

## **An electronically subsidized biomechanical model to study dynamic balance of head uppercut in boxing.**

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### **Problem & introduction:**

Super high performance of high levels' players represents a field of surprise and wonderings, which related to human performance and mechanical variables which happen in it, handled by those experts in kinetic performance development through make a connection between the main kinetic patterns, athletic skills and individual difference in performance as a basic for planning, training and teaching. (9:9)

The balance considered a variable, one of mechanical features and main component in most sports activities, so, studying the main principles of balance and stability, considered one of topics which have a great importance in studying kinesiology and biomechanics, especially, in sport activities which requires revulsion in movements where the player loss balance and necessity of regain quickly this balance to start in new movement. (20:1)

Balance in boxing has a special importance because it is one of sport activities which distinguished with speed and revulsion during offensive and defensive maneuvers which seem clearly in punches and free foot work or which followed by performing punch which requires transfer body centre of gravity to save balance where the boxer loss his balance and regain it one more time, so, balance can't achieved without a proper distance between boxer legs. (43:11) (123:6)

The main stage of head uppercut skill is one of lack balance's aspects, where conducting kinetic duty, when conducting a detailed performance' study, we find that the strength of punch come from the ground while the player pushed the earth' surface with his feet, and here the body in falling case during leaning forward. Explanation of this phenomenon returns to that body weigh centre change its

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place by approach to falling edge line inside pivot base in this moment.

In addition to that biomechanics' rules explain that any body will be in balance case if its gravity centre occurs inside pivot base and if its centre of gravity or line vertically passing on ground surface departs from pivot base, the body will loss its balance and fall. (8:81).

condition of centre of gravity falling inside pivot base is necessary for when body being in stability case fixed speed movement, but this is not found in boxer's movement whether in feet movements (linear or rotational) or the punches which directly follows linear or rotational moving where, we find in both cases that body gain an acceleration (changeable speed).

Maybe the reason hides in exchanged effect between body gravity and ground reaction as (directed) strength lead to changing in linear speed, also, change place of body centre of gravity as for pivot foot means variation of pivot forces with different amount and direction moments, thus mean there isn't rotational balance. (8:82) (12:128)

Also forces of ground reaction in punches isn't in only one stereoisomer, but, it slop according to the kinetic performance's nature, consequently there will be more than one stereoisomer (Horizontal and Vertical), and the outcome of these two stereo isomers are sloped, their direction must crossed in body C.G and pivot base.

So, when thinking in balance, we should put before our eyes, its stereo relation and its physical relation which includes two relations (the equilibrium of different body parts and anti-muscles' equilibrium) as for joint movements' adjustment. (2:46) Grid Hokhmoth (3), Yousef Elsheikh (10) indicates to that we can measure balance by three different way (engineering measuring) which mean (fall angel) where the amount displaced body and let it be above fall edge (pivot base), we can determine this angel by altitude of body C.G and the horizontal dimension of C.G at fall edge, therefore, the fall angel is directly proportional to the degree of body stability, also, the fall edge was big, so the offered work was big.

In light of what mentioned before and what indicated by Grid Hokhmoth (3), Mohamed Yousef Elsheikh (10), Hosam Refky (4), Abd Elhamed Ahmed, that the boxing is one of sport which need stability of body against gravity forces which effect on it, and to necessity of keeping balance continuously during the kinetic performance. Also, because the operation of gaining balance then losing it and the overlapping relationship between them, till reached the suitable balance case during punches performance one of the most important things which the boxer keen on it during rounds. This is one of the most important reasons which made the researcher interest in studying and exploring through his attempt to show a new scientific style (An electronically subsidized biomechanical model) to study the dynamic balance, in general and head uppercut performance in boxing, in particular, as a trying to find values of strength moment and resistance moment, then identifying the common type of lever by studied motion. The researcher will try to calculate

pivot base area by serial measuring, where the boxer should keen on keeping pivot base area between feet including its external borders in a manner ensures the player's balance by significance of general body centre of gravity work line's place inside pivot base area, and knowing the relationship between them, as a result for the general rule of lever law" when strength Torque result = resistance Torque result, the lever will balance regardless the lever's type. Add to this, as strength arm is longer than resistance arm, the force which offered to keep balance is few. So, the researcher tries to know length of resistance and strength arms and their relation with balance via knowing body C.G work line place and how mush it remote from the front pivot edge of player through the biomechanical model which suggested by the researcher, this model depends in the equation's entered value on extracted value of the foot pressure measuring system device for the feet reaction effect points with ground. Also, the researcher will try to know values of the values of potential energy, motion

energy and the total energy of player's body C.G, also conducting the engineering measurement which mentioned by grid Hokhmoth "determining fall angel of skill performance stages under consideration as a scale of balance".

