



Original Article

Title:

Establishing Qualitative Biomechanical-based Exercises of the Three-Point Shot Skill in Basketball

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Abstract

The three-point shot skill in basketball is one of the thrilling shots that attract millions of fans as it is performed outside of the 6.75 m arc to increase the result by three points. Hence, any failure in performing it will greatly affect the result of the game. Such a skill needs highly sophisticated training to get better results. The aim of this study is to identify biomechanical variables enabling to extract qualitative exercises of the three-point shot in basketball and to design qualitative exercises in the light of those variables. The descriptive method will be carried out by applying biomechanical analysis of the 1st ranked player in the NBA league in the three-point shot skill in 2020/2021 by a shot rate of 47.5% using the Motion Track analysis program and building and scheming qualitative exercises (physical, technical exercises, and techno-physical exercises) of the skill according to the analysis outputs. The obtained results showed that biomechanical variables depend on time distribution to performance stages; horizontal and vertical distances of the body's center of gravity, right-hand palm, and the ball path; angular change of elbow, shoulder, and knee joints, and the amount of force of the body's center of gravity and arms. Furthermore, qualitative exercises designed for the three-point shot according to such biomechanical variables are jumping over hurdles with leg straight; bend at knees and jumping up with lifting weight; stretching and bending arms upward and inward with dumbbells; pushing a medicine ball upward and forward with jumping; bending and stretch arms upward and forward with dumbbells; shooting from outside the arc with body weights; shooting from outside the arc; angle of shooting; ball path; angle of shooting and ball path and deep jump from the top of the box.

Keywords:

Biomechanical analysis, Qualitative exercises, Three-point field goals, Basketball



Introduction

Shooting is an essential part in team sports such as basketball as the aim of drawing plans, performing the other offensive skills and cooperation of all efforts of the team to create suitable conditions to shoot on the basket of the competing team (Gasem, 2014), as the 1st article of the law of basketball states that the purpose of each team is to shoot the ball into the basket of the opponent team and to prevent the other team from possessing the ball and scoring the goal (Fawzy, 2014).

The team winning the match is the team having a greater number of successful shots in the competing team's basket and getting a greater number of points (Okazaki et al., 2015). Each team has a strategy different from the other team in increasing attempts of shooting through depending more on the three-point shot, two-point shot, or one-point shot via free throws (Gasem, 2014).

Strong teams and professionals such as National Basketball Association (NBA) teams greatly depend on the three-point shot skill by about 50% of the shooting attempts of the team (Dator, 2021).

The skill of shooting out of a 6.75 m arc is decisive or critical for the team as it enables it to score three points through one shot (*Basketball Biomechanics*, 2017). Stephen SHEA (2018) indicated that teams could simply improve their offense by changing their choice of shooting, making more three shots and getting more points.

Brian Suk (2021) stated that teams adopted more the three-point shot strategy in games scored greater number of three points as compared to their opponents and consequently, they generally tended to have a higher offensive classification, on the other hand, teams not more depending on the three-point shot than other types of shooting had uneven results.

In the contrary, the researcher noticed and realized through statistics of Egyptian teams that they had less rate of three-point shot attempts with the result that the rate of success in scoring points through it was so low as in FIBA International Intercontinental Cup, 2022 Egypt, Zamalek Sporting Club Team that won the last place among four participated teams, the field goals attempts were 75 shots containing 32 three-point shots by 42.7% and 43 two-point shots by 57.3% (*Zamalek at the FIBA Intercontinental Cup 2022*, 2022). In contrast, Flamengo Club Team of Brazil won the 1st place in the same championship, the total field goals attempts were 171 shots containing 112 three-point shots by 65.5% and 59 two-point shots by 34.5% (*Flamengo at the FIBA Intercontinental Cup 2022*, 2022). In FIBA AfroBasket 2021, Egypt participated and came in the 11th place of a total of 16 participating teams and the total field goals attempts were 241 shots containing 96 three-point shots by 39.8% and 145 two-point shots by 60.2% (*Egypt at the FIBA AfroBasket 2021*, 2021). This was different from the Tunisian team that won the 1st place in the same championship as the total field goals attempts were 352 shots containing 157 three-point shots by 44.6% and 195 two-point shots by 55.4% (*Tunisia at the FIBA AfroBasket 2021*, 2022).

Therefore, it is important to develop the number of successful three-point shots versus other shots, to gain more points and win the match. In this context, Brian Suk (2021) assumed that the



team would be the best meaning is to shoot the highest possible number of three-point shots together with shooting the minimum possible number of two-point shots with higher efficiency.

Thus, such a skill needs high precision to get better results and hence, more training should be paid. The researcher noticed that it would be important to prepare qualitative exercises viz. physical as well as technical and techno-physical exercises upon scientific bases according to biomechanical conditions and principles (kinematic and kinetic description) to be employed in their training units.

The qualitative exercises encompass a set of workouts similar to motor path with a specialized technical performance improving quantity, quality, and timing as per the momentary use of muscles operating. They are the most important type of training for basketball players to develop the technical and special physical aspect at the same time. This unique technique and its application leads to a great leap in the level of performance and effectiveness of basketball players and other sports as well (Brekaa & Elbedewy, 2005).

This study ultimately aims to design qualitative exercises viz. physical and technical and techno-physical exercises in the light of biomechanical variables of the three-point shot skill in basketball. Such a study is the first in the limit of the researcher's knowledge where qualitative exercises of the three-point shot skill are designed according to biomechanical indicators as other investigations introduced biomechanical analysis without designing definite exercises, such as the study of Ali and Elgammal (2016), Ali and El Deen (2011), Cabarkapa et al. (2021), Gorshahri et al. (2018) and Veljović et al. (2021). Moreover, the current study also aims to identify biomechanical variables enabling to extract qualitative exercises for the three-point shot skill in basketball and designing qualitative exercises for the skill based on those-variables.

Questions:

- (1) What are the required biomechanical variables to extract qualitative exercises for the three-point shot in basketball?
- (2) Which qualitative exercises in the light of biomechanical variables of the three-point shot skill in basketball, should be designed?

