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Research Paper

Effectiveness of Velocity-Based Training on Upper Body Push Power Development and Front Hook Technique Accuracy in Under-20 Freestyle Wrestlers

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ABSTRACT

Background: The front hook technique in freestyle wrestling requires exceptional upper-body push power and precise timing for successful execution. Velocity-based training (VBT) offers a novel approach to strength development through real-time monitoring of movement velocity, potentially optimizing power adaptations and technique-specific performance in young wrestlers.

Objective: This study aimed to investigate the effectiveness of velocity-based training on upper-body push power development and front hook technique accuracy in under-20 freestyle wrestlers.

Methods: Thirty-two under-20 freestyle wrestlers (aged 17-19 years) from six wrestling clubs in Kirkuk were randomly assigned to an experimental group (n=16) receiving velocity-based training, and a control group (n=16) following traditional percentage-based training. The 12-week intervention included 3 sessions per week, utilizing linear position transducers to monitor velocity zones and optimize training loads. Measurements included upper body push power (bench press throw), front hook success rate, execution accuracy, and power endurance capacity.

Results: The experimental group demonstrated significant improvements compared to the control group ($p<0.05$) in upper body push power (847±89 to 1124±97 watts, +32.7%), bench press 1RM (78.4±8.6 to 97.2±9.1 kg, +24.0%), front hook success rate (58.3±9.4% to 81.7±7.2%, +40.1%), technique accuracy score (6.9±1.2 to 9.1±0.8 points, +31.9%), and power endurance index (76.2±8.4 to 91.6±6.7%, +20.2%).

Conclusion: Velocity-based training effectively improved upper body push power and front hook technique accuracy in under-20 freestyle wrestlers. The individualized training approach enhanced both power development and technical precision, demonstrating superior adaptations compared to traditional percentage-based training methods.

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KEYWORDS: Velocity-based training, upper body power, freestyle wrestling, front hook technique, youth athletes

1. INTRODUCTION

1.1 Background and Significance

Freestyle wrestling represents one of the most dynamic and physically demanding combat sports, requiring athletes to demonstrate exceptional strength, power, and technical proficiency across multiple movement patterns (Al-Najjar & Al-Husseini, 2023, p. 167). The sport's continuous evolution has led to increased emphasis on explosive power development, particularly in the upper body, as wrestlers seek to gain competitive advantages through superior force production capabilities (Demirkan et al., 2022, p. 234).

The front hook technique stands as one of the most fundamental and frequently utilized offensive maneuvers in freestyle wrestling, accounting for approximately 28% of all successful attacks in junior-level competitions (Mohammed & Ahmed, 2023, p. 189). This technique requires rapid upper body extension combined with precise timing and directional control, making it an ideal model for studying the relationship between upper body push power and wrestling-specific performance (Mirzaei et al., 2021, p. 445).

Velocity-based training (VBT) has emerged as a revolutionary approach to strength and power development, utilizing real-time monitoring of movement velocity to optimize training loads and enhance neuromuscular adaptations (González-Badillo & Sánchez-Medina, 2020, p. 378). This methodology represents a paradigm shift from traditional percentage-based training, offering individualized load prescription based on daily readiness and movement quality rather than predetermined percentages of one-repetition maximum (1RM) (Weakley et al., 2021, p. 456).

The unique characteristics of VBT align particularly well with the demands of combat sports, where explosive power development and movement precision are paramount for competitive success (Thompson & Wilson, 2022, p. 234). The ability to monitor and optimize velocity zones enables coaches to target specific adaptations while maintaining high movement quality, potentially leading to superior transfer to sport-specific performance contexts (Banyard et al., 2019, p. 567).

Young wrestlers (under-20) represent a critical population for power development interventions, as this age group demonstrates optimal trainability for neuromuscular adaptations while simultaneously refining technical skills (Al-Rubaie & Al-Kaabi, 2022, p. 123). The integration of advanced training methodologies during this developmental period can establish foundational strength qualities that support long-term athletic development and competitive success.

1.2 Problem Statement

Current strength training practices in youth wrestling often rely on traditional percentage-based methodologies that fail to account for daily fluctuations in neuromuscular readiness and movement quality. These approaches typically utilize fixed percentages of 1RM that may not reflect an athlete's actual capacity on a given training day, potentially leading to suboptimal training stimuli and reduced adaptation rates (Abdullah & Mahmoud, 2022, p. 345).

The front hook technique presents unique biomechanical challenges, requiring wrestlers to generate explosive upper body power while maintaining precise directional control and timing. Many young wrestlers demonstrate adequate strength levels but struggle with the rapid force production and accuracy demands of this fundamental technique under competitive conditions (Hussein & Jaafar, 2023, p. 234).

Traditional training methodologies often separate strength development from technical skill acquisition, potentially limiting the transfer of physical adaptations to wrestling-specific performance contexts. The integration of velocity-based training with technical practice offers a promising approach to simultaneously enhance both power development and technique refinement (Khalid & Nabil, 2022, p. 178).

The limited research examining velocity-based training applications in combat sports, particularly in youth populations, represents a significant gap in the scientific literature. While VBT has been extensively studied in team sports and powerlifting contexts, its specific applications to wrestling performance and technique development require further investigation (Saad & Husam, 2023, p. 289).

1.3 RESEARCH OBJECTIVES

Primary Objective: To investigate the effectiveness of velocity-based training on upper body push power development and front hook technique accuracy in under-20 freestyle wrestlers.

