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Original Article

Analysis of body position, angle and force in lawn tennis service accuracy

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Abstract:
One of the most important aspects in the lawn tennis game is the service. Factors affecting service, besides the body's physical condition and position, are angle of movement and force. Good body position, right angle of movement and strong force will result in a good service. This study aimed to obtain data on body position, angle and force to exactness of service in lawn tennis. This research employed analytical descriptive analysis with four PELTI (Indonesian Lawn Tennis Association) athletes of Aceh province as the subject of the study. A videotape was used as the instrument for body positions, movie maker software and AutoCAD 2007 were used to record the angle, and axis accelerometer sensor and logger pro software were used to know the force. The results of the study showed that (1) overall, position of the body in a service based on the phase of body position movement of all athletes was good. 2) overall, for good results of lawn tennis service, the position of forefoot stand between 35 to 45 degrees to the baseline, the distance between the foot pivot parallel with shoulder, racket rotating movement backwards until your arms are straight and reach an angle of 90 degrees with the body, the position of the forearm that bring racket perpendicular to the field during the stretch, hip rotating, continued rotation of the upper body with your shoulders sideways towards the net, knees bent closer to 160-170 degrees, the angle between the upper arm with upright between 90-110 degrees when impact, good movement on the follow through stage on the technical services was forefoot landing. 3) good service force of lawn tennis was 6.335 kg and acceleration of 94.1 m / s2 so as to give rise to force of 696.16 N.
Key words: analysis, body position, angle, force, service

Introduction

In the lawn tennis game, technique and physical condition are the determining factors for success. The basic techniques in the tennis game are the forehand, backhand, drive, service, slice, spin, dropshot, smash, lob, passing shot and volley. Service is serving the first punch to start the game. Service is the only decisive lob where all players will receive the ball or a player will lose his right in managing the ball and gives a score for the opponent if the service fails. This is in accordance with the opinion of Brown (2001) states that a good service is the key of victory it means that service has 50% of scores compared to the survival hit". Therefore, the service is also considered as an asset for tennis players.

Service is one of the basic techniques in the game of lawn tennis as well as a sign that the game begins. In a further development service is no longer regarded as the beginning of the game, but the form of the first attack. So, a service should be done as best as possible so that the opponent is difficult to restore, so as to give points for player who does service. A good biomotor is required in order to be able to do a good service technique. The useful components of a biomotor in the lawn tennis are endurance, strength, speed, coordination, and flexibility (Sukadiyanto, 2002). Thus, having a good physical condition and mastering accurate service techniques are needed to make a qualified athlete.

Bompa (1994) stated that the basic goal of practice is to achieve physical preparation, techniques, tactics and mental well. The physical preparation and perfect techniques are the basis affecting each other for achieving a good performance. At the time of doing service, there are several steps of movement that must be performed, they are the preparation stage, take back, loading, hitting, contact points, and follow through. Due to the complexity of movement should be done at the time of service techniques, it is necessary to consider the accuracy body position, angle and force in order to be able to do a good service. The research aimed to find out the analysis of body position, angle and force in doing accurate services in lawn tennis.

Methodology

The design of this study is the service accuracy test of the lawn tennis by analyzing body position, angle and resulting movement force. The subject of the study was 4 athletes of the Indonesian Lawn Tennis Association (Pelti) of Aceh province. The instruments that were used in the research were Any Video Converter

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Ultimate Software, Windows Movie Maker 2.6 Software, AutoCAD 2007 Software, Adobe Photoshop CS3 Software, Logger Pro Software and Axis Accelerometer Sensor.

Service movements that were analyzed were as follows: 1) to determine the position of the service body and the stage of preparation analysis, take back, loading, hitting, contact point and Follow-through using Any Video Converter Ultimate software, 2) stage of angle analysis consisting of angles used by hands, angles used by feet, and angles used by body using AutoCAD 2007 Software, and 3) analysis of the force used in which the weight of athletes' bodies and weight of the racket must be weighed, and then the force applied using Sensor Axis Accelerometer which was attached on the arm, right hand bat and the data displayed on the Logger Pro 3.8 Software.

This study was conducted on April 2016 in the Tennis court of Syiah Kuala University in Banda Aceh, Indonesia.

Result and Discussion

1. Body Position in Service

Based on the data of the videotape observation on the ability of the results of best ten services in lawn tennis, the category of every single hitter is shown in the following table.

Table 1. Total of Category of Body Position Per-item of Each Player.

No	Body Position	Total Category		
		Good	Moderate	Bad
1.	Preparation Phase	4 players	0 player	0 player
2.	Take Back	1 player	3 players	0 player
3.	Loading	3 players	1 player	0 player
4.	Hitting	3 players	1 player	0 player
5.	Contact Point	3 players	2 players	0 player
6.	Follow-through	2 players	2 players	0 player

Based on the number of categories above, it can be seen item per item respectively and it can be seen in one of the images of athletes below.

Fig. 1. The preparation phase, take back, loading, hitting, contact point and follow-through

In preparation Position, there were 4 athletes of PELTI Aceh were categorized good, because a good phase position to do service technique is the head position adjusting eyes to the target, knee position was maintained in an upright state. The position of the front foot stands 45 degrees to the baseline, the distance between the fulcrum feet is equal to shoulder. The take back position of 1 athlete was categorized as good because the suitability of arms straight ahead when making the toss, racket rotating movement backwards until his arms were straight and reached an angle of 90 degrees with his body, the position of the forearm that brings racket perpendicular to the field during the stretch, hip rotating, continued rotating upper body with shoulder position sideways towards the net and three athletes were categorized as average.

