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Topography of the Force and the Speed of Its Growth in the Time of Upgrading to Perform the Smash Hit in Volleyball

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Abstract

This research aims to improve the technical performance of the pushing move (upgrading) for performing the smash hit through: identifying the topography of the force of the pushing move (upgrading), identifying the speed of growth of the force in the time of the pushing move (upgrading), identifying the most effective muscles on the speed of growth of the force in the time of the performing the pushing move (upgrading) in the smash hit. The researcher used the descriptive approach with a sample consisted if four high level female volleyball players, each one had (2) attempts, thus the research sample included (8) attempts. The performance of the players were filmed and analyzed via the Force Platform, Electromyography device (EMG 16 Chanel Wireless). The following results were concluded: the correlation coefficient between the speed of the growth of force and the average electrical activity of the pushing move (upgrading) for the smash hit was that the brachial biceps, latissimus dorsi muscle, rectus abdominis muscle, medial vastus quadriceps, right semitendinosus muscle, left femoral quadriceps, left semitendinosus muscle are the fastest shrinking muscles and the most effective and relative to the speed of growth of the force. There was also a negative correlation between the variables of the time of the ultimate force and the speed of growth of the force, and a positive correlation between the variables of the ultimate force at the moment of pushing and the speed of growth of the force. The most effective muscles on the speed of growth of the force for the movement of upgrading (pushing) in smash hit: the medial vastus quadriceps, left femoral quadriceps, and left semitendinosus muscle.

Keywords: *topographic force – the speed of growth of the force*

Introduction

Biomechanics is considered one of the most important sciences in which sport technology is applied, to learn about the basic information about sports movement like analyzing the work of internal and external forces and their effect on the technical performance, and thus getting accurate information about the movement, which can be relied on to build the skill program and improve the technical performance. (5:213)

Muscular force is one of the most important physical elements in all sports activities, because muscles control the movement of the body by shrinking and extending to transfer the limbs from one position to another, and the more the muscle was stronger, shrinking gets more effective, usually the muscles work by duplication, and when a muscle shrinks, the antagonistic muscles relax so as not to hinder the movement. (8:53, 65)

So it becomes obvious how important the compatibility between the work of the shrinking and counter extending muscle groups which operate at the same time, and this is called the "topography of force", which means: "the relative relationship between the maximum values of the forces of the action of various muscular groups of the body," and to form a relatively complete image of the topography of the force of the non-practicing people we would find that the most developed and the strongest muscles are the muscles that work against gravity, such as the extending muscles of the legs, while the topography of the forces of athletes is related to the results achieved, so the bad topography of force can be a major disadvantage to master the logical or ideal performance. (2:289, 290)

The speed is defined as the rate of change in the offset in a certain time, but the word "speed" is not used only on the mere change that takes place in the various positions or one of its parts of the body in this time, but also depends on the speed of change in any indicators or other indications such as the force of the action produced by the athlete, they are the ever-changing directed amount, thus it is necessary to study the change of this force in the time or as so-called "the gradient of force" as it describes the level of growth of the explosive force of athletes in terms associated with the amounts of these differential indicators

by measuring the time of reaching the maximum force or the time of reaching any specific value of them. (2:159, 160-271)

Pushing is very important as it determines the amount of value and speed of kicking-off as well as the flight time and the required altitude, the importance of pushing is due to the contact between the body and the land, in which the force exerted by the player is effective on the path of gravity center, and the path of gravity center of the player in the air is determined by pushing force and the angle of the force. (6:27)

Therefore, the final speed of the volleyball player at the moment of leaving the ground, also the speed of movement of any part of the body would increase the total of the body, and the causing power of the rotational movements performed in the air starts before the player leaves the ground (4:228). The moment of upgrading should be done as quickly as possible by powerful and active pushing by a complete extension of the joints of the foot, the knee and pelvis in order to achieve the highest and most appropriate point in the air. (1:294, 295)