Material and Methods

1 Approach

The descriptive method was selected for the current research by applying biomechanical analysis for the three-point shot and building and scheming qualitative exercises of the skill according to the analysis outputs.

2 Sample

A planned sample was selected for the 1st ranked player in NBA in the three-point shot skill in 2020/2021 viz. Joe Harris by a shot rate of 47.5% (*Most 3 Pointers In NBA Season 2021, 2021; 2020-21 NBA Player Stats: Totals, 2021; Season Leaders, 2021*), Table 1.



Table 1. Player's personal data

Joe Malcolm Harris								
Height	Weight	Age	Training age	Position	Country	Club	T-shirt no.	NBA Debut
1.98 cm	100 kg	30 years	26 years	Shooting Guard and Small Forward	USA	Brooklyn Nets	12	7 years

(Joe Harris / Brooklyn Nets, n.d.; Joe Harris Stats, n.d.)


3 Procedures

The three-point shot skill was divided into three technical stages in purpose to ease its study and analysis Table 2.

Table 2. Technical description of the three-point shot skill in basketball

Stages	Technical description	Illustration
Jumping	<ul style="list-style-type: none"> - Initially, the player stands in front of the hoop and feet are apart with the two shoulders width, feet insteps are frontward together with knees bend. - Hold the basketball with the shooting hand and the other hand is in touch with it from the side, fingers of the hands are open and relaxed without tension and the elbow is pointed to the hoop. - The player starts pushing the ground vertically upward to the full length of the legs by raising the ball above the head and keeping the elbow pointed to the hoop. 	
Shooting	<ul style="list-style-type: none"> - In this stage the motor transfer process takes place from feet to arms. As the player reaches the highest point of the jumping stage, he raises his shoulders stretching his arms up to the highest point to direct the ball towards the hoop and keeping the elbow towards the hoop. - When the arm reaches its full stretch, it is necessary to have the wrist rotate upward and frontward at the moment of releasing the ball from fingertips. 	



Stages	Technical description	Illustration
Landing and balance	<ul style="list-style-type: none">- In this stage, the shooting hand continues to follow the ball and the landing on the feet together with knees bend and turning the torso back a little to maintain the balance of the body.	

(American sport Education program, 2007; Barth & Boesing, 2010)

- A video of Joe Harris performing a 3-point shot in the match from YouTube, was download as MP4 file.
- Converting the MP4 video to MPEG to have the film stored on the Motion Track program to have it readable.
- Loading the film and recalling it on the program to outline the duration the start and end of the analysis of the three-point shot attempt by the player Joe Harris.
- Entering the player's data viz. height, weight, outlining the unit of calibration.
- Outlining body parts and selecting reference points that would be analyzed by putting points on the player in the film.
- Following full motion automatically in the program.
- Extracting Stick figures and Numerical data report of kinematic and kinetic variables of the three-point shot skill analyzed and graphs.
- Determination of the general framework on which designing qualitative exercises would be built viz. the number of repetitions, rest intervals and load intensity in line with the basketball game as follows:

The number of repetitions:

Energy systems are the maestro that control training in general and contribute determining the number of repetitions for the player to perform some exercises. So, it is necessary to know the time of performance of technical stages of the skill. Through energy production systems suitable for the basketball game such as anaerobic phosphate energy system (ATP- CP) suitable for training speed, power, strength, and speed of technical performance of 10 sec. and anaerobic combined energy system (lactic) suitable for training speed endurance, power endurance, strength endurance and technical performance speed endurance of 30 sec. (Albasiti, 1998; Zedan, 2014). The number of repetitions could be determined as follows:

$$\text{Number of repetitions} = \frac{\text{Time of the system}}{\text{time of performance}}$$



The number of sets:

In the anaerobic phosphate system (ATP- CP) of 10 sec. and the anaerobic lactic system of 30 sec., they contain 5 sets (Albasiti, 1998).

Rest intervals:

In the anaerobic phosphate system (ATP- CP) and the anaerobic combined system (lactic) the ratio of work to the rest is 1:3 (Albasiti, 1998; Zedan, 2014). Applying this ratio, the rest time is as follows:

- Rest time in the anaerobic phosphate system (ATP- CP) = $10 \times 3 = 30$ sec.
- Rest time in the anaerobic combined system (lactic) = $30 \times 3 = 90$ sec.

Load intensity:

It consists of three levels 50%, 75% and 100% in three forms medium, less than maximum and maximum load. They are suitable for all exercises within the anaerobic phosphate energy system (ATP- CP) and the anaerobic lactic energy system (Albasiti, 1998; Zedan, 2014). When forming the load on five sets, it will be as in Fig 1.

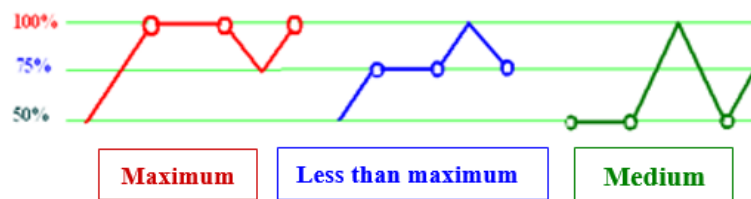


Figure 1. The volume of sets in each level of load (medium, less than maximum, and maximum)

- Designing qualitative exercises for the three-point shot skill in accordance with numerical data of kinematic and kinetic variables extracted from the performance analysis of Joe Harris by using the Motion Track program.
- The analysis of skill and designing qualitative exercises for her were conducted from March 1st, 2022 to May 30th, 2022.


