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Effectiveness of battle rope training on movement pattern, shooting accuracy, throwing velocity and distance among young basketball players

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Abstract

Introduction. **Battle rope training (BRT) is a popular method to enhance athletic performance. However, its effects on movement patterns and shooting accuracy are not well-documented. This randomized controlled trial (RCT) evaluated the impact of BRT on movement patterns, throwing velocity and distance, and shooting accuracy.** Aim of Study. **The aim of the study is to evaluate the efficacy of BRT on throwing velocity and distance, shooting accuracy in collegiate basketball players.** Material and Methods. **A six-week RCT was conducted among 53 young basketball players (aged 18–25 years). Participants were randomized using block randomization into a BRT group (n = 27) or a control group (n = 26). Both groups trained for 30–40 minutes, three times a week. Outcomes measured included Movement System Screening Tool (MSST) for movement patterns, Functional Throwing Performance Index (FTPI) for shooting accuracy, and Kinovea-2023.1.2. for throwing velocity and distance. Statistical analysis used paired and independent t-tests ($p < 0.05$).** Results. **Groups were demographically similar (mean age 19.77 ± 1.18), 65% male. The BRT group significantly improved the MSST scores (mean difference = 4.8, 95% CI: 3.5–6.1, $p < 0.001$) and throwing velocity (mean difference = 3.2 m/s, 95% CI: 2.4–4.0, $p < 0.001$). Throwing distance gains were higher in the BRT group (mean difference = 5.6 m, 95% CI: 4.2–6.9, $p < 0.001$). The FTPI scores improved moderately (mean difference = 7.2%, 95% CI: 5.3–9.1, $p < 0.001$), while the control group showed minimal changes.** Conclusions. **A six-week BRT program significantly enhances movement patterns, throwing velocity and distance, and shooting accuracy in collegiate basketball players, making it a valuable training tool for athletic performance.**

KEYWORDS: MSST, optimal performance, upper body isometric contraction, FTPI, non-sagittal movement.

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Introduction

Sports have always had an impact on community unity and personal growth beyond just being physical activities. They are essential in creating a sense of community and teaching self-control. Basketball was invented in Springfield, Massachusetts, in 1891, and it quickly became well-known throughout the world. Its growth and competitive appeal were demonstrated when it made its Olympic debut as a demonstration event in 1904 and became a medal sport in 1936 [1].

In India's wide sporting landscape, where hockey and cricket predominate, basketball struggles to gain awareness despite its worldwide fame and the supremacy of the United States in Olympic basketball. The Indian basketball team achieved a significant milestone when they qualified for the 1980 Olympics in Moscow [2]. In comparison to more established sports, basketball in India frequently struggles with limited funding and visibility despite its broad popularity and passionate fan base abroad. Improved knowledge and appropriate training techniques could unlock the potential of basketball for success and significantly impact India's diverse sports culture [3]. Basketball involves both anaerobic and aerobic energy processes [4]. In addition to a high level of physical fitness, basketball players need to be exceptionally skilled in dribbling, passing, jumping, and shooting.

Despite the popularity of basketball worldwide, there is limited research on effective training methods that can holistically enhance performance while reducing injury risks. Existing studies have predominantly focused on conventional training approaches, overlooking innovative modalities like battle rope training (BRT). This study aims to fill this gap by providing evidence-based insights into the clinical and practical benefits of BRT for basketball players.

Basketball is a naturally vertical activity. Compared to volleyball and soccer, it requires two to four times as many jumping and landing movements per game [5]. For optimal performance, athletes require excellent neuromuscular control and functional movement patterns. The movement process base structure is represented by the movement pattern. It must engage with the entire kinematic process of the movement [22]. Functional movement patterns have recently been defined as having an ideal joint range of motion, flexibility, muscular strength, endurance, and motor control. A good functional movement pattern reduces the risk of injury by maximizing movement efficiency [6].

