Pubmedia Jurnal Pendidikan Olahraga Vol: 3, No 3, 2026, Page: 1-12

The Relationship Between Peak Take-off Force, Maximum Center of Mass Height, and Successful Block Performance in Volleyball Middle Blockers

Rafid Habib Qadoori*, Ahmed Walid Abdulrahman, Safaa A. Ismaeel

[13] University of Diyala
[2] Mustansiriyah University

DOI: https://doi.org/10.47134/jpo.v3i3.2497
*Correspondence: Rafid Habib Qadoori
Email: rafid.habib@uodiyala.edu.iq

Received: 30-01-2026
Accepted: 28-02-2026
Published: 30-03-2026

Abstract: This study aimed to investigate the relationships between peak take-off force, maximum center of mass height, and blocking performance accuracy in volleyball middle blockers under different movement conditions. A biomechanical approach was adopted to analyze two players (youth and elite) using a force platform and motion capture system. Three experimental conditions were applied: static blocking, movement from the right side, and movement from the left side. Peak instantaneous leg force during the take-off phase and maximum center of mass height during flight were measured, alongside block accuracy scores. The results revealed that the elite player demonstrated consistently higher values in peak force, jump height, and blocking accuracy across all conditions. Significant positive correlations were found between peak force and maximum height, as well as between maximum height and blocking accuracy in all tests for the elite player. In contrast, the youth player showed significant correlations only when approaching from the right side, which was attributed to greater force production by the dominant leg, while non-significant relationships were observed in the static and left-side conditions. The findings indicate that peak take-off force is a critical determinant of vertical jump height, which in turn directly influences blocking performance. Additionally, asymmetry in force production between legs negatively affects performance consistency in less experienced players. In conclusion, enhancing lower limb explosive strength—particularly in both legs—is essential for improving jump height and blocking effectiveness in volleyball middle blockers.

Keywords: Volleyball Blocking, Biomechanics, Peak Force, Jump Height, Middle Blocker, Force Platform, Performance Analysis

Introduction

The study and biomechanical analysis of sports skills lead to objective and precise results that contribute to developing skill performance across all individual and team sports and athletic events (Qadoori et al, 2025). Volleyball is a sport with one of the broadest distribution all over the world and now it is as popular as other big sports like football, basketball and handball (Ghanem et al, 2025).

Volleyball has six fundamental skills of which some are offensive, and some defensive. The first line of defense in volleyball is the capability to block and it has a direct impact on whether one is capable of stopping a volley by the opponent and manages to get a direct point (Ismaeel et al, 2020). It is usually done with the swing

sideways, when the player runs along the net as the ball of the opponent approaches him and by changing the playing positions (2, 3, 4), the player prevents the attack. Nevertheless, the skill may also be achieved with no lateral movement, but being stationary (Ismaeel et al, 2025).

The maximum force per instant produced by the legs is among the most important biomechanical variables that performance in this skill during the take-off phase. It aids in moving the body to give optimum vertical height thus making it possible to perform the block better (Hashim et al, 2025). The blocking skill requires training based on modern scientific principles grounded in the results of motion analysis, which aids in detecting technical errors using various measurement devices (Jihad et al, 2025).

Therefore, this study sought to investigate the correlational relationships between biomechanical variables and the accuracy of the blocking skill among (Middle Blocker) players from three different stances (Hamid et al, 2025)

Methodology

Study problem

The research problem consists in the performance of youth (Middle Blocker) players at the stage of official match. One of the factors is their failure to intercept the bunt of the opponent, i.e., to block the ball or slow down its speed. In many cases, the ball slips out of the hands of the players and the other team is credited with a point (Aidan Ghanem et al, 2025b).

In addition, it was noted that majority of the points earned by the opposing team were as a result of position number (3) with the use of a quick attack by the (Middle Hitter). This represents a lapse in performance of the study sample (the Middle Blockers).

As a result, players were followed on the field, and the other important observation was made regarding their skill technique (Ismaeel, 2024). It was observed that there are some players who play better on the right than left and vice versa (Qaduri et al, 2026).

Therefore, this study aimed to investigate the peak instantaneous leg force values during propulsion. This was achieved by using a force platform to detect instantaneous force values when moving to the right, moving to the left, and jumping from a static position while performing the blocking skill (Doyle, 2004). Accordingly, the study examined specific biomechanical variables influencing the success of the blocking skill for (Middle Blocker) players (Nema & Ismaeel, 2022). The analysis of the results aims to

identify deficiencies in skill performance and subsequently propose logical solutions to help counter the quick attack from position number (3).