**Research goal:**

The research aims to try "building electronically subsidized biomechanical model to study dynamic balance of head uppercut in Boxing" through identifying:

- The nature of electronically subsidized biomechanical model to find the lever work' system for the skill under consideration.
- Determining the pivot base area during head uppercut performance stages.
- Identifying the players' fall angel, movement's amounts, potential energy and total mechanical energy for general body C. G as a scale for balance.

**Research questions:**

1 – What is the nature of electronically subsidized biomechanical model to

identify the work system of lever?

2- What is the area of pivot base during head uppercut performance phases?

3- What is the player's fall angel and amounts of motion, potential and total mechanical energy of general body centre of gravity as a balance standard?

**Research proceedings :-**

**Research Methodology**

The researcher used the descriptive method (case study)by using biomechanical analysis which is suitable for research nature.

**Research sample:**

The sample was selected intentionally among Egyptian team's players, where his excellence in technical performance (tactical feature) of the skill under consideration, taken in account. He is one of players whose obtained advanced places; he is also a high level player who came second in the 2013 African championship. The player performed the skill three times for research purposes. Table(1) illustrates the sample characterization of

**Table (1)**  
**The research sample Characterization of**

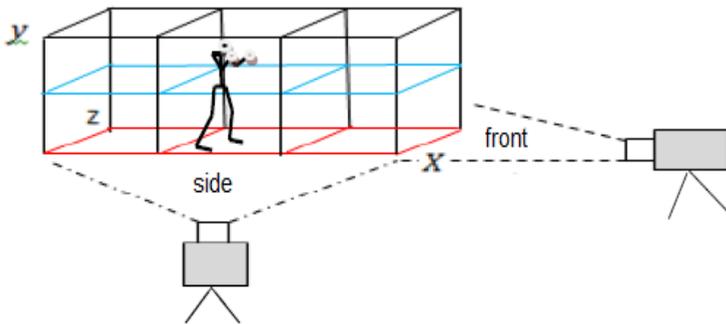
age	Length	weight	Arm length	L. of upper arm	L. of forearm	L. of the trunk	L.of the leg	L.of thigh	L.of shank	L.of foot
18	173c.m	60k.g	78.5c.m	34c.m	26cm	50c.m	96.7c.m	50c.m	46.7cm	42cm

Seen from the table table (1) The research sample Characterization of . Length of the with a the player(173c.m) ; and weight (60k.g).

**The devices and tools which used in research:**

\* the researcher used (2) Basler camera, synchronized between them by their synchronization device, with

the knowledge that the speed of camera 120 frame/sec. the first camera was putted perpendicular to calibration cube and player's lateral plane, while the second camera was putted also, perpendicular to calibration cube but on player's front plane, this is clear in form number (1)



**Form (1)**

**Photography cameras perpendicular to calibration cube according to nature and direction of motion.**

- Foot pressure measuring system's device to measure pressures in foot-bottom. (2m on X axis), (2m on Y axis) and (2m on Z axis).
- Kinetic analyses device (Kwon3D) which provider with 3D-calibration cube, where its dimensions reached
- Control markers as reflectors.
- Measuring tape
- Engineering drawing sheets (1M × 0.70 M) divided into squares

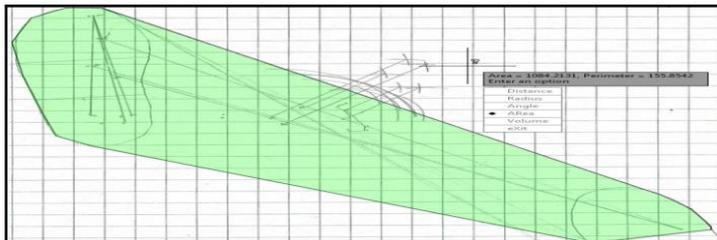
**The equations which used in research:**

**- Calculating pivot base's area, by following these steps:-**

1-Shooting the skill under consideration under the existence of engineering drawing sheets (1 M × 0.70m) divided into squares (5cm×5cm) which putted under boxer's feet.

2- There are two ways to calculate the area, in the first way, the area plus its external borders are divided into triangles, then each triangle area is calculated separately

through the equation =  $\frac{1}{2}$  base \* height. Then the area of all triangles is calculated to give us at final the total area of pivot base, but the researcher didn't rely on this way to reduce error and because he want to get accurate values so, he relied on **Auto Cad.v. 2015** program to calculate the area of pivot base including its external borders. Form (2) shows that.



