A Biomechanical Comparison of the Striking Arm of forehand and backhand Service Skills in squash players

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Abstract

The objective of this research was to identify biomechanical differences of the striking arm of forehand and backhand service skills and the two researchers used the descriptive method depending on video analysis technique of high speed for the skill through the Simi Motor program. The research sample consisted of 5 players classified as the best 10 players at the level of the Arab Republic of Egypt under 19 years.

The two researchers used a statistical program (SPSS) where 10 trials of forehand service and 10 trials of backhand service were treated.

The two researchers concluded that the squash player benefits from the right shoulder velocity of the striking arm during the moment of hitting and the horizontal and vertical velocities of the ball in the backhand service are faster than those in the forehand service. It was recommended that mechanical characteristics achieved by the two researchers enable to determine the effectiveness of the skill performance of backhand and forehand services in squash players in addition to considering giving exercises to improve strength differentiated by speed for the two arms.

Introduction and research problem

Introduction

The service is considered as one of the offensive skills in squash that the player should perform it perfectly to enforce the opponent to defend and to drive him to back corners to make him do side shots from the rear to give a chance to the player to control the mid-court

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and to be in an offensive position permanently.

Ali Jihad (2014) stated that the service was one of the skills of the sport of squash as the player could make use of it in achieving a successful offensive start to win points. The service seems easy to do but it needs long hours of training until the player reaches a well perfect level. It requires a neuromuscular coordination to be successful. The service difficulty enables the player to be in a proper position to hit the ball after being returned from the recipient perfectly as it is the only skill that the player can hit the ball perfectly during his performance. Moreover, it is performed without pressure from the opponent since the player is away from the positioning area (1:99).

The service skill is performed from the right and left serving boxes as the service is performed from the left serving box with the front face of the racket and the service is performed from the right serving box with the back face of the racket and in these two cases the service is a decisive factor to win and to be perfect in the game, therefore, professional players do their best to develop their services to make a pressure to the opponent to imbalance him and to make him attack.

Research problem and its important

The service is one of the important offensive skills that require a long time of practicing and the research problem lies in that if the player continues training on the incorrect technical performance, however, the majority of squash references have not discussed the technical performance of serving whether with the front or back racket faces using the technical favorite method. Players are suffering from the difficulty of service at the beginning of education because some coaches do not know technical performance and they are unable to discover faults. Also, the purpose of serving is not to hit the ball within the court only but to send a difficult shot that the opponent cannot return it and if he returns it he should be in a defensive rather than offensive position to enable the player to win a point and the player

should maintain the service in his possession. This is cannot be done except that the player should perform the skill technically and perfectly controlling the pace of the ball and he should be able to direct the ball towards difficult spots in the court and thus the two researchers conducted the current research for this purpose.

Research objectives

The objectives of the current investigation were to identify biomechanical differences of the striking arm of high service with the front or back face of the racket through the following:

- Knowing significance of biomechanical differences of the striking arm of high service with the front or back face of the racket during the swinging and hitting moments.
- Knowing significance of differences angles and angular velocities of the striking arm of high service with the front or back face of the racket during the swinging and hitting moments.
- Knowing significance of differences of biomechanical parameters of the ball in high service with the front or back face of the racket during the hitting moment.

Research hypotheses:

- There may be significant differences between high service with the front or back face of the racket in the selected biomechanical parameters of the striking arm during the swinging and hitting moments.
- There may be significant differences between the high service with the front or back face of the racket of angles and angular velocities of the striking arm during the swinging and hitting moments.
- There may be significant differences between high service with the front or back face of the racket in biomechanical parameters of the ball.

Research procedures

Method:

The two researchers applied the descriptive method by using biomechanical analysis of two dimensions depending on high speed video imaging and using Simi Motion Analyses.

