



Effects of SCP-SCP-T Exercise on Improving Throwing Performance of Senior Javelin Throwing Athletes

Andi Atssam Mappanyukki*, Nur Indah Atifah

Makassar State University, Indonesia

*Correspondence: E-mail: andi.atssam@unm.ac.id

ABSTRACT

Athlete achievement in javelin throwing is ideally determined by various factors, including adequate physical ability, good technique, and the selection of appropriate training methods. This study aimed to analyse the effect of Standing Cable Pullover-Standing Cable Pullover-Torso (SCP-SCP-T) training on improving javelin throwing performance. The research method used experimental research. The population of this study were senior javelin throwers. The sampling technique used random sampling. The samples of this study were divided into two groups, including 10 athletes in the Standing Cable Pullover-Standing Cable Pullover-Torso (SCP-SCP-T) group and 10 athletes for the control group. The research instruments included weight scale for measuring body weight and javelin throwing ability test, with validity 0.998 and reliability 0.999, for measuring javelin throwing performance. Data analysis was processed using descriptive statistical tests, normality tests, homogeneity tests, and independent sample t-tests. The results found a more significant effect of the SCP-SCP-T training model on improving throwing performance than the training performed in control group with a P-value = 0.017 < 0.05. This study concluded that the modified SCP-SCP-T exercise can improve javelin throwing performance. The results of this study can be the basis for consideration of training methods to improve sport skills.

ARTICLE INFO

Article History:

Submitted/Received February 2025

First Revised March 2025

Accepted April 2025

Publication Date April 2025

Keyword:

Cable Pullover, Javelin Throw, Standing Cable Pullover, Torso

INTRODUCTION

Various factors, including adequate physical abilities and proper techniques, ideally determine the achievement of athletes in the javelin throw sport. Physical abilities, such as muscle strength, arm power, and body flexibility, play a crucial role in supporting the performance of a javelin thrower. In addition, throwing techniques, including javelin grip, initial stance (preparation), run-up, throwing stride, throwing, and follow-through, are also important components that cannot be ignored in achieving maximum results (Škarabot, Brownstein, Casolo, Del Vecchio, & Ansdell, 2021). The optimal combination of physical strengths and correct techniques not only increases the throwing distance but also reduces the risk of injury to athletes, especially during the follow-through phase (Škarabot et al., 2021).

The rapid development of the modern javelin throw requires improvement of athlete abilities. It is generally recognized that improving sport performance must depend on optimal quantification and modification control during the training progress to achieve ideal results. Currently, the literature on javelin training mainly focuses on kinematic analysis or a summary of javelin coach experiences. Experts who conducted research related to javelin throw found that the dominant biomotor aspects determining javelin throw distance included release speed, angle, height, and release motions (Maciel et al., 2018).

In detail, the javelin throwing stages begin with the throwing phase, with the lower extremities contribute significantly to javelin throwing (Takanashi, Kohmura, & Aoki, 2022). Lower leg strength is correlated with athletic throwing performance (Bourdin et al., 2010) and throwing performance is related to lower extremity strength. When the foot is pushed off the ground (push-off), it accelerates the body forward movement and helps rotate the trunk, which in turn helps extend the shoulders to achieve a longer acceleration path (Karampatsos, Korfiatis, Zaras, Georgiadis, & Terzis, 2017). The kinematics of javelin throw include release angle, height, and speed that can be understood through match analysis. Different levels of throwers have different release angles and javelin speeds, with greater segment speeds are found in elite throwers.

The javelin throwing process consists of start and carry, run up, cross step, release (delivery) stride, and release. The release is the result of these movements and these movements are closely related and cannot be separated (Fradet et al., 2004). Aspects to consider when releasing the javelin include lower limb supports and arm throw, where the joints must be positioned at the appropriate angle. Another aspect to consider is the explosive power when throwing (Tauchi-Sato, Ozeki, Houjou, Taguchi, & Fujimoto, 2002).