**Form 2**

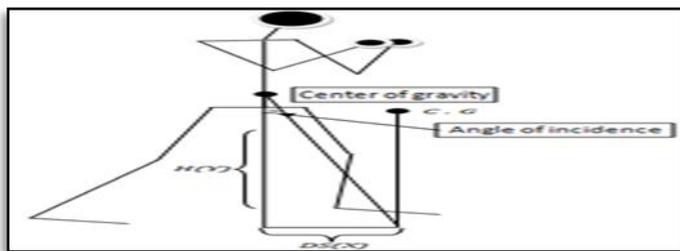
**Form (2) shows calculating the total area of pivot base via ( Auto Cad.v. 2015)**

\* The researcher used the following law to identify the work' system of lever as a scale of balance:

**Strength × arm strength = resistance × arm the resistance**

\* The researcher used the following law to calculate the fall angel:

The Acute angel  $\tan$  (Tangent) = the length of angel's opposite side length / the length of angel's contiguous side.



**Fig. 3**

**Fig. 3: Method of finding incidence angle during phases of performing head uppercut skill**

**Methods of constructing a biomechanical model for identifying lever system work and mechanical advantage**

**First: Theoretical model description**

1- Torque = force \* force arm  
 2- One lever condition is that Torque is balanced only in two cases:

- **First case:** To be balanced by another moment, equal in magnitude and opposite in direction.

- **Second case:** To be equal to a couple Torque of two forces equal in magnitude [couple Torque = magnitude of one force \* distance between their lines of action].

The current study examines the nature of dynamic balance of a boxer while performing head uppercut under the effect of the Torque resulting from his weight and its equivalent

Torque; the couple moment of two forces equal in magnitude.

The researcher argues that the front moment, resulting from body weight, acts to make boxer fall forward. As the boxer remains in balance without falling, this indicates the existence of another moment (opposite to falling direction). This balance and moment result from two forces. One force is ground reaction due to contact between feet and ground. Consequently, there must be another force, equal in magnitude and opposite in direction, to make the couple. This latter force is the tension that occurs in the back muscles of the boxer's body.

Second: Constructing the biomechanical model:

The front and back moments of the boxer are as follows:-

1- **Front Torque:** body weight multiplied by weight arm in

terms of body (C.G.) position (Fig.4), where the first moment =  $A_1 \times W$

2- Back moment: the resultant of a force couple: one force of the couple is the resultant tension in muscles, and the

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2- Back moment: the resultant of a force couple: one force of the couple is the resultant tension in muscles, and the other force is the resultant ground reaction against feet. The resultant of muscle tension may be calculated as follows.

2/1- Resultant tension in all body muscles can be found by the following methods:

**a- tensile force in back( neck muscles):**

if trunk makes an angle  $\theta_1$  with the vertical plane (Fig.5), then the vertical force component is the one that influences body balance. So, the back neck muscles tensile force can be obtained using the following mathematical relationship:  $T_1 \cos \theta_1$

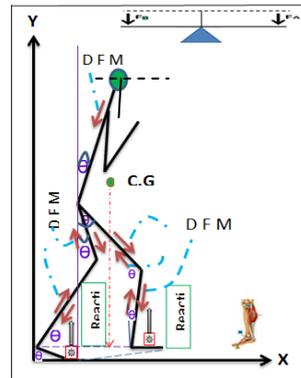
**b- Back muscles:**

same principles of neck muscles can be applied to obtain back muscles tensile force using (Fig.5),:

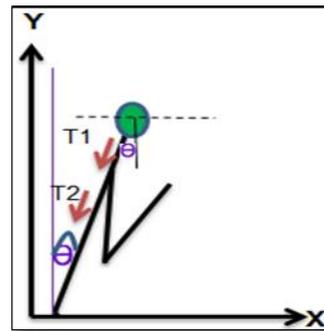
$$T_2 \cos \theta_2$$

other force is the resultant ground reaction against feet. The resultant of muscle tension may be calculated as follows.

2/1- Resultant tension in all body muscles can be found by the following methods:



(Fig.4) Tensile angles In the muscles of the body front and back



(fig.5) Tensile angle in the muscles neck and trunk

### **C- Tensile angle in the arm muscles:**

If upper arm and forearm bone makes an angle  $\theta_9, \theta_{10}$  (fig .6) then tensile force is the algebraic sum of the front and back muscles of the upper arm and forearm because they are parallel and have the same line of action. Then, the tensile force can be calculated from the following :  $T_9 \cos \theta_9$  &  $T_{10} \cos \theta_{10}$

**D- Foreleg muscles:** if the front and back thigh muscles make an angle  $\theta_3$  with the vertical plane (Fig.7), then force is the algebraic sum of the front and back thigh muscles because they are parallel and have the same line of action. Hence, the tensile force can be obtained from the following relationship:  $T_3 \cos \theta_3$

Tension resultant can be obtained from the algebraic sum as follows:

$T_3 = T_{\text{Front thigh muscles}} + T_{\text{Back thigh muscles}}$  Signs must be taken into account, with positive sign taken downwards.