People and research sample

The research sample was selected intentionally comprising (5) players

classified as the best eight players at the level of the republic under 19 years. Each player performed (2) trials of each skill under investigation, hence, the number of trials analyzed and was under statistical treatments became (10) trials with the front face of the racket and (10) trials with the back face of the racket.

Table (1)
Statistical description of the total sample in growth and training age variables (n=5)

Variables	Units	$\bar{X}$	SD	M	Skewness
Age	Year	١٨.٦٧	٠.٥٨	١٩	-١.٧١
Height	cm	١٧٣.٦٧	٤.٠٤	١٧٣	٠.٤٩
Weight	kg	٧٤.٦٣	٢.٨٧	٧٣.٥٠	١.١٨
Training age	Year	٨.٣٣	٠.٥٨	٨	١.٧١

Data in Table (1) indicate that all values of skewness coefficients range from (1.71 to -1.71) in growth and training age variables falling between (-3 and +3) and meaning that the sample is homogeneous.

Tools and devices of collecting data

-Tools used

- Restameter Pe 3000 to measure height to the nearest cm.
- Medical scale for weight in kg.
- Legal squash court + squash ball.

Devices of motor analysis (Attachment 1)

- A developed computer unit.
- Simi Motion Analysis program.
- A number of (2) drawing scales (50cm x 50cm), Calibration 2D
- A number of (2) video camera of high speed from 50 to 250 frame/sec., Fastec Imaging.
- A number of (2) memory cards of (64) GB San Disk brand.
- A number of (2) tripods supplied with an aqueous water.
- Electrical connectors.

Motor analysis program

The two researchers conducted the imaging process

and motor analysis for the two skills under investigation using (Simi Motion Analysis).

Moments under investigation

The two researchers studied the technical analysis of performing the two scales under investigation to stand on the important moments during the performance. They outlined the following moments:

- Swinging moment that is the moment of the commencement of the movement of the wrist holding the racket till the end of swinging moment prior to hitting.
- Hitting moment that is the moment in which the middle of the racket hoop meets the ball prior to drive towards the front line.

Pilot studies

The two researchers conducted the pilot study on Sunday, 6/3/2016 on the court belonging to Al-Hayat International Academy whose office is located in Al-Tajamo Al-Khames, Cairo and the pilot study sample included (2) players outside of the main sample aiming at the following:

- Making sure that the place of imaging as well as tools and devices of collecting data would be viable.
- Outlining the place and height of placing cameras and the angle of imaging.
- Outlining the best degree of lightening required and would be proper for imaging.

Main study

The two researchers carried out the main experiment on Wednesday, 9/3/2016 at 3:00 pm on the court belonging to Al-Hayat International Academy whose office is located in Al-Tajamo Al-Khames, Cairo as the 1st Camera was placed vertically at the distance of 4.50 m from the player and at 4.00 m from the back line of the court with height of 90 cm and 90^{o} angle on the player. The camera was adjusted at 12.5 frame/sec. then the researcher placed the 2nd camera parallel to the front line of the court and at the distance of 5.44 m from the wall of the serving box on the (T) line with a height of 1.78 m as this height is the height of the serving line on the front wall.

Statistical treatments

After analyzing (20) trials and collecting results of motor analysis, the researcher

conducted the suitable statistical treatments to achieve the research objectives and assuring of the validity of hypotheses by SPSS and the researcher was satisfied with 0.05 significance level. Arithmetic mean, median, standard deviation, skewness coefficient and T test were computed.

3/0 Presentation and discussion of results

3/1 Presentation and discussion of the 1st hypothesis states that there may be significant differences between forehand and backhand high services for the selected biomechanical parameters of the striking arm during the swinging and hitting moments.