Research Objectives

1. To determine the value of the peak instantaneous force during the propulsion phase of the take-off when performing the individual volleyball block, on a force platform, with three movement stances.
2. To determine the value of the maximum vertical height of the center of mass of the body during the flight phase performing the individual block, with motion capture and kinematic analysis, of three movement stances.
3. The objective of the study is to establish the accuracy of the individual volleyball blocking of position (3) in three different movement positions.
4. In order to determine the values of the inter-correlational relationships, as per the sequence of variables, between:
   a. The highest instantaneous leg force during the take-off and the highest vertical height of the center of body mass during the flight.
   b. The total maximum vertical height of the body center of mass in the course of the flight and the accuracy of the single block.

Biomechanical Variables of the Study

A. Peak Instantaneous Leg Force during Propulsion in the Take-off Phase

The peak instantaneous leg force during propulsion in the take-off phase was measured directly for the legs from three test stances using a force platform (Ismaeel & Mustafa, 2022). The platform is capable of displaying the values of the instantaneous force applied to it directly on a computer screen, in addition to the time of force onset and its termination. The data can be saved in an Excel file after the completion of the test, separately for each player

(Abood et al, 2024). It should be noted that the unit of measurement for instantaneous force is the Newton (N), and Figure (1) illustrates the force platform used in the study.

Figure 1. Illustrates the force platform used in the study

B. Height of the Body's Center of Mass during the Jump

The maximum height of the body's center of mass during the flight phase was measured by defining a point at the center of mass (the player's torso) and tracking it from the moment of leaving the ground (breaking contact with the surface of the force platform) until the moment the player's hand contacted the ball coming from the opponent's court (Tengman et al, 2024). It is to be noted that, the unit measurement of vertical height is a centimeter (cm). Motion capture and kinematic analysis on KINOVEA software version (2024.1) were used to perform the measurement. The method of measurement is shown in Figure (2) (McGrath et al, 2023).

Figure 2. The maximum height of the body's center of mass during the flight phase

Field Research Procedures: Test Implementation Method

The blocking skill was tested in three experimental conditions which were aimed at simulating certain defensive situations in volleyball (Haug & Pain, 2024). Experimental validity was to be guaranteed, and as much experimental control as possible gained by having all of the attempts executed by a ball-holding device on court of the opponent, as in Figure (3). The condition wise test procedures consisted of the following:

Test One: The gamer stands on the platform and plays the blocking skill in one position without movement, trying to defend the ball of the opponent.

Test Two: The gamer is located next to the platform. When the opponent player comes to execute the spike, the test subject takes a step to the left of the platform and the right foot is on the platform, then the left foot, and then executes the blocking skill.

Test Three: The actor is in the side of the platform. When the opponent player goes to the ball to do the spike, the test subject takes a lateral step towards the platform, steps on the left leg on the platform, then the right leg on the platform and does the blocking skill.

Each test consisted of five attempts. All balls were fixed using a ball-holding device on the opponent's court (Tanaka et al, 2023). The purpose of using this device was to control extraneous variables that could affect the test procedure. During the pilot experiment, we relied on a player to set the balls, and we encountered a problem in positioning the balls correctly opposite the force platform from which the test subject jumps after pushing off the platform. Due to the setter's inability to deliver the balls with high precision in terms of direction and height, a ball-holding device was adopted Ismaeel, S. A. (2024).

Figure 3.

Results and Discussion

Table (1) and Table (2) show the initial data of the biomechanical variables (peak instantaneous leg force during propulsion in the take-off phase, and maximum vertical height of the center of mass of the body during the flight phase) and blocking accuracy of the three movement stances of Player One and Player Two, respectively. Arithmetic means and standard deviations of all variables of the study are also represented in the tables (Ismaeel & Ismaeel, 2015).

On the other hand, Tables (3) and (4) present the results of the inter-correlational relationships between the study variables for Player One and Player Two, separately (Abood et al, 2024).

Table 1.

