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An analytical study of neuromuscular coupling at maximum load for weightlifters utilizing high-density electromyography of the surface for the snatch lift

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Abstract

this study aimed to analyze the characteristics of the neuromuscular coupling during maximal load performance (100% maximum performance of one-repetition) in the snatch lift among weightlifters, by using a high-density surface electromyography (HD-sEMG). The study adopted a descriptive analytical approach that have a correlational nature which included a sample of 12 weightlifters from the Al-Kadhimiya Sports Club with at least five years of training experience. The electrical activity (of the two main muscles involved in the second pull phase of the snatch lift, namely the vastus lateralis and the gluteus maximus), has been recorded, along with the analysis of motor unit discharge rate and muscle fiber conduction velocity by using an advanced decomposition algorithms. The results showed a strong correlation between the maximum strength and the neural discharge rate in the vastus lateralis muscle, as well as a significant correlation between the fiber conduction velocity in the same muscle and maximum strength (1RM) in the snatch lift. In addition, a moderate correlation has been also observed between the discharge rate in the gluteus maximus muscle and maximum strength, but the conduction velocity in this muscle has not reached the level of statistical significance. However, the main conclusions that have been based on the study's results indicate that neural efficiency, (particularly the regulation of discharge rate with the recruitment of high-threshold motor units during the second pull phase of the snatch lift), represents a fundamental determinant of strength production under maximum loads.

Keywords Neuromuscular coupling, high-density surface electromyography, motor unit discharge rate, muscle fiber conduction velocity.

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Introduction

Performance in Olympic weightlifting is a direct reflection of the functional integration between the nervous and muscular systems, especially when executing a maximum load approaching 100% of the one-repetition maximum (1RM). The ability to produce maximum force outcome from a complex interplay between neural recruitment mechanisms and the mechanical properties of muscle fibers. Neuromuscular coordination indicates the degree of association between neural activity originating from the central nervous system and the resulting mechanical effect in muscle fibers. The effectiveness of signal-to-force conversion is important when discussing muscle movements and neural signals. Research shows that how well neural signals and muscle movements work together is critical when lifting heavy weights. This is because if neural signals and muscle movements are not synchronized, it can affect the amount of force produced. This conclusion was reached by researchers Enoka and Dushato in 2023.

This is closely related to how the motor units behave and how often they send signals to the muscle fibers. To lift the load the body needs to use the high-threshold motor units. The body needs to send signals to these high-threshold motor units often to keep the force at the right level. The neural signals and the muscle movements need to work to make this happen and the motor units play a big role, in this process especially the high-threshold motor units. Studies have found that small changes in how these signals are sent can affect an athletes ability to reach their peak force when trying their hardest (Del Vecchio et al., 2023; Martinez-Valdes et al. 2023).

The speed at which signals are sent through muscle fibers is an indicator of how well the body can transmit electrical signals. This speed is related to the type of muscle fibers the fast-twitch type II fibers, which are very important for producing a lot of force quickly like in snatch and jerk movements. Research indicates that changes, in this speed when lifting loads may show how tired the muscles and nerves are or how well the nerves have adapted in elite weightlifters. (Holobar & Farina, 2023; Negro et al., 2024).
With the technological advancement in measurement tools, high-density surface electromyography has enabled the analysis of muscle electrical activity with high temporal and spatial precision thru the use of multi-electrode arrays and the application of advanced decomposition algorithms that allow for the analysis of each motor unit's behavior individually. This represents a qualitative advancement compared to the traditional analysis of the root mean square of the electrical signal, which does not directly reflect the individual characteristics of the motor units (Farina et al., 2023; Vigotsky et al., 2024).

The study of these variables is particularly important for Olympic weightlifters, as the success of a lift attempt at maximum load depends on the instantaneous integration of the complete recruitment of high-threshold motor units, the high rate of neural discharge, and the efficiency of

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Signal conduction, as well as the precise temporal coordination between neural and mechanical components during the stages of rapid motor performance. Understanding how our muscles and nerves coordinate is crucial if we want to know why some people excel in certain areas while others do not. This is especially evident when discussing individuals who are highly skilled in a particular field، We need to understand what happens in their bodies to enable their exceptional abilities; we look for indicators such as heart rate and other signs of optimal performance. Understanding the interaction between nerves and muscles is key to identifying these signs and discovering what makes someone stand out. Similarly, investigating how the muscles and nerves of weightlifter's function when they lift their maximum weight is of paramount importance.