Secondary Objectives:

1. To evaluate the impact of VBT on maximal upper body strength and power output
2. To assess changes in front hook technique success rate and execution accuracy
3. To examine improvements in power endurance and sustained performance capacity
4. To analyze the relationship between power development and technical performance enhancements
5. To investigate training load optimization and neuromuscular adaptation patterns
6. To provide evidence-based recommendations for VBT implementation in youth wrestling programs

1.4 Research Hypotheses

Primary Hypothesis: Velocity-based training will significantly improve upper body push power and front hook technique accuracy in under-20 freestyle wrestlers compared to traditional percentage-based training methods.

Secondary Hypotheses:

1. Participants in the experimental group will demonstrate greater improvements in maximal strength and power output
2. The experimental group will show superior enhancements in front hook success rate and execution accuracy
3. There will be significant improvements in power endurance and sustained performance capacity

4. A significant positive correlation will exist between power development and technical performance gains
5. VBT will demonstrate superior training load optimization and adaptation patterns
6. The velocity-based training protocol will produce greater training adaptations compared to traditional methods

1.5 Research Delimitations

Population Delimitations:

- Under-20 freestyle wrestlers aged 17-19 years
- Minimum 5 years of competitive wrestling experience
- Current participation in regional or national junior competitions
- No history of major upper extremity injuries in the past 12 months
- Baseline bench press 1RM $\geq 1.0 \times$ body weight

Temporal Delimitations:

- Study duration: 14 weeks (2 weeks baseline + 12 weeks intervention)
- Training frequency: 3 sessions per week
- Session duration: 60-75 minutes per session
- Testing periods: Pre-intervention, mid-intervention (6 weeks), and post-intervention

Spatial Delimitations:

- Six wrestling clubs in Baghdad, Iraq
- University of Baghdad strength and conditioning laboratory
- Standardized training facilities with VBT equipment
- Competition-standard wrestling mats for technical assessments

1.6 Operational Definitions

Velocity-Based Training (VBT): A training methodology that utilizes real-time monitoring of movement velocity to prescribe and adjust training loads, targeting specific velocity zones to optimize neuromuscular adaptations.

Upper Body Push Power: The rate of force production during upper body pushing movements, typically measured as peak power output during explosive bench press or similar exercises.

Front Hook Technique: A fundamental freestyle wrestling attack involving an upper body hooking motion combined with forward drive to secure opponent control and scoring opportunities.

Technique Accuracy: The precision and effectiveness of front hook execution as assessed through biomechanical analysis and expert evaluation using standardized criteria.

Power Endurance: The ability to maintain high power output over repeated efforts or extended duration, reflecting the integration of strength and metabolic capacity.

2. LITERATURE REVIEW

2.1 Velocity-Based Training Principles and Applications

Velocity-based training represents a significant advancement in strength and conditioning methodology, utilizing the force-velocity relationship to optimize training prescriptions and enhance performance adaptations. González-Badillo and Sánchez-Medina (2020, p. 378) provided comprehensive analysis of VBT principles and demonstrated that movement velocity serves as a reliable indicator of neuromuscular fatigue and training intensity. Their research established velocity zones corresponding to different training adaptations, enabling precise load prescription for specific performance goals.

Weakley et al. (2021, p. 456) conducted a systematic review of VBT applications across various sports and found that velocity-based approaches produced superior adaptations in power development (18-25% greater improvements) compared to traditional percentage-based training. The study attributed these benefits to the individualized nature of VBT, which accounts for daily fluctuations in neuromuscular readiness and enables optimal training stimulus delivery.

Banyard et al. (2019, p. 567) investigated the reliability and validity of velocity-based training monitoring systems and established that linear position transducers provide accurate and consistent velocity measurements across different exercises and populations. Their findings support the use of VBT technology for precise load prescription and training adaptation monitoring in athletic populations.

Thompson and Wilson (2022, p. 234) examined VBT applications in combat sports and reported significant improvements in both strength and power measures following velocity-based interventions. Their study found that wrestlers who followed VBT protocols demonstrated 23% greater improvements in explosive power compared to traditional training groups, suggesting superior transfer to sport-specific performance demands.

2.2 Upper Body Power Development in Wrestling

The importance of upper-body power in wrestling performance has been extensively documented across various competitive levels and age groups. Al-Rubaie and Al-Kaabi (2022, p. 123) conducted a comprehensive analysis of physical fitness factors in young wrestlers and identified upper-body push power as a primary predictor of competitive success. Their study found strong correlations between bench press power output and tournament performance rankings ($r = 0.76$, $p < 0.01$).

Kraemer et al. (2021, p. 445) investigated the physiological demands of freestyle wrestling and reported that upper-body power contributes significantly to successful technique execution, particularly during attacking phases. Their research demonstrated that wrestlers with superior upper body power (>12 W/kg) achieved 34% higher scoring rates compared to those with lower power outputs.

Mohammed and Ali (2023, p. 189) examined the biomechanical requirements of various wrestling techniques and found that upper-body push movements were involved in 67% of all successful attacks. The study emphasized the critical role of explosive power development in technique effectiveness and competitive performance.

Yoon and Kim (2020, p. 378) provided normative data for upper body power in youth wrestlers and established that elite junior competitors demonstrated significantly higher power outputs (985±124 W) compared to sub-elite athletes (762±98 W). These findings highlight the importance of power development programs in youth wrestling populations.

2.3 Front Hook Technique Biomechanics and Performance

The front hook technique represents one of the most fundamental offensive maneuvers in freestyle wrestling, requiring complex coordination of upper body power, timing, and directional control. Tunnemann and Curby (2022, p. 234) conducted detailed biomechanical analysis of front hook execution and identified key performance factors including initial contact force, hooking velocity, and control maintenance duration.

García-Pallarés et al. (2021, p. 456) investigated the force production patterns during front hook techniques and found that successful execution required peak forces exceeding 1.8 times body weight during the initial contact phase, followed by sustained force production throughout the control phase. The study emphasized the critical importance of upper body power for both technique initiation and completion.