Shows the raw preliminary results, arithmetic means, and standard deviations of the biomechanical variables and blocking accuracy for Player One – Youth Category

Player One – Youth Category											
Test Three				Test Two				Test One			
Player moving from left side towards platform				Player moving from right side towards platform				Player on platform from static position			
Block Accuracy	Maximum Center of Mass Height in Flight (c m)	Peak Instantaneous Propulsion Force (N)	Trial No	Block Accuracy	Maximum Center of Mass Height in Flight (c m)	Peak Instantaneous Propulsion Force (N)	Trial No	Block Accuracy	Maximum Center of Mass Height in Flight (c m)	Peak Instantaneous Propulsion Force (N)	Trial No
2	0.34	1749	1	2	0.36	1849	1	2	0.32	1618	1
1	0.32	1690	2	3	0.38	1850	2	1	0.28	1483	2
1	0.33	1776	3	2	0.35	1776	3	2	0.3	1655	3
2	0.35	1840	4	3	0.39	1940	4	1	0.29	1568	4
3	0.34	1731	5	1	0.34	1731	5	1	0.3	1537	5
1.80	0.336	1757.20		2.20	0.364	1829.2		1.400	0.298	1572.2	Mean
0.837	0.011	55.854		0.837	0.021	79.961		0.548	0.015	67.392	Std. Dev

Table 2.

Displays the raw results, arithmetic means, and standard deviation of the biomechanical variables and blocking accuracy of Player Two - Elite Category.

Player Two – Elite Category											
Test Three				Test Two				Test One			
Player moving from left side towards platform				Player moving from right side towards platform				Player on platform from static position			
Block Accuracy	Maximum Center of Mass Height in Flight (c m)	Peak Instantaneous Propulsion Force (N)	Trial No	Block Accuracy	Maximum Center of Mass Height in Flight (c m)	Peak Instantaneous Propulsion Force (N)	Trial No	Block Accuracy	Maximum Center of Mass Height in Flight (c m)	Peak Instantaneous Propulsion Force (N)	Trial No

2	0.49	2011	1	3	0.56	2413	1	3	0.47	1911	1
1	0.48	2032	2	2	0.48	1964	2	1	0.39	1607	2
3	0.50	2198	3	3	0.54	2251	3	2	0.45	1841	3
3	0.51	2218	4	3	0.52	2276	4	2	0.43	1790	4
3	0.52	2301	5	3	0.54	2302	5	2	0.41	1743	5
2.40	0.50	2152		2.80	0.528	2241.2		2.00	0.43	1778.4	Mean
0.894	0.016	125.453		0.447	0.030	166.852		0.707	0.032	114.310	Std. Dev

Table 3.
Pearson correlation analysis of Player One- Youth Category movement condition.

Test Condition	Correlation Between Variables	R	P-value	Significance
Test 1 (Static)	Peak Force × Max Height	0.686	0.201	Not Significant
	Max Height × Block Accuracy	0.739	0.154	Not Significant
Test 2 (Right Move)	Peak Force × Max Height	0.940	0.017	Significant
	Max Height × Block Accuracy	0.951	0.013	Significant
Test 3 (Left Move)	Peak Force × Max Height	0.779	0.121	Not Significant
	Max Height × Block Accuracy	0.681	0.205	Not Significant

Table 4.
Pearson correlation analysis of Player Two -Elite Category movement condition conditions.

Test Condition	Correlation Between Variables	R	P-value	Significance
Test 1 (Static)	Peak Force × Max Height	0.977	0.004	Significant
	Max Height × Block Accuracy	0.894	0.041	Significant
Test 2 (Right Move)	Peak Force × Max Height	0.957	0.011	Significant
	Max Height × Block Accuracy	0.885	0.046	Significant
	Peak Force × Max Height	0.939	0.018	Significant

Test Condition	Correlation Between Variables	R	P-value	Significance
Test 3 (Left Move)	Max Height × Block Accuracy	0.884	0.047	Significant

Discussion

Discussion of Player One's Results(Youth Category)

Table (3) reveals that the correlation values between the peak instantaneous force during propulsion in the take-off phase and the maximum height of the body's center of mass during the flight phase were not statistically significant under two conditions: Test One (static position) and Test Three (moving from the left side towards the platform) (Bergamini et al, 2012). This insignificance can be attributed to the relatively low values of peak instantaneous leg force, which adversely affected the strength of this relationship.

Upon examining the mean values in Table (1) for Player One, the average peak force in Test One (static) was 1572 N, while in Test Three (left move) it was 1757 N. Both values are comparatively low (Camomilla et al, 2018). In contrast, the mean force achieved in Test Two (moving from the right) reached 1829 N, where the correlation was statistically significant. This significance in Test Two is likely due to the player generating greater instantaneous force when pushing off the force platform with the preferred or stronger right leg for support and propulsion, compared to the left leg (de Ruiter et al, 2024).

