

The effect of strength training on upper extremities strength and ball throwing velocity in blind goalball athletes

El efecto del entrenamiento de fuerza sobre la fuerza de las extremidades superiores y la velocidad de lanzamiento de la pelota en atletas de goalball ciegos

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Abstract. Throwing technique in goalball game is the main attack to score a goal. The study aims to determine the effect of strength training on upper extremity strength and ball throwing velocity in blind goalball athletes. This study was used experimental study. Twenty goalball athletes aged 22.15 ± 1.39 years, height 155.75 ± 4.90 cm, and weight 56.67 ± 5.96 kg participated in this study to evaluate the applied training, undergoing treatment for 8 weeks. Participants underwent upper extremities strength and ball throwing velocity testing before and after treatment. Parametric paired t test was used for data analysis with a significance of 0.05. Paired t-test showed $t_{\text{count}} = 17.178$ (p-value = 0.000) for TW_5s, $t_{\text{count}} = 37.338$ (p-value = 0.000) for TW_15s, and $t_{\text{count}} = 9.303$ (p-value = 0.000) for BTV, which showed an increase in upper extremities strength and ball throwing velocity after blind goalball athletes underwent strength training for 8 weeks. Strength training can be a choice for coaches as an optimal training strategy to increase upper extremity strength and ball throwing velocity in blind goalball athletes.

Keywords: strength training, strength upper extremities, ball throwing velocity, goalball

Resumen. La técnica de lanzamiento en el juego de goalball es el ataque principal para marcar un gol. El estudio tiene como objetivo determinar el efecto del entrenamiento de fuerza sobre la fuerza de las extremidades superiores y la velocidad de lanzamiento de la pelota en atletas ciegos de goalball. Este estudio se utilizó como estudio experimental. Veinte atletas de goalball con edad de $22,15 \pm 1,39$ años, altura $155,75 \pm 4,90$ cm y peso $56,67 \pm 5,96$ kg participaron en este estudio para evaluar el entrenamiento aplicado, sometiéndose a tratamiento durante 8 semanas. Los participantes se sometieron a pruebas de fuerza de las extremidades superiores y velocidad de lanzamiento de la pelota antes y después del tratamiento. Para el análisis de datos se utilizó la prueba t paramétrica pareada con una significación de 0,05. La prueba t pareada mostró $t_{\text{count}} = 17,178$ (valor p = 0,000) para TW_5, $t_{\text{count}} = 37,338$ (valor p = 0,000) para TW_15 y $t_{\text{count}} = 9,303$ (valor p = 0,000) para BTV, lo que mostró un aumento en Fuerza de las extremidades superiores y velocidad de lanzamiento de la pelota después de que atletas de goalball ciegos se sometieran a entrenamiento de fuerza durante 8 semanas. El entrenamiento de fuerza puede ser una opción para los entrenadores como estrategia de entrenamiento óptima para aumentar la fuerza de las extremidades superiores y la velocidad de lanzamiento de la pelota en atletas de goalball ciegos.

Palabras clave: entrenamiento de fuerza, fuerza de extremidades superiores, velocidad de lanzamiento del balón, goalball.

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Introduction

Within the sports activities practiced by people with visual disabilities is goalball, a sport that has had a great massification throughout the world (Godoy-Cumillaf, Ramírez, & Fuentes-Merino, 2022). The aim of the game is to score goals by throwing the goal ball across the opposing team's goal line (Bowerman et al., 2011). The game requires a playing field that is 18 meters long and 9 meters wide. The goalposts are the same size as the field. The field is divided into an opponent's area and a friend's area. Each area is divided by a line. This line is made using a piece of tape with a cable underneath. This cable is what the player's feet will feel to determine their position, thus helping the player to defend or attack (Krzak, Ślężyńska, & Ślężyński, 2015). Athletes who compete in Paralympic sports must meet a classification, goalball athletes are classified based on their visual impairment. There are 3 classifications, namely B1 (cannot see light in both eyes), B2 (field of vision < 5 degrees or visual acuity $2/60$), and B3 (field of vision > 5 degrees and < 20 degrees or visual acuity above $2/60$ to $6/60$).

