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EXPLORING THE RELATIONSHIP BETWEEN SHOT VELOCITY AND GOAL-SCORING PERFORMANCE IN COMPETITIVE GOALBALL

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ABSTRACT

This study aimed to explore the relationships between shot velocity, isometric handgrip strength, flexibility, and goal-scoring performance in goalball athletes under real competitive conditions. The sample included male players (n = 15; age range: 19–44 years) who participated in the International Men's Goalball Tournament "Vytautas the Great LIONS Club Cup" in Vilnius, Lithuania (May 24–26, 2019). Shot velocity was recorded live during matches using a RADAR1 device across three throwing types (low, medium, and thigh-high). Isometric grip strength was assessed using a Lafayette 78010 hand dynamometer, and flexibility was evaluated with the Sit-and-Reach test. Goal-scoring data were extracted from official match statistics. The results showed moderate, but statistically non-significant, positive correlations between shot velocity and goal-scoring performance across all throw types (r = 0.33–0.36), suggesting a potential trend where faster throws may be associated with increased offensive effectiveness. In contrast, isometric grip strength and flexibility demonstrated weak or negligible correlations with both shot speed and scoring, indicating limited predictive value for these isolated physical metrics. These findings suggest that technical execution and perceptual-motor coordination may play a more critical role in goalball offense than raw muscular strength or static flexibility. Coaches should prioritize integrated training approaches that develop throwing mechanics, decision-making under auditory cues, and functional mobility. Future research with larger and more diverse samples is recommended to further investigate the biomechanical and perceptual contributors to scoring performance in goalball.

Key words: goalball, shot velocity, isometric grip strength, flexibility, performance

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INTRODUCTION

Goalball is a Paralympic team sport specifically designed for athletes who are blind or visually impaired, relying exclusively on auditory and tactile perception rather than visual cues. Developed after World War II as a rehabilitation activity for visually impaired veterans, goalball became part of the Paralympic Games program in 1976 (Molik et al., 2015).

Offensive success in goalball depends on precise throwing technique, where shot velocity and ball placement are critical determinants of effectiveness (Bowerman et al., 2011; Link & Weber, 2018). Shot velocity (the magnitude of the ball's velocity vector at release) is influenced by multiple biomechanical and physiological factors, including isometric grip strength, body mass distribution, flexibility, trunk rotation and sequential segmental coordination (Lemos et al., 2016; Barbosa & Leal, 2017; Morato et al., 2021; Rajković et al., 2024).

Most existing research has examined these relationships in laboratory or training environments, where psychological, tactical, and perceptual demands are substantially lower than in competitive matches (Link & Weber, 2018). Competitive play introduces additional variables—such as stress, real-time decision making, and unpredictable auditory stimuli—that can alter motor output and limit the ecological validity of isolated physical tests (Morato et al., 2021; Molik et al., 2015).

Although strength and throwing mechanics are often emphasized in training protocols, their direct association with actual scoring performance remains underexplored. Goal-scoring efficiency likely results from an interplay of kinetic power and perceptual-motor adaptability, particularly in visually impaired athletes who depend on non-visual feedback to adjust their actions (Çolak et al., 2004; Barbosa & Leal, 2017).

Biomechanical research has also established that faster shot velocities markedly increase scoring probabilities in both female and male elite goalball players, reinforcing the competitive advantage conferred by high-velocity throws (Barbosa & Leal, 2017). Time-motion analyses further reveal that the effectiveness of offensive sequences depends not only on maximal ball speed but also on precise timing and spatial positioning, highlighting the interplay between throwing technique and tactical execution (Monezi et al., 2019). Electromyographic comparisons of traditional versus spin-throw techniques indicate distinct muscle activation patterns that may be leveraged in training to optimize velocity generation (Tan, Wu, & Li, 2024). Comprehensive match-performance evaluations confirm that perceptual-motor adaptability and acute auditory situational awareness are critical for offensive success, particularly under the unpredictable conditions of competitive play (Goff & Kesting, 2016).

