Research Article

Using AI Techniques To Analyze The Kinetic Trajectory Of The Center Of Mass, Displacement And Fulcrum To Perform The Snatch Lift For Young Lifters

Abdul Murtafa Abdul Rissan[1], Nasrallah radhi misjel[2]

[1]College of Physical Education and Sport Science, University of Thi-Qar, Thi-Qar, 64001, Iraq. Email: sportnasrallah@utq.edu.iq

Abstract

The research aims to analyze the center of mass pathway and some biomechanical variables in the abduction lift of young lifters using a platform, due to its importance in diagnosing and improving motor performance. The importance of the research lies in studying the role of the center of mass and fulcrums in achieving dynamic balance and the efficiency of technical performance during lifting.

The researcher adopted the descriptive method using the survey method, and the research population was represented by the four clubs of Wasit Governorate participating in the Iraq Clubs Championship for the year (2025), which are (12) quarters, while the sample consisted of (5) weightlifters within the weight category of (61 kg) who were selected by the deliberate method.

The results showed that there were a deviation and fluctuation in the path of the center of mass during the performance stages, which indicates a weakness in dynamic balance and motor control, in addition to the presence of compensatory movements that negatively affected the motor fluidity and the benefit of ground propulsion.
The researcher concluded that the use of the Open Cap platform provides accurate analysis that contributes to the diagnosis of technical errors and the improvement of the biomechanical performance in the snatch lift of young lifters.

Keywords: Weight lifting, snatch lift, center of mass, biomechanical analysis, open cap.

1. Introduction

Weightlifting is an Olympic sport that requires a high level of compatibility between muscular strength, neuromuscular ability, and precise motor control, especially in the snatch lift, which is one of the most technically and biomechanically complex lifts. This lift involves a series of sequential motor phases that must be performed at high fluidity while maintaining the dynamic balance of the body throughout the lifting path, which makes controlling the path of the center of mass, fulcrum points, and overall displacement of the body variable. Critical to the success of the performance.

The center of mass path represents an important indicator that reflects the efficiency of the lifter's motor regulation, as any inappropriate deviation in this path may lead to loss of balance or increased mechanical load on the joints, which negatively reflects on technical performance and digital achievement. Fulcrum and displacement are also accurate biomechanical indicators that contribute to explaining the nature of the interaction between the body and the ground during the different lifting phases, helping to a deeper understanding of how to achieve optimal performance.

In light of the rapid development of kinetic analysis techniques, modern digital platforms have become an important tool in supporting researchers and trainers with accurate quantitative information that contributes to diagnosing and improving performance. One of these modern tools is the Open Cap platform, which provides an analytical environment that helps in processing biomechanical data more accurately and objectively, enhancing the quality of technical evaluation and data-driven training decision-making.
The importance of this research lies in the fact that it sheds light on the analysis of one of the most important biomechanical variables in the lifting lift, which is the center of mass pathway in young lifters, due to its direct role in determining the efficiency and stability of motor performance. Its importance is also evident in the

employment of the Open Cap platform as a modern analysis tool that keeps pace with the technological development in the field of sports sciences, and provides the possibility of moving from traditional evaluation to accurate quantitative evaluation, which contributes to the development of the training process and raising the level of technical performance of lifters Youth.

1.2 Research Problem

Despite the great importance of the snatch lift in weightlifting and the high accuracy it requires in motor control, the path of the center of mass, and the fulcrum points, traditional training still relies heavily on visual appreciation and personal experience in evaluating technical performance, without the existence of an accurate quantitative analysis that clarifies the nature of biomechanical changes during the different stages of lifting, especially in young weightlifters.

The lack of studies that deal with the analysis of the path of the center of the mass using modern digital analysis tools such as the Open Cap platform represents a scientific gap in the understanding of the motor efficiency of this category, which limits the possibility of developing training programs based on accurate objective data that contributes to improving performance and reducing technical errors.

Therefore, the research problem is the following question:

to what extent can the path of the center of mass in the snatch lift be analyzed using the Open Cap platform, and what is the impact of this on the evaluation and improvement of the biomechanical performance of young lifters?