Abdul-Aziz El-Nemr, Nariman El-Khatib (1996), noted that the ability to jump is considered a significant indicator for the muscular ability of the legs and the bottom, it is the cornerstone of the performance of many movements in sport activities which include jumping, El-Sayed Abdel-Maksoud (1997) pointed that the progress in the level of force of the jump leads to increasing the distance or height of the jump, and this provides the appropriate conditions for an effective performance of certain skills, such as smash hit and smash transfer in volleyball, the ability of jumping which is performed by female volleyball players is usually vertical with a little close feet, this action is supported by swinging the arms, he also added that the force of jump is a compound ability which include the following elements: the reflective abilities of the legs or converting the process of getting closer to the level of jumping, the explosive power of the extending muscles of the legs, the style of the jump. (8:34)

The main idea of the criteria for assessing the effectiveness of completion or achievement of performance skills is in comparing the achieved result either through sports levels that the athlete can achieve by building on what he/she has of kinetic ability, in case he/she has the availability of a technique closer to the ideal (highly effective) to perform the motion or by the exerted energy or used force during the implementation of skillful performance of the athletic movement. (2:213)

The researcher concluded from the interviews that she carried out with some players and coaches it was concluded that many volleyball players during their training face many common injuries such as ankle joint injuries. This is a result of faulty training for the working muscular groups force which is resulted from the imbalance in the percentage of shrinking and extending working muscles and the lack of empowerment needed, due to the lack of accurate information of the coaches about the working muscles and the most effective in the performance and the percentage of their contribution leading to disability of the performance of upgrading on which depends the success of this motor duty coupled with a failure to the normal pushing scale which is equal to the multiplication of the force by the time where there is no effect in the explosive movements such as the pushing movements that makes the scale of growing the speed more effective.

Some of the previous studies, which are related to the same area included:

The study by Feng-Jen Tsai, Vu Liu, Shau-Hua Chen, and Vun-Ching Huang (2004) (12) entitled: "Biomechanical Characteristics and EMG Activities of Weighted", the study by Abdel-Rahman Ibrahim Akl (2012) (7) entitled: "Setting the Biomechanics Basics for Pushing by the Two Legs According to Specific Models of Performance", the study by Mohamed Ahmed Abdel-Fattah Mahmoud Zayed (2012) (9) entitled: "The Topography and the Speed of Growing Force in the Time to Perform Explosive Movements for Some Sports Activities", and the study by Krzysztof Dziewiecki, Zenon Mazur, Wojciech Blajer (2012) (10) entitled: "Assessment of Muscle Forces and Joint Reaction in Lower Limbs during the Take-Off from the Springboard", although there is no study has been conducted in the field of volleyball regarding the smash hit skill concerned with the relationship between the muscular activity of the speed of the growing force of the pushing movement (upgrading) as one of the explosive movements that requires of the player greater amount of force to exert in the least possible time, this was the main reason the researcher conducted this study to identify the topography of the force and the speed of its growth in the time of upgrading to perform the smash hit in volleyball by using modern tools and appropriate measuring devices to extract data such as imaging using high frequency cameras, analyzing electrical activity of the muscles "EMG" and the force measuring platform to link the muscular force and the speed of its increase in the time to determine the most effective muscle in the speed of increasing the force to work on directing the training process to improve the technical level of performance to improve upgrading in smash hit, by improving the performance of pushing movement as well as working on selecting and guiding the female players according to their

physical abilities, which would help achieving the desired athletic achievement while reducing exposure to injury.

Aim of the research

Improving the technical performance of the pushing movement (upgrading) in the smash hit through:

- Identifying the topography of the force of the pushing movement (upgrading) in the smash hit.

- Identifying the speed of growing force in time of the pushing movement (upgrading) in the smash hit.

- Identifying the most effective muscles on the speed of growing force of the time of pushing movement (upgrading) in smash hit.

Research questions

- What is the effect of the topographic force on the performance of pushing movement (upgrading) in the smash hit?

- What is the effect of the speed of growing force in time to perform the pushing movement (upgrading) in the smash hit?

- What are the most effective muscles on the speed of the growing force of the pushing movement (upgrading) in the smash hit?

Research procedures

Research methodology:

The researcher used the descriptive approach because it is appropriate to the nature of the research.

Research sample:

The research sample was intentionally selected and it consisted of four high level volleyball female players, with (2) attempts for each player, to have (8) attempts in total.