The primary aim of this study is to examine the relationships among shot velocity (SV), isometric handgrip strength (HGS), and flexibility (FLX) with scoring performance (SP) in elite goalball athletes during real competitive matches. Findings from this investigation may inform evidence-based training interventions aimed at optimizing key capabilities for elite goalball players (Bowerman et al., 2011; Morato et al., 2021).

METHOD

Participants:

Fifteen male goalball athletes diagnosed as blind or visually impaired (n = 15; age range: 19–44 years) were recruited during the International Men's Goalball Tournament "Vytautas the Great LIONS Club Cup" in Vilnius, Lithuania (May 24–26, 2019). Inclusion criteria were: (1) confirmed visual impairment (B1–B3 classification), (2) active participation in organized goalball competitions, and (3) informed consent. Athletes represented five countries (Ukraine, Czech Republic, Spain, Canada, Finland) and varied in competitive experience.

Variables and Measurements:

1. **SV:** Measured live during matches using a RADAR1 Doppler radar gun (Stalker Radar, Richardson, TX, USA; accuracy ±0.1 km/h). Three throw types were recorded: low rolling, medium rolling, and thigh-high. The highest recorded velocity (km/h) for each type was used for analysis.
2. **HGS:** Assessed pre-match with a Lafayette Handheld Dynamometer, model 78010 (Lafayette Instrument Company, Lafayette, IN, USA), measuring maximal voluntary isometric grip force (kg) in a standardized seated posture.
3. **FLX:** To evaluate posterior-chain flexibility (lower back and hamstrings), we employed a modified Sit-and-Reach protocol. Athletes were seated barefoot on the floor with their legs fully extended and the soles of their feet placed firmly against the front edge of a standardized reach box. Keeping their knees straight and hands overlapping, each participant slowly leaned forward, pushing a sliding marker along a measurement scale as far as possible without any bouncing or jerking motions. Two trials were administered, and the highest value achieved was recorded as the Sit-and-Reach score.
4. **SP:** Total goals scored were extracted from official match statistics for each athlete across a minimum of three matches.

Data Collection

All field measurements were conducted on-court during the tournament. SV was captured live with the radar gun positioned lateral to the throwing lane. HGS and FLX tests were administered pre-match by certified FMS practitioners. Goal data were obtained post-match from official score sheets.

Statistical Analysis: Descriptive statistics are presented as mean, standard deviation (SD), minimum (min) and maximum (max). Pearson's correlation coefficients (r) evaluated bivariate relationships between all of the mentioned variables. Significance was set at $\alpha = 0.05$.

Ethical Considerations

The research was conducted in accordance with the Declaration of Helsinki for research involving human participants. Prior to participation, informed written consent was obtained from all athletes or their legal guardians. The study protocol (no. 2019-089) was reviewed and approved by the Ethics Committee of the Lithuanian Sports University (Kaunas, Lithuania).

RESULTS

Descriptive statistics in table 1. revealed a wide range of physical performance characteristics and offensive outputs among the participating athletes. Across the sample (n = 15), SV, HGS and FLX scores showed notable individual variability, reflecting the heterogeneous nature of physical profiles in elite goalball. Pearson correlation analyses were conducted to explore the strength and direction of relationships among key performance variables and goal-scoring success.

Table 1. Descriptive statistics

Variables	Mean	SD	Min	Max
HGS	52.37	9.48	36.00	70.00
SV_{low}	62.00	5.93	50.00	74.00
SV_{medium}	56.07	5.58	42.00	64.00
$SV_{thigh-high}$	50.89	4.32	42.00	60.00
FLX	25.96	12.20	00.00	47.00
SP	8.89	9.72	00.00	29.00

Legend: HGS—maximal isometric handgrip strength (kg); SV_{low}—shot velocity for low-height throws (km/h); SV_{medium}—shot velocity for medium-height throws (km/h); $SV_{thigh-high}$—shot velocity for thigh-high throws (km/h); FLX—flexibility (sit-and-reach distance, cm); SP—Scoring Performance (total goals scored);

A complete correlation matrix is presented in Table 2, illustrating these relationships and highlighting the relative importance – or lack thereof of each variable in relation to scoring. Collectively, the results suggest that while shot speed exhibits a consistent, moderate relationship with offensive performance, other isolated physical metrics such as handgrip strength and flexibility have limited explanatory power.