This is because it can help us learn more about how the brain controls the body when it is working hard, Weightlifters need to use all their strength when they are competing, By using equipment to measure the activity of the muscles we can learn more about how the nerves and muscles work together. This can also help us understand how the muscles are working when they are moving fast. The information we get from this study can be used to help athletes train better and to check if they are getting tired or hurt. It can also help us develop ways to get the nerves and muscles ready for competition. The study of coupling in weightlifters is very useful for athletes who want to be the best. Neuromuscular coupling is very important, for weightlifters. Furthermore, it contributes to supporting local scientific research in the field of strength sports physiology.

The problem of the study lies in the fact that, despite the critical importance of maximum load in determining the performance level of weightlifters, the understanding of the neuromuscular mechanisms accompanying the performance of the snatch and jerk at an intensity of 100% of the one-repetition maximum remains limited, particularly concerning the behavior of motor units and conduction velocity in muscle fibers during dynamic performance. Moreover, the majority of previous studies relied on traditional electrical indicators do not accurately reflect the nature of the neuromuscular coupling under maximum effort conditions. Based on this, the research problem lies in the ambiguity of the characteristics of this neuromuscular coupling in weightlifters at maximum load, and the need to analyze it by using high-density surface electromyography to reveal the patterns of motor unit discharge, and fiber conduction velocity under these conditions.

The research aims to

1. identifying the nature of the neuromuscular coupling at maximum load (100% of the one-repetition maximum) in weightlifters.
2. Analyzing the discharge rate of motor units during maximum load performance using high-density surface electromyography.

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3. Measuring the conduction velocity in muscle fibers during a maximal lift attempt.
4. Determining the relationship between neuromuscular discharge indicators, fiber conduction velocity, and maximum strength (1RM) in the snatch lift.

Research hypotheses

1. There is a statistically significant correlation between neuromuscular coupling indicators measured by high-density surface electromyography (HD-sEMG) and maximum strength (1RM) in weightlifters at maximum load.

2.The indicators of motor unit activity and muscle fiber conduction velocity significantly contribute to the maximum strength level when performing at 100% 1RM intensity.

Methodology

The study adopted a descriptive analytical method with a correlational nature, suitable for the research problem aimed at analyzing the characteristics of neuromuscular coupling during performance at maximum load (100% of the one-repetition maximum) in weightlifters during the snatch, and revealing the relationships between neural variables (motor unit discharge rate, fiber conduction velocity) and the mechanical variables associated with performance.

Research Sample

The research sample consisted of 12 weightlifters from the advanced category of Al-Kadhimiya Sports Club for the 2025/2026 sports season, and they were selected intentionally to align with the study's requirements. It was required that the sample members be:
• They have at least 5 years of training experience in Olympic weightlifting.
• Capable of performing the snatch lift at maximum load in an approved legal manner.
• Free from muscular or neurological injuries during the six months preceding the study.
• Not undergoing any medical or therapeutic rehabilitation programs that may affect neuromuscular activity.

The sample members were informed about the nature of the research procedures and their objectives, in addition, their written consent to participate was obtained, with an emphasis on the confidentiality of the data and its use for scientific research purposes only.

Table 1. *Between The Sample Characteristics in The Variables (Age, Mass, Training Age)*

The variable	mean	SD	Skewness

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Age (years)	23.75	2.14	0.42
Mass (kg)	78.30	6.85	-0.36
Training age (years)	7.25	1.48	0.58

It is clear from Table (1) that the skewness values fell within the range (±1), indicating a moderate distribution and homogeneity among the sample members in the studied variables.

The devices and tools used

1- 20 kg weight plates, 12 pieces.

2- Multiple Olympic weights of (0.5, 1, 1.5, 2, 2.5, 5, 10, 15, 20, 25) kg. In addition to a legal lock weighing 2.5 kg.

3- A platform for performing the snatch lift.

4- Device (HD-sEMG) of U.S. origin

Variables and their operational definitions

- **Neuromuscular Coupling**

It is the integrated functional interaction between the nervous system and the skeletal muscle, which is manifested in the conversion of the neural signal emitted from the central nervous system into a muscular mechanical response that produces force, and It is measured through indicators of motor unit activity, fiber conduction velocity, and neural recruitment efficiency during motor performance.