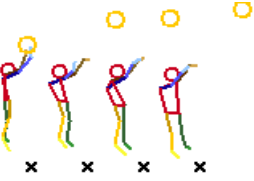
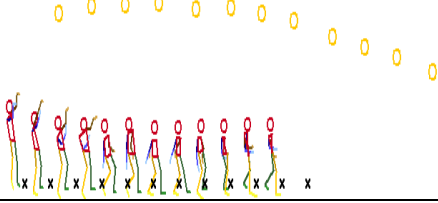
Results and Discussion

I. Biomechanical variables required for extracting qualitative exercises for the three-point shot:



Figure 2. Stages of performance of the three-point shot skill in basketball as per biomechanical analysis

Table 3. Time analysis and the percentage of contribution of the three-point shot stages in basketball

Stages	Picture	Time (sec.)	percentage of contribution	Figure
Jumping	(1-5)	0.33	20%	
Shooting	(6-9)	0.33	20%	
Landing and balance	(10-21)	1.00	60%	
Total		1.66	100%	

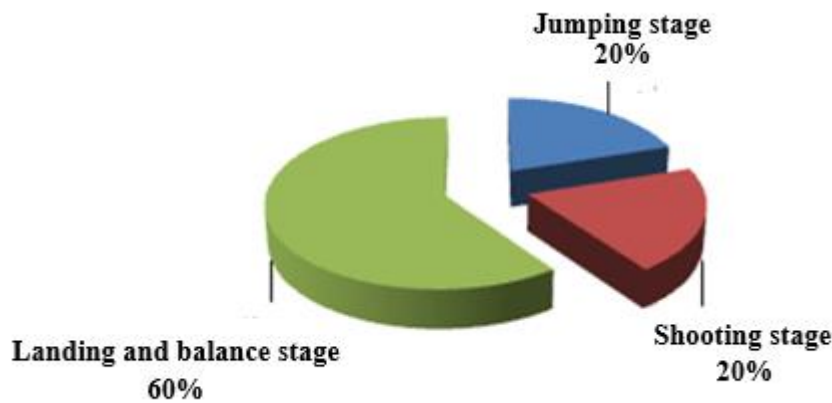

Figure 3. Percentage of the contribution of stages of performance in the three-point shot skill in basketball

Table 3 and Fig 3 illustrate that the whole time of performance of the three-point shot skill equals 1.66 sec. and time of performance of jumping and shooting stages equal 0.33 sec. each by a percentage of contribution of 20% each, whereas the time of performance of landing and balance stage equals 1 sec. by a percentage of contribution of 60% of the total of the skill performance.

It is noticed that it would be important to know the performance time of each stage of the three-point shot skill to determine the number of repetitions in qualitative exercise, whether it was physical or technical in one set for each stage in the performance of the skill.



Table 4. Variables of horizontal and vertical motion (the player – the ball) in the three-point shot skill in basketball

Stages	Picture	Time	Body's center of gravity		Right-hand palm		Ball path	
			horizontal	Vertical	horizontal	Vertical	horizontal	Vertical
			Distance	Distance	Distance	Distance	Distance	Distance
Jumping	1	0.00	0.16	0.85	-0.35	1.51	-0.39	1.51
	2	0.08	0.24	1.01	-0.09	2.05	-0.04	1.90
	3	0.17	0.32	1.31 leaving the ground	0.13	2.25	0.19	2.22
	4	0.25	0.37	1.43	0.32	2.35	0.30	2.44
	5	0.33	0.43	1.58	0.41	2.57	0.37	2.57
Shooting	6	0.41	0.51	1.72 maximum height	0.11	2.83 releasing the ball	0.09	2.92
	7	0.50	0.53	1.65	-0.04	2.57	-0.58	3.52
	8	0.58	0.53	1.57	-0.02	2.63	-0.54	3.58
	9	0.66	0.56	1.43	0.04	2.44	-0.89	3.78
	10	0.74	0.59	1.13	0.22	2.18	-1.60	4.15
Landing and balance	11	0.83	0.67	0.90	0.32	1.99	-1.94	4.32
	12	0.91	0.69	0.85	0.35	1.86	-2.31	4.36
	13	0.99	0.75	0.81	0.24	1.64	-2.68 Distance	4.41 greatest height
	14	1.08	0.92	0.69	0.58	0.78	-3.22	4.25
	15	1.16	1.03	0.75	0.95	0.61	-3.63	4.30
	16	1.24	1.14	0.67 less height	1.38	0.63	-3.87	4.12
	17	1.32	1.22	0.68	1.38	0.65	-4.17	3.97
	18	1.41	1.39	0.74	1.30	0.48	-4.79	3.56
	19	1.49	1.48	0.72	1.30	0.71	-5.07	3.33
	20	1.57	1.61	0.74	1.32	0.89	-5.40	3.07
	21	1.66	1.68	0.74	1.45	0.65	-5.85	2.70

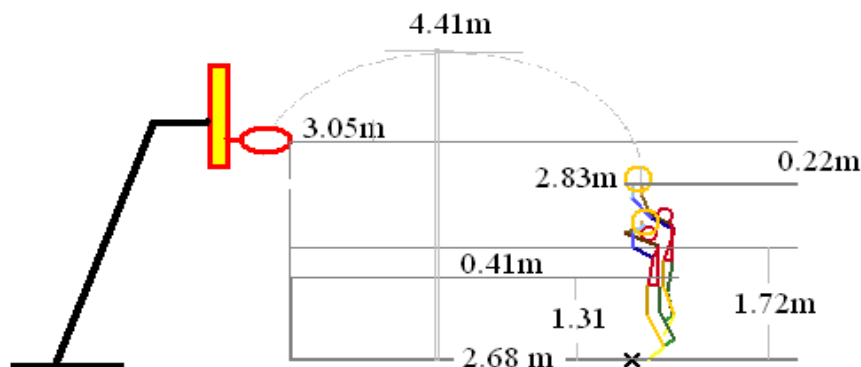


Figure 4. Horizontal and vertical dimensions of the player and the ball in relation to the hoop in the three-point shot



Table 4 and Fig 4 show that the height of the body's center of gravity at the moment of leaving the ground is 1.31 m above and the maximum height reached by the body's center of gravity at the top of the player's flight from stability is 1.72 m and hence, the height of the vertical jump at the moment of shooting is 0.41 m from stability. Also, the height of the right-palm at the moment of releasing the ball in the shooting stage of the three-point shot is 2.83 m and the ball path height is 2.92 m. However, the difference between the height of the shooting point and the hoop is $3.05 - 2.83 = 0.22$ m, and the greatest ball path height from the ground is 4.41 m. This height between the player and the hoop is 2.68 m off the player. In landing and balance stage, the less height of the body's center of gravity is 0.67 m.

