

## Biomechanical characteristics of snatch lift for Egyptian women weightlifters in 81 kg category

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### Abstract

**Objectives:** Improving the technical performance of classic lifts is a fundamental goal in weightlifting training. This enhancement is crucial because it allows weightlifters to lift heavier weights with less effort by optimally using their strength and speed. Many weightlifting coaches focus on designing training programs and developing technical exercises aimed at increasing strength and speed, with the aim of transferring them to the bar in a short period of time to activate its role in the implementation of technical performance and enable the player to control the movement of the bar during the lifting stages, especially in the snatch lift, which is the most difficult movement performance in lifting Weights, as it aims to raise the bar from the ground to the maximum extension of the arms above the head without stopping, which requires the player to perform the performance as quickly as possible in addition to coordinating the movement between the movement of the bar and the movement of the player's body. Although the technical performance of the classic snatch lift is performed by almost all weightlifters around the world in the same manner (full squat), there are many technical differences in the method of implementation and the optimal use of strength and speed. This is confirmed by the results of many scientific studies in weightlifting. Therefore, the idea of this research emerged to identify the kinematics of the snatch lift among weightlifters in the 81-kilo category, as they are the closest players to international and Olympic numbers. This research evaluates technical movement characteristics observed in natural classification 81 kg women weightlifters at their competitive best during snatch lifts in Egypt's Republic of Arab (2023-2024 sports season). **Methods:** The research utilized descriptive investigative methods in combination with survey techniques targeting specific athletic participants from weightlifting competitions of the Republic Championship in 2023-2024 to obtain data from 6 weightlifter athletes since this weight category presented limited athletic excellence. **Results:** This research employs seven stages from its reference model to determine quantitative values for kidnapping lift main stages timings, offsets, and speeds throughout all player executions. Players utilize different bar paths, yet the average calculated metrics match those of the reference model investigated here. **Recommendations:** More studies must be conducted with new samples to determine structural distinctions regarding the kinematic and kinetic properties among classical rise performers. Team training should emphasize student-specific programs established according to individual skill capabilities alongside technical performance traits. Comparison of the Egyptian digital levels and the global levels in the technical aspect, biomechanical.

**Keywords:** Snatch Lift, Bar Path Line, Kinetic Analysis, Biomechanical variables, athletes

### Introduction

Weightlifting athletes and coaches now benefit from modern technology, which helps them track performance and develop better skills. Current technology tracks athlete performance to show clear strengths and weaknesses so proper training can focus on improvement areas. Coaches gain precise insights about athlete performance by tracking real-time data of their moves and actions to create better coaching feedback. According to Wijaya et al. (2024), athletes can enhance their techniques by using advanced tools for isolated training experiences. Technique improvement and error fixing become easier when we study lifting movements in detail (Zavydivska et al., 2024). New ways to rank athlete performance based on body weight and gender help create fair competition and better team selection methods (Huebner & Cole, 2024).

Weightlifting continues its important position in Olympic history because Egypt influenced its transformation and success. Egypt has become a successful weightlifting nation since 1896 by earning 14 Olympic medals despite major sports development changes. Egypt maintains its 16th position among weightlifting nations through proven methods of athlete development plus effective body management and performance strategy. Research on weightlifting competition shows patterns that help predict future success at the Olympics. The 2023 World Championship featured 200 elite weightlifters in a study where Oleshko et al. (2024) found age at maximum strength and best training approaches shape their success rate. Egypt's

weightlifting success shows how global standards and worldwide weightlifting competition continue to grow more difficult (Oleshko et al., 2024). Researchers now focus more heavily on weightlifting by studying body movements, prevention of injuries and mental performance. Research from Kumar and Choudhary in 2024 sheds light on weightlifting as a sport with many aspects while showing how it changes over time. The path to becoming an elite weightlifter requires a total assessment of personal features that combines age information with body traits and personality attributes. The full system supports talent recognition and athlete skill development (Anderson et al., 2022). Athletes need to control their weight to win in weightlifting because they want to compete in lower-weight divisions. Athletes use persistent and short-term weight loss approaches, although female weightlifters usually employ both long-term diet management and consult professional dietitians. Egypt's success in world weightlifting depends on mastering both periodization and weight management methods (Cox et al., 2024).

Competing in Olympic weightlifting requires both strong physical abilities plus accurate execution in the snatch and clean and jerk lifts. Weightlifters need to develop powerful movements fast while strengthening proper muscle control to succeed. Research findings reveal the lower-body explosive power's importance in Olympic weightlifting and demonstrate that snatch pull and clean pull exercises well track both lift success (Sandau & Kipp 2024). Studies show that squats are essential for weightlifting success because 1RM squat strength correlates very strongly from 0.93 to 0.94 with overall lifting performance per Joffe et al. 2022. Elite athletes need to master exact leg-bending angles and controlled bar speeds to do their lifts effectively, according to expert research. The work of Sandau & Granacher (2020) demonstrates that training plans matched to individual needs help athletes lift better during different snatch positions while load impacts bar speed in the snatch lift.

