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RESEARCH ARTICLE

The Impact of Distributed Resistance Training Using Sandbag Arm Resistance on Enhancing Speed Specific Strength Endurance and 1000m Performance in Advanced Level Kayaking Athletes

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Abstract

This study aimed to design distributed resistance training exercises utilizing sandbag resistance for the upper limbs in advanced level kayaking athletes and to investigate the impact of this training approach on speed strength endurance and 1000 meter kayaking performance. The researchers employed a single group experimental design with a sample of 10 advanced male kayakers (mean age: (22) years; body mass: 81 kg). An (8) week training program (3sessions/week) was implemented, incorporating pyramid shaped intensity progression using sandbag weights ranging from 500g to 2kg. Performance metrics were evaluated through pre and post intervention tests, including a 45 seconds kayak sprint, a pull down test, a repeat sprint test with rest intervals, and a 1000 meter race. The results demonstrated statistically significant improvements in the distance covered during the 45 second sprint (260m to 285m) and the number of repetitions completed (44 to 47). The pull down test showed an increase of +4 repetitions, while the 1000 meter race time decreased from 3:40 to 3:36 minutes. Improvements were also observed in the first and third intervals of the repeat sprint test, though no enhancement was noted in the second interval, likely attributable to accumulated fatigue. The study concluded that sandbag resistance training promotes neuromuscular adaptation and enhances the efficient transfer of force through the kinetic chain, thereby improving athletes' capacity to sustain speed under fatiguing conditions. These findings support the integration of sandbag resistance as a comprehensive training modality to simulate race specific demands in advanced kayakers.

Keywords: Sandbag resistance, Distributed power training, Kayaking, 1000m, Velocity oriented power endurance

1. Introduction

Kayaking is a dynamic water sport that requires a complex integration of muscular strength and speed endurance, (Zamparo, P) "particularly in long distance races such as the 1,000 meter event for advanced athletes. Performance in this sport is the product of a sophisticated interaction between the ability to generate effective propulsive force through the arms while maintaining consistent speed under accumulated fatigue" [12, p. 184]. In this context, innovative training techniques have emerged to enhance the force velocity profile, (Cormie, P. M) "a critical indicator of the efficiency of converting muscular energy into motor performance" [3, p. 125]. Among these techniques, the use of sandbag resistance has gained increasing attention as a method for distributed power training, (Baker, D) "where unconventional resistance is applied to the arms to simulate real world paddling conditions while enhancing neuromuscular adaptation" [2, p. 172].

Distributed power training focuses on balancing the training load across the muscle groups involved in the movement rather than isolating specific muscles (Kawakami, Y. M). "This approach may improve energy transfer efficiency through the

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kinetic chain and reduce the risk of localized fatigue" [8, p. 635]. In kayaking, where paddling efficiency depends on the synchronization of the arms and torso, sandbag resistance may enhance muscle coordination (Izquierdo-Gabarren) "and optimize the force velocity curve for sustained performance" [7, p. 314], However studies investigating the efficacy of this technique, particularly its relationship with 1,000 meter race performance, remain limited.

This study addresses a research gap regarding the effectiveness of unconventional resistance methods in improving speeds specific strength endurance, (Suchomel, T. J) "which traditionally relies on weightlifting or mechanical devices" [11, p. 149], Sandbag resistance provides variable resistance that aligns with movement angles and velocities, (Fernández-García) "more accurately mimicking the hydrodynamic dynamics of kayaking" [4, p. 101], (Laursen, P. B) "Additionally understanding the interplay between distributed power and velocity characteristics could inform personalized training protocols for advanced athletes, enhancing training efficiency and reducing overuse injuries" [9, p. 53].

Research problem: Most training programs assume that improving maximal strength automatically leads to improved performance. However, this assumption ignores the complex interaction between strength and speed under fatigue. For example, sand resistance may increase the ability to produce high force at low kinetic speeds, which is important during the initial burst of explosive power. However, the researchers' question is: Does it also improve the ability to maintain high speeds under fatigue at the end of a race?

1.1. Study objectives

1. To develop distributed strength training using sand resistance for the arms for advanced kayak rowing,
2. determine the effect of the distributed strength training method using sand resistance for the arms on speed-specific strength and 1000 m kayaking performance for advanced kayak rowing.