From the explanation, it can be synthesized that javelin throwing is a technical sport that involves precise sequential movements of the lower and upper body segments. The release of the javelin is an important part of the throwing technique (Hussain & Bari, 2012). The release angle is considered an important feature to cover the maximum distance of the throw, where the lower and upper body parts play an important role in javelin throwing (Krzyszowski & Kipp, 2019). The implementation of javelin throwing includes several movements starting from the head, how to hold and carry the javelin, body position when throwing the javelin, how to throw the javelin, and the javelin throwing position. The sequence of movements is a unit of movement that must be trained according to the throwing

movement pattern. However, there has been no standard training to improve javelin throwing so far (Guntoro, 2014).

To enhance the success in javelin throwing, improving the movement pattern from the legs to the arms and the muscles determining the movement of the javelin throw, including the hip to the arm muscles, is needed. In line with this, bench press and clean and snatch exercises are important exercises for athletes to improve their throwing skills (Takanashi et al., 2022). One of the efforts to improve javelin throwing ability is physical training for athletes. Physical training and sport activities can provide changes to all body system functions (Khalaf, 2022). Changes that occur during the training are called responses, while changes that occur due to regular and programmed training according to training principles are called adaptations. The occurrence of changes in increasing physiological abilities due to physical training is related to the use of energy by muscles as well as the forms, methods, and principles of the training (Khalaf, 2022).

Good physical conditions will go hand in hand with good skills. The results of previous research found that specific physiological or performance characteristics could be developed by emphasizing certain training variables according to the focus of the sport (Judge, 2007).

Physical condition is an important aspect for improving the achievement of athletes. Physical development is the factor that needs to be resolved and improved without waiting for a better situation. When athletes do not carry out physical training regularly, they certainly cannot display techniques optimally (Elmagd, 2016). To improve physical conditions, a program must be carried out. Training programs are parts of training management that must be arranged and implemented properly and correctly (Elmagd, 2016).

A directed exercise carrying out the essence of physical exercise or sport activities will better improve the ability of body organ functions. The exercise or activities carried out should be continuous, progressive, and developing, achieving each exercise function, and fulfilling the intensity, time, and frequency of the exercise. To achieve the physiological goal of physical exercise, the physical exercise should be carried out continuously and gradually. To achieve maximum performance, prospective athletes must do sport activities as early as possible by paying attention to the principles of proper and appropriate training (Deely, 2022). To enhance maximum ability in a sport, the training should consider the movement patterns required by the sport to train the anatomy of the body that plays a role when performing the movement. Increasing an athlete ability must be supported by good physical components. This condition must be accompanied by structured training. An athlete can win the title when he has the prime physical condition in every training and competition (McKinney, Velghe, Fee, Isserow, & Drezner, 2018). In addition, efforts to improve throwing ability can be made by practicing for 6 weeks, especially by practicing strength trainings (Karampatsos et al., 2017).

The javelin throwing technique is a movement unity of strength, speed, and flexibility. A long throw is influenced by the flexibility of the trunk before releasing the javelin and the strength and speed (explosive power) of the arm in throwing the javelin that are required for the coordination of muscle works. In the javelin throwing movement, flexibility is important because the arm start movement before releasing the javelin requires good flexibility. The flexibility of trunk, as a generator of javelin throwing power, would make the explosive power of the arm better. In javelin throwers, static and dynamic shoulder flexibility adaptations will

increase strength in the dominant physique (Edouard, Damotte, Lance, Degache, & Calmels, 2013).

The thrower throwing speed is also one of the most important factors. Throwing speed is important for achieving long throwing distance in javelin throwing. To achieve long throwing speed, the transfer of mechanical energy through the kinetic chain plays an important role. The internal and external rotational movements of the upper arm contribute greatly to the kinetic energy transfer and the sport equipment acceleration (Roemer, Köhler, & Witt, 2018).

Physical exercise must consider the basic principles of exercise, such as the level of regularity, exercise loads, and the principle of individuality (Amatriain-Fernández, Murillo-Rodríguez, Gronwald, Machado, & Budde, 2020). In addition, considering the nature and characteristics of javelin throwing as an explosive movement and a series of continuous movements, the training must address the characteristics of javelin throwing movements. The javelin-throwing event is complicated. Through the analysis of javelin throwing movements in sports, biomechanical analysis methods analyze changes in movements from the initial movement to the final movement (Wei & Yalong, 2021). Therefore, the physical training should align with javelin throwing movements to maximize the physical improvement.