Equipment and data collecting tools:

The kinetic analysis device "Dmas 7" with its features, Platform force, Electromyographic device (16 Chanel Wireless EMG), its type is (Mega win 6000) and a volleyball court with a ball thrower and a number of balls.

- Pilot study:

The pilot study was conducted on (2) female player from outside the research sample, on 23/7/2015, at the playground of the Faculty of Physical Education for Girls, Alexandria University, in order to control and determine the variables of the imaging process, determine the angle and dimensions of the imaging camera, locating the calibration model, identify the muscles working in upgrading, and how to connect and adjust the synchronization between the kinetic analysis device (Dmas 7) and the (Platform force), (Electromyography (EMG)) devices.

- Identifying the muscles working on upgrading:

The working muscles were identified through the previous studies, and through the qualitative biomechanical analysis, Mohamed Bereka, Khairiya El-Sokkary (2010) and via the (EMG) device and its measurements of the muscles and the number of valid channels of synchronization of the EMG device and the force measurement platform, and through the pilot study, (10) the muscles working on upgrading in the smash hit were identified.

Main study

The players were imaged for kinetic analysis and extracting the variables of (Platform force), and the electrical activity of muscles using (EMG) on Sunday, 28/7/2015.

A part was determined to be analyzed by the kinetic analysis device using (Dmas 7) with synchronization with (Platform force) and (EMG) devices, which is the upgrading phase, and then the analysis process was conducted.

The following results were conducted for the statistical processors.

Imaging procedures for kinetic analysis:

- The players were prepared, and had the electrodes fixed on the working muscles.

- According to the results of the pilot study, (2) high speed cameras were installed on a triple-legged holder on the hitting side of the players, were each one is away from the upgrading location by (12.75m), while the mid-camera lens is (1.65) meters high from the floor.

- Connecting the (Platform force), (EMG) and the cameras with the kinetic analysis device (Dmas 7), to record the video directly on the analyzing device, where the speed of frequency of the camera was set by 120 cadres per second.

- The targeted muscles were determined on the device.

- The calibration device was imaged at the upgrading location before the performance.

- Imaging and recording the players' attempts while performing the smash hit, according to the international law of volleyball.

- Failed attempts were excluded.

- (2) correct attempts were selected for each player in terms of the level of hitting accuracy in certain areas on the pitch, to be the subject for the biomechanical analysis using the (Dmas 7) software, the electrical activity of muscles using EMG and the variables of force and the power of this force by using Platform force and finally conducting the analysis process and concluding the results.

The force gradient was calculated (the speed of growing force regarding the time) for the pushing movement (upgrading) in the smash hit through the following equation:

Reaction quotation of Verkhoshansky as an indicator of force gradient which is:

$$\text{Gradient} = \frac{\text{F max}}{\text{T max.P}} = \text{N/S Kg}$$

F max = maximum power of the force

T max = time of reaching the maximum value of the force

P = weight of the player (2:261)

Results

Table (1)
The topography of the force of the working muscles during upgrading of the maximum damping up to the maximum value of force during (pushing) upgrading in the smash hit

Channel Number	Muscles	Lowest value	Highest value	Arithmetic mean	Standard deviation
		Value in microvolt V^{q}			
1	Brachial biceps	46	486	256.125	192.997
2	Brachial triceps	13	1776	142.25	96.67434
3	Back deltoid muscle	71	1065	269.125	187.5248
4	Major pectoral muscle	29	711	154.25	98.20205
5	Latissimus dorsi muscle	16	3576	422.75	679.291
6	Supraspinatus muscle	62	780	188	69.99184
7	Rectus abdominis muscle	37	2583	356.875	408.5093
8	Erector muscles	33	419	113.5	48.10999
9	Medial vastus quadriceps	50	1875	521.375	583.2696
10	Right semitendinosus muscle	99	1673	369.5	270.88
11	Right back bronchial muscles	22	1574	225.5	221.6078
12	Right soleus muscle	30	872	196.625	153.3809
13	Left femoral quadriceps	29	1964	298.875	263.025
14	Left semitendinosus muscle	43	1936	373.375	460.8526
15	Left back bronchial muscles	14	2828	425.25	499.0087
16	Left soleus muscle	13	751	265.625	128.0613

Figure (1)
The arithmetic mean of the electrical activity of the working muscles during upgrading of the maximum damping to the maximum value of the force during the (pushing) upgrading in the smash hit