This study focused on the snatch, You can break down snatch into these five parts: first pull, transition, second pull, turnover, and recovery (Korkmaz, S., & Harbili, E., 2015). Research shows that successful snatch performance depends on how fast the weight moves combined with its force output. Snatch performance success depends on reaching high barbell velocities together with strong force outputs (Ang CL, Kong PW. 2023). Better performance in both force application and speed generation results in enhanced power production due to the equation for power. The sport of weightlifting demands fast bursts of force, which is why power measurements help estimate lifting performance (Taber, Christopher MS. et al. 2016). A sports science lab's record of power output helps us understand weightlifting performance results (Ang CL, Kong PW. 2023). Researchers use kinematic analysis to study weightlifting biomechanics, which helps athletes improve their performance using better lifting methods (Lyons et al. 2017). Weightlifters who make it to the top level perform their second pull movement during the snatch at 1.90 m/s, according to studies done by Cao et al. (2022). Experts use barbell trajectories to rate a person's snatching capability by detecting differences between ascent and descent stages. Different gender groups and weight classes perform weightlifting exercises better with customized training methods (Oleshko et al., 2023). Technical testing equipment now lets experts measure body movement as athletes perform daily activities in real-world settings. The system provides quick results and pinpoints technical errors (Ang and Kong., 2023). Coaches use kinematic data to create specialized workouts that correct athletic technique issues, improving athletic results (Chavda et al., 2021). Scientists now study weightlifting techniques by combining multiple measuring tools that assess barbell and human body positions plus leg joint movements (Nagao H. et al. 2019). Cartesian coordinate system tests from Nagao H. et al. (2019) revealed that barbell height and speed determine weightlifting snatch results. Research teams worldwide have used kinematic methods to study snatches (Nagao H. & Team 2019; Nagao H. 2020) before measuring final snatch weights (Cunanan et al. 2020, Cao et al. 2022).

Research by Abdel-Reda, (2023), Cao W. et al. (2022), Cunanan, et al. (2020), Nagao, H. et al. (2020), Cunanan AJ. et al. (2020), Nagao H. et al. (2019), Ulaeanu et al. (2016), Korkmaz & Harbili, (2015) supports the essential role of explosive power and speed in addition to technical. During the initial pull phase, barbell lifters need to use their maximum force to perform liftoff from ground contact. Research reveals the first pull phase to be longer than other stages, demonstrating its critical nature. The transition between first and second pulls demands optimal flexibility in order to succeed. When athletes maintain their speed along with control, they ensure proper transitions between the first pull and maximum stretch of the second pull. At the grip phase, successful lifters demonstrate placement under the bar based on agility and timing skills that enable prime bar stabilization prior to contact. When biomechanical errors exist, they will inevitably lower athletic performance. Biomechanical issues emerge because of insufficient training and improper lifting techniques so athletes require continual skill growth alongside quantitative assessment of motions to enhance lifting capability. The researcher believes that the player's self-feedback process about their movement performance, as well as what they are receiving from the coach, may not be sufficient to provide conscious guidance on objective movement indicators, as it has become necessary, but imperative, that the technical information about the motor performance that the coach gives the player contains quantitative values about the biomechanical changes that directly affect the correction of errors and increase the ability to coordinate the forces that cause the correct movement of the elevator. The researcher sensed an analytic interest in fundamental weightlifting biomechanics that foster peak weights during Overcoming snatch lifts to optimize overall performance while examining differences through their training roles as weightlifter and movement science specialist and Egyptian

Weightlifting Federation technical director. Each player can perform at any intensity level under individual testing conditions, enabling coaches to improve performance levels toward reaching global and Olympic success at 81 kg by Egyptian lifters who compete near world and Olympic standards during the 2024 Paris Olympics. Figure 1 shows the theoretical model of the barbell trajectory in snatch.

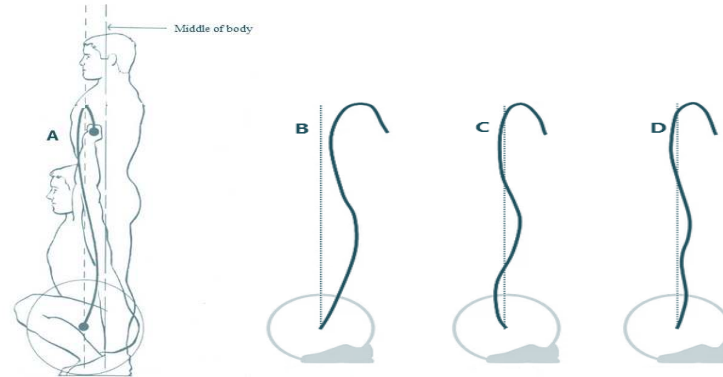


**Figure 1.** Theoretical model of the Barbell Trajectory in snatch. Figure redrawn and adapted from Cunanan, et al. (2020) and Hiskia (1997).

#### **Aim of Study:**

The research investigates bar movement kinetic path biomechanical characteristics in the snatch lift method while determining the skill's kinetic execution stages. Calculates the standard values of basic biomechanical data from the snatch lift skill.

#### **Search questions:**

1. How many levels of the kinetic power of the snatch lift are in the test sample?
2. What is the meaning value of the examined biomechanical variables for the abduction elevator of the test sample?
3. What are the linear kinematic properties of the beam in the snatch lift of the research sample?

#### **Materials and Methods**

##### **Participants**

The research community includes female weightlifters across the period (2023-2024) who are members of the Egyptian Weightlifting Federation in the Arab Republic of Egypt. The study adopted a descriptive method to utilize an intentional sampling method that included the selection of female weightlifters weighing 81 kg who competed in the first republic division championship and achieved rankings from first to sixth place. The total number of participating female athletes reached only Six. The participants in this study were the best six female players in Egypt in the weight of 81 kg with the following characteristics: The study participants had a mean age of  $22.035 \pm 1.33$  years along with a mean height of  $166.2 \pm 0.35$  cm and a mean Body mass of  $80.75 \pm 1.77$  kg with a mean Snatch Result of  $109.50 \pm 2.75$  kg. These players represent Egypt's top players, so they create an ideal selection based on their Olympic Paris 2024 Games readiness. Table 1. Shows the descriptive data for the research participants.