Moreover, it was clear that knowing the horizontal and vertical motion of the player and the ball in each stage of the three-point shot would help determine how far and high are tools used in qualitative exercises.

Table 5. Angular change of the body joints and amounts of forces exerted in the (center of gravity - arms) in the three-point shot skill in basketball

Stages	Picture	Time	Angular change			Force		
			Elbow	Shoulder	Knee	center of gravity	Right arm	Left arm
Jumping	1	0.00	144.40	100.74	109.07	0.00	0.00	0.00
	2	0.08	125.27	123.10	142.72	264.80	32.88	36.80
	3	0.17	46.23	114.40	156.39	196.79	6.78	-6.79
	4	0.25	55.99	112.67	164.84	-275.05	-26.28	-5.87
	5	0.33	59.91	115.19	144.40	56.43	2.72	-8.20
Shooting	6	0.41	136.16	118.56	163.04	-3.33	-3.50	-0.61
	7	0.50	141.04	99.66	166.73	-129.22	-3.33	12.01
	8	0.58	139.95	83.11	169.16	6.41	1.34	-19.65
	9	0.66	160.69	135.24	174.06	86.76	-4.13	13.52
	10	0.74	133.63	114.77	175.23	249.05	28.62	18.87
Landing and balance	11	0.83	174.54	122.30	158.97	-81.16	-7.78	-22.02
	12	0.91	127.82	111.13	144.58	-296.13	-4.24	17.36
	13	0.99	139.34	96.63	172.13	33.93	-16.51	-16.74
	14	1.08	113.80	17.56	135.76	186.25	45.03	12.60
	15	1.16	135.46	23.48	159.38	-103.18	-35.51	-23.10
	16	1.24	142.97	78.39	162.70	2.09	5.34	6.56
	17	1.32	168.62	27.67	174.40	-74.40	-15.86	-7.67
	18	1.41	143.07	6.91	141.56	156.69	3.02	5.57
	19	1.49	120.33	6.54	140.37	-150.15	6.22	-2.76
	20	1.57	89.73	16.40	126.42	68.65	3.17	-3.28
	21	1.66	139.91	9.54	119.92	-79.69	-14.93	5.70



Table 5 reveals that at the beginning of the jumping stage the angle of the knee joint is 109° , at the moment of the player's leaving the ground the angle of elbow joint i.e. the angle of forearm with humerus is 46° and the angle of knee joint 156° . At the moment of the releasing the ball the angle of elbow joint i.e. the angle of forearm with humerus is 136° , the angle of shoulder joint i.e. the angle of humerus with body is 119° and the angle of knee joint 164° . Finally, at the beginning of landing the angle of knee joint is 175° and at the lowest height of the body's center of gravity the angle of the knee joint is 163° .

As a result, determining the angular change of shoulder, elbow and knee joints would help outline body angles during performing physical or technical qualitative exercises.

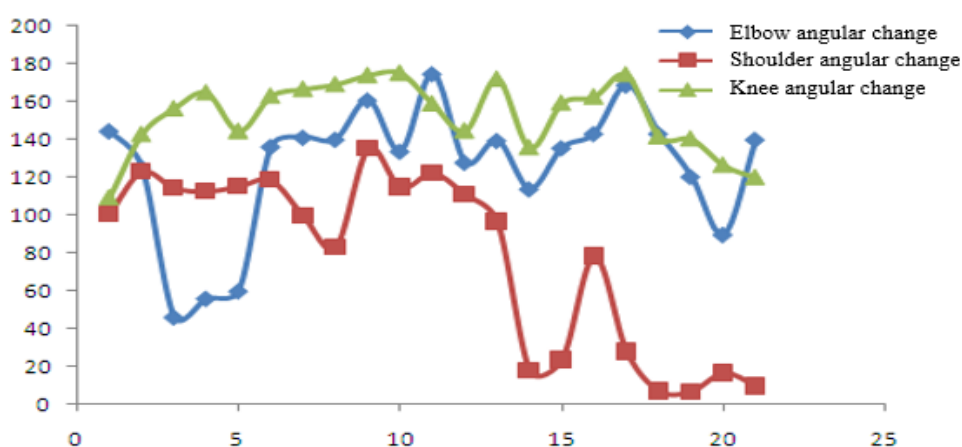


Figure 5. Angular change of elbow, shoulder and knee joints during movement stages of the three-point shot

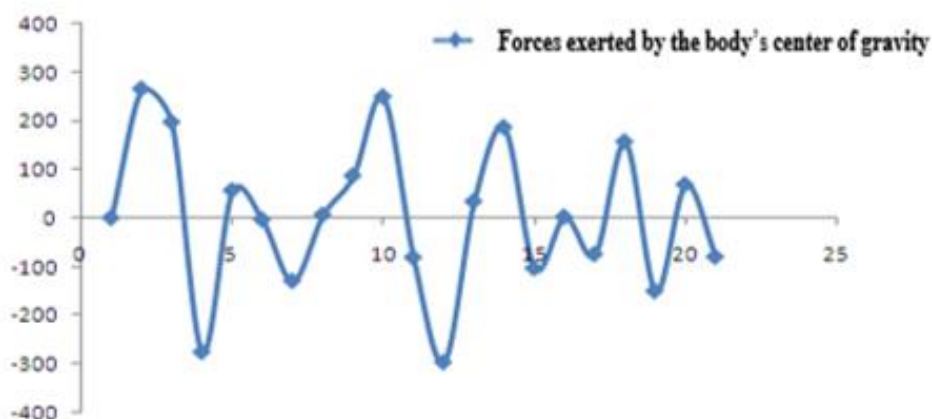


Figure 6. Amounts of forces exerted by the body's center of gravity during movement stages of the three-point shot