Throw is the main attack used to shoot at the goal in goalball, done from anywhere on the field before the 6-

meter line starting from a standing position (Floyd & Mowling, 2019). Therefore, goalball coaches must know the performance of players in each position on the field, and also know the opposing team's game system to encourage throws from different positions. Throw as one of the offensive strategies by throwing the ball across the opponent's goal line, increasing ball throwing velocity will complement this strategy (Bowerman et al., 2011). Ball throwing velocity is a determining factor in a sport that prioritizes goals, so it must be evaluated to test the athlete's level. Different physical skills can determine throwing performance. Maximum strength is a determining quality in offensive goalball actions that influences throwing efficiency (de Campos et al., 2020). Upper extremities strength is a determinant in the game because of its relevance in throwing. A review reports that the physical skills of outstanding goalball athletes include strength, especially in the upper extremities (Ferreira & Tosim, 2023). Therefore, upper extremities strength needs to be developed (Bushenyova, Marchenko, & Torosyan, 2021). A study shown that upper-body explosive strength as a significant predictor that affects ball throwing velocity, is one of the most important game parameters that determines the winner in goalball (Jorgić et al., 2019). Therefore, strength training is very necessary for goalball athletes. The performance capacity of Paralympic athletes is supported

by optimal training strategies. Increased total strength is achieved by specific training such as strength training. Strength training for Paralympic athletes is often similar to that for Olympic athletes, with the additional need for barrier-free access to training rooms and equipment. Strength training is one of the main determinants in the preparation of Paralympic athletes, aiming to increase maximal force with changes in muscle mass (Vanlandewijck & Thompson, 2016). A study reported that the percentage of most strength and power parameters in wheelchair athletes tended to benefit more from strength training (Turbanski & Schmidtbleicher, 2010). However, the study was applied to wheelchair athletes, while it has not been applied to blind athletes, especially goalball athletes. Therefore, this study was conducted with the aim of determining the effect of strength training on upper extremity strength and ball throwing velocity in blind goalball athletes.

Material y methods

Research methodology and procedures

The study used an experimental study. All participants as the experimental group underwent treatment for 8 weeks. The volume and frequency each week were 3 times per week, 3 sets, and 8 repetitions (Vanlandewijck & Thompson, 2016). Testing on upper extremities strength and ball throwing velocity will be assessed before and after undergoing treatment.

Research sample

Twenty goalball athletes who were blind athletes (age 22.15 ± 1.39 years, height 155.75 ± 4.90 cm, and weight 56.67 ± 5.96 kg) participated in this study.

Exploratory experiments

The strength training intervention was performed for 8 weeks, 3 times per week. Training starts with a warm-up which consists of stretching the shoulders and upper limbs. Then training in the form of a barbell bench press (bar only), including 3 sets x 8 repetitions is carried out. The main parts of the training protocol included: 3x8 (40% 1RM), 3x6 (50% 1RM), 3x4 (60% 1RM), 3x3 (70% 1RM), 3x2 (80% 1RM), and 3x1 (90% 1RM). Rest intervals between sets ranged from 3 (load \leq 60% 1RM) to 5 minutes (load $>$ 60% 1RM).

Tests used in the research

Strength upper extremities test

The test is carried out with a barbell bench press. Assessment is based on the number of repetitions the participant can do. The test is carried out in 5 sets, each set with a time limit of 15 seconds of work and 1 minute of rest between sets. In this assessment, the load starts with 40%

1RM then increases by 10% 1RM between sets. The number of repetitions recorded is the first 5 seconds and 15 seconds. Upper extremities strength is calculated by calculating the total weight (TW) during the test. To calculate the overall TW, this is done by adding up the TW in each set (TWset). TW in each set is calculated using the formula $TW_{set} (kg) = load (kg) \times number\ of\ repetitions\ in\ the\ set$ (Szafraniec et al., 2020).

Ball throwing velocity test

The test was carried out at a distance of 12m. Electronic timis gates are used to determine the speed of the ball, expressed in m/s. The 6m line is positioned for the first gate, the opponent's goal line as the second gate. The test is carried out by participants throwing the ball into the opponent's goal through the first gate (contact with the surface). Throwing technique according to what is suitable for the participant. 3 opportunities are given, the best score is used for analysis (Jorgić et al., 2019).

Statistical data

Paired t test was used to determine changes in strength upper extremities and ball throwing velocity performance in blind goalball athletes after undergoing strength training for 8 weeks. Data were analyzed using SPSS 17.0 software.