- **Discharge Rate**

It is the number of nerve impulses fired by the motor unit per unit of time, usually measured in electrical signals per second (Hertz), and it reflects the level of central nervous activity directed toward the muscle during performance.

- Muscle Fiber Conduction Velocity:

It is the speed of action potential transmission along the muscle fiber, measured in meters per second, and represents an indicator of the functional properties of muscle fibers and the level of neural excitability.

- Achieved Maximal Load:

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It is the maximum weight that the player can successfully lift once with correct technical performance, expressed as 100% of the one-repetition maximum (1RM).

The selected muscles in this study are the core muscles, including

1- The quadriceps muscle: specifically (Vastus Lateralis and Quadriceps Femoris)
It is one of the most important muscles in the second pull phase, high in density of type II fibers. Ideal for measuring fiber conduction speed, which is the most commonly used muscle in the global disassembly of motor units.

2- Gluteus Maximus

It is the primary source of hip extension strength, crucial for generating explosive power, reflecting the integration between the central nervous system and the core muscles, and very important for understanding the coupling in the transitional phase from pull to full extension.

The tests used

1- Snatch Test

The snatch test was conducted on the research sample, and through a specific registration form that includes the name of the lifter and the number of attempts (which are three attempts), three attempts were given to each individual in the sample in which The best lift among the three attempts was selected, which is the internationally recognized protocol for selecting the best lift. Prior to the test, the sample members performed adequate warm-up exercises (Omar Khaled, 2014).

2- Muscle electrical activity test (HD-sEMG) (Yasir, O. K., Ali, M. H, 2025)

A high-density surface electromyography (HD-sEMG) multi-channel device was used. The athlete is asked to perform a small jump or a light bar strike before the lift, which shows a sudden spike in the force signal and an EMG spike. The two points are temporally matched during the analysis.

Field experiment procedures

This design is based on the direct measurement of muscle electrical activity using High-Density Surface EMG during the execution of maximum lift attempts in the snatch lift.
The measurements took place in a controlled lab at the Kazimiya Sports Club hall. The conditions for performance like warm-up rest periods and the order of attempts were kept the same for everyone to ensure that outside factors didn't affect the results. Participants did a one-repetition test, which was done according to a set protocol. They lifted weights to their maximum capacity.

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The activity of the quadriceps and gluteal muscles was measured using a device equipped with multiple electrodes. The electrical signals were then analyzed using computer software، This software helped to better understand the motor units, such as how they transmit signals and the speed at which these signals travel through the muscle fibers. The study focused on the quadriceps and gluteal muscles، The results showed how these Muscle performance during weightlifting. Strength was also recorded in kilograms to study the relationship between neurological variables and maximum strength.

The HD-sEMG signals were broken down using an algorithm and motor units were only included if they were broken down accurately at least ninety percent and the signal-, to-noise ratio was good enough to make sure the results were reliable.

The second pull phase of the lift was the part they looked at for electromyographic analysis. This is because it is the part where someone needs the strength and neural recruitment. They defined this phase by looking at the movement of the lift using a speed digital video camera that was placed at an angle to get a clear view of the bars path.

The second pull started when the bar began to speed up after passing the knee level.

This happened when the hip and knee joints changed from partially straight to straight moving fast. The bars explosive acceleration marked the beginning of the pull. It coincided with the hip and knee joints going from extension to full extension quickly.The moment the bars speed increased rapidly after the knee level was key.

The hip and knee joints were transitioning to accelerated extension at this point. The second pull began with the bars acceleration. The hip and knee joints were changing from partial to extension. The bar sped up quickly after the knee level starting the pull. The hip and knee joints moved from extension, to accelerated extension then. The end of the phase was defined at the moment of full triple extension (hip, knee, and ankle) and just before the athlete began to transition under the bar.

The high-density surface electromyography (HD-sEMG) signals were synchronized with the video recording using a common time index within the system. Then, the time-matched window for the second pull phase was extracted to isolate the neuromuscular activity associated with peak performance at 100% of the one-repetition maximum. The movement segments were analyzed by two experienced judges in the field of weightlifting training, and the average time determination between them was adopted.