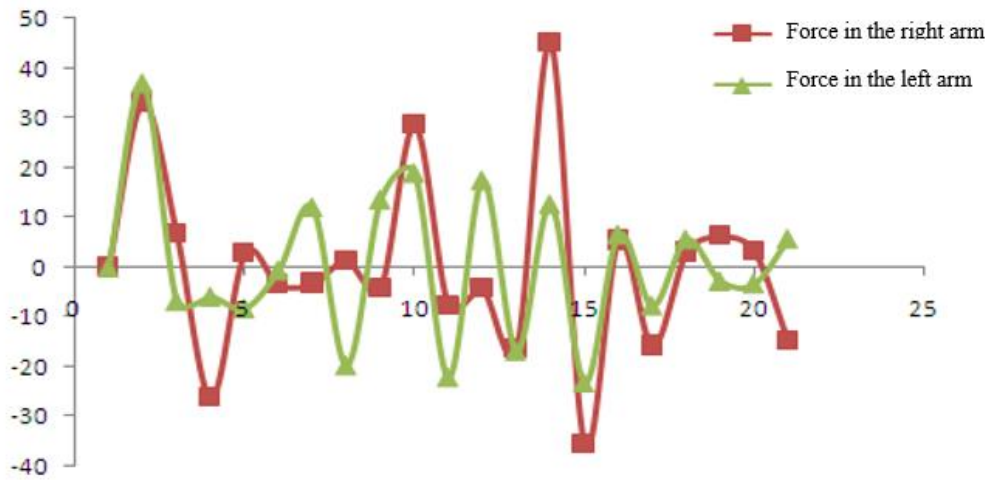


Figure 7. Forces variation in the right arm and the left arm during movement stages of the three-point shot

Table 6. Descriptive statistics of some variables of the movement (Range of angular change – the data of amount of force exerted)

Variables	Angular change (Degree)			Force (Newton)		
	Elbow	Shoulder	Knee	body's center of gravity	Right arm	Left arm
The lowest value	46.23	6.54	109.07			
The highest value	174.54	135.24	175.23			
Range	128.31	128.70	66.16			
Sum				560.93	80.54	59.90

Data of Table 6 that is extracted from Table 5 and Figures 5-7 show that the lowest value of angles of elbow, shoulder and knee joints are 46°, 6° and 109°, respectively, the highest values are 175°, 135° and 175°, respectively. To calculate the range of angular variation in each of elbow, shoulder and knee joints the lowest value is subtracted from the highest value and they are approximately 128°, 129° and 66°, respectively.

Also, it is clear that the amounts of force exerted by the center of gravity, the right arm and the left arm are 560.93, 80.54 and 59.90 Newton, respectively and when converted to kg, the amounts of force exerted by the body's center of gravity, the right arm and the left arm become approximately 57, 8 and 6 kg, respectively.

Hence, knowing the range of each joint would help to determine the motor range of the player's joints when performing qualitative exercises and to know the amount of force exerted would help determine the amounts of weights used in qualitative exercises.

To sum up, based on the data from Tables 3-6 and Figures 2-7, biomechanical variables are reliable enough to design and build qualitative exercises for the three-point shot skill. Time



distribution of the performance stages; horizontal and vertical distances of the body's center of gravity, the right-hand palm, the ball path; angular change of elbow, shoulder, and knee joints and the amount of force of the body's center of gravity and arms, all are controlling factors.

By this result the answer to the first research question stating, "What are the required biomechanical variables to extract qualitative exercises for the three-point shot in basketball?", is established.

II. Establishing Qualitative exercises based on biomechanical variables of the three-point shot:

(1) Qualitative exercises in the jumping stage (physical exercises)

The number of repetitions of exercises in the jumping stage:

Table 3 clarifies that the duration of the jumping stage is performed is 0.33 sec. and hence:

- Number of repetitions of the exercise in the jumping stage = $10/0.33= 30$ rep. If the goal of the exercise is to develop leg power, arm power, arm strength, or speed of technical performance.
- Number of repetitions of the exercise in the jumping stage = $30/0.33= 90$ rep. If the goal of the exercise is to develop leg power endurance, arm power endurance, arm strength endurance, or speed endurance of technical performance.

When performing physical exercises of leg power, the plyometric exercise is taken viz. jumping over hurdles with straight legs. The number of repetitions for jumping over hurdles is 30 jumps in one unit as a maximum in 5 sets and at the load levels (medium, less than maximum, and maximum) this number will be as follows:

- Medium level of 5 sets, the number of repetitions will be 15/15/30/15/22 jumps.
- Less than the maximum level of 5 sets, the number of repetitions will be 15/22/22/30/22 jumps.
- Maximum level of 5 sets, the number of repetitions will be 15/30/30/22/30 jumps.

Height of hurdles:

Table 4 shows that the height of hurdle in physical exercises of leg power in the plyometric exercise viz. jump over hurdles with straight legs is known and calculated by subtracting the height of the body's center of gravity at the moment of leaving the ground from the maximum height reached by the body's center of gravity at the top of flight from the stand, equals = $1.72 - 1.31= 0.41$ m. and at medium, less than maximum and maximum load levels, this height will be as follows:

- Medium level contains 5 hurdles, the height will be 20/20/40/20/30 cm.
- Less than the maximum level containing 5 hurdles, the height will be 20/30/30/40/30 cm.
- Maximum level containing 5 hurdles, the height will be 20/40/40/30/40 cm.



Weight, angle and range of arms exercises performance:

Table 6 illustrates that the weight of arms in physical exercises of arms power in the exercise of pushing a medicine ball forward and upward with a jump.

- Weight of the medicine ball held by the player to push it forward and upward with the right hand with jump is approximately 8 kg i.e. 8% of the player's weight.
- Weight of the medicine ball held by the player to push it forward and upward with the left hand with jump is approximately 6 kg i.e. 6% of the player's weight.