From the results of observations, researchers found that physical training that is not relevant to the physical components of biomotor dominance would not provide good effects on javelin throwing ability. Weight training that trains the muscles that play a physiological anatomical role will provide a significant effect. Therefore, the authors designed a training method, namely Standing Cable Pullover Torso (SCP-T) and Standing Cable Pullover Bench Press Torso (SCP-BT). The exercise targets specific muscles to be trained. This exercise is a form of weight training that develops skeletal muscles well. The Standing Cable Pullover-Standing Cable Pullover-Torso (SCP-SCP-T) exercise and the Standing Cable Pullover-Bench Press-Torso (SCP-BT) exercise are trainings that combine basic, special, and specific exercises to increase the dominant biomotor component in the javelin throw event.

Based on the results of observations conducted in the field, the performance of javelin throwers in various championships has not been optimal. Athletes are often unable to achieve their best results, both the throwing distance and the techniques executed. This reflects a gap between expectations and reality in the field. This gap indicates an urgent problem that needs to be identified and addressed more systematically. Some causal factors may be the root of this problem. One of the important factors is the physical training method applied by the coach. Physical training methods that are not appropriate and do not target the specific needs of athletes can affect the development of physical abilities. The nonoptimal performance of athletes can be caused by the lack of variation in training methods, thus it should be adjusted to the individual needs of athletes especially for increasing explosiveness and flexibility which are important for javelin throwing (Granacher, 2023).

In addition, the lack of attention to the natural talent factors of athletes, the quality of training services, and the quality of the matches held can also be other causal factors (Strüder, Jonath, & Scholz, 2023).

One of the fundamental problems that needs to be addressed immediately is the physical abilities of athletes, especially in terms of muscle strength, explosive power, and body flexibility. These three components are basic elements that affect the effectiveness and efficiency of javelin throwing. Muscle strength is needed to produce sufficient power in the

run-up and throw, while explosiveness is important in supporting the acceleration of the throw. Explosiveness and body flexibility become notable keys in javelin throwing because these components allow athletes to optimize the acceleration during the critical phase of the throw (Häring et al., 2023). Body flexibility is also crucial for supporting the optimal range of motion when performing the follow-through so that the throw can reach the maximum distance (Häring et al., 2023).

A number of previous studies have discussed the efforts to improve physical abilities to support the achievements of javelin throwers. Studies have explored physical training methods designed to improve strength, power, and flexibility. International studies have confirmed that a training that focuses on strengthening core muscles and body stability is effective in improving javelin throw performance (Oyama & Palmer, 2022). Plyometric training programs can significantly increase throwing power and speed, which play an important role in achieving optimal results in competitions (Faigenbaum et al., 2007).

However, these studies still have weaknesses related to the effectiveness of the methods used. Some methods have not been able to significantly improve the overall physical performance needed by javelin throwers (Ali, 2022). One of the main obstacles is the lack of an integrated training program that can simultaneously increase strength, power, and flexibility optimally (Micheo, 2012). In addition, due to individual variability, the exercise should apply a personalized approach to achieve better results (Bourdon et al., 2017).

Previous studies have identified that shoulder, chest, and torso muscle strengths are highly correlated with throwing distance in javelin throwing athletes. Cable training can provide consistent resistance throughout the movement and can be customised to sport-specific movement patterns (Campos et al., 2020). This makes cable-based training potential for improving javelin throwing performance.

However, research that specifically evaluates the effectiveness of SCP-SCP-T training for improving javelin throwing performance is still limited. This exercise has the potential to bridge the gap between traditional strength trainings and the specific movements of javelin throwing by providing the right stimulus for the movement patterns and muscle groups involved.