**Table 1. Sample characteristics.**

| Subjects | Age   | Height (m) | Body mass (kg) | Snatch Result |
|----------|-------|------------|----------------|---------------|
| 1        | 22.41 | 165        | 80.8           | 110           |
| 2        | 22.53 | 169        | 81.7           | 112           |
| 3        | 22.82 | 167        | 80.8           | 110           |
| 4        | 23.9  | 167        | 79.9           | 110           |
| 5        | 22.83 | 168        | 80.7           | 100           |
| 6        | 21.77 | 166        | 79.8           | 115           |
| Mean     | 22.71 | 167        | 80.62          | 109.50        |
| SD±      | 1.33  | 0.35       | 1.77           | 2.75          |

##### **Devices and utilities for data collection**

We used a calibrated medical scale to measure weight in integer kilograms and a restameter to measure height in centimetal segments. The inclusion of reflective stickers illustrates particular bar positions along with indicators for 15 important body points of the player. Competitive weightlifters employ this set for their weightlifting competitions. Panasonic video cameras (CCD 100X) operated at 50 units/second with tripods supporting water-balanced camera setups for the data collection on an 8.3D MaxTraq 2.2 PC-based system analyzing motion data, and (2 \* 1 \* 2) dimensions defined by the calibration equipment. 10. USB with a size of 256 GB.

### Data Collection

The performance of lifts at both events utilized a GoPro HERO4 Black digital video camera (San Mateo CA USA) operating at 720p resolution (1280 by 720 pixels (px)) with a 240 fps recording speed. Camera positioning followed recommended parameters to reduce errors in barbell kinematic measurements recorded along the barbell's sagittal axis (Cunanan AJ. Et al. 2020). A tripod position was selected so that the camera faced competition proceedings but maintained positions 15 m and 11 m from the left end of the platform. The GoPro camera operated from 0.71 meters above the platform surface, directly in front of and running parallel to its central point.

### Video Analysis

An analysis of video data occurred through Kinovea software version 0.8.27 from the Kinovea open-source project. The working area within the software was set to 400% zoom to enhance precision when users placed markers and performed distance measurements. Displacement data for the barbell was measured using Kinovea's automatic tracking feature by positioning a digitized marker at the center point of the barbell before the lift-off. Recorded data points were in px. Raw data were converted from px to cm using a respective scaling coefficient (WWC: 0). The barbell movement data underwent 20-point moving average smoothing after transforming pixel units (px) into centimeters (cm) using distinct scaling coefficients for WCCs ( $0.71 \text{ cm}\cdot\text{px}^{-1}$ ) and PAWC ( $0.67 \text{ cm}\cdot\text{px}^{-1}$ ). The experiment outcomes were extracted from the processed data after smoothing.

### Basic Experimental Procedures:

A preliminary research test in the weight room took place on December 22, 2023. Researchers used this initial assessment to determine the suitability of the controlled conditions in the weight room for future experiments. During this preliminary testing phase, both research assistants learned about the experiment procedures that they would execute during the main research phase. The researcher finalized the exploratory study objectives and then scheduled collaboration with the Tala'ea El-Geish Club technical director and the Egyptian Weightlifting Team technical director to film and prepare participants between January 3 and January 10, 2024. The athletes completed their six attempts by following this advancement order: (80% - 85% - 90% - 95% - 100% - 110%) based on the maximum lift reached during the snatch technique. The researcher processed the research sample's attempt data on the computer platform for sequence numbering and preparation of player videos according to analysis needs.

### Calculating the biomechanical variables under study:

The investigation measured both the number of fundamental components and the duration of significant phases during the snatch performance.

- Time of each stage of the basic performance of the snatch lift
- Angular velocity of the primary joints (ankle, knee, and thigh) in the snatch lift

Snatch lift measurements include main joint angular displacements from wrist to knee to thigh as well as work and kinetic energy expenditure from first pull to second phases.

- Kinematic variables of the plan for the bar in the snatch lift.

### Statistical treatments of research variables:

Statistical processing for research data involved the SPSS 26 program that computed mean and standard deviation and graphical displays of research variables.

### Results

Table 2. Presents details about the movement patterns in snatch lifts combined with temporal information related to a successful implementation of the skill and barbell velocity measurements. During the snatch movement, the barbell velocity changes can be visualized to reflect the barbell's kinematic performance. M1 represents the barbell's journey until the barbell reaches its initial maximal knee joint angle from the starting position. The first segment (M1) in Figure 2 signifies the full extent of knee motion from starting to finishing positions, with M2 used to show this entire motion between knee maximum and minimum points. M3 through M6 illustrate the path of the barbell for squats as seen in Figure 2.

**Table 2. Phases and time instants for analyzing the snatch.**

| No. | Phases in Snatch        | Time and critical moments in Snatch                              |
|-----|-------------------------|------------------------------------------------------------------|
| 1   | First pull              | Barbell liftoff (1)                                              |
| 2   | Transition              | First maximum knee extension (2)                                 |
| 3   | Second pull             | Maximum knee flexion (bar max Vv) (3)                            |
| 4   | Turnover                | Bend knees for an extended speed after achieving full access (4) |
| 5   | Catching and Absorption | Control of the bar and absorption of movement (5)                |
| 6   | Fixation                | Put the bar on your arms as you squat (6)                        |
| 7   | Stand                   | Leave your squatting stance to rise for snatches (7)             |