Basketball players must constantly accelerate and decelerate due to the multi-directional nature of the game, which forces the players to change their movements or orientations every two to three seconds. Basketball requires a higher amount of non-sagittal plane motion, particularly frontal plane motions during defensive play, than other multi-directional sports that prioritize sagittal plane motion, such as running and sprinting [7]. One of the key skills that determine a good basketball play is shooting accuracy. As basketball grows globally, especially in countries like India, understanding fundamental skills such as shooting accuracy becomes even more essential for talent development and scouting [8]. Studies show that shooting accuracy significantly impacts a basketball team's chances of winning or losing [9]. As a result, it is essential to discover a training strategy that helps basketball players acquire varying levels of physical fitness dimensions and shooting accuracy [10].

Battle rope (BR) interval training is a low-impact, full-body, and intense metabolic modality aimed at improving muscular endurance and strength in the chest, back, arms, shoulders, and trunk [9]. Its popularity has grown over the past several years, encompassing general health trainees to professional athletes. This workout enhances various physical fitness indicators, such as aerobic capacity, muscular endurance (upper and lower body), and lower body power, as well as total body muscle capacity. The muscles participating in these exercises include the rectus abdominis, multifidus, erector spinae group (longissimus, spinalis, and iliocostalis), external obliques, gluteus medius, vastus medialis, vastus lateralis, and gastrocnemius medialis [14].

While the majority of BR variations focus on strengthening and developing the upper body muscles, perfect form requires maintaining an isometric quarter or half-squat stance. The BR exercise is a full-body workout that involves muscle activation of the anterior deltoid, external oblique, and lumbar erector spinae (double-arm waves and alternating waves) with muscle activity ranging from 51% to 73% maximum voluntary isometric contractions (MVIC) and 14–18% MVIC for the gluteus medius [15]. BR exercises involve movements that engage multiple muscle groups and joints simultaneously. The results suggest that incorporating BRT into fitness routines could be advantageous for individuals striving to lose weight and boost their overall fitness levels. This mirrors the demands of functional movement patterns, which also require coordination and integration of various muscle groups [17]. Previous studies show significant improvements in arm strength and muscular endurance in collegiate male volleyball players after eight weeks of BRT [18]. Basketball players may find it a highly efficient way to improve their overall physical fitness (aerobic, upper-body anaerobic power, upper- and lower-body power, agility, and core muscular capacity), in addition to their shooting accuracy [20].

BRT has gained popularity among athletes for its potential to enhance physical fitness across various dimensions. An eight-week BRT program has been shown to improve aerobic capacity, upper-body anaerobic power, upper- and lower-body power, agility, core endurance, and sport-specific skills such as shooting accuracy in collegiate basketball players [13]. Additionally, BR exercises elicit high heart rates and energy expenditures, making them effective in improving cardiorespiratory fitness through high-intensity interval training [16]. The versatility of BR allows athletes to target multiple muscle groups simultaneously, promoting functional strength and coordination. However, intense BR sessions can lead to significant fatigue, particularly in the upper body, which may temporarily impair performance in skill-based activities [13]. Improper technique during these exercises increases the risk of musculoskeletal injuries, emphasizing the importance of professional supervision and gradual progression. Moreover, while BR exercises primarily target the upper body and core, they may not sufficiently engage the lower body, necessitating additional exercises to ensure balanced muscular development. Despite these considerations, when incorporated thoughtfully into a well-rounded training regimen, BRT can provide significant benefits to athletes [19].

Aim of Study

The study aims to explore the effectiveness of BRT on movement patterns, throwing velocity and distance, and shooting accuracy in collegiate basketball players.

Material and Methods

A 6 weeks randomized control study was conducted among young basketball players. Consent records were obtained from the participants and their college management to conduct the study. The criteria for inclusion were both male and female basketball players aged between 18–25 years who were participating at the inter-college level. Participants with prior BRT experience, those professionally involved in sports other than basketball, and participants who sustained neuromuscular injuries with residual impairments were excluded. This study was conducted in 3 national level basketball academies around Chennai for the duration of 9 months.