By considering the aforementioned problems, researchers felt the need to develop or modify a more effective and appropriate physical training method. The training method is expected to increase the strength, muscle power, and flexibility of javelin throwers. For this reason, this study aimed to analyse the effect of the Standing Cable Pullover-Standing Cable Pullover-Torso (SCP-SCP-T) training program on improving javelin throwing performance in senior athletes. The results of this study are expected to give a scientific contribution to the development of more effective and efficient training methods to improve the performance of senior javelin throwing athletes.

Through innovations in physical training methods, this study aimed to overcome the limitations of previous studies and answer the challenges faced by coaches and athletes in improving performance in the javelin throw sport. Innovation in this training method is expected to be a solution to problems found in the field so that it can help athletes achieve their best potential. Researchers hope that, through this study, a more comprehensive and effective training method can be produced to help athletes optimize their physical and technical abilities, which in turn can improve javelin throw performance both at national and international levels.

METHODS

This study used a quantitative research approach to determine the effect of Standing Cable Pullover - Standing Cable Pullover - Torso (SCP-SCP-T) training on improving throwing performance. Based on the hypothesis of the study, the type and design of this study employed experimental research. The determination of the sample size used simple random sampling.

Participants of the Study

The population of this study were South Sulawesi javelin throwing athletes totalling 20 athletes. The sampling technique used Simple Random Sampling. The samples were divided into two groups, with 10 athletes assigned into experimental group and 10 athletes assigned into control group.

Instrument of the Study

Data collection instruments involved body weight scales for measuring body weight and javelin throwing ability tests, with validity 0.998 and reliability 0.999, for measuring throwing achievements (Ratnasari, 2016). The intervention was conducted over a period of six weeks.

Data Analysis

Data analysis included descriptive statistics to summarize the data, normality testing using the Shapiro-Wilk test, and homogeneity testing using Levene's Test. To determine the significance of differences between groups, independent sample t-tests were applied with a 95% confidence level ($\alpha = 0.05$).

This methodological design ensured a controlled comparison between the experimental and control groups and allowed for assessing the effectiveness of the SCP-SCP-T training intervention in improving athletic throwing performance.

RESULTS

Table 1 presents the descriptive statistics of the two groups. However, to determine statistical significance, further inferential tests were required. shows the mean and standard deviation (SD) of each group. The data showed mean and SD differences. Table 1 presents the descriptive statistics of both groups. It shows that the experimental group (SCP-SCP-T) experienced a larger improvement in mean score compared to the control group, indicating the effect of the intervention.

Table 1. Descriptions of the Analysis Results of the SCP-SCP-T Group and the Control Group

	Group 1 SCP- SCP-T Pre-test	Group 1 SCP- SCP-T Post-test	Group 2 Control Pre-test	Group 2 Control Post-test
Mean	21.5840	29.0430	21.5840	24.7440
Median	20.7050	23.6750	21.7550	30.0900
Std. Deviation	5.28486	4.74013	3.78160	3.65556
Minimum	16.18	19.78	17.12	22.65
Maximum	29.95	32.45	29.16	33.89

The results of the normality test in the standing cable pullover-standing cable pullover-torso (SCP-SCP-T) group and the control group with $p > 0.05$, meaning that the data were normally distributed. The results of the homogeneity of variance test. The data diversity was not significantly different with $p > 0.05$ and the smallest $p = 0.255$, meaning that all variables (javelin throwing performance of athletes) had a homogeneous variance.

Table 2. Independent Sample t-Test Result

Variables	t-value	df	Sig. (2-tailed)
Pretest	6.777	18	0.033
Post-Test	6.325	18	0.017

Table 2 presents the results of the independent t-test comparing the experimental and control groups. Both pre-test and post-test comparisons showed statistically significant differences ($p < 0.05$). The post-test t-value (6.325, $p = 0.017$) indicates that the SCP-SCP-T training program had a significant effect on improving javelin throwing performance. These results suggest that the SCP-SCP-T training program contributed to a meaningful improvement in javelin throwing performance, as evidenced by the greater gains in the experimental group compared to the control group.