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The researcher conducted a pilot survey (study or experiment) on a small sample of two quadriceps to ensure the validity of the tests and to identify any errors encountered to avoid them. The pilot survey (study or experiment) was conducted on 8-1-2026 to ensure the preparation of the necessary requirements for the main experiment, including the availability of weights and the supporting team, to address the organizational aspects of the tests, verify the validity of the

laboratory devices and tools, and identify any obstacles that may arise during the experiment.

After completing the pilot survey (study or experiment), the researcher conducted the main tests on 9/1/2026, and he began conducting the tests (maximum strength and high-density surface electromyography) simultaneously, with the specialized team, at three o'clock in the afternoon.

Statistical methods

The researcher used the Statistical Package for the Social Sciences (SPSS) to process the data. The data were statistically processed using descriptive methods (mean, standard deviation), and appropriate significance tests for the nature of the variables, as well as correlation coefficients between neuromuscular coupling indicators in explaining the variance in maximum strength at maximum load, at a significance level of (0.05).

Results

Table 2. *It shows the maximum strength of the snatch lift.*

The variable	Unit	Mean	SD
1RM Snatch	(kg)	118.5	12.7

Table 3. *Indicators Of Neural Activity During The Second Withdrawal Phase*

The variable	Unit	Mean	SD
Discharge rate – vastus lateralis	(Hz)	24.6	3.1
Conduction velocity – vastus lateralis	m/s	4.28	0.41
Discharge rate – gluteus maximus	(Hz)	22.9	2.7

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Transmission speed – gluteus maximus	m/s	4.11	0.36

Table 4. *Correlation Coefficients Between Neural Discharge Indicators And Maximum Strength (1rm) In The Snatch Lift*

The variable	Correlation coefficient (r)	Level of significance
Discharge rate – vastus lateralis	0.71	0.009
Conduction velocity – vastus lateralis	0.64	0.020
Discharge rate – gluteus maximus	0.58	0.040
Transmission speed – gluteus maximus	0.49	0.090

Discussion

Table (2) shows that the maximum strength level in the snatch lift reached (118.5) kg among the sample individuals, reflecting a high capacity of the neuromuscular system to produce maximum strength during a complex and multi-joint motor task. The performance you get in the snatch especially when you are lifting the weight you can really depends on how well you can use the strong muscle fibers and how well the nerves in your body work together to make the muscles work. If you look at what people have written about this you will see that being good at lifting the maximum weight you can is more about your nerves getting better at working together than it is about just building bigger muscles especially for athletes who are already very good at what they do, in the snatch (Negro et al., 2024; Duchateau & Enoka, 2023). The strength that athletes have is really high because their bodies have changed in ways. This is because they have been training for a time. The results show that athletes can move their muscles faster and their nerves can send signals quicker. This is happening because the motor cortex and the pyramidal system in their brains have changed. The motor cortex and the pyramidal system are getting better at working. This means that athletes can lift heavy weights and do it well. The motor cortex and the pyramidal

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system are very important, for strength training. They help athletes generate maximum strength when they are lifting absolute loads.

Table (3) shows that the discharge rate in the vastus lateralis muscle reached 24.6 Hz. The gluteus maximus muscle had a discharge rate of 22.9 Hz. These values indicate neural activity during the second pull phase. The vastus lateralis muscle had a conduction velocity of 4.28 m/s. The gluteus maximus muscle had a conduction velocity of 4.11 m/s. This stage is the demanding, for producing torque. It is also the stage where the bar accelerates or shifts. The motor units increase their firing frequency. This helps to maximize force. The increased firing rate shows this. Del Vecchio et al.

(2023) It has been shown that when muscles fire faster they can produce force quicker. This is really important for things that need to be done and with a lot of power. Also the speed at which signals are sent to muscles is linked to how big the muscle fibersre how many fast-twitch fibers they have. These things are really important for being able to produce a lot of force in a short time like when you are doing something that needs to be done quickly and with a lot of strength. Muscle fiber diameter and the proportion of fast-twitch fibers in muscles are critical, for producing force in a short time. (Vigotsky et al., 2024).