Table 2. Correlation table

Variables	SP	SV_{low}	SV_{medium}	$SV_{thigh-high}$	HGS	FLX
SP	1.00	0.36	0.33	0.35	0.05	-0.19
SV_{low}	0.36	1.00	0.53	0.35	0.06	-0.09
SV_{medium}	0.33	0.53	1.00	0.63	0.10	-0.08
$SV_{thigh-high}$	0.35	0.35	0.63	1.00	-0.14	-0.21
HGS	0.05	0.06	0.10	-0.14	1.00	0.20
FLX	-0.19	-0.09	-0.08	-0.21	0.20	1.00

Legend: SP—Scoring Performance (total goals scored); SV_{low}—shot velocity for low-height throws (km/h); SV_{medium}—shot velocity for medium-height throws (km/h); $SV_{thigh-high}$—shot velocity for thigh-high throws (km/h); HGS—maximal isometric handgrip strength (kg); FLX—flexibility (sit-and-reach distance, cm).

The most noteworthy finding was a moderate positive correlation between shot velocity and goals scored. Specifically, the correlation between low rolling shot velocity and goal-scoring performance was r = 0.36, while the correlation for medium rolling shots was r = 0.33, and for thigh-high jumping shots r = 0.35. Although these relationships did not reach statistical significance ($p > 0.05$), they consistently suggest that higher shot speeds may be associated with increased offensive output in competitive play. This trend supports the hypothesis that faster throws present greater difficulty for defenders and may increase the probability of scoring.

In contrast, HGS showed a very weak correlation with goals scored (r = 0.05), indicating a lack of predictive value. Similarly, it had minimal associations with SV across all throw types (r ranging from -0.12 to 0.13), reaffirming that raw isometric strength does not directly translate into throwing effectiveness or match performance in goalball.

An unexpected result was the relationship between flexibility, and goal-scoring performance. This relationship was weakly negative (r = -0.19), contradicting previous assumptions that greater flexibility might support improved throwing technique or range of motion. While this correlation was also non-significant, it raises important questions about the functional role of flexibility in elite goalball and suggests that static flexibility, at least in isolation, may not contribute meaningfully to offensive output.

DISCUSSION

The primary aim of this study was to investigate the relationships between shot velocity, isometric handgrip strength, and flexibility with goal-scoring performance in elite goalball athletes during real competitive matches. This approach adds to the limited body of research exploring performance variables in ecological, in-game conditions—an area emphasized in recent literature as essential for understanding functional athletic output (Morato et al., 2021; Link & Weber, 2018).

The most notable finding was the moderate but non-significant positive correlation between shot velocity and goal-scoring performance (r = 0.33 to 0.36). While these correlations did not meet conventional thresholds for statistical significance, likely due to the small sample size, their consistency across all three throwing types (low, medium, thigh-high) suggests that shot velocity may play a meaningful role in offensive success. This trend aligns with prior research showing that faster throws significantly increase the likelihood of scoring in elite male and female goalball (Barbosa & Leal, 2017; Link & Weber, 2018). Given that goalball players rely primarily on auditory tracking and spatial inference to defend, even modest increases in ball speed may reduce defenders' reaction time, enhancing scoring potential.

Contrary to common assumptions in sports performance, isometric grip strength did not correlate meaningfully with either shot speed or scoring outcomes (r = –0.12 to 0.13 with velocity; r = 0.05 with scoring). This challenges the belief that upper-body strength is a key performance driver in throwing-based sports. Unlike sports such as handball or baseball, which demand open-kinetic-chain upper-body power, goalball throws are underhand and depend heavily on whole-body coordination and rhythm (Bowerman et al., 2011). These findings support the view that technical efficiency, kinetic chain synchronization, and perceptual timing may be more critical for generating effective throws than isolated force production (Tan et al., 2024).