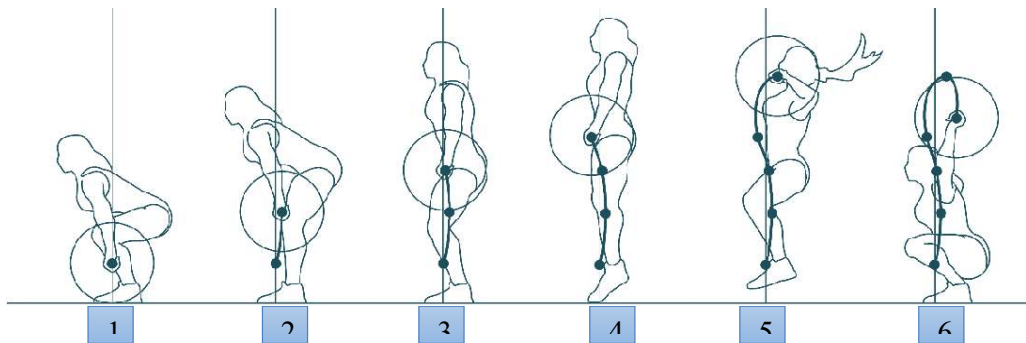


**Figure 2.** Phases and time instants for analyzing the snatch

The value of the averages of the biomechanical variables under investigation for the levity of the snatch of the research sample. Table 3 displays a detailed analysis of research participants' snatch height technical stages at their individual group level. Research participants performed their first draw in ( $0.52 \pm 0.15$ ) seconds before completing the crossing to knee at ( $0.20 \pm 0.30$ ) seconds. During figure 3 performance, participants took ( $0.17 \pm 0.22$ ) seconds to perform their second pull, followed by ( $0.25 \pm 0.18$ ) seconds to perform their average turning and immersion phase, then ( $0.27 \pm 0.16$ ) seconds for their holding and stabilizing phase.

**Table 3. Time Phases analysis**

| N | Parameters  | MU | X    | SD±  |
|---|-------------|----|------|------|
| 1 | first pull  | s  | 0.52 | 0.15 |
| 2 | transition  | s  | 0.20 | 0.30 |
| 3 | second pull | s  | 0.17 | 0.22 |
| 4 | turnover    | s  | 0.25 | 0.18 |
| 5 | catching    | s  | 0.27 | 0.16 |

X = Average, SD± = Stander deviation

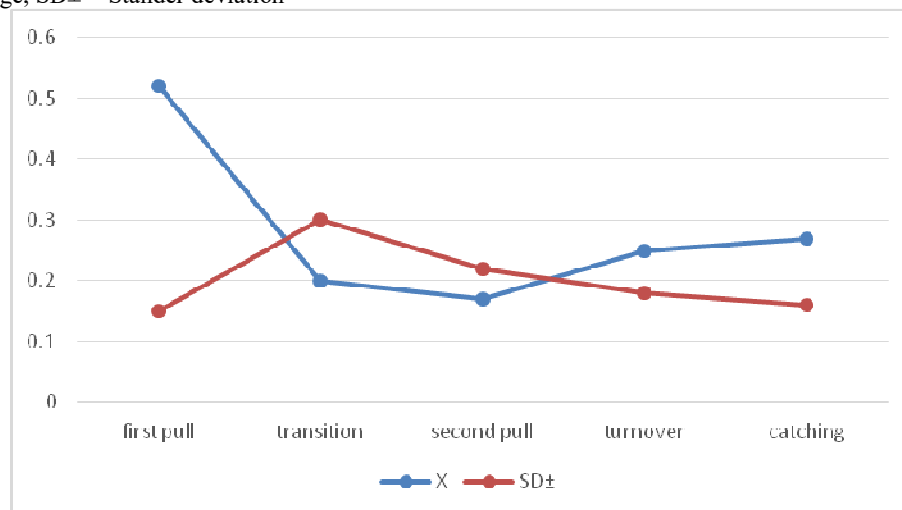


**Figure 3.** The insights in this data set reveal the mean values together with standard deviation measurements for biomechanical variables found in the snatch moment within the study group.

### Angular Kinematics

Table 4 displays the average angular velocities of major joints during the lift snatch movement. The first pull of the lift snatch movement showed ankle velocity at 74.2 d/s while the knee reached 228.4 d/s and the hip sustained 163.3 d/s angular velocity. The ankle displayed 236.4 d/s angular velocity, the knee showed 333.6 d/s, and the hip demonstrated 336.5 d/s in the second pull of a single trial. The first pull phase showed an ankle angular displacement of 128.4 d/s, which gradually transitioned to knee displacement of 146.5 d/s before arriving at hip displacement of 106.7 d/s. The joint angles in the second pull showed that the ankle reached a maximum of 147.1 d/s while the knee angled to 165.7 d/s and the hip extended to 195.2 d/s. This study presents these findings through research sample figure 4.

**Table 4. Angular velocity and angular displacement of joints (ankle- knee- hip) in the first and the second pulls**

| N | Joints | mu   | Angular velocity |     |             |      | Angular displacement |     |             |     |
|---|--------|------|------------------|-----|-------------|------|----------------------|-----|-------------|-----|
|   |        |      | First pull       |     | Second pull |      | First pull           |     | Second pull |     |
|   |        |      | X                | SD± | X           | SD±  | X                    | SD± | X           | SD± |
| 1 | Ankle  | °. s | 74.2             | 6.1 | 236.4       | 9.8  | 128.4                | 7.4 | 147.1       | 5.3 |
| 2 | Knee   | °. s | 228.4            | 8.9 | 333.6       | 8.3  | 146.5                | 9.2 | 165.7       | 3.6 |
| 3 | Hip    | °. s | 163.3            | 9.7 | 336.5       | 10.7 | 106.7                | 7.1 | 195.2       | 4.7 |