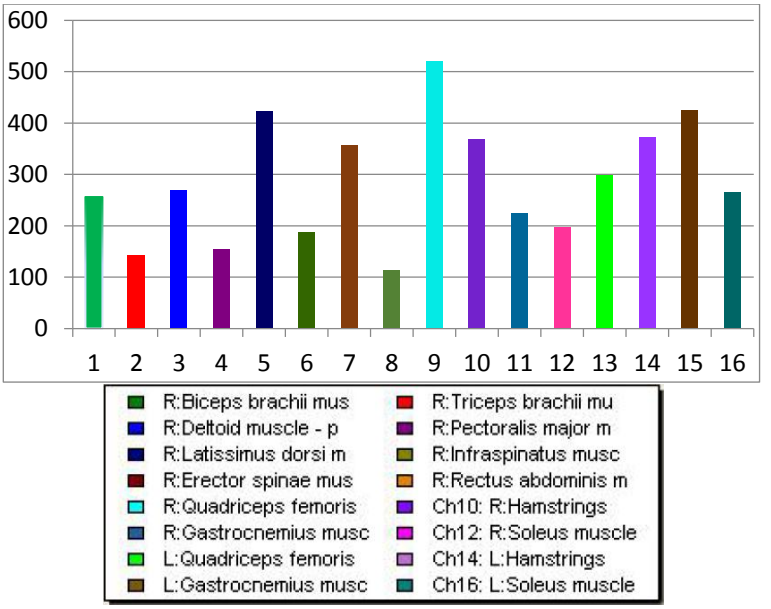

Table (1) that presents the topography of the force of the working muscles during upgrading in the smash hit of the maximum damping up to the maximum value of force (upgrading) and Figure (1) show that the muscle that recorded the highest electrical activity of the maximum damping up to the maximum value of force in the attempts within the research in the pushing movements in smash hit is (the medial vastus quadriceps followed by latissimus dorsi muscle, left back bronchial muscles, left semitendinosus muscle, right semitendinosus muscle, rectus abdominis muscle, left femoral quadriceps, back deltoid muscle, left soleus muscle, brachial biceps, right back bronchial muscles, right soleus muscle, supraspinatus muscle, major pectoral muscle, brachial triceps and finally erector muscles), where the arithmetic means of the electrical activity of the maximum damping up to the maximum value of the forces in microvolts respectively were (521.375 – 422.75 – 425.25 – 373.375 -369.5 – 298.875 – 356.875 – 269.125 – 265.625 – 256.125 – 225.5 – 196.625 – 188 – 154.25 – 142.25 – 113.5)

Figure (2)
Percentages of contribution of the working muscles during the upgrade by (pushing) upgrading in the smash hit

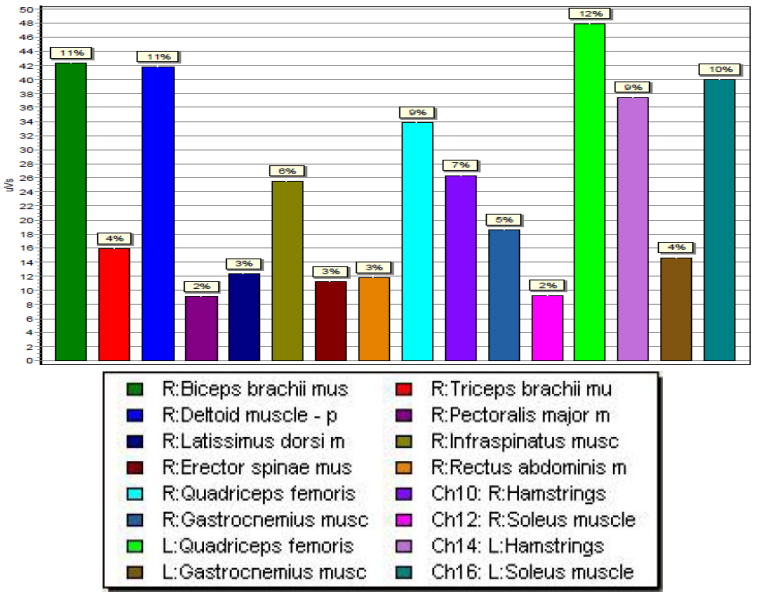

Table (2)
The arithmetic mean and standard deviation of the speed of the growing force of upgrading (pushing) movement in the smash hit