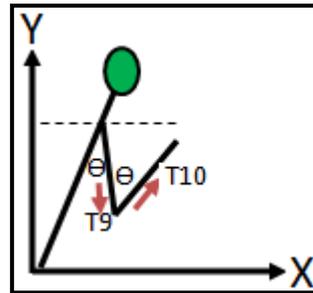
### **E- Shank muscles tensile force:**

If shank bone makes an angle  $\theta_4$ , (fig .8) then tensile force is the algebraic sum of the front and back muscles of the shank because they are parallel and have the same line of action. Then, the tensile force can be calculated from the following:

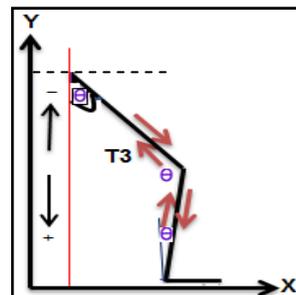
$$T_4 \cos \theta_4$$

The resultant tension is:

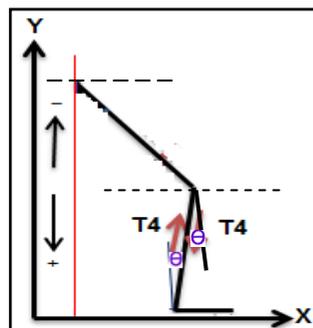
$T_4 = T_{\text{front shank muscles}} + T_{\text{back shank muscles}}$



(fig.6) Tensile angle in the arm muscles



(Fig.7) Tensile angle in the muscles of the fore leg



(Fig.8) Tensile angle of the leg muscles

### F- Tensile force of back leg muscles :

Same calculations of foreleg apply to back leg. As for thigh, the following equation applies:

$$T5 \cos \theta_5$$

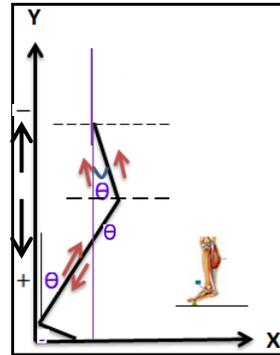
Tension resultant can be obtained from the algebraic sum as follows:

$T5 = T_{\text{Front thigh muscles}} + T_{\text{Back thigh muscles}}$  As for leg the equation becomes

$$T6 \cos \theta_6$$

Tension resultant can be obtained from the algebraic sum as follows:

$T6 = T_{\text{Front thigh muscles}} + T_{\text{Back thigh muscles}}$  (fig.9)



(Fig.9) Tensile angle of back leg muscles

### G - back foot :

When the back foot is supported by the instep and heel raised, with angle  $\beta$  to the horizontal plane, (fig.10) then force in feet muscles are calculated as follows:

$T7 \sin \beta_7$ , and  $T8 \sin \beta_8$  for the other foot. So, the tensile force of muscles is the algebraic sum of vertical components.

The final form of tensile forces becomes:

$$T = T1 \cos \theta_1 + T2 \cos \theta_2 + T3 \cos \theta_3 + T4 \cos \theta_4 + T5 \cos \theta_5 + T6 \cos \theta_6 + T7 \sin \beta_7 + T8 \sin \beta_8 + T9 \cos \theta_9 + T10 \cos \theta_{10}$$

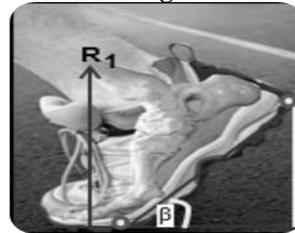
### **2/1 Resultant reaction (R) – the basis of constructing the sportive model**

According to Fig.11,  $R_h$  is the resultant reaction at the left foot,  $R_3$  is the reaction at the right foot, and  $R_f$  is the total resultant reaction of the left and the right feet; equal to the algebraic sum of ( $R_h$ ,  $R_3$ ), being two parallel forces normal to the horizontal ground. Hence, resultant  $R_f$  is in the direction of the two forces ( $R_h$ ,  $R_3$ ), obtained from the following relationship:

$$R_f = R_h + R_3$$

Also,

$$R_h \times L_1 = R_3 \times L_2$$



(fig.10) Tensile angle of back leg muscles

Where L1 and L2 are the distance of the points of action of the feet reactions from the vertical component of the body C.G., and the resultant feet reaction norm is equal to the sum of the two forces norms ( $R = R_1 + R_2$ ), and its point of action divides the distance between  $R_1$  and  $R_2$  reciprocally, calculated from:  $R_1/R_2 = L_2/L_1$

Where  $L_2$  is the arm of  $R_2$ , and  $L_1$  is the arm of  $R_1$ . From applications done by the researcher on (**medilogic Foot Pressure Measuring System**), the back forefoot pivot point was deduced along with the pivot points of the (**forefoot**) on the ground. The closer the reaction resultant is to the C.G. point of action, the higher the weight moment is; leading to more turning and increasing body fallout possibility.