1.3 Research Objectives

The research aims to:

1. Analyze the path of the center of the block during the stages of the performance of the snatch lift in young lifters using the Open Cap platform
2. Identify the biomechanical changes associated with the different lifting stages (starting, pulling, transitioning, and receiving stages)

2. Research methodology and field procedures:

2.1 Research Methodology:

The descriptive method has been adopted in the survey method to suit the nature of the problem and achieve the research objectives, as descriptive studies contribute to adding real information about the current reality of various sports phenomena that positively or negatively affect sports as a whole, and such information occupies a great degree of importance in the ability to evaluate the current situation, and this may result in either approving it, supporting and supporting it, or proposing new means and methods for development for the better."[(1)]

2.2 Research population and sample

The research population is "the sum of the vocabulary that the researcher aims to study to achieve the results of the study, and he can generalize the results of the study to all his vocabulary",[2] while the research sample represents "a number of individuals or things that are selected according to a certain rule or method from the statistical community that represents this community". Hence[3], the research population represented by the four clubs of Wasit Governorate participating in the Iraqi Clubs Weightlifting Championship for the sports season (2025) was determined. As for the research sample, they were selected by the deliberate method, and they are four (5) weightlifters representing the weight of (55 kg) and they represent (41.55%) of the original population. As shown in Table (1)

Table (1): Shows the details of the research sample

[1]Muhammad Hassan Allawi and Osama Kamel Rateb: Scientific Research in Physical Education and Sport Psychology, Cairo, Dar Al-Fikr Al-Arabi, 1999, p. 132.

(2) Mohamed Abdel Hamid: Scientific Research in Media Studies, 1st Edition, Cairo, World of Books, 2000, p. 130.

(3) Ali Al-Fartousi: Principles of Statistical Methods in Physical Education , Baghdad, Al-Muhaimen Press, 2007, p. 77.

Percentage of Sample	Sample	Weight class	Club Name	t
20%	1	61	Kut	1
20%	1	61	Al, Numaniyah	2
600%	3	61	Powder	3

2.2.1 Sample homogeneity

In order to achieve homogeneity among the members of the research sample, and to avoid the impact of factors that may affect the results of the experiment in terms of the individual differences in the sample, the researcher conducted a homogeneity of some anthropometric specifications and measurements that may have an impact on the results, including (chronological age, training age, mass, and length), and the torsion coefficient was extracted by means of the arithmetic mean, standard deviation, and standard error of the anthropometric measurements to ensure the homogeneity of the sample. The values of all measurements showed the lowest 30%), which indicates the homogeneity of the sample. As shown in Figure (3) and Table (2).

Table (2): Shows the values of the arithmetic media, standard deviations, and coefficient of difference value for a sample of research:

Significance	Divergence coefficient	Standard deviation	Arithmetic mean	Measurements
homogeneous	4.46%	2.66	59.64	Mass (kg)
homogeneous	11.76%	0.52	4.42	Training Age (1 Year)
homogeneous	0.86%	1.52	177.75	Overall Length (cm)
homogeneous	3.82%	0.76	19.87	Chronological age
homogeneous	0.46%	0.43	93.81	Leg lengths
homogeneous	0.97%	0.776	80.02	Arm length

2.3 Aids, tools and assistive devices;

2.3.1 Means of Information Collection:

- Note.
- Personal interviews. (*)
- Arab and foreign sources and references.
- International Information Network (Internet).

The researcher conducted personal interviews with experienced and specialized professors

- Tests & Measurement

2.3.2 Tools and Devices Used:

⦿ Tape measure.
⦿Stationery (papers, pens).
⦿Medical Scale (1).
⦿ iPhone 17 Pro Max (4)
⦿ Mobile Kickstand (4)
⦿ HP Laptop Computer.
⦿ Bodybuilding hall.
⦿ Extra interior lighting for photography.
⦿ Chessboard
⦿ Regular bar with enough different weights

2.4 Field Research Procedures:

These procedures aim to introduce all the procedures completed by the researcher, in order to prepare to collect the necessary data to answer the research objectives and verify the validity of the hypotheses.