\* X = Average, SD± = Stander deviation

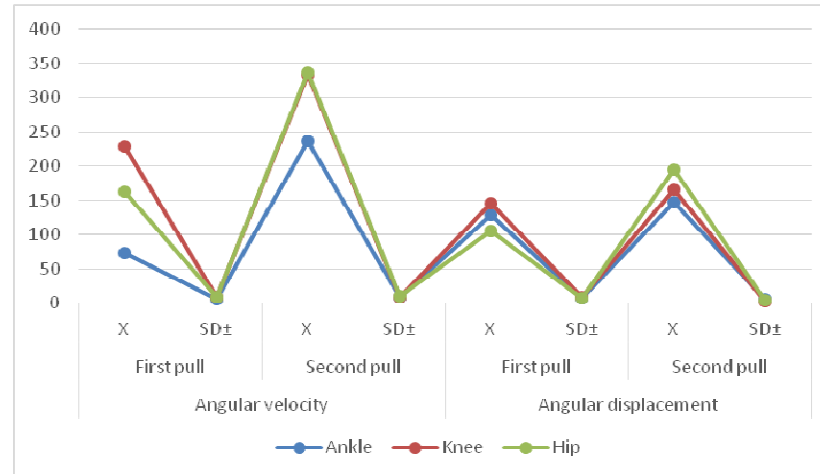


**Figure 4.** Angular joint velocities at ankle, knee, and hip are included in the data for both the first and second pulls.

Results of absolute and relative power work and kinetic energy measures in the snatch lift appear in Table 5 among the research participants. Researchers recorded absolute power values at  $(1042.3 \pm 12.7)$  watts/kg for the first pull phase, followed by  $(2844.7 \pm 12.6)$  watts/kg in the second pull stage among the participants in the study. The absolute power in the first pull was  $(1042.3 \pm 12.7)$  watts/kg and in the second pull  $(2844.7 \pm 12.6)$  watts/kg. Data shows the first push produced relative power of  $6.84 \pm 2.12$ , whereas the second push produced relative power of  $18.9 \pm 1.44$  and absolute work of  $554.4 \pm 12.6$  for the first push and absolute work of  $378.5 \pm 9.6$  for the second pull (Figure 5).

**Table5. Power output and Mechanical work in first and second pulls of snatch**

| N | Variables            | First pull |      | Second pull |      |
|---|----------------------|------------|------|-------------|------|
|   |                      | X          | SD±  | X           | SD±  |
| 1 | Absolute power (w)   | 1042.3     | 12.7 | 2844.7      | 12.6 |
| 2 | Relative power (kg)  | 6.84       | 2.12 | 18.9        | 1.44 |
| 3 | Absolute work (J)    | 554.4      | 12.6 | 378.5       | 9.6  |
|   | Relative work (J.kg) | 3.77       | 1.52 | 2.62        | 1.49 |

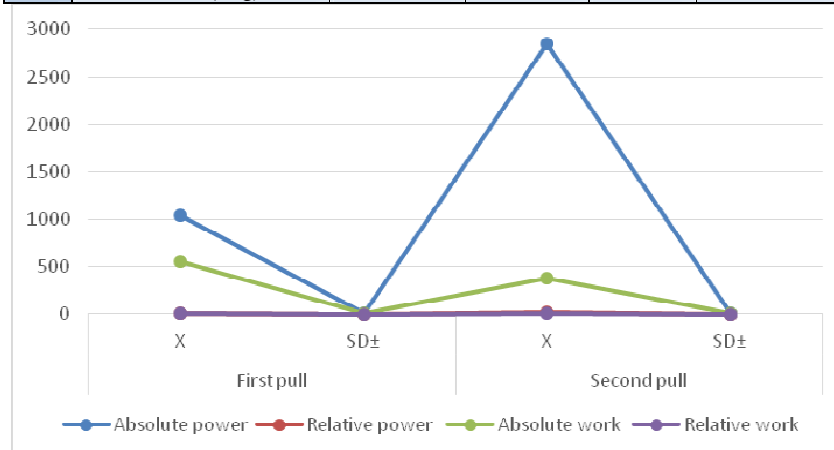


**figure 5.** The provided data comprise power output measurements and mechanical work assessments for the first and second pull movements in the snatch.

The linear barbell movement during the snatch appears in Table 6 alongside key aspects of Olympic lifting along with supporting variables. The motion analysis system indicated barbell heights at 0.54 m during the first pull and 0.95 m during the second pull while demonstrating improved barbell elevation ability thanks to large-generated forces by athletes. Technique along with optimal force production attained a barbell elevation of 1.08 m. During descent, the negative gravitational rattle measure stands at 0.20 meters while vertical velocity oscillations achieved 1.88 m/sec and 1.87 m/sec during the initial and subsequent barbell pulls, indicating improved acceleration needed to maintain flight throughout the lift motion. The pull phase toward the athlete resulted in horizontal movements of 2.77 cm in the first pull followed by 2.23 cm in the second pull, thus indicating both reduced movement and exceptional stability throughout the transition, which indicates a slight reduction without compromising transition stability. Vertical displacement data points to the need for barbell control after reaching peak elevation, as measurements show the barbell extended to 3.18 cm upwards.

**Table 6. Linear kinematics of the barbell in snatch**

| N | Variables of Linear kinematics of the barbell in snatch                              | MU  | X    | SD±  |
|---|--------------------------------------------------------------------------------------|-----|------|------|
| 1 | Barbell height at the end of first pull                                              | m   | 0.54 | 0.13 |
| 2 | Barbell height at the end of second pull                                             | m   | 0.95 | 0.22 |
| 3 | Maximal height of barbell                                                            | m   | 1.08 | 0.15 |
| 4 | Drop displacement barbell                                                            | m   | 0.20 | 0.12 |
| 5 | Maximal vertical velocity of barbell in first pull                                   | m.s | 1.88 | 0.14 |
| 6 | Maximal vertical velocity of barbell in second pull                                  | m.s | 1.87 | 0.17 |
| 7 | Horizontal displacement toward player in the first pull                              | cm  | 2.77 | 0.44 |
| 8 | Horizontal displacement toward player in the first pull                              | cm  | 2.23 | 0.82 |
| 9 | Horizontal displacement toward player after beginning of descent from maximum height | cm  | 3.18 | 0.77 |