Mirzaei et al. (2021, p. 445) examined the neuromuscular activation patterns during front hook execution using electromyography and reported that pectoralis major, anterior deltoid, and triceps brachii demonstrated peak activations exceeding 85% of maximum voluntary contraction. This finding highlights the specific muscle groups requiring targeted power development for optimal technique performance.

Franchini et al. (2020, p. 567) analyzed the success rates of various wrestling techniques across different competitive levels and found that front hook techniques were attempted in 35% of all attacking sequences but succeeded in only 42% of attempts. The study identified power limitations as a primary factor in technique failure, supporting the need for targeted power development interventions.

2.4 Training Adaptations in Youth Athletes

The unique characteristics of youth athletes present both opportunities and challenges for strength and power development interventions. Lloyd and Oliver (2022, p. 345) provided comprehensive review of youth training adaptations and demonstrated that adolescent athletes (16-19 years) exhibit optimal trainability for neuromuscular power development, with potential for 25-40% improvements following appropriate interventions.

Saad and Husam (2023, p. 289) specifically examined power development in young Iraqi wrestlers and found significant improvements in upper body strength (21% increase) and power output (28% increase) following 10-week training interventions. The study emphasized the importance of individualized training approaches for optimizing adaptations in youth populations.

Slimani et al. (2019, p. 612) investigated the effects of various training modalities on power development in young combat sports athletes. Their meta-analysis revealed that velocity-based training approaches produced superior adaptations compared to traditional methods, with effect sizes ranging from 0.8 to 1.6 for power-related outcomes.

Todos-Fajardo et al. (2020, p. 423) examined the neuromuscular adaptations to power training in youth athletes and found that velocity-based approaches enhanced both neural drive and muscle architecture adaptations. Their findings suggest that VBT provides optimal stimuli for comprehensive power development in developing athletes.

Progress to high levels is one of the most important goals of athletic achievement, and after athletic excellence is the result of training based on science and experience for individuals who possess physical, skill, tactical, psychological, and other abilities and are distinguished from others by the superiority of this ability that qualifies them to achieve the best achievements. (2024, p. 34)

2.5 Sport-Specific Training Transfer

The transfer of training adaptations from general strength exercises to sport-specific performance represents a critical consideration in program design. Vardar et al. (2019, p. 234) demonstrated that training programs incorporating sport-specific movement patterns and velocity characteristics produced superior transfer to competitive performance compared to general strength training approaches.

Abdullah and Mahmoud (2022, p. 345) investigated the relationship between upper body power training and wrestling technique performance in young athletes. Their study found that wrestlers who engaged in power-focused training demonstrated 24% improvements in technique success rates compared to those following traditional strength protocols.

Hussein and Jaafar (2023, p. 234) examined the specificity of training adaptations in combat sports and reported that velocity-based training approaches enhanced both physical capacity and movement quality simultaneously. Their findings support the integration of VBT with technical practice for optimal performance development.

Khalid and Nabil (2022, p. 178) conducted longitudinal analysis of training transfer in youth wrestlers and found that athletes who followed individualized power development programs achieved superior competitive results compared to those using standardized approaches. The study emphasized the importance of tailored training interventions for young athletes. As they rise and increase in size, they become stronger and more effective in action. (Ghaidan Fouad) (2024, p. 883)

3. METHODOLOGY

3.1 Research Design

This study employed a randomized controlled trial design with repeated measures (pre-test, mid-test, post-test) to examine the effects of velocity-based training on upper body push power and front hook technique performance. The experimental design utilized a parallel group structure with participants randomly assigned to either the experimental group (velocity-based training) or control group (traditional percentage-based training).

3.2 Participants

Sample Size Calculation: Based on previous research by Thompson and Wilson (2022, p. 236) and using G*Power 3.1.9.7 software, a sample size of 32 participants was calculated to detect a large effect size (d = 0.8) with 90% power and α = 0.05, accounting for a 15% dropout rate.

Inclusion Criteria:

- Male freestyle wrestlers aged 17-19 years
- Minimum 5 years of competitive wrestling experience
- Current participation in regional or national junior competitions
- Baseline bench press 1RM ≥ 1.0 × body weight
- No history of major upper extremity injuries in the past 12 months
- Demonstrated proficiency in front hook technique execution

Exclusion Criteria:

- Current injury or medical condition affecting upper body training
- Previous experience with velocity-based training (>4 weeks)
- Concurrent participation in other research studies
- Use of performance-enhancing substances
- Inability to commit to the full training program duration

Recruitment and Randomization: Participants were recruited from six wrestling clubs in Baghdad, Iraq: Al-Zawraa Sports Club, Al-Shorta Sports Club, Al-Quwa Al-Jawiya Sports Club, Al-Karkh Sports Club, Nadi Baghdad Sports Club, and Al-Rasheed Sports Club. Following informed consent and baseline testing, participants were randomly assigned to groups using stratified randomization based on initial 1RM bench press values. The final sample consisted of 32 wrestlers: experimental group (n=16, age: 18.1±0.8 years, body mass: 67.3±8.2 kg) and control group (n=16, age: 18.3±0.7 years, body mass: 66.8±7.9 kg).

3.3 Ethical Considerations

This study was approved by the Research Ethics Committee of the University of Kirkuk (Ethics Approval Number: UoK/CPES/2023/094) and the Iraqi Ministry of Youth and Sports Research Committee (Approval Number: MYS/RC/2023/178). All participants and their parents/guardians provided written informed consent after receiving comprehensive information about study procedures, potential risks, and benefits.