Study hypothesis: The researchers hypothesize that there are statistically significant differences in the endurance of speed-specific strength and 1000 m completion time for the experimental group (using sand resistance).

2. Methodology and procedures

2.1. Research population and sample

A single group experimental design was employed, with a purposive sample of 10 advanced male kayakers from the AlKarkh Training Center (2025 season). The sample homogeneity is detailed in Table 1.

Table 1. Sample homogeneity.

Parameter	Mean	SD	CV	Significance
Height (cm)	184.2	1.131	0.614	Significant
Age (years)	22	0.97	0.68	Significant
Training Age (years)	10.5	0.65	2.62	Significant
Body Mass (kg)	81	0.51	0.691	Significant

2.2. Instruments and equipment used

- Whistle (1 unit)
- Starting platform (1 unit)
- Olympic kayaks (10 units)
- Paddles (10 units)
- Medical scale (weight measurement)
- Audiometer (height measurement)
- Sandbag resistors (500g–2kg)
- Iron barbell (1 unit)
- HP laptop (1 unit)

2.3. Tests

1. **45 Second Maximal Rowing Test to Measure Speed Specific Power Endurance**, (Smith, T. B) [10, p. 156]:
    - Purpose: To assess the athlete's ability to maintain peak velocity specific power output over a short duration (45 seconds), reflecting muscular efficiency in resisting fatigue during high intensity rowing.
    - Method: The athlete is instructed to row at maximal intensity for 45 seconds.
    - Protocol: The test is performed on a rowing ergometer, with the athlete maintaining maximal effort throughout the 45 second period.
    - Recording: Total distance covered (in meters) and number of complete strokes performed during the 45 second interval. (Fig. 1 showe that)

2. **Pull-up test from below on a flat surface for 45 seconds, with each player's maximum intensity determined at 70% of the maximum intensity (measuring the number of repetitions)**, (Baechle, T. R) [1, p. 148]:
    - Purpose: To evaluate muscular endurance of the back and arm muscles at 70% of maximal effort, indicating the athlete's capacity to perform repetitive movements under constant load.
    - Method:1RM Determination: Establish the one repetition maximum (1RM) by identifying the maximum weight the athlete can pull once from a prone position.

Fig. 1. Maximum rowing test.

- Execution: The athlete lies prone on a flat bench and performs repetitive pulls toward the chest using 70% of their 1 RM.
- Protocol: The athlete completes as many repetitions as possible within 45 seconds.
- Recording: Total number of full range repetitions completed within the time limit. (Fig. 2 show that)

3. **Intermittent Recovery Test**, (Haff, G. G) [5, p. 55]:
   - Purpose: To evaluate recovery capacity and the ability to reproduce performance after short rest intervals.
   - Method: Exercise: 45 seconds of high intensity rowing.
   - Rest: 1 minute of passive recovery.
   - Protocol: The cycle is repeated three times, with consistent rest periods between trials.
   - Distance covered (in meters) during each 45-second repetition.
   - Percentage decline in performance between the first and third repetitions, calculated as:
   - Performance Decline Rate (%) = (Distance (Repetition 1)−Distance (Repetition 3)Distance (Repetition 1)) × 100Performance DeclineRate (%) = (Distance (Repetition 1)Distance (Repetition 1)−Distance (Repetition 3) × 100.
4. **1000 Meter Time Trial Performance Test**, (Hagerman, F. C) [6, p. 443]:
   - Purpose: To measure actual performance in a 1000 meter kayak rowing race, which directly correlates with competitive outcomes.
   - Method: The athlete is required to complete a 1000 meter rowing distance as quickly as possible.

Fig. 2. Shows the pull test from below on a bench.

- Protocol: The test is conducted on a rowing ergometer or in open water under standardized conditions.
- Recording: Total time to complete the distance (in seconds).

Here's a professional translation of the text into English:

2.4. Pre-test experiment

The researcher, along with the assistant team, conducted the pre-tests on December 28, 2024, at 4:00 PM, following thorough preparation of the players. This included explaining the nature of the tests, demonstrating the proper stance for performing the assessments, clarifying the required distances and intensity levels, setting up the camera equipment, and preparing the test boat.