DISCUSSION

The results showed that the SCP-SCP-T training method significantly improved throwing performance in javelin throwers. This improvement is relevant to previous literature findings, showing that weight training that focuses on the arm muscles (such as standing cable pullover) is effective in increasing the strength of the muscles involved in throwing and pulling movements. SCP-SCP-T training that incorporates external loads could provide greater resistance, thereby increasing muscle adaptations to trainings. Other research suggests that training that incorporates external load resistance in a programmed manner, such as the bench press, can significantly increase the recruitment of fast-twitch muscle fibers, which contributes to increased maximal strength in explosive arm movements (Furrer & Handschin, 2024).

Based on the analysis, the Standing Cable Pullover-Standing Cable Pullover-Torso (SCP-SCP-T) training could affect the performance of senior javelin throwing athletes including Specific Muscle Strengthening. SCP-SCP-T training could effectively strengthens the main muscles involved in javelin throwing, especially the shoulder rotator muscle groups, posterior deltoids, latissimus dorsi, and torso rotation muscles which are important for throwing movements (Bartlett, Müller, Lindinger, Brunner, & Morriss, 1996). This study also found an increase in Kinetic Coordination. The combination of movements in this exercise helps develop the kinetic chain required for optimal energy transfer from the legs to the arms during throwing (Tauchi, Murakami, Endo, Takesako, & Gomi, 2009). This exercise simulates the movement pattern of javelin throwing, especially in the final phase of the throw or 'delivery phase' with adjustable resistance (Klimashevsky, 2018). SCP-SCP-T significantly improves shoulder stability while training torso rotation ability, which is a critical component in generating high throwing velocity (Trasolini et al., 2022).

Physiologically, this exercise increases the activation of motor units in the muscle, increasing maximal strength. However, the higher significant difference in athletes weighing more than 75 kg could be attributed to their greater muscle mass and their ability to tolerate heavier loads during training, which supports a more significant increase in arm strength. Athletes with greater muscle mass have a better capacity to efficiently recruit motor units during heavy resistance training, resulting in a more significant increase in muscle strength

compared to athletes with lower muscle mass. This is due to the overload principle, where larger muscles can overcome greater resistance and thus produce faster strength adaptations (Ruple et al., 2023).

Athletes with lower body weight may require a greater training volume to achieve equivalent improvements. Athletes with lower body weights tend to require a higher training volume to maximize muscle adaptations because they have a smaller muscle mass capacity to withstand greater resistance efficiently (Zouita et al., 2023). In addition, other factors, such as shoulder joint flexibility and trunk stability, may also be important in supporting optimal arm strength improvements. Shoulder joint flexibility and trunk stability play an important role in supporting arm strength performance, especially in movements that require coordination between muscle strength and optimal range of motion (Faigenbaum et al., 2007).

Explosive power is important in javelin throwing, where the ability to produce maximal force in a short period is key. Resistance training focused on power has been shown to improve the neuromuscular system ability to rapidly recruit motor units, resulting in greater force output in a short period (Sánchez Pastor, García-Sánchez, Marquina Nieto, & de la Rubia, 2023).

Resistance training focused on power could significantly improve the neuromuscular system ability to efficiently recruit motor units, which is critical for performance in sports such as javelin throwing, where speed of force production is a major factor in success. Athletes weighing more than 75 kg showed more significant increases in explosive power, likely due to their ability to handle greater loads during training, which enhances fast-twitch muscle adaptations associated with power (Sánchez Pastor et al., 2023).

Another aspect to consider is the individual technique in utilizing explosive power during the javelin throw. While explosive power increases, the ability to translate this increase into sport-specific performance is highly dependent on technique and movement timing. Athletes who do not master their technique well may not be able to utilize the full potential of the power increases they have gained (Gamble, 2012).

The increase in flexibility refers to biomechanical principles, where a greater range of motion allows for an extended time of force application, which ultimately improves performance. It allows for a greater range of motion, which extends the time of force application to the muscle (Barua, 2025). This, in turn, helps improve overall performance, especially in movements that require explosive power and precise control (Barua, 2025). For example, shoulder and hip flexibilities are critical in throwing movements, where greater angles of rotation can accommodate longer and more powerful force applications. Research shows that well-programmed resistance training not only increases muscle strength but also increases the elasticity of the connective tissue around the joint, resulting in increased flexibility.