2.4.1 Tests and variables used in the research:

2.4.1.1 Achievement test with a snatch lift

- ✓ Test Name: Kidnapping Lift.
- ✓ Purpose of the test: Measurement of the achievement of the hijacking lift.
- ✓ Devices and Tools:

1- Regular iron bar weighing (20) kg.
2- Iron weights of different weights.
3- Wooden platform for performance.

Performance Description: The bar or (weight bar) is placed in front of the lifter's legs horizontally, as the lifter takes the starting position , so the lifter starts by pulling the bar vertically next to the body, passing through the knee, which is called the first pull, then the bar pull is completed until it reaches the top of the thigh, then the lifter increases the force and speed explosively to lift the bar to the maximum possible height, then the body is pulled under the bar very quickly, then the bar lifter receives the bar with arms fully extended above the head (squat position) and then gets up Gradually until it reaches a full standing position with the bar still fixed above the head then joins the feet in a straight line and maintains stability and waits for the referee's signal to finish lifting

- ✓ **Scoring: Scoring the result of the best attempt and the highest possible weight from three attempts.**
- ✓ A fixed weight of (75 kg) was adopted in the snatch lift test for all sample members, in order to ensure the standardization of performance conditions and reduce the effect of load intensity difference on the biomechanical variables under study. The difference in weight raised between players may lead to variation in temporal and kinetic indicators, energy transfer indicators, and all other biomechanical variables.

Fixing the weight at (75 kg) came as a suitable load for the abilities of young players, which achieves two basic conditions: the first is to ensure the success of attempts and reduce the possibility of technical failure during performance, and the second is to unify the external load in order to isolate the differences resulting from the efficiency of motor performance and technique, and not the difference in the amount of weight lifted.

Therefore, the use of a uniform weight in the test contributes to raising the degree of experimental control, and makes the analysis of variables more objective, especially when analyzing the lift phases, their time indicators, kinetics, energy transfer, and other biomechanical variables during performance

2.5 Main experience

The main experiment was conducted on Friday (5/12/2026) after the completion of the reconnaissance experiment and the validity of the devices and tools. This experiment was conducted in the hall of the National Center for the Gifted in Baghdad Governorate. The test was applied to the research sample and with the help of the assistant work team with (3) attempts to lift the abduction. The experiment was filmed using side and front cameras to cover all stages of motor performance.

The cameras were distributed in a way that allows the analysis of the player's technical performance, as two side cameras were placed to track the movement of the main joints during the drag and push stages, and a front camera to track the path of gravity and maintain the accuracy of determining the center of mass, and a rear camera. The place of performance was determined within the approved lifting platform, provided that the implementation is carried out according to the correct technical method for each.

It was also confirmed that the athletes perform the movements legally and within the technical conditions adopted in the sport of weightlifting, with all attempts recorded for the purpose of later analysis using kinetic analysis software.

2.5.1 Videography

In order to analyze biokinematic variables, and in order to arrive at a scientific method for studying these variables, the researcher used videography. Videography is "one of the important means in detecting errors and controlling the convergence or distance of the technical performance levels of the players"[(1). The] researcher used a mobile camera number (3), the first camera was placed vertically on the right side of the lifter, at a distance of (4) meters, and the second was placed vertically on the left side of the lifter, and at a distance of (4) meters, and the third was placed behind The player is at a distance of (4) meters and also vertically, and the height of the cameras from the ground surface is (135 cm), which is the height that ensures the player's appearance from the beginning of the movement until its end.

2.5.2 Calibration using a chess board [(1)]

Calibration with a chessboard is one of the most common ways to ensure accurate 3D motion tracking when using multiple cameras. This procedure aims to define the internal and external parameters of each camera in order to minimize the error of converting two-dimensional dots into three-dimensional coordinates, which is critical when analyzing explosive movements such as netting and snatching.