Table 5 shows that the angle of the elbow i.e. the angle of the forearm with the humerus is 46° at the moment of the player's leaving the ground and hence, the player during performing the exercise of pushing the medicine ball upward and forward with the jump, should have an angle of elbow joint of 46° i.e. acute angle at the moment of leaving the ground in the jumping stage and the range of elbow joint is 128 as in Table 6.

Table 6 shows that the weight of arms in physical exercises of arms strength in exercise of dumbbells upward and inward stretch and bend arms is as follows:

- Dumbbells weight held by the player to stretch and to bend the arm upward and inward the body with the right hand is approximately 8 kg i.e. 8% of the player's weight.
- Dumbbells weight held by the player to stretch and to bend the arm upward and inward the body with the left hand is approximately 6 kg i.e. 6% of the player's weight.

Table 5 clarifies that the angle of the elbow at the beginning of the jumping stage is 144° , the angle of shoulder joint is 100° , the angle of the elbow joint at the end of the jumping stage is 60° and the shoulder joint is 115° and hence, they are angles of the beginning and the end of the exercise of dumbbells upward and inward stretch and bend arms in the jumping stage.

Weight, angle and range of performing exercises of legs:

Table 6 outlines that the weight of legs in physical exercises of legs power in the exercise of bend knees and jumping upward with holding weight is as follows:

- The weight held by the player to perform the exercise of bend knees and jumping upward is approximately 57 kg i.e. 57% of the player's weight.

Moreover, Table 5 and Table 6 illustrate that the last bend of the knee in the jumping stage is 109° i.e. the player should begin the exercise with an obtuse knee angle of 109° and should reach an angle of 156° at the moment of leaving the ground and to jump with completing the angular change of the knee joint to reach an angle of the knee of approximately 175° with a range of 66° .



(2) Qualitative exercises in the shooting stage (technical) (physical) exercises:

The number of repetitions of exercises in the shooting stage:

Table 3 shows that the duration to perform the shooting stage is 0.33 sec and hence:

- The number of repetitions of the exercise in the shooting stage = $10/0.33= 30$ rep. If the goal of the exercise is to develop legs power, arms power, arms strength, or the speed of technical performance.
- The number of repetitions of the exercise in the shooting stage = $30/0.33= 90$ rep. If the goal of the exercise is to develop leg power endurance, arm power endurance, arm strength endurance, or speed endurance of technical performance.

When performing technical exercises of speed and accuracy of skill performance represented by the number of shots i.e. shooting from outside the arc, the number of repetitions of shooting is 30 shots in one set as a maximum in 5 sets and when the load intensity levels (medium, less than maximum and maximum) the number of repetitions is as follows:

- Medium level of 5 sets is 15/15/30/15/22 shots.
- Less than the maximum level of 5 sets is 15/22/22/30/22 shots.
- Maximum level of 5 sets is 15/30/30/22/30 shots.

Height of obstacle:

Table 4 illustrates that it is possible to adjust the angle and height of the shooting when performing exercises of the three-point shot with a jump by placing an obstacle and its height. The latter can be calculated by subtracting the diameter of the basketball measuring 7 from the vertical distance of the ball path at the moment of releasing the ball at the top player's height = $2.92\text{ m} - 0.24\text{ m} = 2.68\text{ m}$ and at the distance of approximately 0.09 m i.e. 10 cm from the player.

Also, it is possible to adjust the angle of the ball path when performing technical exercises of the three-point shot with a jump by placing an obstacle. The height of the obstacle can be known by subtracting the basketball diameter measuring 7 from the top height of the ball path = $4.41\text{ m} - 0.24\text{ m} = 4.17\text{ m}$. The obstacle is at a distance of 2.68 m from the player toward the basket that the player should shoot over it to have the ball get into the hoop.

Weight, angle and range of performing exercises of arms:

Table 6 shows the weight assigned for arms in physical exercises of arms strength represented by the exercise of Dumbbells bend and stretch arms upward and forward as follows:

- Weight of Dumbbells held by the player with the right hand is approximately 8 kg i.e. 8% of the player's weight.
- Weight of Dumbbells held by the player with the left hand is approximately 6 kg i.e. 6% of the player's weight.

Table 5 indicates that the angle of the elbow joint at the beginning of the shooting stage when the player's releases the ball is 136° , the angle of the shoulder joint is 119° , and the angle of the elbow joint at the end of the shooting stage is 161° and the shoulder joint is 135° and hence,



they are angles of the beginning and the end of Dumbbells bend and stretch arms upward and forward exercise in the shooting stage.

(3) Qualitative exercises in the stage of landing and balance (physical exercises):

The number of repetitions for exercises of landing and balance stage:

Table 3 shows that the duration of performing the landing stage is 1 sec and hence:

- Number of repetitions in deep jump = $10/1 = 10$ jumps (to develop leg power).
- Number of repetitions in deep jump = $30/1 = 30$ jumps (to develop leg power endurance).

When performing the physical exercise of leg power represented by deep jump, the number of repetitions of the box jump is 10 jumps in one set as a maximum by 5 sets and for medium, less than maximum, and maximum load levels, the number of repetitions is as follows:

- Medium load level of 5 sets, it is 5/5/10/5/8 jumps.
- Less than the maximum load level of 5 sets, it is 5/8/8/10/8 jumps.
- Maximum load level of 5 sets, it is 5/10/10/8/10 jumps.

Box height:

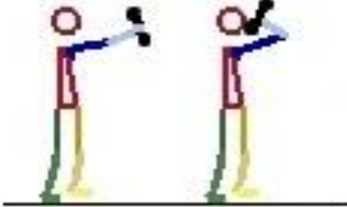
Table 4 illustrates that the box height on which the deep jump is performed can be calculated by subtracting the lowest height of the body's center of gravity of 0.67 m from its top height 1.72 m, the box height equals 1.05 m.