Javelin throwing performance is highly dependent on the athlete ability to coordinate various aspects, such as strength, flexibility, technique, and momentum management. The ability to maximize torque through trunk rotation and the utilization of momentum from the legs to the arms plays an important role in throwing performance. Therefore, although strength and power increase, these improvements do not always translate into better performance in javelin throwing if carried out without the mastery of proper technique (Morriss & Bartlett, 1996).

Specific technique training such as setting the throwing angle, balance, and movement rhythm are essential in javelin throwing to improve performance significantly (Narkhede, 2025). Therefore, an effective training program should integrate strength, power, and

flexibility components with proper technique development to ensure optimal results (Narkhede, 2025).

This discussion shows that SCP-SCP-T training is effective in improving arm strength, explosive power, and flexibility. However, javelin throwing ability requires a more holistic approach, where physical strength improvements must be supported by adequate technique development. Although strength and power training such as SCP-SCP-T is effective in improving physical components, such as arm strength, explosive power, and flexibility, optimal javelin performance requires a holistic approach (Hirsch, 2025). In addition, these results also underscore the importance of considering individual physical characteristics, such as body weight, in designing optimal training programs for athletes. In the future, more integrated training programs, including the development of sport-specific techniques, can be designed to optimize all aspects that support javelin performance more effectively.

CONCLUSION

The results of the research conclude that there was an effect of the Standing Cable Pullover - Standing Cable Pullover-Torso (SCP-SCP-T) combination exercise on throwing performance. Based on the findings and limitations of the study, it is recommended that coaches develop training programs that integrate Standing Cable Pullover - Standing Cable Pullover-Torso (SCP-SCP-T) more widely and variedly, with an emphasis on individual adaptation and the specific needs of athletes. Variations in training can help prevent boredom and increase athlete motivation. Further research can use biomechanical technology to better understand the mechanisms behind the performance improvements caused by SCP-SCP-T. For example, the use of video analysis or motion sensors can provide deeper insight into how this exercise affects specific movements in javelin throwing. It is also recommended that similar studies be conducted on groups of athletes with different skill levels, including junior or beginner athletes, to see if similar results can be achieved. This could also include research on athletes from other sports that require similar biomotor components. Further research is also recommended to evaluate the long-term effects of the SCP-SCP-T training. Longitudinal studies involving longer training periods may provide a clearer picture of how this method affects athlete performance in the long term. Furthermore, it is also recommended to integrate this physical training with a supportive mental and nutritional development program, as these factors also play an important role in improving overall athlete performance.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

REFERENCES

- Abou Elmagd, M. (2016). Benefits, need and importance of daily exercise. *Int. J. Phys. Educ. Sports Health*, 3(5), 22-27.
- Ali, H. S. A. (2022). The effect of compound training on some morphological measurements and explosive power of working muscles, and the level of achievement by javelin throwing. *International Journal of Yogic, Human Movement and Sports Sciences*, 7(2), 39–42.