**- Methods of determining type of level made by weight and reaction during performance stages:**

**1-** Draw a line between the first point of action (A) in the front part of the forefoot and the second point of action (B) in the back part of the same foot (heel) (fig.11).

**2-** Measure line length and the forefoot reaction resultant point of action  $\epsilon$ .

**3-** Draw a line from E to the back foot reaction point of action (C). This line is the resultant of the feet reactions.

**4-** The point of action of the resultant reaction divides the distance between the two points of action by  $R_1 : R_2$ . The same applies to weight.

**5-** Finding the arm of force and resistance using engineering mechanics principles followed.

**6-** Obtaining the type of lever. The back Torque is the resultant of multiplying one force T (resultant) or R (resultant reaction) by the distance between them.

Torque 2 = Tension (T) \* Distance between or Torque 2 = Reaction \* Distance between  
Due to the difficulty of obtaining muscle tension values accurately in practice, T can be replaced by R in calculating Torque 2.

$$\text{The back torque arm} = \frac{\|Z\|^2}{|T|} \quad \text{or} \quad \frac{\|Z\|^2}{|R|}$$

Positive root of squared torque

Standard of one force



**Practical application of the proposed sportive model for identifying level type and balance state of the skill examined:**

**First:** constructing the model used three foot pivot points: A and B in the left foot, and C in

the right foot; as per preparing stand adopted by the boxer. So, the researcher found point coordinates on paper as shown in (fig.11). coordinates during uppercut performance of the first frame were as follows:

**Table (3)**

**Coordinates values of reaction effect points on right and left foot during punch performance phases**

phases	frame	time	axis	L . foot		R. foot
				A	B	C
preparatory	5	0.04	X	25.7 C.M	24.95 C.M	74 C.M
			Y	60.4 C.M	42.9 C.M	14.5 C.M

**Second:** Measuring right/left forefoot and heel reactions using Foot Pressure Measuring **Left foot :**

$$R_1 = 15.39$$

So, the left foot resultant is:  $R_f = 15.39 + 15.01 = 30.40$

**Third:** finding the distance between the front and back reaction points of action of the left foot

System, for measuring pressures under foot as shown (12). Values were as follows:-

$$R_2 = 15.01$$

In light of the reaction points of action on (x, y) as in table (3), the distance between points A and B of the left foot through the following equation:

$$AB = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad AB = \sqrt{(306.812)} = 17.5 \text{ C.M}$$

(1).....

$$AB = \sqrt{(24.95 - 25.7)^2 + (42.9 - 60.4)^2}$$

$$AB = \sqrt{(-0.75)^2 + (-17.5)^2}$$





**Eighth: Finding values of strength and resistance and identifying the type of lever:-**

In light of what reported in general rule of levers law, it is "when the strength Torque result = the resistance moment's result" the lever will be stable, apart from its type. And in light of the real values which extracted from

biomechanical model, the researcher could get moments of strength and resistance for the first cadre in preparatory stage of head uppercut and judged on balance type, it came as following:-

The resistance Torque = the resistance (reaction's outcome) \* arm the resistance

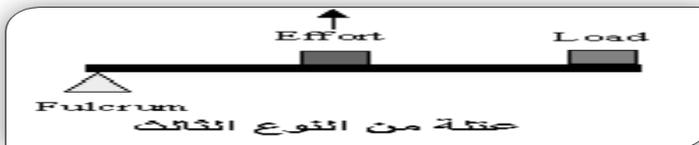
Anticlockwise R = 60.42\*6.6 = (+) 398.838

**\*The strength Torque = the strength (weight) × arm strength**

Clockwise W = 60\*6.35 = (-) 381.00

In light of applying the biomechanical model on cadre number (1), preparatory stage, and in light of the real values which mentioned above in table (1) and values of arm strength' length and arm the resistance's length which also mentioned above . in form (11), the researcher found that the common type of lever is the third type. Form (13). The researcher also applied the model by the same previous way on

rest of the eight cadres of head uppercut skill, to ease application and reduce errors, the researcher intended to design software where the biomechanical model was entered in it, to get values immediately. The model's results of skill' stages (preparatory, main, finality) came as shown in table (4) as following: -