Table (2)

Significance of differences for biomechanical parameters between forehand and backhand services during the swinging moment

n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
1	Right shoulder horizontal displacement	0.59	0.13	0.31	0.09	5.34*
2	Right shoulder vertical displacement	1.44	0.03	1.52	0.02	6.78*
3	Right shoulder horizontal velocity	-0.08	0.17	0.71	0.41	5.65*
4	Right shoulder vertical velocity	0.46	0.49	0.06	0.14	2.47*
5	Right elbow horizontal displacement	0.48	0.18	0.14	0.08	5.28*

FollowTable (2)
Significance of differences for biomechanical parameters between forehand and backhand services during the swinging moment
n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
6	Right elbow vertical displacement	1.19	0.03	1.28	0.03	6.35*
7	Right elbow horizontal velocity	1.65	0.88	1.82	0.54	0.53*
8	Right elbow vertical velocity	-0.29	0.36	0.19	0.33	3.12*
9	Right hand wrist horizontal displacement	0.16	0.12	-0.16	0.09	6.85*
10	Right hand wrist vertical displacement	1.19	0.06	1.47	0.03	13.24*
11	Right hand wrist horizontal velocity	1.74	1.22	0.63	0.56	2.61*
12	Right hand wrist vertical velocity	-1.59	0.73	-1.41	0.38	0.70

Value of tabulated *t* at 0.05 level of significance and 18 degree of freedom = 2.101

Data in Table (2) illustrate that values of means of horizontal displacement of shoulder and elbow have longer high service with backhand than the forehand service with the exception of the right hand wrist horizontal displacement that has longer service with forehand than the backhand. The two researchers attributed this result to that during the moment of swinging the striking arm in forehand service was further in the moment of swinging as it came from outside of the body till the point of hitting but in the backhand service the striking arm came from the fore chest and upward and therefore, the hand wrist moved longer than

in the forehand service. This was in agreement with that of Gamal Al-Shafei (2001) that the swinging in the forehand service came from the right side and outside of the body making a right angle between the elbow angle with the forearm. The swinging in the backhand service came from the fore chest making an acute angle between the elbow and the forearm in front of the chin.

Also data in Table (2) show that the vertical displacement of the right shoulder, the right elbow and the right hand wrist of the striking arm have higher values of means in the forehand service than that in the backhand service. The two researchers attributed this result to that in the forehand service the striking arm came from a higher position and the angle between the forearm and the brachium would be semi right angle during the swinging moment leading to complete the process of motor transmission from the trunk to arms. This findings agreed with the results of Yong – Hwan *et al* (2007) that the maximum velocity of the racket during back swinging was determined according to the amount of vertical displacement of the shoulder of the striking arm.

Also data in Table (2) show that the horizontal velocities of shoulder and elbow are greater in the forearm service whereas the horizontal velocity of the wrist is greater in the backhand service. The two researchers attributed this result to that the horizontal displacement in the backhand service was longer than that in the forehand service as the motor path of the striking arm during the moment of swinging in backhand service took a swinging distance from the fore chest till the racket hitting point with the ball and this agreed with Ali Jihad (2014) that the swinging in forehand service was less strength and distance than that in backhand service due to difficulty in technical performance in backhand service.

Also data in Table (2) illustrate that means of vertical velocities of the right shoulder, elbow and hand wrist are greater in backhand service than forehand service and the two researchers attributed that

to the freedom of the motor path of the racket as it comes from the fore chest in the swinging moment, therefore, the values of means of vertical velocities were greater in backhand service than forehand service and thus agreed with the open kinematic series that this swinging gave a good chance to generate strength as it was a single skill and its preliminary phase was counter motion wise. Forehand and backhand were closed skills that the was not enforced with conditions or time of performance and this agreed with the study of Yong-Hwan *et al* (2007) concluded that time of performance of backhand strike from the moment of backhand swinging till the end of the follow-up phase comprised 0.39 sec included 0.24 sec. from the moment of backhand swinging till the moment of hitting and 0.15 sec.