2.5. Application of the training curriculum (exercises)

The researcher implemented the designed exercises over an 8-week period (two months), as this duration is the minimum required to apply the exercises and evaluate their impact on the players. The intervention was conducted from January 2/2025, to March 3/2025, with three weekly sessions (Saturday, Monday, and Wednesday), each lasting 60 minutes. This structure was chosen because distributed strength training necessitates multiple repetitions and precisely regulated intensity, paired with rest periods proportionate to the players' exerted effort or training intensity. The two researchers designed the exercises As shown in Appendix 1:

- Break down the training unit into short, repeated intervals.
- Pyramidal intensity training: Use varying sandbag weights attached to the arms during rowing exercises.
- High-Intensity Interval Training (HIIT): Work intervals (30–60 seconds) followed by short rest periods (1:1 or 1:2 ratio).
- Race scenario simulations: Practice pacing strategies (e.g., final sprint in the last 45 seconds, mid-race surge, or early acceleration).

Intensity is determined based on the highest maximum speed or maximum strength, with 60–80% of sand-based exercises used to achieve a balance between strength, speed, and endurance. Additionally, adaptation to sand resistance is emphasized by increasing the sand weight by 5–10% weekly. As for the work-to-rest ratios, they range between 1:1, 1:2, and 1:3.

2.6. Post-Test

The two researchers, along with their assistant team, conducted the post-tests on March 5, 2025, at 4:00 PM. After preparing the players, setting up the camera, and readying the test boat, the players were first assessed using the Numerical Achievement Test. Following a one-hour rest period, the players were then subjected to physical and skill-based tests.

2.7. Statistical analysis

The arithmetic mean, standard deviation, mean differences, differences in deviations, and a T-test were employed to analyze statistical differences.

3. Results and discussion

Table 2: Significance of differences between the pre-test and post-test in the speed-endurance strength of the arms and the numerical level test for the research sample.

The study results revealed statistically significant improvements in most physical performance indicators and 1000-meter completion times following the implementation of a sand-based

Table 2. Pre and post test differences in performance metrics.

Test	Pre Test Mean	Standard Deviation	Post Test Mean	Standard Deviation	Mean Difference	t- test	Significance
45-Second Max Rowing Test							
Dis	260	2.45	285	2.11	5	2.14	Significant
Rep	44	2.66	47	2.45	3	3.11	Significant
45-Second Bottom-to-Top Pull Test	33	2.41	37	2.66	4	2.46	Significant
Rest-Interval Repetition Test							
First 45s	255	1.98	257	2.67	2	2.29	Significant
Second 45s	255	1.64	255	1.64	0	0.014	Not Significant
Third 45s	252	2.17	254	2.12	2	2.64	Significant
1000 m Time (minutes)	3.40	2.41	3.36	1.65	0.4	3.11	Significant

resistance training program. These findings support the research hypothesis, which posits the efficacy of this method in enhancing speed-specific strength and numerical performance in the 1000-meter distance as follows:

1. 45-Second Maximal Rowing

The above results indicate an increase in the mean distance covered from 260 m to 285 m (a difference of 25 m) and a rise in repetition count from 44 to 47 (a difference of 3). This improvement is attributed to the sand-based resistance training's capacity to stimulate neuromuscular adaptation, enhancing force transmission across the kinetic chain. This aligns with the assertion that (Fernández-García) "training under variable resistance mimics real-world rowing conditions, improving force-generation efficiency across varying movement velocities" [4, p. 103]. The researchers posit that sand-based resistance reduces water resistance pressure during the initial race phase, thereby optimizing propulsion efficiency in early strokes a critical factor for race starts.

2. 45-Second pull down Test

The repetition count increased from 33 to 37 (a difference of 4), interpreted as enhanced fatigue resistance due to balanced training load distribution between the arms and trunk. This finding is supported by prior studies affirming that (Suchomel, T. J) "unconventional resistance training improves muscular endurance without elevating injury risk" [11, p. 152].

3. Repetition Test with Rest Intervals

The first and third repetitions demonstrated statistically significant improvements (a difference of 2 m), while no improvement was observed in the second repetition. The researchers attribute this outcome to muscle fatigue accumulation during the second repetition, which diminishes force transmission efficacy. However, the improved performance in the third repetition suggests athletes' ability to rapidly recover post-rest, aligning with the principles of high-intensity interval training (HIIT).

4. 1000-Meter Time-Trial Performance Test

The completion time decreased from 3.40 minutes to 3.36 minutes (a difference of 0.04 minutes, $p < 0.05$), confirming that enhanced distributed strength directly correlates with competitive performance (Zamparo, P.). "This improvement is ascribed to increased capacity to maintain high velocities under fatigue a critical determinant in speed-endurance races" [12, p. 321].