1- Preparing the chess board

A chess board with equal-sized squares and precisely known dimensions, such as 30 × 30 cm, is chosen. The panel is positioned securely within the performance area so that it is within the field of view of all the cameras used, such as two side cameras and a front camera. It is also important to ensure that there is appropriate and uniform lighting to facilitate accurate recognition of corners and edges.

2- Recording calibration images

The chessboard is moved to multiple locations and angles in front of the cameras to cover the full range of expected action of the movement. Short photos or videos are recorded for each pose, making sure all angles and intersections are clear. Temporal synchronization between cameras should also be ensured to facilitate the identification of spatial relationships between them.

3. Internal Calibration

Chessboard images are used to extract the internal parameters of each camera, which include focal length, center of image, and lens distortion. The system analyzes the intersection points of the chess squares in the different images, and then calculates these values in order to correct for visual distortions in subsequent recordings.

4. External Calibration

This step aims to determine the position and direction of each camera in relation to the overall coordinate system. Using the chessboard as a reference, the spatial position of each camera on the three axes X , Y, and Z is calculated, as well as its direction and rotation in space. This stage is necessary to ensure that the paths of the joints extracted from the different cameras are accurately intersected within a single three-dimensional point.

---

(1) Fouad Tawfiq Al-Samarrai: A Source Previously Cited , 1982, p. 228.

(1) minichino ,joseph howse :learning open cv4 computer vision with python3,3ed,packt publishing ,united kingdom,2020,p150

5. Check the accuracy of the calibration
After the calibration is completed, the re-dropped error is calculated for each chessboard point. This error is preferably within very small limits measured in millimeters, reflecting a high level of accuracy in tracking the movement of major joints such as the knee, hip, shoulder and ankle during motor performance.

6- Applying Calibration to Recording Transactions
After the calibration is completed, the cameras are used to record the kinetic performance of the jerr and snatch lifts. The system converts the two-dimensional coordinates of the articulated points into three-dimensional coordinates using the triangulation feature, where the location of each joint is determined by the intersection of the sight lines issued by the different cameras, while applying correction algorithms to improve the accuracy of the final motor path.

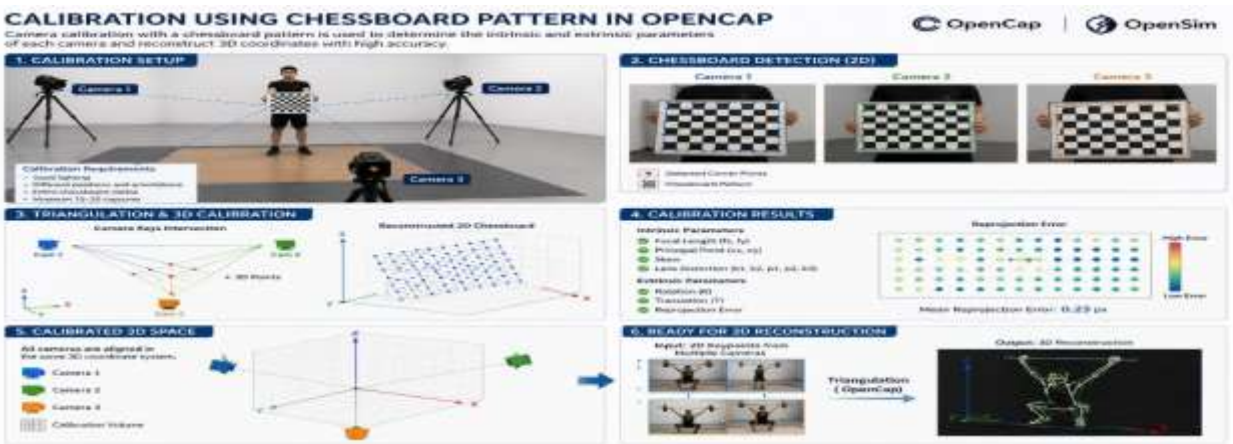

Figure (4): Demonstrates the importance of calibration in motion analysis

2.5.3 Triangulation in OpenCap [4(1)]
Triangulation is one of the basic principles on which OpenCap relies in reconstructing three-dimensional coordinates of kinetic points from two-dimensional data captured by multiple cameras. This property is based on a geometric concept based on locating a point in space through the intersection of sight lines from two or more cameras.