**Form (13) Lever of The third type**



**Second: the results of determining pivot base' area for head uppercut performance's phases.**

**Table (5)**  
**Values of calculating pivot base area for head uppercut performance phases**

Skill performance phases	Preparatory phase			Main phase			Finality phase		
The cadre	5	92	101	149	154	159	164	197	216
Time second)	0.04	0.76	0.84	1.24	1.28	1.32	1.36	1.64	1.8
Pivot (cm2)	1176.2	1177.6	1179.1	1068.7	1064.2	1063.5	1072	1132	1156

**Table (5)** shows that values of calculating pivot base area for head uppercut performance phases which the researcher extracted through direct observation for pivot base of each cadre, each cadre was entered separately in Auto Cad 2015 program, with the followed calibration to calculate the total area of pivot base with high accuracy, the area of pivot base reached (1176.2cm<sup>2</sup>) in the beginning of skill in preparatory stage, then continued in increasing till the end of this phase at value (1179.1cm<sup>2</sup>), then continued in decreasing in the beginning of main phase till the end of phase where it reached the smallest value (1063.5cm<sup>2</sup>) then increased again till it reached (1156cm<sup>2</sup>) in the end of finality phase .

The researcher attributes- the increase in pivot

base area at preparatory phase - to the nature of uppercut performance technique where in this moment, the player tries collect his forces which will come from ground by pushing hind foot instep through bending the knees, and by conjunction, getting down of striking arm and torso makes the hind foot's heel approach to ground, as a result, the part which touch ground becomes within pivot base's area, and that make an increase in this area.

The researcher also attributes the decrease in this area at the main phase to because of occurring inverse operation, to what happened in the preparatory phase. In the main phase the player pushed the hind foot to ground with stretching the knees and changing kinetic pass' direction of uppercut, then decrease in

hind foot's area, in addition to semi significantly decrease in for foot.

The researcher also, attributes the 2<sup>nd</sup> increase in finality stage, to 2<sup>nd</sup> inverse operation of main phase; this operation is the player's returning to preparatory phase which goes along with basic stance

**Third: the results of the player's fall angel, potential energy's amounts, movement power and the total power of general body centre of gravity as a standard of balance.**

**A) Results of the player's fall angel of general body centre of gravity:**

**Table (6)  
The player's fall angel during phases of head uppercut performance**

Skill performance phases	Preparatory phase			Main phase			Finality phase		
The cadre	5	92	101	149	154	159	164	197	216
Time second)	0.04	0.76	0.84	1.24	1.28	1.32	1.36	1.64	1.8
Fall angel (Degree	1.9	2.69	2.98	4.38	4.21	4.00	3.93	3.73	3.78

**Table (6)** shows that fall angel values of the skill under consideration where, the gradual rise of fall angel appears for us, where the smallest angel reached (1.9degree) in 1<sup>st</sup> cadre at preparatory phase because the horizontal area of body centre of gravity line is small and near to mid-pivot base which reached (2.5cm) horizontally with height 75cm. also, the biggest angel reached (4.38 degree) in 1<sup>st</sup> cadre for main phase which reached (3.3cm)

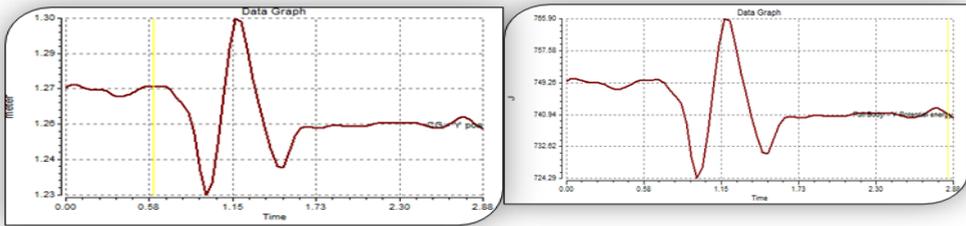
horizontally with height (70cm).

The researcher attributes the gradual rise for horizontal area of general body centre of gravity work line of the player and because it is near to pivot base' front edge. Also, we can explain that via the mechanical view where the exchanged effect between body weight and ground reaction as a directed force Leads to change the place of body centre of gravity according to pivot foot, also, ground

reaction's forces in punches can't be in only one stereoisomer but it is also sloped according to the kinetic performance's nature, so, there

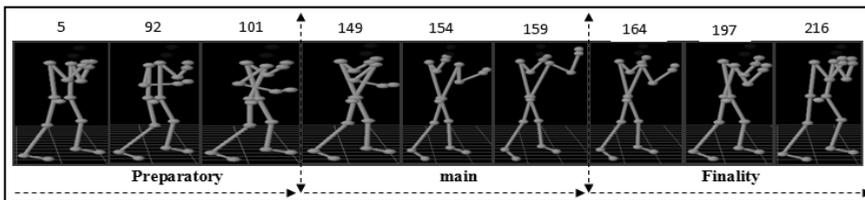
will be more than on stereoisomer; horizontal and vertical, the outcome of these two isomers are inclined.