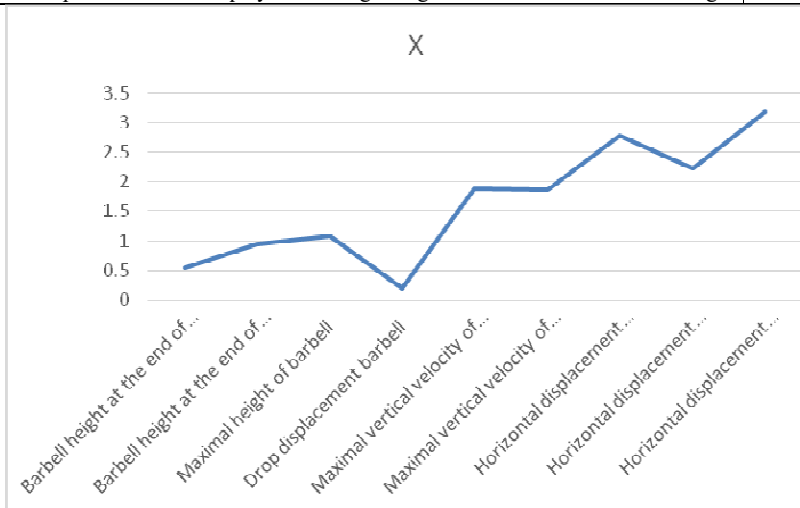


Figure 6. Average line of the bar path in the snatch lift of the research sample

## Discussion

This descriptive study examined the mechanically expressed barbell trajectory in the snatch lift method along with its motor execution stages and measured the standard values of essential biomechanical parameters. Table and Figure 2. show that all weightlifters in the research sample can demonstrate seven technical stages of snatch lift, and this is consistent with what Cunanan AJ. et al. (2020), Nagao H., et al. (2019), Liu, G. et al. (2018) where all the studies conducted to determine the kinematic properties of the hijacking have confirmed that they consist of seven technical stages: Weightlifters perform starter setups before initiating the first pull through knee bar crossings toward a full extension followed by transformation phases to a bar clearance stage before settling into fixation followed by control and finishing the rep with positioning at the bar. His ability to control hand and body movements maintains high levels of muscular control during the lifting process. Nagao, H. et al. (2020) also added that a weightlifter who can perform a snatch lift during its technical stages gives more strength and speed to the movement of the bar, especially in the first three stages, which is reflected positively on the process of turning and falling under the bar, as it must be at maximum speed during the rise of the bar to the top and before it falls under the influence of gravity, which makes it difficult for the player to control, install and follow up, as well as the stage of standing in the bar from squatting. From this standpoint, the researcher finds that the women players' enjoyment of the research sample with the ability to show the seven technical stages is evidence of the technical mastery of the snatch lift, as it means the optimal use of force, which enables

the player to lift greater weights during weightlifting competitions. The findings in the above evidence support the researcher's first question answer.

Table 3. illustrates the temporal characteristics of the technical performance stages in the snatch height of the research sample in each group separately, where the average time of the first draw among the members of the research sample was  $(0.52 \pm 0.15)$  seconds, while the average time was The crossing of the bar to the knee stage is  $(0.20 \pm 0.30)$  and the average time for the second pull is  $(0.17 \pm 0.22)$  seconds, and the average turning and immersion time under the bar is  $(0.25 \pm 0.18)$  seconds, and the average time for the holding and stabilizing stage is  $(0.26 \pm 0.16)$  seconds. The first pull duration proved to be the longest because athletes maintain stability while moving from remainders against gravity therefore requiring maximum force output in order to cancel its effect thus slowing down the total motion compared to the other main steps, the side it is The longest in terms of vertical displacement of the bar. This is consistent with the findings of Jon, M. H., & Rim, U.-R. (2023), Ang CL, Tusher, Yu. L et al (2022), Cao W et al (2022), Oleshko, V et al (2022), Zaras, N et al. (2021), Chavda, S et al. (2021), and Lyon, B.C et al. (2017) who point out that the weightlifter spends most of their time doing these activities During the first pull implementation, besides, it is the phase in which the bar has the highest amount of motive force when the bar is lifted from its stable position with respect to the Earth's gravity. This is in turn consistent with Cox A et al. (2024), Kwon P. W. (2023), Kwon P. W. (2023), Cunanan A. J. et al. (2020). They have highlighted that the dynamic temporal composition of the technical performance of the snatch lift varies from one player to another in light of a set of factors, the most important of which are body weight, height and movement pattern. Nonetheless, all players require a preparatory phase at the beginning of the lift to get the best Anatomical positions coupled with enhanced grip on the bar to achieve a better Stability base. The stage of crossing the bar to the knee is crucial for weightlifters, as it helps maintain the acceleration gained during the first pull. During this phase, the body moves horizontally to allow the bar to pass the knees without altering its horizontal movement, ensuring that the bar's speed remains consistent. The shorter the duration of this stage, the better the lifter can control the bar's horizontal freedom and vertical movement, reaching the first third of the thigh. At this point, the second phase begins, characterized by explosive power. This phase relies on the simultaneous engagement of the thigh muscles, back muscles, and metatarsal height to the fullest extent. The lifters must pull their shoulders up while keeping the elbows elevated and slightly back, facilitating a smooth transition to falling beneath the bar. This involves bending the knees, moving the head back, and extending the arms upward in a rapid diving motion. This phase is critical for achieving maximum speed, and the lifter must begin to descend beneath the bar before it reaches its peak height. This allows for the best anatomical position to receive the bar, extending the arms fully to control its descent due to gravity. This stage, known as the stopping movement of the bar, merges the bar with the lifter's center of gravity, creating a unified mass resting on the lifter's fulcrum. This position also enables the lifter to absorb excess kinetic energy by bending the knees, which is referred to as the distance of the bar's fall on the lifter. This distance serves as a biomechanical indicator of the lifter's skills.