Table (3)

Significance of differences for biomechanical parameters between backhand and forehand service skill during the hitting moment n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
1	Right shoulder horizontal displacement	0.62	0.13	0.42	0.09	4.43*
2	Right shoulder vertical displacement	1.46	0.02	1.56	0.03	9.86*
3	Right shoulder horizontal velocity	0.11	0.15	0.25	0.17	1.92
4	Right shoulder vertical velocity	0.27	0.26	0.05	0.09	2.31*
5	Right elbow horizontal displacement	0.73	0.12	0.35	0.09	7.16*

Follow Table (3)
Significance of differences for biomechanical parameters between backhand and forehand service skill during the hitting moment
n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
6	Right elbow vertical displacement	1.16	0.04	1.28	0.04	7.54*
7	Right elbow horizontal velocity	0.94	0.48	1.32	0.31	2.35*
8	Right elbow vertical velocity	-0.38	0.39	-0.33	0.42	0.40
9	Right hand wrist horizontal displacement	0.79	0.15	0.37	0.09	6.44*
10	Right hand wrist vertical displacement	0.97	0.07	1.18	0.06	7.64*
11	Right hand wrist horizontal velocity	5.06	0.71	5.55	0.64	1.63
12	Right hand wrist vertical velocity	-1.21	0.27	-1.91	0.34	5.03*

Value of tabulated *t* at 0.05 level of significance and 18 degree of freedom = 2.101

Data in Table (3) show that values of means of right shoulder, elbow and wrist horizontal displacements are higher during the moment of hitting in backhand service than those in the forehand service and the two researchers attributed this finding to that in the moment of hitting the ball in backhand service the player tended the trunk forwards to keep the body balance due to the nature of swinging and placing his arm before the body and so the point of hitting was approximately in front of the right instep giving the player more priority in hitting and follow-up process. For the forehand service the hitting arm was closer to the body in the optimum anatomical position and this agreed with Ali Jihad (2014) that in the backhand service the player

tended the trunk forwards due to swinging the hand to the lift that the elbow, forearm and wrist got into the player's body to make an optimal swinging and strength during hitting the ball.

Also data in Table (3) illustrate that values of means of the right shoulder, elbow and wrist displacements in the backhand service are higher than those in the forehand service and the two researchers related this finding to that in the backhand service the moment of hitting between the racket and the ball was higher than the trunk as the hitting arm came from the fore chest and the racket was higher than the head, hence, there was a difficulty in the swinging process and the motor path of the racket giving more swiftness for the movement of arm and trunk during the moment of hitting, by contrast, in the forehand service the hitting arm enjoyed more freedom during the moment of hitting.

Also data in Table (3) demonstrate that horizontal velocity of the right shoulder; elbow and wrist are lower in the backhand service than those in the forehand service the two researchers related that finding to that the player made a brake with the wrist, elbow and shoulder during the moment of hitting the ball with the racket to be able to direct the ball to the legal service zone i.e. the lower the velocity in the hitting arm would be the more improvement in the direction process and accuracy but in the forehand service the motor path of the hitting arm starting from the shoulder passing with the elbow till the wrist would require higher velocity because the arm movement was towards the legal service zone within the body circumference.

Also results in Table (3) show that means of vertical velocity of the right elbow and wrist are lower in the backhand service than those in the forehand service and the two researchers attributed this finding to the death out made by the player during the moment of hitting that helped motor transmission from the shoulder to the wrist as the player fixed the wrist and elbow to get complete benefit from the reverse swinging of the hitting arm. This movement looks like the movement of whip. For the significance of differences of the vertical velocity of the right shoulder in backhand service, their means are higher than those in the forehand service and the two researchers related this finding to that the player tended the shoulder forwards and downwards to have more freedom and better balance

during the moment of hitting and by contrast, in forearm service the shoulder joint would be in the natural anatomical position. This was explained by Gamal Mohammed Ala'a Al-Din and Nahed Anwar Al-Sabbagh (1999) that motor transmission may be from the trunk to extremities as in throwing and serving events and may be from extremities to the trunk as in all forms of takeoff.