Table 7. Qualitative exercises designed according to biomechanical variables of the three-point shot skill in basketball

Stages	Exercise type	Exercise explanation	Illustration
Jumping	Physical (Legs power)	<p align="center">Exercise of straight legs hurdle jump</p> <p>Description: Hurdle height 0.41 m, number of jumps 30 ones/set, rest time between sets 30 sec, number of sets 5 sets, load exercise levels on 5 sets as follows: - Medium 15/15/30/15/22 jumps - Less than maximum 15/22/22/30/22 jumps - Maximum 15/30/30/22/30 jumps</p> <p>Performance method: (Stand) then jump over hurdles with straight legs and knees as illustrated.</p>	
Jumping	Physical (Legs power)	<p align="center">Exercise of bend knees and jumping upward with holding weight</p> <p>Description: The weight equals 57% of the player's weight, the number of jumps 30 ones/set, rest time between sets 30 sec, number of sets 5, load levels on five sets as follows: - Medium level 15/15/30/15/22 jumps - Less than maximum 15/22/22/30/22 jumps - Maximum level 15/30/30/22/30 jumps</p> <p>Performance method: (Stand with feet apart- weight on shoulders), the player bends their knees with 109° angle to reach 156° angle at the moment of getting off the ground and jumps in place upward with straightening knees to make approximately 175° angle with a knee motor range of 66° as illustrated.</p>	



<p>Jumping</p>	<p>Physical (Arms strength)</p>	<p>Exercise of stretching and bending arms upward and inward with dumbbells</p> <p>Description: Dumbbells weight for the shooting hand 8% of the player's weight, 6% for the other hand, number of repetitions 30 ones/set, rest time between sets 30 sec, number of sets 5, load on the 5 set as follows:</p> <ul style="list-style-type: none">- Medium level 15/15/30/15/22 rep.- Less than maximum level 15/30/30/22/30 rep.- Maximum level 15/30/30/22/30 rep. <p>Performance method: (Stand feet apart – arms stretched upward- holding dumbbells with hand palms facing down), the angle of shoulder joint i.e. angle of the humerus with the body approximately 100°, angle of elbow joint i.e. angle of the forearm with humerus approximately 144° at the beginning of the exercise, the player bends arms upward and inward and toward the chest to reach an angle of the shoulder joint approximately 115° and the angle of elbow joint approximately 60° as illustrated.</p>	
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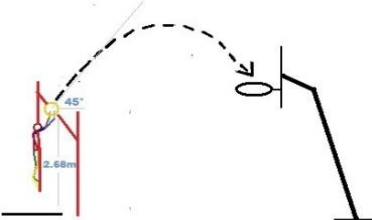
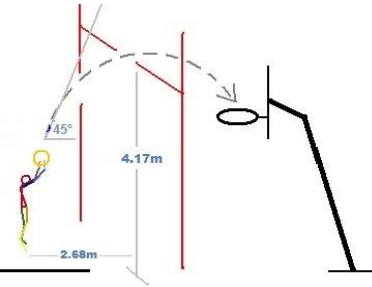
<p style="text-align: center;">Shooting</p>	<p style="text-align: center;">Physical (Arms strength)</p>	<p style="text-align: center;">Exercise of pushing a medicine ball upward and forward with jumping</p> <p>Description: Weight of the medicine ball for the shooting hand 8% of the player's weight and for the other hand 6% of the player's weight, number of repetitions of pushing the ball 30 rep/set, rest time between sets 30 sec., number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/23 rep. - Less than maximum level 15/23/23/30/23 rep. - Maximum level 15/30/30/23/30 rep. <p>Performance method: (Stand- holding the medicine ball on one hand and the other hand touching it from the side) like holding the basketball when performing the three-point shot skill, elbow angle 46°, the player jumps with pushing the medicine ball over and forward that the motor range of the joint 128° as illustrated.</p>	
<p style="text-align: center;">Shooting</p>	<p style="text-align: center;">Physical (Arms strength)</p>	<p style="text-align: center;">Exercise of bending and stretch arms upward and forward with dumbbells</p> <p>Description: Weight of dumbbells for the shooting hand 8% of the player's weight and 6% for the other hand, number of repetitions 30 rep/set, rest time between sets 30 sec, number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/22 rep. - Less than maximum level 15/22/22/30/22 rep. - Maximum level 15/30/30/22/30 rep. <p>Performance method: (Stand – arms upward- holding dumbbells and hand palm frontward) angle of shoulder i.e. angle of humerus with the body approximately 119° and angle of elbow joint i.e. angle of the forearm with humerus approximately 136° at the beginning of the exercise, the player swings arms up and front</p>	



		to reach the angle of shoulder joint approximately 135° and the angle of elbow joint approximately 161° as illustrated.	
Shooting	Techno-physical (Arms power with shooting)	<p align="center">Exercise of shooting from outside the arc with hand weights</p> <p>Description: A basketball measuring 7 for men and measuring 6 for women, a legal distance for the three-point shot, the legal height of the hoop, shooting hand weight 8% of the player’s weight, and 6% for the other hand, number of repetitions 30 rep/set, rest time between sets 30 sec, number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/22 rep. - Less than maximum level 15/22/22/30/22 rep. - Maximum level 15/30/30/22/30 rep. <p>Performance method: (Stand with weights around the wrist and hold the basketball) the player performs the three-point shot skill with jumping as illustrated.</p>	
Shooting	Techno-physical (Legs power with shooting)	<p align="center">Exercise of shooting from outside the arc with body weights</p> <p>Description: A basketball measuring 7 for men and 6 for women, a legal distance for shooting the three-point shot, the legal height of the hoop, weighted vest of 57% of the player’s weight, number of repetitions 30 per set, rest time between sets 30 sec, number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/22 rep. - Less than maximum level 15/22/22/30/22 rep. - Maximum level 15/30/30/22/30 rep. <p>Performance method: (Stand wearing a weighted vest- holding basketball) the player performs the three-point shot skill as illustrated.</p>	