3.4 Testing Procedures

Pre-testing Protocol: All participants underwent comprehensive baseline testing over a 2-week period. Testing sessions were conducted at consistent times (2:00-5:00 PM) to control for circadian rhythm effects. Participants were instructed to avoid intensive training 72 hours before testing, maintain normal dietary habits, and avoid caffeine intake 6 hours before assessments.

Testing Battery:

1. **Anthropometric Measurements:**
   - Height and body mass using calibrated equipment
   - Body composition via DEXA scan (Lunar Prodigy, GE Healthcare)
   - Limb length measurements for normalization
2. **Maximal Strength Assessment:**
   - **1RM Bench Press:** Progressive loading protocol with 3-5 minute rest intervals
   - **Verification:** Second attempt within 105% of initial 1RM
   - **Safety:** Experienced spotters and safety equipment
3. **Upper Body Power Assessment:**
   - **Bench Press Throw:** 40% 1RM load, 3 attempts with 2-minute rest
   - **Equipment:** Smith machine with linear position transducer (GymAware PowerTool)
   - **Variables:** Peak power, mean power, peak velocity
4. **Front Hook Technique Assessment:**
   - **Success Rate:** 20 technique attempts against live opponent
   - **Accuracy Score:** 10-point scale assessed by three certified coaches
   - **Biomechanical Analysis:** Force plates and motion capture system
   - **Video Analysis:** High-speed cameras for technique evaluation
5. **Power Endurance Assessment:**
   - **Repeated Bench Press:** 70% 1RM to failure with 1-second pause
   - **Power Maintenance:** 5 consecutive bench press throws at 40% 1RM
   - **Fatigue Index:** Decline in power output across repetitions

3.5 Training Interventions

Experimental Group - Velocity-Based Training:
The VBT protocol was designed based on established velocity zones (González-Badillo & Sánchez-Medina, 2020) and adapted for wrestling-specific power development. Training sessions were conducted 3 times per week with 48-72 hours between sessions.

Equipment Specifications:

- **Velocity Monitoring:** GymAware PowerTool linear position transducer
- **Load Adjustment:** Real-time feedback and automatic load modification
- **Safety Systems:** Power rack with safety bars and spotting assistance

Session Structure:

- Warm-up: 15 minutes (dynamic mobility, activation exercises)
- VBT training: 45-50 minutes (4-5 exercises targeting velocity zones)
- Technical practice: 15 minutes (front hook drilling with resistance)

- Cool-down: 10 minutes (static stretching, recovery protocols)

Velocity Zone Targeting:
Weeks 1-3: Power Development Phase
- Target Velocity Zone: 0.75-1.00 m/s (power zone)
- Load Range: 30-50% 1RM (adjusted based on velocity feedback)
- Volume: 4 sets × 3-5 repetitions
- Rest: 3-4 minutes between sets

Weeks 4-6: Strength-Speed Phase
- Target Velocity Zone: 0.50-0.75 m/s (strength-speed zone)
- Load Range: 50-70% 1RM (adjusted based on velocity feedback)
- Volume: 4 sets × 3-4 repetitions
- Rest: 3-4 minutes between sets

Weeks 7-9: Speed-Strength Phase
- Target Velocity Zone: 0.75-1.00 m/s (returning to power emphasis)
- Load Range: 30-50% 1RM (adjusted based on velocity feedback)
- Volume: 5 sets × 3-5 repetitions
- Rest: 3-4 minutes between sets

Weeks 10-12: Peak Power Phase
- Target Velocity Zone: 1.00-1.30 m/s (speed zone)
- Load Range: 20-40% 1RM (adjusted based on velocity feedback)
- Volume: 5 sets × 3-6 repetitions
- Rest: 3-4 minutes between sets

Primary Exercises:
1. **Bench Press (Competition Grip):**
   - Primary power development exercise
   - Velocity monitoring on every repetition
   - Load adjustment based on velocity feedback
2. **Incline Bench Press:**
   - Upper chest emphasis for wrestling-specific angle
   - Velocity zone targeting similar to bench press
   - 30° incline angle
3. **Push Press:**
   - Explosive total-body power development
   - High velocity emphasis (>1.0 m/s)
   - Olympic lifting derivative
4. **Medicine Ball Chest Pass:**
   - Explosive power expression
   - Wrestling-specific movement pattern
   - Partner resistance and feedback

Control Group - Traditional Percentage-Based Training:
The control group followed a traditional percentage-based training program commonly used in wrestling strength training. Training sessions were matched for frequency, duration, and exercise selection.

Session Structure:
- Warm-up: 15 minutes (dynamic mobility, activation exercises)
- Strength training: 45-50 minutes (4-5 exercises using percentage-based loading)
- Technical practice: 15 minutes (front hook drilling)
- Cool-down: 10 minutes (static stretching, recovery protocols)

Training Progression:
Weeks 1-3: Hypertrophy Phase
- Intensity: 70-80% 1RM
- Volume: 4 sets × 8-10 repetitions
- Rest: 2-3 minutes between sets

Weeks 4-6: Strength Phase
- Intensity: 80-90% 1RM
- Volume: 4 sets × 4-6 repetitions
- Rest: 3-4 minutes between sets

Weeks 7-9: Power Phase
- Intensity: 50-70% 1RM
- Volume: 4 sets × 3-5 repetitions (explosive intent)
- Rest: 3-4 minutes between sets

Weeks 10-12: Peaking Phase
- Intensity: 60-80% 1RM
- Volume: 3 sets × 3-5 repetitions
- Rest: 3-4 minutes between sets

Primary Exercises:
- Bench press (competition grip)
- Incline bench press
- Push press
- Medicine ball chest pass

3.6 Data Collection
Data collection was supervised by certified exercise physiologists, experienced wrestling coaches, and trained research assistants. All equipment was calibrated according to the manufacturer's specifications before each session. Standardized verbal instructions and visual demonstrations were provided to all participants.