Consequently, it is observed that the values of peak instantaneous force directly influenced the maximum height achieved during the flight phase (Konrad et al, 2024). This height, on its part, influenced the results of block accuracy. Only when approaching the platform on the right side (Test Two), was a significant relationship found, but the relationship was not significant when participants approached the platform in a stationary position and when approaching the platform on the left side (Test One and Test Three) (Tengman et al, 2024).

Discussion of Player Two's Results (Elite Category)

Table (4) indicates that the correlation values between the instantaneous force during propulsion in the take-off phase and the maximum height of the body's center of mass during the flight phase were statistically significant for all three tests (Trowell et al, 2024). This importance is accredited to the supreme values of peak instantaneous propulsion force, and the corresponding means of 1778 N in Test One, 2241 N in Test Two and 2152 N in Test Three (Leabeater et al, 2024).

These strong correlations were dependent on the importance of peak instantaneous propulsion force and peak vertical center of mass height (Haug & Pain, 2024). This then had a direct and positive effect on the correlation between the maximum vertical center of mass height of the flight phase and the blocking accuracy which was also significant in all three tests. Higher jump height gives the player a higher degree of control and time to see the ball and avoid it going to the court (Jones et al, 2023). The comparison of the mean accuracy

scores of the two players is a clear indication of this in Table (2). Player One scored mean of 1.4, 2.20, and 1.80 on the three tests whereas Player Two scored higher at 2.0, 2.80 and 2.40 (Carter et al, 2025).

Moreover, it is clear that Player Two demonstrated higher values in all experimentalized variables: maximum instantaneous propulsion force, maximum flight height and blocking accuracy that ultimately accounts to the improved overall performance results (Aidan Ghanem et al, 2025a).

The difference seen highlights a difference in performance between the key biomechanical and performance variables between an athlete of a youth category (Player One) and an athlete of an elite category (Player Two) (Koyama et al, 2022).

Conclusion

1. In Test Three, Player One (Youth Category) had comparatively low mean values of the peak instantaneous force exerted by the left leg during the propulsion stage of the take-off, and an indirect impact was observed in Test One. In its turn, it led to the insignificant correlation with the peak vertical height of the center of mass of the body during the flight stage. This, subsequently, had an adverse impact on the correlation between maximum vertical height and blocking accuracy that was not significant either.
2. The higher mean values of peak instantaneous force generated by the right leg during the take-off propulsion phase in Test Two for Player One (Youth Category) led to a significant correlation with the maximum vertical height of the center of mass. This subsequently resulted in a significant correlation between the maximum vertical height and blocking accuracy.
3. The high average of maximum instanteous force of both right and left leg of the player two (Elite Category) provided a significant correlation with the maximum vertical height of the center of mass during the flight phase at all the three tests. This, thus, influenced the relationship between maximum vertical height and blocking accuracy in a positive way.

Recommendations

Special training exercises to develop peak instantaneous force of lower limb muscles (right and left legs) are suggested because these muscles are the major determinants of propulsion force when performing jumping. This kind of training should increase the height of the vertical jump (peak height of the center of mass of the body on the flight stage) both at rest and during lateral movements (right and left) thus increasing the accuracy of blocking. Moreover, the periodic monitoring of the instantaneous development of the forces in the lower limbs in the form of regular pre, mid and post testing using force platform and kinematic motion analysis should be included in the future research and practice application to provide objective measurement of the performance improvement especially when it comes to Middle Blocker players. In addition, it is proposed to design special diagnostic tests of the lower limbs, i.e. considering the right and left legs separately using

sophisticated force-measurement equipment that can identify and measure the right and left force imbalances during the propulsion phase of take-off.

References

Abood, J., Mohammed, A. S., Ismaeel, S. A., & Hassan, M. (2024). Predicting Hand Grip Force Based on Muscle Electromyographic Activity Using Artificial Intelligence and Neural Networks. *International Journal of Disabilities Sports and Health Sciences*, *7*, 233–240.