Interestingly, flexibility—as measured by the Sit-and-Reach test—showed a weak negative correlation with goal scoring (r = –0.19), and no meaningful associations with shot speed. While earlier assumptions have linked flexibility to improved throwing mechanics through increased joint range of motion, these results suggest that static posterior-chain flexibility does not necessarily translate into functional throwing power or accuracy. This is consistent with modern training perspectives emphasizing dynamic mobility and segmental control over static flexibility for performance transfer (Monezi et al., 2018). Furthermore, flexibility showed a moderate but non-significant correlation with grip strength (r = 0.35), which might reflect general physical preparedness but appears irrelevant for match performance.

Another critical factor to consider is the context of data collection. All measurements occurred during an international tournament, where fatigue, psychological pressure, and tactical complexity likely influenced athletic output. Previous studies have highlighted that physical capacities are often expressed differently under competitive versus laboratory settings, due to increased cognitive and perceptual demands (Molik et al., 2015; Morato et al., 2021). This could explain the weak predictive power of strength and flexibility metrics in our study. Even if athletes possess high muscular potential, the execution of a throw in goalball requires simultaneous sound localization, tactical decision-making, and motor control—skills that traditional strength testing does not capture.

These findings offer practical recommendations for coaching and athlete development in goalball. First, training should not overly emphasize isolated strength development. While foundational strength is important, it should be integrated into neuromuscular coordination drills, technical throwing instruction, and perceptual-motor training scenarios that mimic match play. Emphasizing release timing, auditory

response drills, and throwing mechanics optimization may yield more functional improvements in scoring effectiveness than traditional resistance training alone (Bowerman et al., 2011; Link & Weber, 2018).

Second, given the lack of benefit observed from static flexibility, training for mobility and range of motion should focus on dynamic and sport-specific movements. Exercises that improve hip and shoulder control during rotational and underhand movements, rather than generic hamstring or lower-back stretching, are likely to have better transferability (Rajković et al., 2024; Tan et al., 2024).

Finally, this study supports the importance of adopting a multidimensional approach to training. Performance in goalball is influenced by biomechanical, sensory, and tactical variables acting simultaneously. Coaches, strength and conditioning professionals, and sport psychologists should collaborate to design training environments that simulate the noise, timing constraints, and unpredictability of actual matches (Goff & Kesting, 2016).

CONCLUSION

This study explored the relationships between shot velocity, isometric grip strength, flexibility, and goal-scoring success in competitive goalball. While no statistically significant correlations were found, the data revealed a consistent trend – higher shot velocities were moderately associated with increased scoring performance. In contrast, grip strength and static flexibility showed weak or negligible associations with both shot speed and offensive output.

These findings suggest that successful goalball performance relies more on technical execution, perceptual-motor coordination, and dynamic movement quality than on isolated physical capacities. Coaches and practitioners should therefore prioritize training strategies that enhance throwing mechanics, reaction timing, and auditory decision-making—rather than focusing solely on maximal strength or static flexibility.

By collecting data under real match conditions, this study offers ecologically valid insights into the factors influencing offensive effectiveness in goalball. Still, the limited sample size constrains statistical power. Future research with larger and more diverse samples, along with detailed biomechanical and perceptual assessments, is needed to further clarify the determinants of goal-scoring performance in this sport.

Ultimately, these results support a holistic, game-specific approach to athlete development in goalball—one that blends physical preparation with technical precision and sensory adaptation to meet the complex demands of competition.

In summary this study found that shot velocity trends positively with scoring, while grip strength and flexibility appear to have little relevance to goal-scoring performance in elite goalball. These results reinforce the importance of integrated training programs that combine technical, perceptual, and motor demands. Future studies should investigate these relationships in larger and more diverse populations, ideally incorporating kinematic motion analysis, biomechanical modeling, and perceptual tracking technologies to better understand how throws result in goals under competitive constraints.

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