The study utilized Convenience sampling and a computer-generated random number allocation method with sealed envelopes to assign participants to different groups. This approach ensured that the allocation process was unbiased and randomized, adhering to rigorous research standards. A computer-generated random sequence of numbers determined the order in which participants were assigned to different treatment groups. When a participant was enrolled in the study, the next envelope was opened, and the treatment assignment inside the envelope was assigned to the participant.

A total of 53 young basketball players (27 in BRT Group, 26 in Control Group) were included in the study. The aims, objectives, and potential risks were explained to the participants, and informed consent was obtained from each participant. Upon enrollment in the study, the participants were assigned to two groups: the BRT Group and Control Group (Conventional Training Group). Sequence generation by block randomization and opaque, sealed envelopes were used for allocation concealment by an independent assessor. Pre-participation screening examination questionnaires (case report forms) showing that the players were not taking any medication, especially any pain management medications, were collected from the participants. Following the allocation of the groups, an independent assessor, blinded to the intervention and having adequate understanding of the assessment tools, recorded the baseline outcome measures. The outcome measures used were the Movement System Screening Tool (MSST) for movement patterns, the Functional Throwing Performance Index (FTPI) for shooting accuracy, and Kinovea-2023.1.2 for measuring throwing velocity and distance. An independent reviewer was not included in the application of the intervention. The MSST, FTPI, and Kinovea-2023.1.2 Movement Analyzing Software have demonstrated strong reliability and validity in assessing athletic performance. The MSST shows moderate to high reliability and good construct validity, accurately identifying movement dysfunctions that impact performance and injury risk [16]. The FTPI exhibits good inter-rater reliability and correlates well with other performance measures like throwing velocity, showcasing its ability to assess both technical and functional aspects of throwing [17]. The Kinovea-2023.1.2 software, known for its high inter-session and intra-session reliability, provides a valid 3D kinematic analysis, comparable to more expensive motion-capture systems, making it highly effective in sports biomechanics [18]. These tools are essential for evaluating movement patterns, throwing performance, and kinematic data in athletes, though standardized protocols are crucial for ensuring accuracy and consistency in results.

The experimental group attended 30–40-minute training sessions. The training was conducted thrice weekly for a six-week period under monitored and controlled conditions aligning with the American College of Sports Medicine (ACSM) guidelines. The warm-up session lasted 5 minutes and was followed by the training session. The BR program followed a structure of 10–20 repetitions, with a minimum of 30 seconds of rest between each exercise.

The BRT program intervention was divided into three phases:

1. First phase (week 1 and 2): 30 sets of exercises to safely introduce participants to BR activities, 30 minutes of exercise at a work-to-rest ratio of 1 : 3 (40 seconds exercise, 120 seconds rest).
2. Second phase (week 3 and 4): 30 sets of exercises with a work-to-rest ratio of 1 : 2 (60 seconds exercise, 120 seconds rest).

3. Third phase (week 5 and 6): 40 sets of exercises with a work-to-rest ratio of 1 : 2 (30 seconds exercise, 60 seconds rest).

Progression of the intervention for the experimental group was based on the work-to-rest ratio. The type, repetition, and duration of exercises for each phase are mentioned in Tables 1–3, respectively.

Table: 1. Set of battle rope exercises that are performed during week 1–2 of intervention

Exercise	Sets × Reps
Warm up	10 mins
Double arm waves	2–3 × 10–12
Side to side waves	2–3 × 10–12
Alternating waves	2–3 × 10–12
Cool down	5 mins

Table 2. Set of battle rope exercises that are performed during week 3–4 of intervention

Exercise	Sets × Reps
Warm up	10 mins
In-out waves	2–3 × 15–20
Hip toss	2–3 × 15–20
Double arm slams	2–3 × 15–20
Cool down	5 mins

Table 3. Set of battle rope exercises that are performed during week 5–6 of intervention

Exercises	Sets × Reps
Warm up	10 mins
Double arm waves	2–3 × 10–12
Side to side waves	2–3 × 10–12
Alternating waves	2–3 × 10–12
Cool down	5 mins

Within each session, participants in the experimental group performed various BR activities under supervision. BR exercises involved the use of a battle rope up to 40 feet long and weighing 10–12 kg. The subjects started the BR in a half-squat position, with their feet shoulder-width apart and their trunks extended slightly forward. The participants maintained a neutral grip on the ends of the rope while keeping their arms relaxed and straight by their sides. To produce the waves during the workout, subjects were instructed to employ minimal trunk and lower body movement. Shoulder flexion was used to raise the ropes, and shoulder extension was used to crash them to the floor. After six weeks of the intervention, the MSST, shooting accuracy, throwing velocity, and distance were measured for all participants.