Attempts	Time of the maximum force	The maximum force in newtons	Speed of growing force Newton / Sec.km S.N
1	0.039	2495.107	820.2193
2	0.039	1801.161	592.098
3	0.032	2355.111	1098.466
4	0.039	2292.572	877.372
5	0.048	2395.113	767.664
6	0.033	2141.121	998.192
7	0.032	1536.312	666.802
8	0.038	1619.224	591.822
9	0.038	1348.431	563.254
10	0.044	1512.201	545.527
11	0.027	2101.162	1215.950
12	0.025	2295.192	1434.495
13	0.036	2110.312	837.425
14	0.038	2106.142	791.783
15	0.029	2549.201	1441.041
16	0.038	2124.115	916.357
Arithmetic mean	0.0359	2048.905	884.904
Standard deviation	0.0060	373.671	288.341

Table (3)
Matrix of Pearson correlation coefficient between the variables of time of the maximum force, the maximum force and the speed of the growing force of the pushing movement (upgrading) in the smash hit (N=16)

Variables	Time of the maximum force	The maximum force in newtons	Speed of growing force Newton / Sec.km S.N
Time of the maximum force			
The maximum force in newtons	- 206.0		
Speed of growing force Newton / Sec.km S.N	- 761.0**	- 709.0**	

** Significant at the level 0.01 = 0.574
* Significant at the level 0.05 = 0.426

Table (2) of the pushing movement (upgrading) in smash hit shows that the highest level of the speed of growing force was in the first attempt, where it was (1434.495Newton / Sec.km) and the time of maximum force was = (0.025sec.), which is the least time of all attempts while the highest value of the maximum force was in the first attempt where it was (2295.192Newton).

Table (3) of the matrix Pearson correlation coefficient shows that there is a negative relationship between the two variables of the time of maximum force and the speed of the growing force while there is a positive relationship between the two variables of the maximum force at the moment of pushing and the speed of growing force.

So the time of maximum force is the effective and decisive factor on the speed of the growing force of the pushing movement (upgrading) in the smash hit because when the time decreases and the maximum force increases, this indicates the high level of performance, and the index of the forces to the speed of growing force, the change in the player's speed do not depend solely on the force exerted, but also rely on the time of exerting the force.

This conforms to what is noted by Sawsan Abdel-Moneim et al. (1991), Bastawissy Ahmed (1997), Krzysztof Dziewiecki, Zenon Mazur, Wojciech Blajer (2012) that the pushing of the body depends primarily on the speed of launching which relates to the ability of the player to make a large force and high speed. (14:228), (1:294, 295) (14:14)

El-Sayed Abdel-Maksoud (1997) points that the performance of sports movements in the higher levels allows taking a short time only to expand the use of the force, as the explosive power is performed in a very short period of time, in which it is necessary to use the maximum level of force as possible, so the proper and regular training reduces the time required for shrinking the rapid muscle fibers, as well as improving the compatibility between the working and confronting muscles, which leads to decreasing the effect of break of the confronting muscles or finally get rid of it, its level also depends on the velocity of shrinking of the muscle fibers. (3:122-126)

Gamal Alaa-Eldin, Nahid Anwar El-Sabbagh (2007) noted that in case the period of time is short to perform the movement, superiority will be to the high-level athlete regarding the force gradient since the times of performing the movements of basic phases decrease positively while the athletes upgrade to the physical rehabilitation level, which means a positive increase in the importance of speed of the growing force, since the time of showing the maximum force in a lot of kinetic performances decreases, therefor pushing in the vertical jump takes a period of time less than 250 mm/sec. (2-162:163)

Table (4)
The correlation coefficient between the speed of growing force and the average of the electrical activity of the pushing movement (upgrading) in the smash hit (N = 16)

