynamic balance (Y-balance test: Anterior, Posteromedial, Posterolateral Reach)

DISCUSSION

The present comparative experimental study was conducted to evaluate and compare the effectiveness of kettlebell training and Combat rope training on grip strength and dynamic balance among recreational table tennis players. The results demonstrated that both interventions produced statistically significant improvements in grip strength and dynamic balance following the eight-week training program. However, between-group comparison revealed that Combat rope training produced greater improvements than kettlebell training in all measured variables.

Table tennis is a high-speed intermittent sport that requires rapid directional changes, repetitive upper limb movements, and precise neuromuscular coordination. Optimal performance depends on the integration of muscular strength, balance, coordination, and reaction ability. Kondrič *et al*. (2013) **[4]** reported that table tennis involves both aerobic and anaerobic energy systems and requires considerable neuromuscular coordination and postural control. Similarly, Zhang *et al*. (2023) **[5]** emphasized that physical fitness components such as strength, balance, and coordination play an important role in successful performance. Grip strength is an important component of upper limb function and a key determinant of performance in racket sports. Adequate grip strength contributes to effective racket control, stroke accuracy, and force generation. Cronin *et al*. (2017)3 **[1]** highlighted the importance of grip strength in sports involving hand-held equipment, while Bohannon (2019) **[14]** identified grip strength as an indicator of overall musculoskeletal function.

In the present study, both groups demonstrated significant improvement in dominant and non-dominant hand grip strength. However, the Combat rope group showed greater improvement compared to the kettlebell group. This finding may be attributed to the continuous gripping requirement and repetitive oscillatory movements involved in Combat rope exercises, which require sustained contraction of the forearm flexor and extensor muscles. Continuous activation of these muscles enhances neuromuscular recruitment and muscular endurance. Previous studies by Saikia (2022) **[36]** and Makadada (2020) **[35]** also reported that resisted upper limb exercises significantly improve grip strength and performance accuracy in racket sport athletes.

Kettlebell training also resulted in significant improvement in grip strength due to dynamic lifting and stabilization demands that activate forearm musculature and upper limb stabilizers. Eckert and Snarr (2016) **[37]** reported that kettlebell training enhances muscular strength and functional performance through multi-joint movements. Similarly, Beltz *et al*. (2013) **[38]** observed improvements in grip strength following kettlebell training. However, kettlebell exercises involve intermittent gripping rather than continuous contraction, which may explain the comparatively smaller improvement observed in this group. Dynamic balance is another important component of athletic performance in table tennis, as players must maintain stability while performing rapid and complex movements. Efficient postural control allows players to maintain proper body alignment and execute strokes effectively. Paillard (2019) **[34]** reported that athletes with higher skill levels demonstrate superior postural control due to enhanced neuromuscular coordination and proprioception.

Both groups in the present study demonstrated significant improvement in dynamic balance, with greater improvement observed in the Combat rope group. Combat rope training involves rhythmic oscillatory movements requiring coordinated activation of the upper limbs, trunk, and lower limbs, which enhances proprioceptive input and neuromuscular control. Ratamess *et al*. (2015) **[26]** reported that Combat rope exercises produce significant neuromuscular responses and improve muscular endurance and coordination. Kettlebell training also improved balance through activation of core stabilizing muscles and control of an offset center of mass. Jay *et al*. (2011) **[23]** and McGill (2010) **[20]** reported that kettlebell exercises enhance postural coordination and core stability, contributing to improved balance and functional performance.

From a biomechanical perspective, table tennis strokes involve coordinated activation of the kinetic chain including the lower limbs, trunk, and upper limbs. Improved grip strength enhances racket stability and stroke precision, while improved balance supports efficient movement and positioning during rallies. Combat rope training closely simulates repetitive upper limb movements and dynamic postural adjustments required in table tennis, which may explain the superior improvements observed in the Combat rope group.

Overall, the findings of the present study indicate that both kettlebell and Combat rope training are effective for improving grip strength and dynamic balance among recreational table tennis players, with Combat rope training demonstrating comparatively greater benefits.

CONCLUSION

The present study examined the effects of kettlebell and combat rope training on gripping power, postural control, and performance in recreational racket sports players. The findings indicate that both training methods significantly improved gripping power and postural stability, which are essential for effective racket control and movement efficiency in table tennis. Kettlebell training enhanced muscular strength, core stability, and postural control through dynamic multi-joint movements. Combat rope training improved gripping endurance, coordination, and upper-limb activation due to continuous oscillatory movements. Overall, functional training using kettlebell and combat rope exercises can effectively enhance performance and physical fitness in recreational racket sports players while also contributing to injury prevention.

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