Figure (5):Explains the triangulation property in OpenCap

2.5.4 Steps to Use OpenCap in 3D Motion Analysis [5(1)]

1. Define the objective of the analysis

The objective of the study was to analyze the three-dimensional motion of the nut, snatch, and clean and raised lifts, in order to evaluate the explosive capacity of the lower limbs and the efficiency of neuromuscular coordination during the drag, push and landing phases, as well as to determine the vital performance indicators of each stage.

2- Preparing the imaging system
Three carefully distributed cameras were used, with two side cameras positioned to track the flexion of the joints and force output at the lower extremities, while a front camera was used to track the path of the bar and ensure accurate center of mass identification. The shooting speed has also been set to 120 frames per second to ensure explosive movements are captured with high accuracy, with the athlete wearing tight clothing to minimize tracking errors.

3. Implementation of the registration process
The kinetic performance attempts of the netter and snatch lifts were recorded in a controlled environment, with the

---

(1) Richard hartley ,Andrew zisserman :multiple view geometry in computer vision ,2ed,united kingdom,cambridge university press,2003,p655.
(1) Simon prince :computer vision models and lnference,1ed,Cambridge university,unitedd kigdom2023, p19.

joints being clear at all angles and the cameras in sync to ensure the accuracy of the captured data.

4. Upload data to the program
After the recording was completed, the videos were uploaded to OpenCap for processing and analysis, where the data was prepared for the motor posture estimation stage.

5- Estimation of three-dimensional motor posture
Computer vision and deep learning techniques were used within the software to extract the positions of the body's joints and the path of the center of mass in a three-dimensional manner by converting the 2D data into an integrated kinetic model.

6. Data Purification
Smoothing and filtering techniques have been applied to the extracted data to reduce noise and improve the quality of the kinetic cues, contributing to the increased accuracy of the final results.

7- Calibration procedure
This step included determining the internal parameters of each camera such as focal length and lens distortion, as well as determining the location and spatial orientation of each camera through external calibration, so as to ensure the accuracy of the three-dimensional reconstruction.

8- Applying the Triangulation Feature
Triangulation was used to convert joint coordinates from two-dimensional to three-dimensional by intersecting the sight lines emitted by different cameras, while using debugging algorithms to get the best estimate of joint positions.

9. Data export for advanced analysis
The data were exported in TRC and CSV formats for use in OpenSim software, to perform kinematic and dynamic analysis and extract microvariables such as joint angles, torque, and muscle forces.

10- Extraction of biomechanical variables
A range of important variables were extracted, including joint angles, angular velocities, center of mass acceleration, and ground force, during the pull, thrust and reception phases.