3/2 Presentation and discussion of the 2nd hypothesis states," there may be significant differences between the forehand and backhand services for angles and angular velocities of the hitting arm during the moments of swinging and hitting".

Table (4)

Significance of differences of biomechanical parameters of angles between backhand and forehand services during the moment of swinging n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
1	Right shoulder angle	10.92	1.46	43.23	6.87	14.25*
2	Right shoulder angular velocity	1.13	0.74	-3.40	2.49	5.74*
3	Right elbow angle	90.14	7.04	93.89	7.46	0.53
4	Right elbow angular velocity	- 4.74	2.78	2.42	2.46	6.59*
5	Right hand wrist angle	146.98	3.16	182.29	17.81	6.50*
6	Right hand wrist angular velocity	-2.20	2.79	-0.83	16.32	0.04

Value of tabulated *t* at 0.05 level of significance and 18 degree of freedom = 2.101

Data in Table (4) show that values of angles of right shoulder, elbow and wrist are less in the backhand service than those in the forehand service and the two researchers related this finding to the anatomical position of the striking arm during the striking moment. In the backhand service the swinging of the striking arm came from the top of the head and fore chest whereas in the forehand service the striking arm was adjacent to the body and upwards.

Also data in Table (4) reveal that means of values of

angular velocities of the right shoulder in backhand service are less than those in the forehand service because the swinging of the striking arm was inwards the body, hence, there was a disability in the swinging process, by contrast, in the forehand service the swinging of the striking arm was adjacent to the body and outwards. Angular velocities of right elbow and wrist in backhand service are higher than those in forehand service and the two researchers attributed this finding to that the anatomical position of the joints of elbow and wrist in forehand service was difficult as the arm was outwards of the body, by contrast, in the backhand service the swinging was inwards of the body and this agreed with Elliott Bruce *et al*. (1996) that the percentages of contribution of revolutionary movement of the upper limb in the performance were 46.1%, 18.2% and 12% for shoulder, wrist and elbow joints; respectively. Also the results show that the pronation of elbow and extra contracting of elbow joint played an important role in generating sufficient velocity for the racket during the pre-hitting phase.

Table (5)

Significance of differences of biomechanical parameters for angles between backhand and forehand services during the hitting moment n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
1	Right shoulder angle	14.09	1.52	17.71	5.25	1.71
2	Right shoulder angular velocity	0.67	0.74	-3.59	1.16	10.43*
3	Right elbow angle	152.26	5.28	157.65	25.54	1.32
4	Right elbow angular velocity	- 0.94	1.98	30.67	9.10	11.35*
5	Right hand wrist angle	137.69	6.12	120.33	47.55	0.68
6	Right hand wrist angular velocity	-0.53	1.63	45.14	27.79	4.73*

Value of tabulated *t* at 0.05 level of significance and 18 degree of freedom = 2.101

Data in Table (5) reveal that there are no significant differences between the backhand and forehand services during the hitting moment for angles of right shoulder, elbow and wrist whereas there are significant differences in angular velocities of right shoulder, elbow and wrist angels in favor of the forehand service rather than the backhand service during the hitting moment. The two researchers related this finding as a logical result to the freedom of the motor bath of the hitting arm in the forehand service during the moment of hitting. That agreed with Ariff Fadiah *et al*. (2012) that contracting the elbow joint with the pronation from the wrist played an important role in generating the necessary velocity for performance represented by the velocity of the hoop during the moment of hitting in addition to angles of joints of the upper part of the body affected the performance of the forehand and backhand skills in squash as the angular velocities and angular acceleration of joints would represent a parameter to know the speed of the projectile i.e. the ball resulted from the strength of hitting with the hoop.

3/3 Presentation and discussion of the 3rd hypothesis states" identifying significance of differences for biomechanical parameters of the ball in backhand and forehand services during the hitting moment".