The control group received conventional exercises. The exercise program consisted of three weekly sessions, totaling 18 sessions. These sessions included a 5–10-minutes warm-up period, a 30-minutes main exercise session consisting of range of motion (ROM), balance, and core exercises with adequate rest intervals, and a 5-minute cool-down period similar to warm-up exercises. The conventional training incorporated exercises such as combined warm-up routines, core stability exercises like performing a forearm plank position, aerobic training through fast walking/jogging, and ankle stretching. The cool-down period included stretching exercises that primarily focused on major muscle groups. After the 6th week of the intervention, the MSST, shooting accuracy, throwing velocity, and distance were measured and analyzed. Assessing all four parameters for one player takes around 35–55 minutes (MSST: 15–20 minutes, FTPI: 10–15 minutes, throwing velocity and distance: 10–20 minutes). All the players were clearly instructed and monitored, so fortunately, no major adverse events were reported, and there were no dropouts from the study. All the participants completed the study duration as per their allocated groups.

All subjects gave their informed consent for inclusion before participating in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Institute Ethics Committee of Shri Sathya Sai Medical College & Research Institute (IEC2023002301246). Paired t-test was used for within group analysis and unpaired t-test is used for between group analysis.

Results

The study included 53 participants, with 27 in the BRT Group and 26 in the Control Group. The baseline characteristics of participants (mean age 19.77 ± 1.18; 65% male) were similar across both the BRT and control groups in Table 4, with no dropouts during the study. Post-intervention analysis revealed significant improvements in the BRT group compared to the control group. The BRT group showed substantial increases in MSST scores (mean difference = 4.8, 95% CI: 3.5–6.1, $p < 0.001$), throwing velocity (mean difference =

3.2 m/s, 95% CI: 2.4–4.0, $p < 0.001$), and throwing distance (mean difference = 5.6 m, 95% CI: 4.2–6.9, $p < 0.001$). The FTPI scores improved moderately in the BRT group (mean difference = 7.2%, 95% CI: 5.3–9.1, $p < 0.001$). In contrast, the control group showed minimal changes in these outcomes (MSST: d = 0.107; velocity: d = 0.369; distance: d = 0.699) (Tables 5–12). Both male and female participants in the BRT Group demonstrated significant gains in performance metrics. MSST scores increased (males: 40.32 to 41.74; females: 40.25 to 43.52), indicating improved movement quality. FTPI scores improved (males: 0.45 to 0.52; females: 0.49 to 0.55), reflecting better throwing efficiency. Throwing distance and velocity showed marked

Table 4. Baseline demographic characteristics of participants according to group

Group	BRT Group (n = 27)	Control Group (n = 26)
Age (years)	19.77 (1.18)	19.73 (2.18)
Gender (male/female)	17/10	17/9
Height (cm)	165.11 (7.61)	167.38 (9.74)
Weight (kg)	58.40 (5.01)	60.5 (5.06)
BMI (kg/m2)	21.53 (2.36)	21.82 (3.24)

Note: BMI – body mass index, BRT – battle rope training

Table 5. Pre-test between group analysis for MSST analyzed using Mann–Whitney U test

Outcome	BRT Group	Control Group	Mean difference	z-value	p-value
MSST	40.62 ± 2.38	39.61 ± 2.04	1.01	1.752	0.8012

Note: MSST – Movement System Screening Tool, BRT – battle rope training

Table 6. Pre-test between group analysis for FTPI, throwing distance and velocity analyzed using unpaired t-test