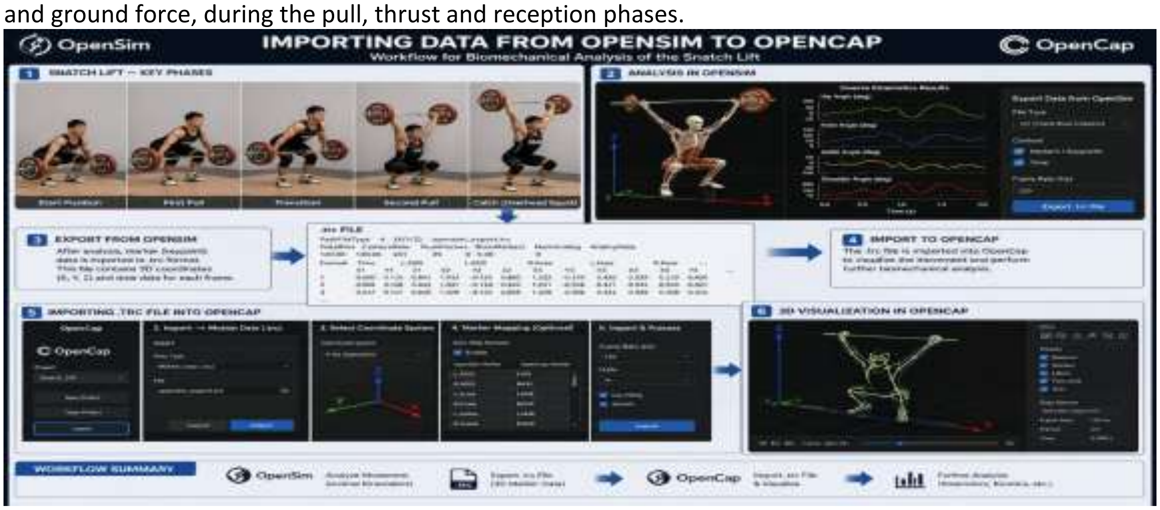

Figure (6): Shows data import from Open Cap to Open SIM

2.6 Statistical Methods:

1- Arithmetic mean.
2- Standard deviation.
3- Standard error.
4- Divergence coefficient

5- Percentage.
6- Kay square
7- Artificial Intelligence Algorithms

3. Present, analyze and discuss the results

3.1. Presentation of the results of the Mass Center, Displacement, and Ground Fulcrum Path

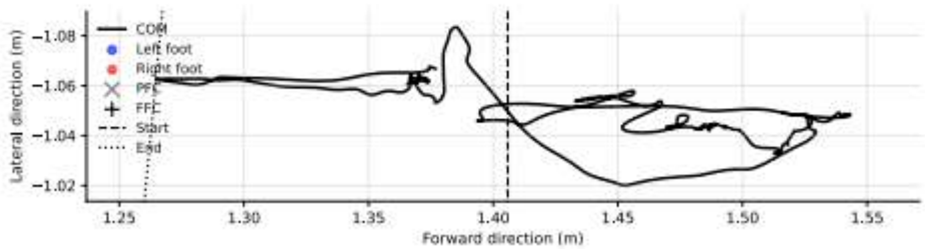

Figure (12): Shows the results of the center of mass, displacement, and ground fulcrums

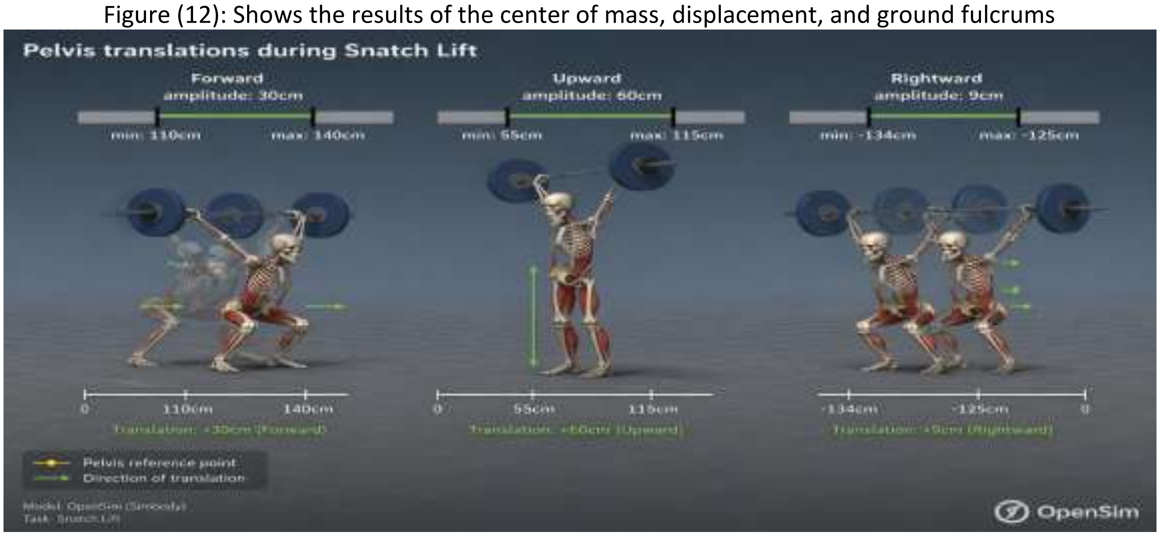

Figure (13): Shows the results of the center of mass, displacement, and ground fulcrums

3.1.2 Description of biomechanical variables [*]

- *Center of Mass Trajectory (COM):*

It is the path taken by the center of mass of the lifter's body during the execution of the snatch lift, and expresses the movement of the body in the space and the extent to which it is stable during the performance.