<p>Shooting</p>	<p>Technical (Accuracy and quickly shooting at the hoop)</p>	<p>Exercise of shooting from outside the arc</p> <p>Description: A basketball measuring 7 for men and 6 for women, a legal distance for the three-point shot, the legal height of the hoop, number of repetitions 30 shots per set, rest time between sets 30 sec, number of sets 5, load on the five sets as follows:</p> <ul style="list-style-type: none">- Medium level 15/15/30/15/22 rep.- Less than maximum level 15/22/22/30/22 rep.- Maximum level 15/30/30/22/30 rep. <p>Performance method: (Stand with holding the basketball) performing the three-point shot as in the illustration. with the following techniques:</p> <ul style="list-style-type: none">- The hoop is inclined by an angle of 45° with legal height.- Legal hoop.- Two hoops over each other with legal height.	
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<p align="center">Shooting</p>	<p align="center">Technical (Accuracy of shooting the ball angle)</p>	<p align="center">Exercise of the angle of shooting</p> <p>Description: A basketball measuring 7 for men and 6 for women, a legal distance for the three-point shot, the legal height of the hoop, an obstacle of 2.68 m height at the distance of approximately 10 cm from the player, number of repetitions 30 shots per set, rest time between sets 30 sec, number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/22 rep. - Less than maximum level 15/22/22/30/22 rep. - Maximum level 15/30/30/22/30 rep. <p>Performance method: (Stand with holding the basketball) in front of an obstacle at a height of 2.68 m and at a distance of approximately 10 cm from the player within the distance between the player and the basket that the player jumps and shoots over the obstacle as illustrated.</p>	
<p align="center">Shooting</p>	<p align="center">Technical (Accuracy of angle of the ball path)</p>	<p align="center">Exercise of the ball path</p> <p>Description: A basketball measuring 7 for men and 6 for women, a legal distance for the three-point shot, the legal height of the hoop, an obstacle of 4.17 m and the distance of 2.68 m from the player, number of repetitions 30 shots per set, rest time between sets 30 sec, number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/23 shots - Less than maximum level 15/23/23/30/23 shots - Maximum level 15/30/30/23/30 shots <p>Performance method: (Stand holding the basketball) in front of an obstacle at the height of 4.17 m and at the distance of 2.68 m from the player within the distance between the player and the basket that the player jumps and shoots at the hoop over the obstacle (i.e. the ball passes over the obstacle directly) as illustrated.</p>	



<p style="text-align: center;">shooting</p>	<p style="text-align: center;">Technical (Accuracy of shooting angle and the ball path)</p>	<p style="text-align: center;">Exercise of the angle of shooting and ball path</p> <p>Description: A basketball measuring 7 for men and 6 for women, a legal distance for the three-point shot, the legal height of the hoop, an obstacle of 2.68 m height and at the distance of approximately 10 cm from the player and another obstacle of 4.17 m height and at the distance of 2.68 m from the player, number of repetitions 30 shots per set, rest time between sets 30 sec, number of sets 5, load on five sets as follows:</p> <ul style="list-style-type: none"> - Medium level 15/15/30/15/23 shots - Less than maximum 15/23/23/30/23 shots - Maximum level 15/30/30/23/30 shots <p>Performance method: (Stand with holding the basketball) in front of the obstacle at the height of 2.68 m and at the distance of approximately 10 cm from the player within the distance between the player and the basket followed by the obstacle at the height of 4.17 m and at the distance of 2.68 m from the player that the player jumps and shoots toward the hoop over the two obstacles (i.e. the ball passes over the two obstacles to get into the hoop) as illustrated.</p>	
<p style="text-align: center;">Landing and balance</p>	<p style="text-align: center;">Physical (Legs power)</p>	<p style="text-align: center;">Exercise of a deep jump from the top of the box</p> <p>Description: A box of 1.05 m height, number of repetitions 10 jumps per unit, number of sets 5, rest time between sets 30 sec.</p> <p>Performance method: (Stand on the top of the box) jumping downward to reach an angle of bending knees 163° as illustrated.</p>	



Through the above presentation on how to extract and design qualitative exercises in each stage of the motor performance of the three-point shot skill whether it is physical, technical or techno physical according to results of biomechanical variables of the skill and Table 7 it is clear that the qualitative exercises designed for the three-point shot skill in the jumping stage are jumping over hurdles with straight legs; bending knees and jumping upward with holding a weight and stretching and bending arms upward and inward with dumbbells, in the shooting stage, they are pushing a medicine ball upward and forward with jumping; bending and stretching arms upward and forward with dumbbells; shooting from outside the arc with hand weights; shooting from outside the arc with body weights; shooting from outside the arc; the angle of shooting; the ball path and the angle of shooting and ball path, and in the landing and balance stage, they are deep jump from the top of the box.

With this result, the second research question stating “Which qualitative exercises in the light of biomechanical variables of the three-point shot skill in basketball, should be designed?”, is answered

Conclusions

In the light of the research objectives, questions, and methods used and on the basis of the results achieved, it is concluded that controlling biomechanical variables to design and build qualitative exercises of the three-point shot skill in basketball are time distribution of performance stages; the horizontal and vertical distance of body’s center of gravity, right-hand palm and the ball path; angular change of elbow, shoulder and knee joints and the amount of force of the body's center of gravity and arms. Qualitative exercises designed for the three-point shot skill based on biomechanical variables in the jumping stage are jumping over hurdles with straight legs; bending knees and jumping upward with holding a weight and stretching and bending arms upward and inward with dumbbells, in shooting stage, they are pushing a medicine ball upward and forward with jumping; bending and stretch arms upward and forward with dumbbells; shooting from outside the arc with hands weights; shooting from outside the arc with body weights; shooting from outside the arc; the angle of shooting; the ball path and the angle of shooting and ball path, and in landing and balance stage, they are deep jump from the top of the box.

Therefore, the researcher recommended that coaches use these qualitative (physical, technical, and techno-physical) exercises prepared according to biomechanical indicators of the three-point shot skill in basketball while training their teams as they are more specialized and highly effective on developing the level of technical performance and so increasing chances of scoring more points in games



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