Quality Control Measures:
- Test-retest reliability coefficients > 0.90 for all strength measures
- Inter-rater reliability > 0.85 for technical assessments
- Blinded evaluation for technique scoring
- Standardized environmental conditions (temperature: 22-24°C, humidity: 45-55%)

3.7 Statistical Analysis
Statistical analyses were performed using SPSS version 29.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean ± standard deviation, 95% confidence intervals) were calculated for all variables. Data normality was assessed using the Shapiro-Wilk test and Q-Q plots. Homogeneity of variances was verified using Levene's test.

Primary Analyses:

- Three-way repeated measures ANOVA (group × time × training phase) for each dependent variable
- Effect sizes calculated using partial eta-squared (η^2p) and Cohen's d
- Post-hoc comparisons using Bonferroni correction for multiple comparisons
- Independent t-tests for between-group comparisons at each time point

Secondary Analyses:

- Pearson correlation analysis for relationships between variables
- Multiple regression analysis to identify predictors of performance improvement
- Individual response analysis using smallest worthwhile change calculations
- Training load analysis comparing VBT and traditional approaches

Statistical Significance:

- Alpha level set at $p < 0.05$ for statistical significance
- Effect size interpretations: trivial ($d < 0.2$), small ($0.2 \leq d < 0.5$), medium ($0.5 \leq d < 0.8$), large ($d \geq 0.8$)
- Clinical significance defined as >10% improvement in primary outcome measures

4. RESULTS

4.1 Participant Characteristics and Compliance

All 32 participants completed the study with 97.6% adherence to training programs. No training-related injuries occurred during the intervention period. Baseline characteristics showed no significant differences between groups, confirming successful randomization (Table 1).

Table 1: Baseline Participant Characteristics

Variable	Experimental Group (n=16)	Control Group (n=16)	p-value	Effect Size (d)
Age (years)	18.1 ± 0.8	18.3 ± 0.7	0.482	0.26
Height (cm)	172.4 ± 6.2	173.1 ± 5.9	0.738	0.12
Body mass (kg)	67.3 ± 8.2	66.8 ± 7.9	0.856	0.06
Wrestling experience (years)	8.4 ± 1.6	8.1 ± 1.8	0.612	0.18
Bench press 1RM (kg)	78.4 ± 8.6	77.9 ± 9.2	0.873	0.06
Upper body power (watts)	847 ± 89	832 ± 94	0.634	0.16

4.2 Upper Body Strength and Power Outcomes

4.2.1 Bench Press 1RM: The experimental group demonstrated significant improvements in maximal bench press strength across all testing time points (Table 2).

Table 2: Bench Press 1RM Results

Group	Pre-test (kg)	Mid-test (kg)	Post-test (kg)	Change (kg)	% Change	Effect Size (η²p)
Experimental	78.4 ± 8.6	88.2 ± 9.1*†	97.2 ± 9.1*†	+18.8 ± 4.2	+24.0%	0.896
Control	77.9 ± 9.2	82.3 ± 8.9*	85.7 ± 9.4*	+7.8 ± 3.1	+10.0%	0.445

*Significantly different from pre-test ($p < 0.05$) †Significantly different from control group ($p < 0.05$)

4.2.2 Upper Body Push Power: Upper body push power showed dramatic improvements in the experimental group (Table 3).

Table 3: Upper Body Push Power Results

Group	Pre-test (watts)	Mid-test (watts)	Post-test (watts)	Change (watts)	% Change	Effect Size (η²p)
Experimental	847 ± 89	1012 ± 97*†	1124 ± 97*†	+277 ± 56	+32.7%	0.923
Control	832 ± 94	897 ± 89*	934 ± 92*	+102 ± 41	+12.3%	0.467

*Significantly different from pre-test ($p < 0.05$) †Significantly different from control group ($p < 0.05$)

4.2.3 Power Endurance Index: Power endurance capacity demonstrated significant improvements in the experimental group (Table 4).

Table 4: Power Endurance Index Results

Group	Pre-test (%)	Mid-test (%)	Post-test (%)	Change (%)	% Change	Effect Size (η²p)
Experimental	76.2 ± 8.4	84.8 ± 7.2*†	91.6 ± 6.7*†	+15.4 ± 4.1	+20.2%	0.834
Control	75.8 ± 9.1	78.9 ± 8.6*	81.2 ± 8.9*	+5.4 ± 3.2	+7.1%	0.378

*Significantly different from pre-test ($p < 0.05$) †Significantly different from control group ($p < 0.05$)

4.3 Front Hook Technique Performance

4.3.1 Success Rate

The experimental group showed remarkable improvements in front hook success rate (Table 5).

Table 5: Front Hook Success Rate Results

Group	Pre-test (%)	Mid-test (%)	Post-test (%)	Change (%)	% Change	Effect Size (η²p)
Experimental	58.3 ± 9.4	71.2 ± 8.1*†	81.7 ± 7.2*†	+23.4 ± 5.8	+40.1%	0.934
Control	57.9 ± 8.8	62.4 ± 9.2*	65.8 ± 8.6*	+7.9 ± 4.1	+13.6%	0.423

*Significantly different from pre-test ($p < 0.05$) †Significantly different from control group ($p < 0.05$)

4.3.2 Technique Accuracy Score: Technique accuracy demonstrated substantial improvements following VBT (Table 6).

Table 6: Front Hook Accuracy Score Results

Group	Pre-test (points)	Mid-test (points)	Post-test (points)	Change (points)	% Change	Effect Size (η²p)
Experimental	6.9 ± 1.2	8.2 ± 1.0*†	9.1 ± 0.8*†	+2.2 ± 0.7	+31.9%	0.867
Control	6.8 ± 1.1	7.3 ± 1.0*	7.7 ± 1.0*	+0.9 ± 0.5	+13.2%	0.389

*Significantly different from pre-test ($p < 0.05$) †Significantly different from control group ($p < 0.05$)

4.3.3 Technique Execution Time: Execution time for front hook techniques showed significant improvements in the experimental group (Table 7).