Variables	The speed of growing force
The speed of growing force	
Brachial biceps	0.023
Brachial triceps	-0.005
Back deltoid muscle	-0.009
Major pectoral muscle	0.276
Latissimus dorsi muscle	0.401
Supraspinatus muscle	0.376
Rectus abdominis muscle	-0.396
Erector muscles	0.259
Medial vastus quadriceps	*0.534
Right semitendinosus muscle	0.125
Right back bronchial muscles	*0.530
Right soleus muscle	0.417
Left femoral quadriceps	*0.474
Left semitendinosus muscle	0.078
Left back bronchial muscles	*0.557
Left soleus muscle	0.248

* Significant at the level 0.05 = 0.426

It is clear from Table (4) of the correlation coefficient between the speed of growing force and the average of the electrical activity of the pushing movement (upgrading) in the smash hit that the brachial biceps, latissimus dorsi muscle, rectus abdominis muscle, medial vastus quadriceps, right semitendinosus muscle, left femoral quadriceps, and left semitendinosus muscle are the fastest in shrinking and the most effective and relative to the speed of growing force, although of the left soleus muscle is more active, these muscles are faster in shrinking and effective in the speed of the growing force of the pushing movement (upgrading) in the smash hit at the moment of pushing as shown in the research results.

Thus, the amount of electrical activity produced by the muscles is not a key indicator on the speed of growing force, which means that it is not a requirement that the muscles are the most effective in performance contribution or to be more effective in the pushing resulted from gradient force (speed of growing force) and the crucial component that affects the performance is the time of reaching the maximum force.

Whatever the order of the muscles in terms of the amount of electrical activity, they work in hormonal manner with consistency together to perform the movement, however, there are muscles responsible for the force and other muscles are responsible for the speed.

Mohamed Allawy (1989), Jensen, CR and Fisher, AG (1990), Feng-Jen Tsai, Vu Liu, Shau-Hua Chen, and Vun-Ching Huang (2004) point that the speed of shrinking of the muscle vary from one person to another and from one muscle to another, and that the speed of muscle shrinking indirectly affect the explosive ability through their effect on one of the compounds (speed) (11-75) (13-128) (12-16, 17).

Conclusions

According to the results of the statistical analysis of the data the following conclusions were reached:

I) The order of the muscles which recorded the highest electrical activity in the performance of upgrading (pushing) movement in the smash hit:

1- Medial vastus quadriceps

2- Latissimus dorsi muscle

3- Left back bronchial muscles

4- Left semitendinosus muscle

5- Right semitendinosus muscle

6- Rectus abdominis muscle

7- Left femoral quadriceps

8- Back deltoid muscle

9- Left soleus muscle

10- Brachial biceps

11- Right back bronchial muscles

12- Right soleus muscle

13- Supraspinatus muscle

14- Major pectoral muscle

15- Brachial triceps

16- Erector muscles

II) The order of the muscles which recorded the highest percentage of contribution in upgrading (pushing) movement in the smash hit:

1- Left femoral quadriceps

2- Back deltoid muscle

3- Brachial triceps

4- Left soleus muscle

5- Medial vastus quadriceps

6- Left semitendinosus muscle

7- Right semitendinosus muscle

8- Supraspinatus muscle

9- Right back bronchial muscles

10- Brachial biceps

11- Left back bronchial muscles

12- Latissimus dorsi muscle

13- Rectus abdominis muscle

14- Erector muscles

15- Right soleus muscle

16- Major pectoral muscle

III) Conclusions of the speed of growing force of the performance of upgrading (pushing) movement in the smash hit:

- There is a negative correlation between the variables of the time of maximum force and the speed of the growing force.

- There is a positive correlation between the variables of the maximum force at the moment of pushing and the speed of growing force.

- The time of the maximum force is the decisive factor in the effect of the speed of growing force.

IV) The most effective and active muscles on the speed of the growing force of upgrading (pushing) movement in the smash hit:

- Medial vastus quadriceps

- Left femoral quadriceps

- Left semitendinosus muscle

Recommendations

In the light of the conclusions the researcher recommends the following:

- Develop training programs in light of the topography of the force, and the percentages of muscles contribution to the pushing movement (upgrading) in terms of the qualitative exercises, training with weights and plyometric training.

- Further research is required on explosive movements such as pushing movement in different volleyball skills where the modern advanced kinetic analysis devices are used like the force platform for measuring the force and the painter of electrical activity of muscles.

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