Table and Figures 4. The first pull of the snatch lift produced an average joint angular velocity at the major limb control sites (carpal, knee, and thigh) where wrist foot reached (74.2) d/s and knee achieved (228.4) d/s and thigh exceeded (163.3) d/s. The evaluation displayed two strokes with mean angular velocities of (163.3) d/s for the thigh during the first stroke followed by (236.4) d/s for the wrist during the second stroke with (333.6) d/s for the knee and (336.5) d/s for the thigh. The foot angle changed between (128.4) d/s for the wrist foot and (146.5) d/s for the knee and (106.7) d/s for the thigh throughout the first pull before ranging between (147.1) d/s for the wrist and (165.7) d/s for the knee and (195.2) d/s for the thigh during the second pull. For the wrist and (165.7) d/s for the knee and (195.2) d/s for the thigh in the research sample. These results are useful in explaining the muscular work around the main joints of the ankle joint in the first pull, the knee joint during the transition, and the thigh joint in the second pull, where Yeom D-C. et al. (2023), Sandau I, Granacher U. (2020), Cunanan AJ. et al. (2020), Nagao H., et al. (2019), Liu, G. et al. (2018) The extensor muscles around the joints of the wrist, knee, thigh and knee contribute to controlling the work of the muscles of the lower extremity in a sequence that starts from the thigh to the wrist while pulling the bar off the ground. Cunanan AJ. et al. (2020), Nagao H., et al. (2019) also reported that this sequence is related to the three stages of complete withdrawal during the hijack. Also emphasized that higher level players always exhibit greater angular acceleration in the second pull stage resulting in a large angle displacement in the lower extremity joints enabling the player to produce a large amount of muscular work and motor ability that results in a significant increase in Speed up your bar. The researchers believes, through his experience in analyzing the kinetic performance of many upper-level players in weightlifting, that the transition phase is considered one of the critical stages in the snatch lift, so it is necessary to maintain in it the speed of angular change of the knees, especially in the stage of pushing the knee back and then pushing it back forward to be the base A start where the bar rises above the knee level quickly enough to store a flexible, recoverable energy as a reflex response to the backward stretching movement and then contract forward in a central muscular action of the extensor muscles of the knee joint and the results showed the second pull, the maximum extension speed of the thigh was greater than the maximum extension speed of the knees, Which led to an increase in the acceleration of the bar and contributed to the implementation of the second pull in an explosive manner, and these results are consistent with the findings of Cunanan AJ. et al. (2020), Nagao H., et al. (2019) In addition, the researcher noticed the largest angular velocity in the knee joint

was in the first pull while the largest displacement in the thigh joint was during the pull. Secondly, according to the researcher, the choice of exercises for the development of the first and second pulls and the transitional phase is of great importance because these exercises work directly on the development of the muscular work in the lower extremity, which has an effective role in increasing the movement effectiveness when lifting large weights in the snatch lift.

Table and figure 5. show that the average work and the kinetic energy of the shot and the relative during the snatch lift of the research sample, where the value of the absolute power in the first pull was (1042.3) watts. while it was in the second draw (2844.7) watts. while the relative power was in the first draw (6.84 kg) and in the second draw (18.9 kg), whereas the second push produced relative power of 18.9 and absolute work of 554.4 J for the first push and absolute work of 378.5 J for the second pull. During the first push researchers recorded 3.77 J.kg relative work output followed by cultural task measurements of 2.62 J.kg Absolute work output in the second pull. The results were consistent with those reported by Cao W. et al. (2022) and Cunanan AJ. et al. (2020), who stated that the amount of absolute power was greater in the first pull compared to the second. This can be attributed to the fact that high-level athletes tend to lift the bar from the ground with significant force and in less time, allowing them to maintain the impact of force on the bar during the phase of crossing the knee. Additionally, they invest this strength more effectively in the second pull stage, where the relative ability is greater than in the first pull. This observation aligns with findings from Nagao, H. et al. (2020), Liu, G. et al. (2018), and Korkmaz, S., & Harbili, E. (2015). The data also indicate that the absolute and relative amounts of mechanical work were larger in the first pull than in the second. This is due to the relatively slow nature of the first phase, which can be considered force-oriented, while the second pull is faster and more powerful. Antoniuk, O.V. et al. (2016) noted that the absolute mechanical work in the first pull primarily focuses on lifting the bar to an appropriate speed, facilitating the athlete's ability to cross the bar at the knee while maintaining acceleration without significant decrease. The duration of the first pull plays a crucial role in increasing the amount of work done. Cunanan AJ. et al. (2020) mentioned that an athlete's success in reaching the bar during the second pull stage at high speed enables them to accelerate the bar quickly over a shorter time and distance. This explains the reduced second pull time for higher-level athletes, who require less work to achieve high acceleration, ensuring they are positioned correctly under the bar as it continues to rise. Lucero, R.A.J. et al. (2019) and Antoniuk, O.V. et al. (2016) highlighted significant changes in the technical performance of weightlifting, particularly in the snatch lift. Weightlifters at higher levels are now focusing on generating maximum movement at the beginning of the lift and investing that energy in the phase of crossing the bar to the knee, as well as in the force application during the second pull. This approach aims to enhance the inertia phase of the bar's movement at the end of the second pull. The researcher attributes this trend to the increased interest among weightlifting athletes over the past decade in building muscle mass while significantly reducing fat ratios.