Result

Description of the performance data of strength upper extremities and ball throwing velocity in the strength training group is shown in Table 1. Before undergoing strength training, the strength upper extremities in goalball athletes produced a total weight of 120.90 ± 31.73 kg in the first 5 seconds and 810.75 ± 184.48 kg when reaching 15 seconds. After undergoing strength training, the strength upper extremities in goalball athletes experienced an increase in total weight of 24.194% in the first 5 seconds and 19.222% when reaching 15 seconds. So that in the final test, the total weight in the first 5 seconds was 150.15 ± 27.81 kg while when reaching 15 seconds it was 966.60 ± 198.47 kg. In addition to upper extremities strength, ball throwing velocity also increased by 4.443%, which was 2.61 ± 0.19 m/s during pretest and 2.73 ± 0.22 m/s during posttest (Table 1). The increase of 20 athletes in TW_5s, TW_15s, and BTV can be observed in Figure 1 and Figure 2.

Table 1.
Data Description of Upper Extremities Strength and Ball Throwing Velocity in the Strength Training Group

Variables	Test	Mean \pm SD	Improvement
Strength Upper Extremities (kg)	Pretest_TW_5s	120.90 \pm 31.73	24.194%
	Posttest_TW_5s	150.15 \pm 27.81	
	Pretest_TW_15s	810.75 \pm 184.48	19.222%
	Posttest_TW_15s	966.60 \pm 198.47	
Ball Throwing Velocity (BTV) (m/s)	Pretest_BTIV	2.61 \pm 0.19	4.443%
	Posttest_BTIV	2.73 \pm 0.22	

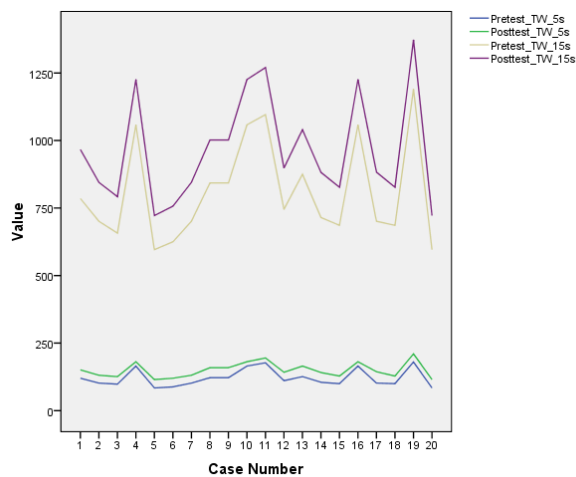


Figure 1. Individual values in TW_5s and TW_15s after 8 weeks of strength training.

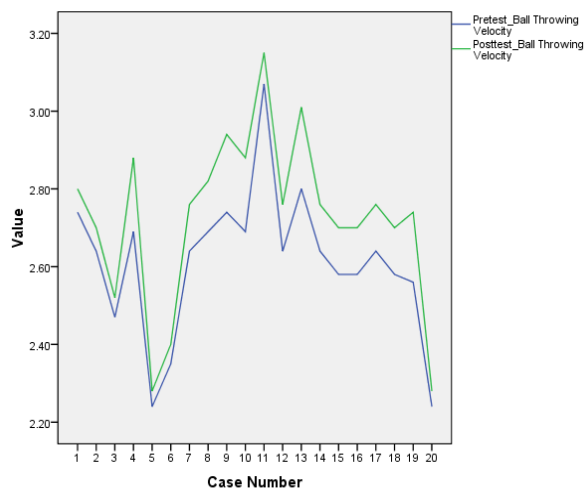


Figure 2. Individual values in Ball throwing velocity after 8 weeks of strength training.

Table 2. Difference Test of Initial Test and Final Test of Upper Extremities Strength and Ball Throwing Velocity in the Strength Training Group

Variables	Test	Mean Difference±SD	t	p-value
Strength Upper Extremities (kg)	TW_5s	29.25±7.61	17.178	0.000*
	TW_15s	155.85±18.67	37.338	0.000*
Ball Throwing Velocity (BTV) (m/s)	BTV	0.12±0.06	9.303	0.000*

* significance at 0.05 (p-value < 0.05)

Table 2 shown the paired t-test of upper extremities strength performance and ball throwing velocity in the strength training group. All variables showed a significant increase with $t_{count} = 17.178$ and p-value = 0.000 for TW_5s, $t_{count} = 37.338$ and p-value = 0.000 for TW_15s, and $t_{count} = 9.303$ and p-value = 0.000 for BTV.