- **Forward Displacement:**

It is the amount of change in the position of the center of mass forward during the lift of the snatch.

- **Lateral Displacement:**

The amount of change in the position of the center of the block to the right or left during the performance of the snatch lift.

- *Foot Contact Points:*

These are the sites where the feet contact the ground during the performance of the snatch lift, through which the force is transferred from the ground to the body, and are the basis for achieving balance and motor stability.

3.1.3 Discussion of the results

[All] **definitions are taken from the Poen Cap System**

1. Block Center Path (COM Path):

The results showed that the path of the center of mass extended approximately from (1.26 m) at the beginning of the movement to about (1.54 m) at the end of the performance, i.e. with a horizontal range of motion of about (0.28 m). This range indicates the existence of a gradual and balanced forward transition of the center of mass during the stages of the snatch lift, which reflects the player's ability to direct the force smoothly without the occurrence of sharp deviations in the movement path. This range is relatively acceptable in the height of the snatch, because the increase in the forward path is Large leads to the removal of weight from the body and a higher torque on the spine, while a limited range indicates the proximity of the weight to the body and the achievement of higher mechanical efficiency. The continuation of the path within a convergent line of motion indicates good neuromuscular compatibility during the withdrawal and reception phases. Garhammer has pointed out that the relatively short path of gravity and center of mass is associated with increased performance effectiveness and reduced mechanical energy loss during lifting [(1).]

2. Lateral Direction:

The lateral displacement of the center of mass ranged approximately between (-1.08 m) and (-1.02 m), i.e. a lateral range of about (0.06 m). This range is relatively limited, indicating that the athlete maintained good lateral stability during the performance, as small lateral deviations reflect the lifter's ability to stabilize the pelvis and torso and maintain the line of action of the force in a vertical direction. The reduced lateral range also indicates the efficiency of the muscles that stabilize the lower limb, especially the hip and torso muscles, in preventing Lateral tilt during the rapid transition between the intake and reception stages. If the lateral range is greater than that, it may indicate poor motor control or the presence of kinetic compensation that affects the success of the lift. Enoka believes that the relative reduction in lateral oscillation is an important mechanical property for high-level lifters, as it reduces the loss of balance during performance[(2).]

3. Forward Direction:

The results showed that the forward displacement of the movement started at about (1.26 m) and then gradually increased to reach approximately (1.54 m), with a difference of about (0.28 m). This forward transition reflects the player's ability to move the center of mass and weight in a consistent manner during the performance stages, especially after the second pull and entry below the weight. This range indicates that there is a natural forward movement that is compatible with the requirements of the snap lift, because the player needs to reposition the body under the weight during the Reception stage. Staying displacement within this range also indicates that the weight remained relatively close to the body and no excessive forward thrust occurred that could result in loss of lift control. Gourgoulis et al. have shown that maintaining a relatively limited horizontal trajectory is an important indicator of technical efficiency and reduction of torque on the body during the lift of the shovel [(3).]

4. Starting Point:

The starting point appeared at coordinates of approximately (1.26 m) in the forward direction and (-1.06 m) in the lateral direction, indicating that the player started the performance from a relatively stable position prior to the execution of the first pull. This positioning reflects the presence of a balanced weight distribution on the feet, which helps to produce ground force effectively during the beginning of the lift. The result is that the player has a proper foundation that has helped him maintain balance from the start of the lift. Baumann et al. have confirmed that the quality of the initial position directly affects the efficiency of the subsequent drag stages and the success of the full technical performance of the lift [(1).]