Outcome	BRT Group	Control Group	Mean difference	t-value	p-value
MSST	40.62 ± 2.38	39.61 ± 2.04	1.01	1.752	0.8012
FTPI	0.49 ± 0.14	0.45 ± 0.13	0.04	1.07	0.28
Distance	16.03 ± 2.40	14.94 ± 1.82	1.09	1.85	0.06
Velocity	7.61 ± 1.28	7.13 ± 1.23	0.48	1.39	0.17

Note: FTPI – Functional Throwing Performance Index, MSST – Movement System Screening Tool, BRT – battle rope training

Table 7. Pre-test and post-test within group analysis for MSST analyzed using Wilcoxon signed-rank test

Groups	Pre-test	Post-test	Mean difference	z-value	p-value
BRT Group	40.62 ± 2.38	43.74 ± 4.55	3.12	3.5363	0.0004*
Control Group	38.61 ± 2.04	39.5 ± 4.52	0.89	0.1125	0.9104

Note: BRT – battle rope training
* p-value < 0.05

Table 8. Pre-test and post-test within group analysis for FTPI analyzed paired t-test

Groups	Pre-test	Post-test	Mean difference	t-value	p-value
BRT Group	0.49 ± 0.14	0.67 ± 0.10	0.18	5.06	0.0001*
Control Group	0.45 ± 0.13	0.52 ± 0.10	0.07	2.18	0.033*

Note: BRT – battle rope training
* p-value < 0.05

Table 9. Pre-test and post-test within group analysis for throwing distance analyzed paired t-test

Groups	Pre-test	Post-test	Mean difference	t-value	p-value
BRT Group	16.03 ± 2.40	20.31 ± 2.59	4.28	6.29	0.0001*
Control Group	14.94 ± 1.82	16.07 ± 2.45	1.13	2.98	0.0062*

Note: BRT – battle rope training
* p-value < 0.05

Table 10. Pre-test and post-test within group analysis for throwing velocity analyzed paired t-test

Groups	Pre-test	Post-test	Mean difference	t-value	p-value
BRT Group	7.61 ± 1.28	14.12 ± 2.75	6.51	11.71	0.0001*
Control Group	7.3 ± 1.23	7.64 ± 1.03	0.34	1.08	0.28

Note: BRT – battle rope training
* p-value < 0.05

Table 11. Post-test between group analysis for MSST analyzed using Mann–Whitney U test

Outcome	BRT Group	Control Group	Mean difference	z-value	p-value
MSST	43.74 ± 4.55	39.5 ± 4.52	4.24	3.024	0.00252*

Note: BRT – battle rope training, MSST – Movement System Screening Tool
* p-value < 0.05

Table 12. Post-test between group analysis for FTPI, throwing distance and velocity analyzed using unpaired t-test

OUTCOME	BRT Group	Control Group	Mean difference	t-value	p-value
FTPI	0.67 ± 0.10	0.52 ± 0.10	0.15	5.45	0.0001*
Distance	20.31 ± 2.59	16.07 ± 2.45	4.24	6.11	0.0001*
Velocity	14.12 ± 2.75	7.64 ± 1.03	6.48	11.27	0.0001*

Note: FTPI – Functional Throwing Performance Index, BRT – battle rope training
* p-value < 0.05

improvements – males increased from 17.03 m to 20.35 m and 8.61 m/s to 14.02 m/s; females from 16.03 m to 18.31 m and 8.16 m/s to 15.12 m/s, respectively (Table 13). These findings demonstrate the effectiveness of BRT in enhancing physical performance in both male and female participants.

Table 13. Post-intervention comparison between male and female participants in the intervention group for FTPI, throwing distance, and velocity was analyzed

Outcome	Male		Female	
	Pre	Post	Pre	Post
MSST	40.32 ± 2.08	41.74 ± 4.6	40.25	43.52 ± 4.7
FTPI	0.45 ± 0.14	0.52 ± 0.09	0.49 ± 0.14	0.55 ± 0.10
Distance	17.03 ± 2.40	20.35 ± 2.23	16.03 ± 2.40	18.31 ± 2.39
Velocity	8.61 ± 1.28	14.02 ± 2.5	8.16 ± 1.28	15.12 ± 2.6