**B) Results of potential energy amounts for general body centre of gravity**



**Form (14)**

**Form (14) shows potential energy's curve and the vertical distance during performance phases form (15)**



**phases of head uppercut performance**

**Table (7)**

**The potential energy of body centre of gravity during head uppercut performance phases.**

Skill performance phases	Preparatory phase			Main phase			Finality phase		
The cadre	5	92	101	149	154	159	164	197	216
Time(second)	0.04	0.76	0.84	1.24	1.28	1.32	1.36	1.64	1.8
Potential energy's amount (joule)	750.5	728.1	724.5	731.5	736.1	751.7	759.8	741.8	740.9

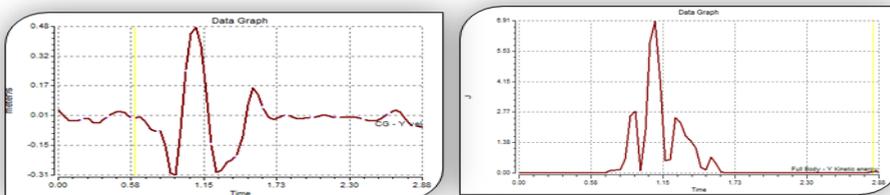
**Table (7) & form (14)** show the potential energy amounts and engineering curve of body centre of gravity vertical displacement' values. The researcher noticed in this result the gradual decrease for potential energy at preparatory phase where potential energy begin with value (750.2joule), then the value still increasing in beginning of main phase till it reached smallest value in this phase (731.5joule) and biggest value (751.7 joule) , where it continued in increasing then decreasing in finality phase. The amount of potential energy was stable in the end of finality phase at value (740.9joule).

The researcher attributes decrease then increase followed by a decrease, to the physical law of potential energy, which give for  $PE=m \times g \times h$ . according to the law we find that the height (h) is the main controller which change because the mass(m) of body and gravity (g) are stable, so, the potential energy is stored energy relates to body'

setting for the level of earth' surface, also - the gravity, mass, and the height of this setting- plays an important role in calculating the potential energy, according to nature of uppercut performance' phases technique. The player's gravity centre is on high-height at the beginning of performance. Then follow that a decrease in the vertical height of body centre of gravity, and the potential energy decreased as a result, then the vertical displacement of body centre of gravity increased and this make energy amount increase. And the opposite happens in the final stage. So, this and the engineering curve of vertical height of body centre of gravity are considered an explanation for fluctuation which occurs in engineering curve of potential energy during performance phases of head uppercut performance.

### C) Results of motion energy amounts for general body centre of gravity:-

**Form (16)**



**Form (16) shows the curve of motion energy and vertical velocity during performance phases**

**Table (8)**  
**Amounts of kinetic energy of body centre of gravity during head  
 uppercut performance phases**

Skill performance phases	Preparatory phase			Main phase			Finality phase		
	The cadre	5	92	101	149	154	159	164	197
Time second)	0.04	0.76	0.84	1.24	1.28	1.32	1.36	1.64	1.8
Motion energy amount (joule)	0.00	2.77	0.13	3.02	5.56	6.9	5.30	2.45	0.05

**Table (8)** & form (16) shows amounts of motion energy and engineering curve of body C.G vertical velocity, where the researcher noticed increase and decrease in values reached in the beginning of performance (0.00joule), then it increase again and decrease till reached (0.13) joule, after that the amount increased in the beginning of main stage till the end, the value ranged from (3.02 joule to 6.9 joule). Then this value decreased in the final stage till the end where it reached the smallest value (0.05 joule).

The researcher attributes this result to the main variable in physical law, it is (velocity), where the law provide for  $\mathbf{KE} = \frac{1}{2} \times m \times v^2$  There are many derivatives for this formulation, we can notice that the velocity square makes motion energy at first

depended on velocity ( $v^2$ ). Motion energy changes as velocity changes, so, doubling the velocity increase motion energy.

Thus, we can explain these gained values at table (8), the reason for being motion energy (0.00 joule) is that the velocity amount reached in this moment (0.00 m/sec), then the value changed because the velocity amount changed too, there is direct relation between velocity amount and motion energy. The maximum value of motion energy reached (6.9 joule) in punching moment in main phase. At the same time the velocity amount reached maximum amount (0.48 m/sec), because the horizontal distance of body centre of gravity is big, so, the amount of motion energy increased, therefore the offered mechanical work will be big also.