The data presented in Table 6 offers a detailed analysis of the kinematic variables involved in the snatch lift. The barbell height at the end of the first pull is recorded at 0.54 m, exhibiting variability among athletes with a standard deviation of 0.13 m. Following the second pull, the barbell reaches a height of 0.95 m, which reflects increased force and momentum, along with a broader range of heights achieved (standard deviation of 0.22 m). The peak barbell height reaches 1.08 m, indicating consistency across athletes (standard deviation of 0.15 m). The barbell's drop displacement after reaching its maximum height is 0.20 m, with a standard deviation of 0.12 m, suggesting variability in the descent phase. Maximal vertical velocity during the first pull is measured at 1.88 m/s (standard deviation of 0.14 m), while during the second pull, it decreases slightly to 1.87 m/s (standard deviation of 0.17 m), indicating a shift in focus from speed to lifting technique. Horizontal displacement during the first pull is 2.77 cm (standard deviation of 0.44 cm), which decreases to 2.23 cm in the second pull (standard deviation of 0.82 cm), suggesting greater variability in this phase. After the bar reaches its peak height, horizontal displacement is recorded at 3.18 cm (standard deviation of 0.77 cm), showing further variability during the descent.

Overall, the data highlights consistent patterns in height and velocity during the snatch lift, while revealing variability in horizontal displacements, particularly during the second pull and descent. These results align with the findings of Oleshko, V. et al. (2022) and Kuznetsova, Z. M. et al. (2020), who noted that the bar moves towards the athlete during the first pull, turns away during the second, and then returns to proximity during the peak height. Additionally, Arauz, P. et al. (2024) and Abdel-Reda, A.-J. I. (2023) emphasized that the horizontal movement of the bar during the pull phase is a crucial application of muscle strength. While the horizontal movement is small, it plays a significant role in assessing the technical quality of the snatch lift. Greater discrepancies in horizontal displacements during lifting reflect higher work and effort required to control the bar's trajectory. The findings are consistent with the work of Cao W. et al. (2022) and Nagao H. et al. (2019), who indicated that linear vertical and horizontal mobility, along with maximum vertical velocity, are key indicators in predicting the success of weightlifting athletes. This aligns with Sandau I, Granacher U. (2020) and Lucero, R. A. et al. (2019), who proposed that elite weightlifters exhibit two distinct speed curve models: one with two peaks and another with a single peak, resulting from a gradual acceleration through the pull phases. Higher-level athletes demonstrate smoother transitions during the pull phase, with minimal deceleration, except in cases of rapid starts or extreme fatigue, as noted by Cunanan AJ. et al. (2020), Lucero, R.A.J. et al. (2019), and Antoniuk, O.V. et al. (2016). These athletes also tend to experience a reduction in maximum vertical

displacement and velocity when lifting heavier weights, as external load variables affect bar speed and trajectory. The researchers provided that the individual performance of an athlete, along with anthropometric characteristics, plays a significant role in shaping the bar's path. However, this should not deviate from the established kinematic model of the snatch, as suggested by Kumar S., Choudhary R. (2024), Ang CL, Kong PW. (2023), Nagao, H. et al. (2020), Nagao H. (2019), Liu, G. et al. (2018), and Korkmaz, S., & Harbili, E. (2015). These authors emphasize that the path of the bar in the snatch should resemble the letter "S" in shape, with the axis of movement aligning with an imaginary line of the body. The bar's proximity to the athlete's body should be maintained within limits that do not adversely affect its velocity. The researchers underscore that the stability of the bar's path, regardless of the weight being lifted, is crucial for evaluating the effectiveness of the movement. Coaches should focus on ensuring that the bar's path remains consistent to optimize performance and achieve the desired kinetic outcomes in weightlifting.

### Conclusions

This research introduced a field-based biomechanical assessment system that studied snatch lift kinetics alongside dynamics for 81 kg weight category women's weightlifters. Researchers recorded videos that were analyzed with Kinovea software for six athletes participating in the study. The analysis revealed both essential snatch lift performance stages and fundamental kinetic metrics after final study completion. The research examined four principal parameters affecting the snatch technique that included bar elevation changes at each specific lift phase as well as the pull-force acceleration in both parts of the movement and bar position at both strike points and the total movement curve trajectory. The analysis procedure enabled investigators to check whether athletes maintained their optimal bar speed necessary for performing the snatch lift effectively. These measurement methods revealed potential technical shortcomings that occurred when speed decreased in the transition section of the lift. Sports scientists and coaches receive valuable information to discover technical errors in multiple phases of the snatch lift through these findings. The collected data provides evaluative insights which support performance assessment along with error detection and helps direct training methods and competitive techniques.

### Recommendations

Based on the biomechanical analysis of the snatch lift for Egyptian women weightlifters in the 81 kg category, several recommendations and directions for future studies are proposed. Technological tools need implementation to control performance aspects in training duration while supplying instantaneous feedback data on execution efficiency. Each athlete should develop custom performance models that will help track changes in their physical capabilities to define specific development goals. Studying elite weightlifters in comparison with less experienced athletes will create valuable insights about skill differences which could help develop training adaptations. The creation of training programs based on athletes' performance abilities helps maximize their development. The outcome of performance depends on continuous monitoring of training stages to guide data-based alterations. Future research needs to study these three domains: advanced technology development in biomechanical analysis and motion sensor capability; biomechanical consequences of prolonged heavy lifting on weightlifters' bodies; weight category comparison of lifting performance; alongside evaluation of psychological aspects affecting competition readiness and performance outcome. This research focuses on developing optimal training programs for Egyptian weightlifters by advancing performance-based knowledge.

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All subjects who were included in the research had given their consent to participate in the research.

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