Discussion

This study purpose was determined the effect of strength training on upper extremities strength and ball throwing velocity in blind goalball athletes. The findings of

the study indicate that strength training for 8 weeks can increase upper extremities strength as seen from participant performance in TW_5s and TW_15s, and ball throwing velocity as seen from participant performance in BTV test. Previously, there has been no study analyzing the effect of strength training on upper extremities strength and ball throwing velocity in blind goalball athletes, this is because strength training was conducted on cerebral palsy athletes. As conducted by Szafraniec et al (2020), studied the effect of strength training on muscle strength and movement velocity in cerebral palsy individuals, and reported that during 6 weeks of strength training there was significant potential to increase muscle strength and movement velocity performance. Although the training and samples were different, strength training conducted on blind goalball athletes for 8 weeks also showed significant potential to increase upper extremities strength and ball throwing velocity performance.

During 8 weeks of strength training, participants performed bench press exercises using loads of 40%-90% 1 RM. This increased load is a stimulus for the neuromuscular to achieve functional adaptation in terms of increase. The adaptation is greater activation of the agonist muscle group, as well as higher peak forces, which occur with each repetition (Szafraniec et al., 2020). Vanlandewijck & Thompson also agree that to maximize progress towards a specific goal, different intervention programs are needed such as pyramid sets, meaning that the training set develops starting from lighter loads with more repetitions in the first set, then heavier loads with fewer repetitions in the next set (Vanlandewijck & Thompson, 2016). Therefore, by implementing strength training, upper extremity strength and ball throwing velocity in goalball athletes have increased.

The findings of this study indicated that increasing upper extremities strength is very important for goalball athletes in increasing ball throwing velocity. In line with this, Jorgić, et al (2019) also explained something similar, that in the goalball athlete training process it is very important to develop explosive power/strength of the upper body to increase ball throwing velocity. Explosive strength is important when the player successfully defends the ball from the opponent's attack, then immediately directs the caught ball towards the opponent's goal when the opposing team is not yet in a defensive position, so that the chance of scoring a goal is higher. In the bench press test with loads of 40%-80%, this study reported an increase in total weight of 24,194% in the first 5 seconds and 19,222% when it reached 15 seconds. A study on other throwing sports reported that maximal upper body strength in the bench press test of 38%, 52%, and 67% had a moderate correlation with throwing velocity (Marques et al., 2007).

Regarding throwing velocity in this study, blind goalball athletes performed 2.73 ± 0.22 m/s in the ball throwing velocity test, which was lower than 3.13 ± 0.58 m/s of goalball athletes in national and international rankings studied by Jorgić, et al (2019). It was also lower than elite male goalball athletes who performed 15.03 ± 1.63 m/s and elite

female goalball athletes who performed 12.57 ± 1.25 m/s in the throwing velocity test (Goulart-Siqueira et al., 2018). The reason for having a lower velocity may be due to the different playing experience in the sample of this study. As elite goalball athletes who occupy international rankings require a long playing experience. This was reported by Battaller-Cervero et al (2022) that years of playing experience had a significant correlation with throwing velocity, where the playing experience in the sample was 10 ± 5 years of playing experience.

Conclusion

Based on the implementation of strength training for 8 weeks for blind goalball athletes, the results were able to increase the potential of blind athletes in the performance of upper extremities strength and ball throwing velocity. This study concluded that strength training can be applied to blind goalball athletes. Strength training is very effective in increasing absolute muscular endurance, motor ability elements and athletic abilities, this occurs because of the increase in muscular strength. In this study, the increase in muscular strength of the upper extremities of blind goalball athletes increased so that the athlete's motor ability in performing ball throwing velocity also increased. Thus, strength development is considered not only a physical fitness need but also fundamental to overall physical existence.

Recommendations

This study provides implications that in designing training for goalball blind athletes, strength training can be an alternative for coaches to improve athlete muscular strength. In addition to increasing muscular strength, strength training can also increase muscle mass, reduce body fat, and prevent injury in athletes. However, this study only examined muscular strength, therefore further researchers can study using other variables such as muscle mass, body fat, and injury prevention in goalball blind athletes.

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Conflicts of Interest

The authors declare no conflicts of interest.

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