The researcher also sees that this gained results of motion and potential energies' values; is a decrease in potential energy corresponding with an increase in motion energy. Because the kinetic path of punch is similar to kinetic path

of a pendulum in the ups and downs, this confirms the credibility of values which the researcher reached.

#### **D) Results of total mechanical energy amounts of general body centre of gravity**

**Table (9)**

#### **Results of total mechanical energy amounts of general body centre of gravity during head uppercut performance phases**

<b>Skill performance phases</b>	<b>Preparatory phase</b>			<b>Main phase</b>			<b>Finality phase</b>		
The cadre	5	92	101	149	154	159	164	197	216
Time(second)	0.04	0.76	0.84	1.24	1.28	1.32	1.36	1.64	1.8
Motion energy amount (joule)	750.5	730.8	724.6	734.5	741.6	758.6	765.1	744.2	740.9

**Table (9)** shows a decrease in total mechanical energy amount at preparatory phase, then an increase in main phase, then decrease for second time. The researcher attributes that to the fact that mechanical energy of a system is the sum of its potential and kinetic energies according to mechanical energy law;  $E=Pe=Ket$  In light of uppercut performance technique's nature the researcher noticed downfall in body C.G height towards ground gravity because of bending knees, so, the values of potential energy decreased in this moment and the values of kinetic energy increase, by

considering the ground surface level is the reference level, because general body C.G in the end of this stage remains on specific height without touch ground or even approach. So, the body gained kinetic and potential energies which give us the total mechanical energy at the end, then the centre of gravity in main phase will increase by stretching the knees, after that it decrease again, the player still keep mechanical energy, which is mix of potential and kinetic energies till the end of the performance.

#### **Research conclusions:-**

- Distributing the mechanical loads of body on foot in light of preparation stand and nature of rising punch performance, is unequal, where, average of loads disruption reached (68%) of heel area, (92%) of fore foot area, which led to change work line of body centre of gravity and how much it near to fighter fore foot than his heel.

- Efficiency of the purposed biomechanical model in studying and determining the common type of lever during performance stages.

- According to biomechanical model results, the third type of levers to presence of work line of collector (gained) reaction behind work line of body centre of gravity which stretched resistance arm out than effort arm, therefore the third type is considered the most common during the three stages of uppercut to head performance.

- Applying biomechanical model requires finding foot reaction effect points. In light of foot pressure measuring system there are three effect points for foot reaction where in front foot there are two effect points in fore foot and

heel, while the hind foot has one effect point in fore foot.

- Length of resistance arm than effort arm gives a big kinetic range for player of which affect positively on velocity efficiency.

- The lever has not mechanical feature during performance phases because resistance arm longer than force.

- Unstable balance is considered the common type during performance phases because the resistance arm bigger than effort arm and the two torques of resistance and force are unequal.

- increasing friction area in preparatory stage, then decreasing in main phase because of inverse operation in approaching sometimes to ground service level and sometimes else moving away ground surface level, in heel during performance phases.

- the horizontal displacement for work line of general body centre of gravity reached biggest value during punching, of which made bigger incidence angle compared with two phases (preparatory and finality).

- The boxer gains greater value for potential energy in

the beginning of the performance, then changes opposite to these values, were occurred during the three phases, because of changing the vertical displacement's values of potential energy and the vertical speed of movement's energy.

- there is slight changes in horizontal displacement for body center of gravity work line during the three cadres of main phase as an attempt from the boxer to not increase the incidence angle and keep balance.

**Research recommendation:**

- It is preferable for the boxer in the beginning of main phase to move from the third type of lever to the second type through clump up on insteps to make work line of collected reaction effect between two effect points of foot reaction in fore foot only, and making resistance in the middle to benefit from mechanical feature of the lever; increasing punch strength.

- Relying on the biomechanical model which the researcher reached to, in studying and finding type of lever in dynamic movements for similar skills in different

sport or analyzing walking movement.

- Using an electronic program which designed by the researcher, for coaches to ease dealing with the biomechanical model.

- Avoiding exaggeration in bending of the knees during preparatory stage, decreasing the body's resistance to gravity and specific time of punch

- Save pivot base' area with the breadth of pelvic increase the boxer's balance, as well as, improving punch efficiency.

- Increase the vertical speed through increasing the amount of foot reaction which resulting from pushing ground to make sure increasing amounts of boxer's movement energy.

- In view of mastery of unstable balance during performance phases, so, it is necessary to interest in balance exercise which aims to neuromuscular compatibility, to increase correlations between labor muscles and Anti muscles of Boxer body especially, hind back muscles.

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