- Amatriain-Fernández, S., Murillo-Rodríguez, E. S., Gronwald, T., Machado, S., & Budde, H. (2020). Benefits of physical activity and physical exercise in the time of pandemic. *Psychological Trauma: Theory, Research, Practice, and Policy*, 12(S1), S264.
- Bartlett, R., Müller, E., Lindinger, S., Brunner, F., & Morriss, C. (1996). Three-Dimensional evaluation of the kinematic release parameters for javelin throwers of different skill levels. *Journal of Applied Biomechanics*, 12(1), 58–71.
- Barua, R. (2025). Unleashing Human Potential: Exploring the Advantage of Biomechanics in Sport Performance. In *Global Innovations in Physical Education and Health*, 409-436.
- Bourdin, M., Rambaud, O., Dorel, S., Lacour, J. R., Moyon, B., & Rahmani, A. (2010). Throwing performance is associated with muscular power. *International Journal of Sports Medicine*, 31(7), 505–510.
- Bourdon, P. C., Cardinale, M., Murray, A., Gatin, P., Kellmann, M., Varley, M. C., ... & Cable, N. T. (2017). Monitoring athlete training loads: consensus statement. *International journal of sports physiology and performance*, 12(s2), S2-161.
- Deely, C., Tallent, J., Bennett, R., Woodhead, A., Goodall, S., Thomas, K., & Howatson, G. (2022). Etiology and recovery of neuromuscular function following academy soccer training. *Frontiers in Physiology*, 13, 911009.
- Edouard, P., Damotte, A., Lance, G., Degache, F., & Calmels, P. (2013). Static and dynamic shoulder stabilizer adaptations in javelin throwers: A preliminary study. *Isokinetics and Exercise Science*, 21(1), 47–55.
- Faigenbaum, A. D., McFarland, J. E., Keiper, F. B., Tevlin, W., Ratamess, N. A., Kang, J., & Hoffman, J. R. (2007). Effects of a short-term plyometric and resistance training program on fitness performance in boys age 12 to 15 years. *Journal of Sports Science and Medicine*, 6(4), 519–525.
- Fradet, L., Botcazou, M., Durocher, C., Cretual, A., Multon, F., Prioux, J., & Delamarche, P. (2004). Do handball throws always exhibit a proximal-to-distal segmental sequence? *Journal of Sports Sciences*, 22(5), 439–447.
- Furrer, R., & Handschin, C. (2024). Molecular aspects of the exercise response and training adaptation in skeletal muscle. *Free Radical Biology and Medicine*, 223(1), 53–68.
- Gamble, P. (2013). *Strength and conditioning for team sports: sport-specific physical preparation for high performance*. Routledge.
- Granacher, U., & Borde, R. (2017). Effects of sport-specific training during the early stages of long-term athlete development on physical fitness, body composition, cognitive, and academic performances. *Frontiers in physiology*, 8, 810.
- Guntoro, T. S. (2014). The effect of training method and motor ability on javelin throw technique. *Asian Social Science*, 10(5), 159–162.
- Häring, I., Mopuru, S. K. R., Walz, T. P., Dhanani, M., Sandela, N., Finger, J., ... Kirchheim, K. (2023). Overall Markov Diagram Design and Simulation Example for Scalable Safety Analysis of Autonomous Vehicles. 2261–2268.
- Hirsch, S. M., Chapman, C. J., Singh, H., Baker, D. G., & Frost, D. M. (2025). A Critical Appraisal of Using Barbell Velocity Data to Regulate Training. *The Journal of Strength & Conditioning Research*, 39(3), 360-372.
- Hussain, I., & Bari, M. A. (2012). Javelin Throwing Technique : A Biomechanical Study. *Issn*, 3(1), 20–25.
- Judge, L. . (2007). Developing Speed Strength: In-Season Training Program for the Collegiate Thrower. *Strength and Conditioning Journal*, 29, 42–54.