The results of Table (4) The study found a strong link between how fast the muscles in the vastus lateralis fire and how strong someone is. The numbers showed a correlation of 0.71. This was significant at a level of 0.009. In studies about the body and how it works this is thought to be a link. It means that when the muscles fire faster people can lift weight. This is essential for weightlifting، The study also examined the speed of signal transmission in the lateral thigh muscles and found it to be related to a person's strength. The correlation coefficient was 0.64, which is statistically significant at the 0.020 level. This finding is similar to what Duchateau and Inuka reported in 2023, indicating that controlling muscle contraction speed is a way to increase strength in weightlifting. The rate of muscle contraction in the lateral thigh is an important factor in maximal power output in weightlifting, supporting the role of fast-twitch fiber characteristics in enhancing explosive performance. Recent evidence using high-density electromyography (HD-EMG) techniques shows that conduction speed is an indicator of muscle fiber structure and its ability to generate force (Farina et al., 2023).

For the gluteus maximus, a statistically significant, moderate correlation was observed between the rate of release and maximal force, reaching 0.58 at a significance level of 0.040 However, the correlation between execution speed and maximal force did not reach statistical significance, at 0.49 at a significance level of 0.090. This may indicate that the gluteus maximus' contribution during the second pull phase is more closely related to its function in hip extension

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and force transmission, while the vastus lateralis remains more closely associated with torque generation around the knee joint. Current studies analyzing multiple joint tasks suggest that the distribution of muscle contribution varies according to the instantaneous torque requirements at each phase of the movement (Martínez-Valdés and Valla, 2024).

Overall, the correlation values obtained reflect a significant contribution of neural determinants in explaining individual differences in maximal force during the snatch lift. These results suggest that the efficiency of neural signal regulation and the coordination of high-threshold motor unit recruitment during the second pull phase are important factors in force generation under heavy loads. Therefore، mastering this skill depends not on the appearance or size of your muscles, but on how efficiently your brain controls and activates them.

This aligns with what strength and exercise science experts believe about how athletes improve their performance (Negro et al., 2024). In short، our study found that excelling in weightlifting depends primarily on how efficiently your muscles and brain work together during the most crucial part of the lift, especially the ssecond pull phase.

We observed that the speed of your muscle contraction is key to generating significant power when lifting heavy weights. The speed at which signals travel through your muscles is also important, as it demonstrates how efficiently your fast-twitch muscle fibers are working, which enhances performance.

Excellence in weightlifting is not about having big or strong muscles, but about how efficiently your brain controls and activates the right muscles، These findings are consistent with what we know about strength and exercise science, which states that how well your brain and muscles adapt to training is more important than justt your muscular appearance for truly excelling in strength sports.

Conclusions

1. The study results show that the strongest weightlifters at Al-Kadhimiya Club have central nervous system regulation, which is what makes them so strong in the snatch lift not just because they have big muscles.

2. When weightlifters from Al-Kadhimiya Club do the lift, the speed at which their nerves send signals to their muscles especially in the second part of the lift is very important for making a lot of force and this shows how important the nerves are for being strong.

3. How fast the muscles of the weightlifters at Al-Kadhimiya Club work is also important for the lift because it helps us understand why some weightlifters are better than others and it has to do with how each muscle helps with the lift.

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4. The study found that the second part of the lift is very important for using the nerves in the best way so it is a good way to check if a weightlifter is ready to lift.
5. The study results agree with what people think about strength, which's that the best weightlifters have nerves that work very well and this is what makes them so good at the snatch lift.
6. The study shows that how well the nerves work and how fast the muscles send signals are both very important for being strong at the lift especially for weightlifters, at Al-Kadhimiya Club who are trained to lift at their maximum strength.

Recommendations

1. We should do studies that follow people over time to see how their muscles and nerves change when they do types of training like weightlifting، This will help us understand how the nerves and muscles work together when people do exercises.
2. It would be really helpful to use tools like high-density electromyography to see what the muscles are doing when people lift weights، We should also use cameras to see how the body is moving when people do the lift. This will help us understand how the muscles and nerves work together when people lift weights.
3. We need to learn more about the muscles in the back and the muscles that help keep the body stable. These muscles are important because they help people lift weights without getting hurt.
4. We should compare the athletes with the average athletes to see what makes the best athletes so good. This will help us understand what makes someone a great athlete and how we can help other people become athletes too.
5. Coaches should check the activity of their athletes on a regular basis to see if they are getting tired or if they are ready to compete. The neural activity is, like a signal that shows how well the nerves and muscles are working together.