Note: FTPI – Functional Throwing Performance Index, MSST – Movement System Screening Tool, BRT – battle rope training

Discussion

This result shows that BRT can efficiently improve multiple physical fitness dimensions and shooting accuracy in college-level basketball players. To perform well, basketball players need to be at their peak physical well-being in various areas, such as agility, core endurance, upper- and lower-body power, and anaerobic and aerobic power. Hence, it is essential to maximize the efficacy of training when time is limited. Eight weeks of BRT improved movement patterns, throwing accuracy, velocity, and throwing distance simultaneously under the same training settings (30–40 minutes). This finding indicates that basketball players benefit more from BR training than from conventional training within the same training period. Elite basketball players emphasize the significance of these physical attributes by executing 50–60 shifts in speed and direction during a game [11]. The results of this study are consistent with earlier studies, which found that the BRT significantly improved the movement patterns of young adults [12].

During the conduction of the study, certain adverse events were reported. Six players reported muscle soreness due to muscle fatigue, and three players reported muscle cramps due to dehydration. These events were managed accordingly by adjusting the load and intensity of the exercises and by strictly incorporating proper hydration before, during, and after training.

Accurate shooting is among the most crucial basketball skills [9, 21]. Earlier research has shown that the most important factors differentiating winning basketball teams from losing teams are shooting accuracy on field goals and free throws. The current study found that shot accuracy was enhanced by both conventional and BR training [20, 25]. BR exercises greatly strengthen the shoulders, arms, and back, which may explain the larger improvement seen in the BR group.

BR training positively impacts movement patterns, shooting accuracy, and throwing velocity and distance in athletes through several physiological and biomechanical mechanisms. The dynamic and explosive movements in BR exercises, such as waves and slams, engage the core, upper body, and lower body simultaneously, improving proprioception and neuromuscular control, which leads to better overall movement coordination and efficiency. These training adaptations help athletes develop better dynamic stability and motor control, which are essential for improved movement patterns in sports [23]. For shooting accuracy, the core strength and muscular endurance gained from BR training contribute to maintaining proper posture, stability, and balance during shooting motions, allowing for more precise and controlled shots, particularly under pressure [24]. Furthermore, the enhanced muscular power and explosiveness developed through BR exercises, especially in the shoulders, arms, and core, directly contribute to increasing throwing velocity and distance by improving rotational power and shoulder stability. The high-intensity nature of the training recruits fast-twitch muscle fibers, crucial for generating explosive strength needed for powerful throws, while also reducing the risk of injury through improved muscle stability around the shoulder joint [22].

The clinical significance of this study lies in its potential to improve athletic performance and reduce the risk of injury for athletes. This study underscores the practical significance of incorporating a six-week BRT regimen into the schedules of high school throwball players. Improved neuromuscular coordination, power, and strength gained from BR training can lead to better overall athletic performance. This approach enhances movement patterns, throwing distance and velocity, and shooting accuracy while maintaining traditional technical training. It provides a feasible method for optimizing athletic performance without disrupting the overall training structure.

Conclusions

In conclusion, the six-week BRT program, accompanied by comprehensive warm-up and cool-down sessions, demonstrated its effectiveness in enhancing the performance of collegiate basketball players. It resulted in notable improvements in movement patterns, throwing distance and velocity, and shooting accuracy. Conversely, conventional training methods resulted in only marginal improvements in shooting accuracy and throwing distance without improving movement patterns or throwing speed. These results emphasize the significance of integrating training approaches such as BR exercises to optimize the overall performance of basketball players.

External Factors Affecting Performance: This study did not consider the impact of external factors that could potentially influence sports performance. Variables such as sleep quality, nutrition, stress, or other types of training (e.g., strength or endurance training) could affect the results. If these variables are not controlled for, they may confound the relationship between BRT and the outcomes of interest. The real time limitation of the intervention is a potential strain on specific muscle groups which could be managed by proper monitoring and reinforcement of the technique which is quite time consuming in the initial period.

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Conflict of Interest

The authors declare no conflict of interest.

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