- Karampatsos, G. P., Korfiatis, P. G., Zaras, N. D., Georgiadis, G. V., & Terzis, G. D. (2017). Acute Effect of Countermovement Jumping on Throwing Performance in Track and Field Athletes During Competition. *31(2)*, 359–364.
- Khalaf, Y., Ahmed, S., & Mohamed, H. (2022). The Impact of a training program on some special physical abilities and the performance record of javelin throwing competition. *International Journal of Sports Science and Arts*, *20(1)*, 121-138.
- Klimashevsky, O. (2017). Biomechanical Structure Specifics of the Javelin Throwing Technique of elite Athletes. *Physical education, sport and health culture in modern society*, *40 (4)*, 99-103.
- Krzyszowski, J., & Kipp, K. (2019). Prediction of Throwing Distance in the Men's Javelin At the 2017 IAAF World Championships. *ISBS Proceedings Archive*, *37(1)*, 344.
- Maciel, B. T., Rodrigues, R., Santos, D., Cordeiro, N., Portella, A., Devson, D., ... Prata, B. (2018). Effects of physical exercise at the workplace for treatment of low back pain: A systematic review with meta-analysis. *Revista Brasileira de Medicina Do Trabalho*, *16(2)*, 225–235.
- Micheo, W., Baerga, L., & Miranda, G. (2012). Basic principles regarding strength, flexibility, and stability exercises. *Pm&r*, *4(11)*, 805-811.
- McKinney, J., Velghe, J., Fee, J., Isserow, S., & Drezner, J. A. (2018). Defining Athletes and Exercisers. *The American Journal Cardiology*, *123(3)*, 532–535.
- Morriss, C., & Bartlett, R. (1996). Biomechanical Factors Critical for Performance in the Men's Javelin Throw. *Sports Medicine*, *21(1)*, 438–446.
- Narkhede, A., Khedkar, S., Kalode, R., Nimje, A., Ramteke, A., Dhapodkar, C., & Waghmare, U. (2025). Javelin throw training machine: a comprehensive Review. *Technological Innovations & Applications in Industry 4.0*, 6-17.
- Oyama, S., & Palmer, T. G. (2023). Effectiveness of core exercise training programs designed to enhance ball-throwing velocity in overhead athletes: a systematic review. *Strength & Conditioning Journal*, *45(2)*, 177-187.
- Roemer, K., Köhler, H. P., & Witt, M. (2018). Influence of Trunk Model DoF on Shoulder Kinematics in Javelin Throwing-A Case Study. *ISBS Proceedings Archive*, *36(1)*, 1004.
- Ruple, B. A., Plotkin, D. L., Smith, M. A., Godwin, J. S., Sexton, C. L., McIntosh, M. C., ... Roberts, M. D. (2023). The effects of resistance training to near failure on strength, hypertrophy, and motor unit adaptations in previously trained adults. *Physiological Reports*, *11(9)*, 1–14.
- Sánchez Pastor, A., García-Sánchez, C., Marquina Nieto, M., & de la Rubia, A. (2023). Influence of Strength Training Variables on Neuromuscular and Morphological Adaptations in Prepubertal Children: A Systematic Review. *International Journal of Environmental Research and Public Health*, *20(6)*, 4833.
- Škarabot, J., Brownstein, C. G., Casolo, A., Del Vecchio, A., & Ansdell, P. (2021). The knowns and unknowns of neural adaptations to resistance training. *European Journal of Applied Physiology*, *121(3)*, 675–685.
- Takanashi, Y., Kohmura, Y., & Aoki, K. (2022). Evaluation of explosive strength ability of the upper body for athletic throwers. *Journal of Human Sport and Exercise*, *17(1)*, 211–224.
- Tauchi-Sato, K., Ozeki, S., Houjou, T., Taguchi, R., & Fujimoto, T. (2002). The surface of lipid droplets is a phospholipid monolayer with a unique fatty acid composition. *Journal of Biological Chemistry*, *277(46)*, 44507–44512.
- Tauchi, K., Murakami, M., Endo, T., Takesako, H., & Gomi, K. (2009). Biomechanical analysis of elite javelin throwing technique at the 2007 IAAF World Championships in Athletics. *Bulletin of Studies in Athletics of JAAF*, *5*, 143–149.

- Trasolini, N. A., Nicholson, K. F., Mylott, J., Bullock, G. S., Hulburt, T. C., & Waterman, B. R. (2022). Biomechanical Analysis of the Throwing Athlete and Its Impact on Return to Sport. *Arthroscopy, Sports Medicine, and Rehabilitation*, 4(1), e83–e91.
- Wei, W., & Yalong, L. (2021). Study on treatment and rehabilitation training of ligament injury of javelin throwers based on sports biomechanics. *Measurement: Journal of the International Measurement Confederation*, 171(4).
- Zouita, A., Darragi, M., Bouselmi, M., Sghaier, Z., Clark, C. C. T., Hackney, A. C., ... Zouhal, H. (2023). The Effects of Resistance Training on Muscular Fitness, Muscle Morphology, and Body Composition in Elite Female Athletes: A Systematic Review. *Sports Medicine*, 53(9), 1709–1735.