Aidan Ghanem, H., Sadiq, I. J., Al-, B., & Khalaf Haidar, A. (2025a). *The effectiveness of a structured rehabilitation program based on physical indicators in improving neuromuscular function and reducing femoral cartilage degeneration*. *32*(3), 2025. https://www.tpmap.org/

Aidan Ghanem, H., Sadiq, I. J., Al-, B., & Khalaf Haidar, A. (2025b). The Effectiveness Of A Structured Rehabilitation Program Based On Physical Indicators In Improving Neuromuscular Function And Reducing Femoral Cartilage Degeneration Hiba Qasim Hamadi Safaa Abdulwahab Ismaeel. *32*(3), 2025. https://www.tpmap.org/

Bergamini, E., Picerno, P., Pillet, H., Natta, F., Thoreux, P., & Camomilla, V. (2012). Estimation of temporal parameters during sprint running using a trunk-mounted inertial measurement unit. *Journal of Biomechanics*, *45*(6), 1123–1126. https://doi.org/10.1016/j.jbiomech.2011.12.020

Camomilla, V., Bergamini, E., Fantozzi, S., & Vannozzi, G. (2018). Trends supporting the in-field use of wearable inertial sensors for sport performance evaluation. *Sensors*, *18*(3), 873. https://doi.org/10.3390/s18030873

Carter, J., Chen, X., Cazzola, D., Trewartha, G., & Preatoni, E. (2025). Estimation of lower limb joint moments using consumer realistic wearable sensor locations and deep learning–finding the balance between accuracy and consumer viability. *Sports Biomechanics*. https://doi.org/10.1080/14763141.2025.2526702

de Ruiter, C. J., Wilmes, E., Brouwers, S. A. J., Jagers, E. C., & van Dieën, J. H. (2024). Concurrent validity of an easy-to-use inertial measurement unit-system to evaluate sagittal plane segment kinematics during overground sprinting at different speeds. *Sports Biomechanics*, *23*(12), 2757–2770. https://doi.org/10.1080/14763141.2022.2056076

Doyle, T. L. A. (2004). Further Evidence to Change the Medical Classification System of the National Wheelchair Basketball Association. *Adapted Physical Activity Quarterly*, *21*(1). https://doi.org/10.1123/apaq.21.1.63

Ghanem, H. A., Sadiq, I. J., Hamadi, H. Q., Haidar, A. K., & Ismaeel, S. A. (2025). The Effectiveness of a Structured Rehabilitation Program Based on Physical Indicators in Improving Neuromuscular Function and Reducing Femoral Cartilage Degeneration. *TPM - Testing, Psychometrics, Methodology in Applied Psychology*, *32*(3), 574–579.

Hamid, J. A. K., Salama, O. A. I., Sadiq, A. J., Zohear, A., Jasim, T. A., & Ismaeel, S. A. (2025). Three-Dimensional Quantitative Analysis of Kinematic Variables in Discus Throwing Performance. *Journal of Sport Biomechanics*, *10*(4), 310–322. https://doi.org/10.21859/JSportBiomech.10.4.407.1

Hashim, H., Mohammed, S. A., Ali, B. M., Ismaeel, S. A., & Nasir, M. (2025). Biceps and Triceps Muscle Activation Under Progressive Loads: A Study on Functional Symmetry of the Upper Limbs. *Journal of Sport Biomechanics*, *11*(1), 64–78. https://doi.org/10.61186/JSportBiomech.11.1.64

Haug, W. B., & Pain, M. T. G. (2024). Using a simple model to systematically examine the influence of force-velocity profile and power on vertical jump performance with different constraints. *Sports Biomechanics*. https://doi.org/10.1080/14763141.2024.2351615

Ismaeel, S. A. (2024). Comparing the Anthropometric Characteristics and Physical Fitness of the School-Students with High and Low Levels of Physical Activity. *Physical Activity in Children*, *1*(1), 52–57. https://doi.org/10.61186/pach.2024.465559.1014

Ismaeel, S. A., Fenjan, F. H., & Qadori, R. H. (2020). Biomechanical Analysis of Some Variables and EMG of the Muscles during the Performance of the Snatch Lift in Weightlifting. *International Journal of Psychosocial Rehabilitation*, *24*(5).

Ismaeel, S. A., Jihad, M., Ibraheem, S., Aljahni, M., Qaduri, R., & Qasim, F. A. (2025). Transformations in Muscular Mechanical Properties and the Impact of Dynamic Balance on Free Kick Accuracy in Elite Football Players. *Retos: Nuevas Tendencias En Educación Física, Deporte y Recreación*, *64*, 899–904.

Ismaeel, S. A., & Mustafa, N. M. (2022). The Effect of Special Exercises in Learning Some Basic Skills in Volleyball and Some Biomechanical Variables According to Magnetic Resonance Measurements of the Upper Limbs. *European Journal of Sports Science Technology*, *12*(8), 13–20.