Table 7: Front Hook Execution Time Results

Group	Pre-test (seconds)	Mid-test (seconds)	Post-test (seconds)	Change (seconds)	% Change	Effect Size (η²p)
Experimental	2.84 ± 0.34	2.41 ± 0.28*†	2.12 ± 0.26*†	-0.72 ± 0.19	-25.4%	0.823
Control	2.87 ± 0.31	2.73 ± 0.29*	2.64 ± 0.32*	-0.23 ± 0.14	-8.0%	0.334

*Significantly different from pre-test ($p < 0.05$) †Significantly different from control group ($p < 0.05$)

4.4 Correlation Analysis: Strong correlations were found between upper-body power improvements and technical performance measures (Table 8).

Table 8: Correlation Matrix Between Variables (Change Scores)

Variable	1	2	3	4	5	6
1. Upper Body Power	-					
2. Bench Press 1RM	0.856**	-				
3. Power Endurance	0.789**	0.721**	-			
4. Front Hook Success Rate	0.834**	0.767**	0.812**	-		
5. Technique Accuracy	0.798**	0.745**	0.756**	0.923**	-	
6. Execution Time	-0.723**	-0.689**	-0.734**	-0.889**	-0.867**	-

**$p < 0.01$

4.5 Training Load Analysis: VBT demonstrated superior training load optimization compared to traditional methods (Table 9).

Table 9: Training Load Comparison

Variable	VBT Group	Traditional Group	p-value	Effect Size (d)
Average Training Load (kg)	1247 ± 186	1356 ± 201	0.023	0.56
Load Variability (CV%)	14.3 ± 2.8	8.9 ± 2.1	<0.001	2.18
Velocity Consistency (CV%)	7.2 ± 1.4	12.6 ± 2.8	<0.001	2.34
Training Efficiency Index	0.87 ± 0.09	0.74 ± 0.11	<0.001	1.29

4.6 Individual Response Analysis

Individual response analysis revealed that 15 out of 16 participants (93.8%) in the experimental group achieved clinically meaningful improvements (>15%) in upper body power, compared to 7 out of 16 participants (43.8%) in the control group. For front hook success rate, 14 out of 16 participants (87.5%) in the experimental group achieved meaningful improvements compared to 6 out of 16 participants (37.5%) in the control group.

4.7 Between-Group Comparisons at Post-Test: Independent t-tests revealed significant between-group differences at post-test for all primary outcome measures (Table 10).

Table 10: Between-Group Comparisons at Post-Test

Variable	Experimental Group	Control Group	t-value	p-value	Cohen's d	95% CI
Bench Press 1RM (kg)	97.2 ± 9.1	85.7 ± 9.4	3.47	0.002	1.25	[4.2, 18.8]
Upper Body Power (watts)	1124 ± 97	934 ± 92	5.62	<0.001	2.02	[118, 262]
Power Endurance (%)	91.6 ± 6.7	81.2 ± 8.9	3.67	0.001	1.32	[4.8, 16.0]
Front Hook Success Rate (%)	81.7 ± 7.2	65.8 ± 8.6	5.51	<0.001	1.98	[10.0, 21.8]
Technique Accuracy (points)	9.1 ± 0.8	7.7 ± 1.0	4.23	<0.001	1.52	[0.7, 2.1]
Execution Time (seconds)	2.12 ± 0.26	2.64 ± 0.32	-4.92	<0.001	-1.77	[-0.74, -0.30]

5. DISCUSSION

5.1 Primary Findings

This study demonstrates that 12 weeks of velocity-based training significantly improves upper-body push power and front hook technique performance in under-20 freestyle wrestlers. The experimental group showed superior improvements across all measured variables compared to the control group, with effect sizes ranging from large to very large, indicating both statistical significance and substantial practical importance.

The 32.7% improvement in upper body push power represents a remarkable enhancement in a critical performance determinant for wrestling success. This finding substantially exceeds typical improvements reported in traditional strength training studies and suggests that the individualized, velocity-driven approach of VBT optimized power development adaptations (Weakley et al., 2021, p. 458).

5.2 Mechanisms of Superior VBT Adaptations

The superior training adaptations observed in the experimental group can be attributed to several unique characteristics of velocity-based training:

Individualized Load Prescription: VBT's ability to adjust training loads based on real-time velocity feedback ensured that each athlete trained at optimal intensities relative to their daily readiness state. This individualization likely prevented both under-training and excessive fatigue, enabling more consistent adaptation stimuli (González-Badillo & Sánchez-Medina, 2020, p. 380).

Velocity-Specific Adaptations: The targeting of specific velocity zones throughout the training program enabled systematic development of different strength qualities. The progression from power zones (0.75-1.00 m/s) to strength-speed zones (0.50-0.75 m/s) and back to high-velocity zones (>1.00 m/s) provided comprehensive power development while maintaining movement quality (Banyard et al., 2019, p. 569).

Enhanced Neuromuscular Efficiency: The constant velocity monitoring and feedback likely enhanced neuromuscular efficiency by promoting optimal motor patterns and reducing compensatory movement strategies. This effect was evidenced by the superior velocity consistency observed in the VBT group (7.2% vs. 12.6% coefficient of variation).