5. End:

The results showed that the end point of the movement was approximately stable at (1.53–1.54 m) in the forward direction and within a lateral range of approximately (-1.04 m), indicating that the player was able to finish the

---

[(1)] Garhammer, John. Op. cit .p73
[(2)] Enoka, Roger M. Op. cit ..p412
[(3)] Gourgoulis, V., N. Aggeloussis, P. Mavromatis, and G. Garas. "Three-Dimensional Kinematic Analysis of the Snatch of Elite Greek Weightlifters." Journal of Sports Sciences 18, no. 8 (2000) p362.
[(1)] Baumann, Wolfgang, Klaus Gross, Peter Quade, Peter Galbierz, and Adam Schwirtz. "The Snatch Technique of World Class Weightlifters at the 1985 World Championships." International Journal of Sport Biomechanics 4, no. 1 (1988) p60

performance while maintaining balance after receiving the weight and getting up. The convergence of the end point with the general trajectory line indicates a decrease in motor aberrations after stabilization, which is a positive indicator of the quality of neuromuscular control during the final stage. The limited lateral change at the end is also indicative of the player's success in fixing the weight above the basement without major vibrations. Zatsiorsky believes that endpoint stability is an important indicator of technical proficiency in Olympic lifts, as it reflects the integration of strength and balance during the final weight stabilization (2)

4- Conclusions and recommendations

1- The trajectory shows relative stability at the beginning of the movement, followed by a clear deviation before the moment of change, indicating poor motor control at the critical transition.
2- The presence of a noticeable lateral oscillation of the center of mass indicates an imbalance in dynamic balance and an inefficiency in steering the movement forward.
3- The spacing between the contact points of the feet before and after the change reflects an inaccurate distribution of the steps, which negatively affects the motor flow.
4- The decrease and then rise in the path of the center of mass indicates a partial loss of kinetic energy as a result of poor utilization of ground propulsion.
5- Path widening after the point of change indicates increased compensatory movements, which is evidence of a lack of neuromuscular stability during performance.

1. Focus on dynamic balance exercises to improve control of the center of mass trajectory during motor transitions.
2. Develop the ability to steer movement forward through speed drills with direction control.
3. Train the accuracy of the steps and reduce the spacing between them with motor coordination exercises.
4. Improve the efficiency of ground power investment through repetitive jumping and push-ups.
5. Strengthen the muscles responsible for stability, especially in the lower extremities, to reduce compensatory movements and achieve better stability.

Sources

[1] Muhammad Hassan Allawi and Osama Kamel Rateb: Scientific Research in Physical Education and Sport Psychology, Cairo, Dar Al-Fikr Al-Arabi, 1999, p. 132.
[2] Mohamed Abdel Hamid: Scientific Research in Media Studies, 1st Edition, Cairo, World of Books, 2000, p. 130.
[3] Ali Al-Fartousi: Principles of Statistical Methods in Physical Education, Baghdad, Al-Muhaimen Press, 2007, p. 77.
[4] minichino, joseph howse: learning open cv4 computer vision with python3,3ed, packt publishing, United Kingdom,2020, p150
[5] Richard hartley, Andrew zisserman: multiple view geometry in computer vision ,2ed, united kingdom, Cambridge university press,2003, p655.
[6] Simon prince: computer vision models and lnference,1ed, Cambridge university, united kigdom2023, p19.
[7] Gourgoulis, V., N. Aggeloussis, P. Mavromatis, and G. Garas. "Three-Dimensional Kinematic Analysis of the Snatch of Elite Greek Weightlifters." Journal of Sports Sciences 18, no. 8 (2000) p362.
[8] Baumann, Wolfgang, Klaus Gross, Peter Quade, Peter Galbierz, and Adam Schwirtz. "The Snatch Technique of World Class Weightlifters at the 1985 World Championships." International Journal of Sport Biomechanics 4, no. 1 (1988) p60
[9] Ztsorsky, Vladimir M., and William J. Kraemer. Science and Practice of Strength Training. 2nd ed. Champaign, IL: Human Kinetics, 2006. p1

(2) Zatsiorsky, Vladimir M., and William J. Kraemer. Science and Practice of Strength Training. 2nd ed. Champaign, IL: Human Kinetics, 2006 .p189.