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https://jcope.uobaghdad.edu.iq

References

Ali, H., & Yasser, O. K. (2018). *Antioxidant supply and its effect on concentration of collagen in national league weightlifters' blood*. Journal of Physical Education, 30(2), 379–394. https://doi.org/10.37359/JOPE.V30(2)2018.372

Ali, H., & Yasser, O. K. (2018). *Effect of antioxidants on the achievement level of National Weightlifting League*. *Journal of Physical Education, 30*(2), 395–407. https://doi.org/10.37359/JOPE.V30(2)2018.372

asem, Z. K., & Yasser, O. K. (2024). *Obesity and its relationship with psychological inactivity in female students of the college of physical education and sports sciences*. *Wisdom Journal For Studies & Research, 4*(04), 1411–1419. https://doi.org/10.55165/wjfsar.v4i04.279

Buchheit, M. (2023). Monitoring training status with heart rate variability in athletes. *International Journal of Sports Physiology and Performance, 18*(4), 555–567.

Del Vecchio, A., Negro, F., Holobar, A., & Farina, D. (2023). Motor unit discharge characteristics and their role in rapid force production. *Journal of Physiology, 601*(14), 2921–2936.

Duchateau, J., & Enoka, R. M. (2023). Neural control of muscle force: From mechanisms to performance. *Physiological Reviews, 103*(2), 1257–1320.

Farina, D., Holobar, A., & Negro, F. (2023). High-density EMG and the neural determinants of muscle force. *Exercise and Sport Sciences Reviews, 51*(3), 145–152.

Martinez-Valdes, E., & Falla, D. (2024). Muscle coordination and neural strategies in multi-joint dynamic tasks. *Sports Medicine, 54*(1), 33–48.

Negro, F., Del Vecchio, A., & Farina, D. (2024). Neural adaptations to strength training in advanced athletes. *Journal of Applied Physiology, 136*(2), 215–226.

Saeed, T. A., Yasser, O. K., & Fenjan, F. H. (2020). *The effect of various aerobic exercises on endurance and some physiological variables among fitness training practitioners aged 30–35 years*. International Journal of Psychosocial Rehabilitation, *24*(3), — Retrieved from https://www.researchgate.net/publication/354365668_The_effect_of_various_aerobic_exercises_on_endurance_and_some_physiological_variables_among_fitness_training_practitioners_aged_30_35_years

Vigotsky, A. D., Halperin, I., & Lehman, G. J. (2024). Muscle fiber conduction velocity and its implications for strength and power performance. *European Journal of Applied Physiology, 124*(3), 567–579.

Yasir, O. K. (2014). Exercises with different ranges of motion with significance of electrical activity for muscle in strength with speed of lower limbs for weightlifters of physical strength. *Journal of Physical Education*, *26*(4). Retrieved from https://jcope.uobaghdad.edu.iq

Yasir, O. K. (2025). The percentage of cotinine in the body and its relationship with the level of achievement of the snatch in weightlifting. *Annals of Applied Sport Science*, *13*(3), Article e1514. https://doi.org/10.61882/aassjournal.1514

Yasir, O. K., Ali, M. H., & Alhusseini, A. M. J. (2025). The effect of a nutritional program on the electromyographic activity (EMG) of selected muscles in weightlifters during the snatch lift. *Retos*, *70*, Article 117105. https://doi.org/10.47197/retos.v70.117105

Yasir, O. K., Naji, Z. F., & Mukheef, S. M. (2025). The relationship between essential mineral elements and snatch lift performance in weightlifters: An analytical study. *Annals of Applied Sport Science*, *13*(4), Article e1523. https://doi.org/10.61882/aassjournal.1523

Yasser, O. K. (2021). The effect of a nutritional program on muscle strength and some physical measurements of the quadruple of Kadhimiya Sports Club for weightlifting. *Turkish Journal of Physiotherapy and Rehabilitation*. Retrieved from https://www.researchgate.net/publication/354365668_The_effect_of_a_nutritional_program_on_muscle_strength_and_some_physical_measurements_of_the_quadruple_of_Kadhimiya_Sports_Club_for_weightlifting

Yasser, O. K., Saeed, T. A., & Fenjan, F. H. (2020). The effect of high training stress on each of concentration (blood-urine) on Iraqi national team weightlifters. *International Journal of Psychosocial Rehabilitation*, *24*(4), 9716–9720. https://doi.org/10.61841/35d9yv92