Autoregulation Benefits: The autoregulatory nature of VBT allowed for real-time adjustments based on neuromuscular readiness, potentially optimizing recovery-adaptation cycles and reducing the risk of overtraining. This was reflected in the higher training efficiency index observed in the experimental group (0.87 vs. 0.74).

5.3 Front Hook Technique Performance Improvements

The dramatic improvements in front hook performance (40.1% increase in success rate, 31.9% improvement in accuracy score, 25.4% reduction in execution time) can be attributed to several interconnected factors:

Enhanced Explosive Power: The significant improvements in upper body push power directly translated to enhanced force production during the initial contact phase of front hook techniques. The strong correlation between power improvements and technique success rate (r = 0.834) supports this relationship.

Improved Movement Quality: The velocity-based approach emphasized movement quality alongside force production, leading to enhanced neuromuscular coordination patterns that transferred effectively to technique execution. The improvement in technique accuracy scores suggests that VBT enhanced both physical capacity and movement precision.

Reduced Execution Time: The enhanced power output enabled wrestlers to complete front hook techniques more rapidly, potentially providing tactical advantages by reducing opponent reaction time. The 25.4% reduction in execution time represents a substantial improvement in technique efficiency.

Power Endurance Enhancement: The 20.2% improvement in power endurance capacity enabled wrestlers to maintain high-quality technique execution throughout extended training sessions and competitions. This adaptation is critical for young athletes who may compete in multiple matches per day.

5.4 Comparison with Previous Research

The power development improvements observed in this study exceed those reported in most previous VBT research in combat sports. Thompson and Wilson (2022, p. 236) reported 23% improvements in explosive power following VBT interventions, while the current study achieved 32.7% improvements. This superior adaptation may be attributed to the young age of participants, the wrestling-specific exercise selection, and the systematic velocity zone progression.

The technique performance improvements also exceed those typically reported in wrestling training studies. Hussein and Jaafar (2023, p. 236) found 18% improvements in technique success rates following power training interventions, compared to the 40.1% improvement observed in the current study. This suggests that the velocity-based approach produces superior transfer to wrestling-specific performance.

The correlation strengths between power and technique measures (r = 0.834) support previous findings by Al-Rubaie and Al-Kaabi (2022, p. 125) and provide strong evidence for the mechanistic relationship between upper body power and wrestling technique success.

5.5 Training Load Optimization

The VBT group demonstrated superior training load optimization compared to the traditional percentage-based approach. Despite using lower average training loads (1247 kg vs. 1356 kg), the VBT group achieved greater adaptations, suggesting enhanced training efficiency. The higher load variability in the VBT group (14.3% vs. 8.9%) reflects the individualized nature of the training prescription, accommodating daily fluctuations in neuromuscular readiness.

The superior velocity consistency achieved by the VBT group (7.2% vs. 12.6% coefficient of variation) indicates better movement quality maintenance throughout the training program. This finding supports the concept that VBT enhances not only force production but also movement efficiency and technical execution.

5.6 Practical Applications and Implementation

The results of this study have several important implications for wrestling training and coaching practice:

Youth Development Programs: The superior adaptations observed in young wrestlers support the implementation of VBT in youth development programs. The individualized nature of VBT makes it particularly suitable for young athletes who may exhibit varying maturation rates and training responses.

Technology Integration: The successful implementation of VBT requires appropriate technology (linear position transducers) and coach education. The investment in VBT technology appears justified by the superior adaptations and training efficiency observed in this study.

Periodization Applications: The velocity zone progression used in this study provides a practical framework for periodizing VBT in wrestling contexts. The systematic targeting of different velocity zones enables coaches to emphasize specific adaptations during different training phases.

Technique Integration: The combination of VBT with technique-specific practice demonstrated superior transfer to wrestling performance. This approach supports the integration of strength and technical training for optimal development.

5.7 Limitations and Considerations

Several limitations should be considered when interpreting and applying these results:

Population Specificity: The study included only under-20 male freestyle wrestlers from a specific geographic region. The effectiveness of VBT may vary in different populations, including female wrestlers, older athletes, or those with different training backgrounds.

Technology Requirements: The implementation of VBT requires specialized equipment and technical expertise that may not be available in all training environments. The cost-benefit analysis of VBT implementation requires careful consideration.

Learning Effects: The novelty of VBT may have contributed to initial improvements, and responses may differ in athletes with extensive VBT experience. Long-term studies are needed to assess the sustainability of VBT adaptations.

Technique Specificity: The study focused specifically on front hook techniques. The transfer of VBT benefits to other wrestling techniques requires further investigation.

5.8 Future Research Directions

Based on the findings of this study, several areas warrant further investigation:

Long-term Adaptations: Research examining the sustainability of VBT adaptations over extended periods would inform long-term program design and maintenance strategies.

Dose-Response Relationships: Studies investigating different VBT parameters (velocity zones, training frequencies, session durations) would help optimize program design for different populations and goals.

Gender and Age Comparisons: Investigation of VBT responses in female wrestlers and different age groups would expand the evidence base for this training method.

Competition Performance: Studies examining the transfer of VBT adaptations to actual competition outcomes would strengthen the practical relevance of this training approach.

Technique Generalization: Research investigating VBT effects on various wrestling techniques would provide broader insights into the applications of this training method.

6. CONCLUSION

This study provides compelling evidence that velocity-based training is a highly effective method for improving upper-body push power and front hook technique performance in under-20 freestyle wrestlers. The 12-week intervention produced significant improvements in all measured variables, with the experimental group demonstrating superior adaptations compared to the control group across multiple performance domains.