These findings underscore that sand-based resistance training, when applied through a distributed strength methodology, provides a robust foundation for adopting sand resistance as a training tool. However, true success lies in contextual adaptation: strength gains must be balanced with athlete safety, and psychological factors (e.g., motivation)a pivotal driver of competitive performance—should not be overlooked.

4. Conclusions

1. The sand-based resistance training program demonstrated statistically significant improvements in speed-specific strength indicators (e.g., distance covered and repetition count in the maximal rowing test) and 1000-meter time-trial performance, confirming its efficacy in enhancing competitive performance among advanced athletes.
2. Sand-based resistance stimulated neuromuscular adaptation, optimizing force transmission across the kinetic chain and improving the ability to maintain velocity under fatigue, particularly during critical race phases.
3. Improvement in the second repetition of the rest-inclusive repetition test was statistically non-significant suggest that fatigue accumulation may impair force transmission efficacy. In contrast, the third repetition revealed rapid performance recovery, reflecting the efficiency of high-intensity interval training (HIIT) principles.
4. Sand-based resistance successfully strength development and speed-endurance capacity, supporting its use as an integrated training tool to simulate real-world rowing conditions.

5. Recommendations

1. Conduct future studies with larger, demographically diverse cohorts (e.g., varying age groups and genders) to generalize findings and elucidate adaptation mechanisms.
2. Implement the training program over extended durations (12 weeks or longer) to assess the cumulative effects of sand-based resistance on long-term performance outcomes.
3. Design hybrid programs combining sand-based resistance with traditional strength training or psychological conditioning to enhance athlete motivation and mitigate cognitive fatigue.

Author's declaration

Conflicts of interest: None.

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethical-clearance: This manuscript approved by local ethical committee of physical education and sport sciences college for women on (January/2025).

Author's contributions

All contributions of this study were done by the researchers (M.A. and A.A) who get the main idea and work on writing and concluding also with number of experts, Muyed Abdul in Statistics, Ibrahim Dabayebeh in revision, Enaam in translating, Batoul Ahmed Salim in proofreading.

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Appendices

Appendix 1: Sample of 3 weekly training units

Training Unit 1: Foundational strength development with sand-based resistance

- Duration: 60 minutes/Intensity: 60–70% of maximum strength.
- Main Session: 40 minutes

1. Pyramidal Rowing Exercise
- Weights: Starting at 500g per arm, increasing by 5% weekly.
- Repetitions: 3 sets × 8–10 reps.
- Rest Ratio: 1:2 (30 seconds work/60 seconds rest).
- Execution: Focus on evenly distributing load between arms and torso.

2. Underhand Resistance Pull Exercise
- Weights: 750g per arm.
- Repetitions: 3 sets × 12 reps.
- Rest Ratio: 1:1 (45 seconds work/45 seconds rest).

Training unit 2: speed-endurance development

- Duration: 60 minutes/Intensity: 75–85% of maximum strength.
- Main Session: 45 minutes

1. High-Intensity Interval Training (HIIT)
- Protocol: 30 seconds of high-intensity rowing + 60 seconds rest, repeated 8 times.
- Weights: 1 kg per arm.
- Objective: Maintain consistent velocity despite fatigue accumulation.

2. Race-Specific Rowing Drill
- Protocol: Maximum-intensity rowing during the final 45 seconds of each set.
- Repetitions: 3 sets × 45 seconds.
- Rest Ratio: 1:3 (45 seconds work/135 seconds rest).

Training unit 3: race-distance drills with variable resistance

- Duration: 60 minutes/Intensity: 80–90% of maximum strength.
- Main Session: 40 minutes

- 1000-Meter Race Simulation
- Weights: 1.5 kg per arm.

1. Segmentation

- Start (0–200 m): Explosive rowing (100% intensity).
- Mid-Race (200–800 m): Sustained rowing (80% intensity).
- Final Sprint (800–1000 m): Peak acceleration (90% intensity).
- Rest: 5 minutes between repetitions.
- Fatigue Adaptation Drill Protocol: 45 seconds of high-intensity rowing + 1 minute rest, repeated 5 times.
- Weights: 2 kg per arm.