Table (6)

Significance of differences for biomechanical parameters of the ball in forehand and backhand services n1=n2=10

No.	Biomechanical parameters	Backhand service		Forehand service		Computed *t*
		$\bar{x}$	SD	$\bar{x}$	SD	
1	Squash ball X	0.70	0.12	0.40	0.12	5.92*
2	Squash ball Y	0.61	0.10	0.82	0.17	4.28*
3	Squash ball v(X)	10.93	5.25	8.44	3.13	4.21*
4	Squash ball v(Y)	3.83	0.49	2.47	1.05	3.71*

Value of tabulated *t* at 0.05 level of significance and 18 degree of freedom = 2.101

Data in Table (6) illustrate that there are significant differences in horizontal displacement of the ball in backhand and forehand services in favor of the backhand service and the two researchers related that to the player who threw the ball in front of the body in the backhand service to furnish a chance to swing better and in the forehand service the player threw the ball inwards the body due to the distance of swinging the hitting arm because the swinging process came from the back to the front. Also data in the same table show that there are significant differences in the vertical displacement of the ball in the forehand service rather than the backhand service in favor of the forehand service as values of means of the vertical displacement in forehand service are higher than those in the vertical displacement in backhand service and the two researchers attributed that to the point of hitting between the ball and the racket in the forehand service would be in front of the trunk area directly but in the backhand service this point would be a little bit below the trunk. Also data in the same table there are significant differences between the backhand service and the forehand service in horizontal and vertical velocities of the ball as values of means of horizontal and vertical velocities in the backhand service are higher than those in vertical velocities in the forehand service and the two researchers attributed that to the player who threw the ball forwards towards the serving box in the backhand service to gain more velocity for the ball and this agreed with Yong-Hwan *et al*. (2007) that the maximum velocity of the racket and the ball would be defined as per the shoulder, elbow and wrist depending on the motor transmission process from parts of the upper limb to the racket then to the ball.

Conclusions and recommendations

Conclusions

In the light of the research objectives, the sample and procedures, the two researchers concluded the following:

4/1/1 The horizontal velocity of the hitting arm is considered a preliminary phase in different

direction of the basic movement.

- The phase of the beginning of swinging the hitting arm in the preliminary phase has a great effect on the velocity of serving the ball.
- The squash player benefits from the velocity of right shoulder of the hitting arm during the moment of hitting.
- The horizontal and vertical velocities of the ball in backhand service are faster than the forehand service.

Recommendations:

Mechanical characteristics achieved by the two researchers can be used to determine the effectiveness of the skill performance of the backhand and forehand services for squash players.

- The two researchers recommended that special training programs be placed for backhand and forehand services for squash players as per the research results.
- Using individual specialization in training as per requirements of each player.
- Considering giving exercises to improve strength differentiated speed for both arms.

References

Arabic references:

1- Gamal Al-Shafei (2001): Squash (History, Teaching and Practicing Skills, Rules of Play). Arab Thought House, Cairo.

2- Gamal Mohammed Ala'a Al-Din and Nahed Anwar Al-Sabbagh (1999): Kinematics. 7th Ed., Book House, Cairo.

3- Ali Jihad Ramadan (2014): Squash (Teaching, Practicing Judgment), Al-Furat Press, Bagdad.

Foreign references:

1- Ariff Fadiah, et al. (2012): Joint angle production during squash forehand and backhand stroke, Paper presented at the 30th international conference on biomechanics in sports, Australia - Melbourne.

2- Elliott, B., Marshall, R., & Noffal, G. (1996): The role of upper limb segment rotations in the development of racket-head speed in the squash forehand. Journal of sports sciences, 14(2) pp 159-165.

3- Yong-Hwan, et al. (2007): The kinematic analysis of the upper extremity during backhand stroke in squash. Korean journal of sport biomechanics, 17(2) pp 145-156.