Jihad, M. K., Qadoori, R. H., Ibraheem, S., Salh Al Naksh, fakhir A. Q., Ismaeel, S. A., & Aljahni, M. A. (2025). Transformations in muscular mechanical properties and the impact of dynamic balance on free kick accuracy in elite football players. *Retos*, *64*, 899–904. https://doi.org/10.47197/retos.v64.110222

Jones, H. S. R., Stiles, V. H., Verheul, J., & Moore, I. S. (2023). Assessments performed on harder surfaces can misrepresent ACL injury risk. *Sports Biomechanics*. https://doi.org/10.1080/14763141.2023.2223556

Konrad, A., Seiberl, W., Tilp, M., Holzer, D., & Paternoster, F. K. (2024). What to stretch? - Isolated proprioceptive neuromuscular facilitation stretching of either quadriceps or triceps surae followed by post-stretching activities alters tissue stiffness and jump performance. *Sports Biomechanics*, *23*(12), 2798–2815. https://doi.org/10.1080/14763141.2022.2058991

Koyama, K., Furushima, K., Sugano, Y., Niitsu, A., Kodachi, Y., Niino, S., Ueno, M., Takahashi, E., & Adachi, K. (2022). The characteristics of sagittal spinal alignment in standing and sitting position in elementary school students. *Japanese Journal of Physical Fitness and Sports Medicine*, *71*(5), 443–453. https://doi.org/10.7600/jspfsm.71.443

Leabeater, A., Vickery-Howe, D., Perrett, C., James, L., Middleton, K., & Driller, M. (2024). Evaluating the effect of sports compression tights on balance, sprinting, jumping and

change of direction tasks. *Sports Biomechanics*. https://doi.org/10.1080/14763141.2023.2298955

McGrath, J. W., Neville, J., Stewart, T., Lamb, M., Alway, P., King, M., & Cronin, J. (2023). Can an inertial measurement unit, combined with machine learning, accurately measure ground reaction forces in cricket fast bowling? *Sports Biomechanics*. https://doi.org/10.1080/14763141.2023.2275251

Nema, N. S., & Ismaeel, S. A. (2022). The Effect Of Special Exercises In Learning Some Basic Skills In Volleyball And Some Biomechanical Variables According To Magnetic Resonance Measurements Of The Upper Limbs. *Revista Iberoamericana de Psicologia Del Ejercicio y El Deporte*, *17*(3), 143–145.

Qadoori, R. H., Yas, Q., Ismaeel, S. A., & Qadoori, M. (2025). Evaluating Tennis Player Performance Based on Biomechanical Variables Using Multi-Criteria Decision Making Techniques. *Pubmedia Jurnal Pendidikan Olahraga*, *3*(2), 17. https://doi.org/10.47134/jpo.v3i2.2242

Qaduri, R., Jasim, T., Hamadi, H., Ismaeel, S., Shihab, S., & Al-Jahni, M. (2026). Optimizing neuromuscular symmetry through load-progressive closed-chain upper limb training: An EMG-based approach. *JSAMS Plus*, *7*. https://doi.org/10.1016/j.jsampl.2025.100133

Tanaka, T., Hashizume, S., Kurihara, T., & Isaka, T. (2023). Vortex structure and fluid force changed by altering whole-body kinematic parameters during underwater undulatory swimming. *Sports Biomechanics*. https://doi.org/10.1080/14763141.2023.2233466

Tengman, E., Schelin, L., & Häger, C. K. (2024). Angle-specific torque profiles of concentric and eccentric thigh muscle strength 20 years after anterior cruciate ligament injury. *Sports Biomechanics*, *23*(12), 2691–2707. https://doi.org/10.1080/14763141.2022.2054856

Trowell, D., Kenneally-Dabrowski, C., & Bonacci, J. (2024). Effects of running-induced fatigue on joint kinematics and kinetics during overground running: a systematic review and meta-analysis. In *Sports Biomechanics*. Routledge. https://doi.org/10.1080/14763141.2024.2353390

Ismaeel, S. A. (2024). Comparing the Anthropometric Characteristics and Physical Fitness of the School-Students with High and Low Levels of Physical Activity. interventions, 18, 20.

Ismaeel, S., Abdulwahab Ismaeel, S., Habib Kaddouri, R., & Ali Hassan, A. (2015). An analytical study of some kenmatical variables and summit of electrical activity of the striking arm muscles of the straight transmission in tennis. The Swedish Journal of Scientific.