Key findings include:

1. **Substantial enhancement of upper body push power** (32.7% increase), indicating remarkable improvements in a critical performance determinant for wrestling success
2. **Significant improvement in maximal strength** (24.0% increase in bench press 1RM), demonstrating comprehensive strength development
3. **Enhanced power endurance capacity** (20.2% improvement), supporting sustained high-quality performance throughout extended efforts
4. **Dramatic improvement in front hook technique success** (40.1% increase in success rate), representing the primary technical outcome of interest
5. **Superior technique execution quality** (31.9% improvement in accuracy score, 25.4% reduction in execution time), demonstrating both performance and efficiency benefits
6. **Optimized training load management** (higher training efficiency index, better velocity consistency), indicating superior training program design

The exceptionally strong correlations between power improvements and technical performance enhancements (r = 0.834) provide compelling evidence that VBT creates specific adaptations that directly benefit wrestling technique execution. This finding supports the principle of training specificity and demonstrates the importance of individualized, velocity-driven training approaches for young athletes.

The practical significance of these results extends beyond laboratory measurements to real-world wrestling performance. The improved upper body power and enhanced front hook technique execution represent fundamental capabilities that directly influence competitive success. The superior training load optimization observed with VBT suggests that this approach enables more efficient use of training time and resources.

The novel application of velocity-based training to wrestling-specific power development represents a significant advancement in combat sports training methodology. This approach addresses the critical need for individualized training methods that account for daily fluctuations in neuromuscular readiness while maintaining focus on sport-specific performance outcomes.

The high individual response rate (93.8% achieving meaningful power improvements) demonstrates the robust effectiveness of this training approach across diverse athlete populations. This finding is particularly important for youth development programs, where individual variation in training responses is common.

Future research should continue to explore the applications of velocity-based training in various wrestling populations and techniques, with particular attention to long-term adaptations, optimal velocity zone progressions, and competition performance transfer. The current findings provide a strong foundation for evidence-based implementation of VBT in wrestling training programs.

The implications of this research extend beyond freestyle wrestling to other combat sports requiring similar power qualities and technique characteristics. The principles of velocity-based training may be successfully adapted to various combat sports contexts, providing a valuable framework for individualized power development in young athletes.

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APPENDICES

Appendix A: Velocity-Based Training Protocol

Phase 1: Power Development (Weeks 1-3)

- Target Velocity Zone: 0.75-1.00 m/s
- Load Range: 30-50% 1RM (adjusted based on velocity feedback)
- Volume: 4 sets × 3-5 repetitions
- Rest Intervals: 3-4 minutes between sets
- Exercises: Bench press, incline press, push press, medicine ball throws

Phase 2: Strength-Speed (Weeks 4-6)

- Target Velocity Zone: 0.50-0.75 m/s
- Load Range: 50-70% 1RM (adjusted based on velocity feedback)
- Volume: 4 sets × 3-4 repetitions
- Rest Intervals: 3-4 minutes between sets
- Exercises: Bench press, incline press, push press, weighted medicine ball throws

Phase 3: Speed-Strength (Weeks 7-9)

- Target Velocity Zone: 0.75-1.00 m/s
- Load Range: 30-50% 1RM (adjusted based on velocity feedback)
- Volume: 5 sets × 3-5 repetitions
- Rest Intervals: 3-4 minutes between sets
- Exercises: Bench press, incline press, push press, plyometric push-ups

Phase 4: Peak Power (Weeks 10-12)

- Target Velocity Zone: 1.00-1.30 m/s
- Load Range: 20-40% 1RM (adjusted based on velocity feedback)
- Volume: 5 sets × 3-6 repetitions
- Rest Intervals: 3-4 minutes between sets
- Exercises: Bench press throws, medicine ball explosions, speed bench press

Appendix B: Front Hook Technique Assessment

Assessment Criteria (10-point scale):

1. **Setup Position (2 points):** Proper stance, grip establishment, body positioning
2. **Initial Contact (2 points):** Timing, angle of approach, force application
3. **Hooking Motion (3 points):** Arm trajectory, power application, control maintenance
4. **Follow-through (2 points):** Completion of technique, positioning for advantage
5. **Overall Execution (1 point):** Fluidity, confidence, technical precision

Biomechanical Analysis:

- Force plate measurements during technique execution
- High-speed video analysis (1000 fps)
- EMG analysis of key muscle groups
- 3D motion capture for kinematic analysis

Appendix C: Training Load Monitoring

VBT Monitoring Parameters:

- Mean velocity per repetition
- Velocity loss within sets
- Velocity loss across sets
- Load adjustments based on velocity feedback
- Total training volume (sets × reps × load)

Traditional Training Monitoring:

- Planned loads based on percentage of 1RM
- Actual loads lifted
- Repetitions completed
- Subjective rating of perceived exertion (RPE)
- Total training volume (sets × reps × load)

Appendix D: Statistical Analysis Details

Power Analysis:

- Anticipated effect size: $d = 0.8$ (large effect)
- Alpha level: $\alpha = 0.05$
- Power: $1-\beta = 0.90$
- Sample size per group: $n = 16$
- Total sample size: $N = 32$

Assumption Testing:

- Normality: Shapiro-Wilk test and Q-Q plots
- Homogeneity of variance: Levene's test
- Sphericity: Mauchly's test (for repeated measures)
- Outliers: Boxplot analysis and z-score screening

Effect Size Interpretations:

- Cohen's d: 0.2 (small), 0.5 (medium), 0.8 (large)
- Partial eta-squared: 0.01 (small), 0.06 (medium), 0.14 (large)
- Correlation coefficients: 0.3 (small), 0.5 (medium), 0.7 (large)