Loading position of 3 athletes were categorized as good as suitability of knees bent closer to angle of 100-120 degrees, hip rotating to the maximum, continued rotating the upper body with both legs push to occur stepping, the position of the forearm that brings racket perpendicular to the field at the time stretch with the position of the racket head on their heads and one athlete is considered as average because when the time of loading movement, the arm that toss was not straight up next to the body to help turn around knee.

The hitting positions of 3 athletes were categorized as good as suitability of feet drove into the top, position of racket fell down beside the back of their bodies, the head of the racket running from the back to the shoulder, when an upward force was continued upper arm was raised, followed by movement of elbow extension, turnover internal shoulder, forearm pronation, wrist flexion which occurred on the journey towards

the point of contact and 1athlete was categorized as average because at the time of hitting movement, the position of the arms or handle of the racquet did not not form an angle of 90 degrees.

The position of the contact point, 3 athletes were categorized as good because the height of the ball when the impact was at the point of highest achievement and was in front of the top, the angle between the upper arm and knee between 90-110 degrees at the time of impact and 1 athlete was categorized as average because of the time of contact point movement, the position of the racket did not form an angle of 110 degrees and was late to do the impact.

Position of follow-through, two athletes were categorized as good because the suitability of landing with front feet, swing the racket head to make a big circle, balanced body position for preparation for a subsequent blow and 2 athletes were categorized as average.

2. Lawn Tennis Service Angle

The presented results were obtained through observation of live videotape of the best service capability out of 10 services. To analyze the angle of movement by the PELTI athletes of Aceh Province in doing services in tennis, the data presented here was the observation of videotape, then to be more accurate, the video was terminated in each frame and each frame was used as the image of the beginning of the movement until the end of the movement. The angles used by the athletes at the time of the preparation phase on a tennis service can be analyzed through the pictures, one of the athletes can be seen in the picture below.

Fig. 2. The angle of preparation, take back, loading, hitting, contact point and follow through

Tables 2, 3, 4, 5, 6, 7 below show the angles used by the athletes in the preparation phase, take back, loading, hitting, contact point and follow-through in lawn tennis services as follows.

Table 2. Preparation Phase Service Angle

No	Name	Corner of Front Feet and Baseline	Flexion angle of Racket Grip Sleeve	Knee flexion angle		Distance Between Fulcrum Legs
				Front	Back	
1	Zulkarnaen	35^0	143^0	170^0	173^0	0.22 Meter
2	Iskandar	44^0	163^0	174^0	178^0	0.17 Meter
3	M. Al Munawir	31^0	155^0	174^0	169^0	0.16 Meter
4	Khairullah	22^0	134^0	177^0	178^0	0.31 Meter

Table 3. Service Angle of Take Back Phase

No	Name	Angles of Movement						Wrist
		Shoulder		Elbow		Knee		
		Right	Left	Right	Left	Right	Left	
1	Zulkarnaen	128^0	127^0	160^0	127^0	169^0	176^0	162^0
2	Iskandar	127^0	121^0	146^0	143^0	174^0	170^0	156^0
3	M. Al Munawir	122^0	111^0	139^0	153^0	173^0	165^0	163^0
4	Khairullah	105^0	148^0	114^0	157^0	167^0	170^0	174^0

Table 4. Service Angle of Loading Phase

No	Name	Angles of Movement						Wrist
		Shoulder		Elbow		Knee		
		Right	Left	Right	Left	Right	Left	
1	Zulkarnaen	133^0	70^0	151^0	69^0	151^0	170^0	143^0
2	Iskandar	70^0	145^0	72^0	173^0	170^0	155^0	142^0
3	M. Al Munawir	84^0	121^0	15^0	167^0	152^0	152^0	177^0
4	Khairullah	129^0	149^0	167^0	165^0	171^0	174^0	105^0

Table 5. Service Angle of Hitting Phase

No	Name	Angles of Movement						
		Shoulder		Elbow		Knee		Wrist
		Right	Left	Right	Left	Right	Left	
1	Zulkarnaen	139^0	64^0	159^0	57^0	151^0	179^0	139^0
2	Iskandar	59^0	139^0	62^0	163^0	175^0	146^0	142^0
3	M. Al Munawir	73^0	128^0	54^0	157^0	144^0	144^0	169^0
4	Khairullah	132^0	138^0	171^0	168^0	172^0	169^0	98^0

Table 6. Service Angle of Contact Point Phase

No	Name	Angles of Movement						
		Shoulder		Elbow		Knee		Wrist
		Right	Left	Right	Left	Right	Left	
1	Zulkarnaen	80^0	126^0	63^0	152	175^0	173^0	180^0
2	Iskandar	151^0	79^0	133^0	$-^0$	158^0	178^0	109^0
3	M. Al Munawir	142^0	27^0	171^0	52^0	174^0	177^0	162^0
4	Khairullah	149^0	$-^0$	169^0	$-^0$	179^0	179^0	180^0

Table 7. Service Angle of Follow-through Phase

No	Name	Angles of Movement		
		Knee		Wrist
		Right	Left	
1	Zulkarnaen	170	122	148
2	Iskandar	98	158	121
3	M. Al Munawir	168	168	159
4	Khairullah	117	140	131

2. The Used Ball Force

The results of force presented were the results which were based on data through Axis Accelerometer Sensor appliance that was obtained in the field, the ability of the results of the best services out of ten services. The results which were obtained through Axis Accelerometer Sensor can be seen in each graph below. Before determining the forces as a whole, it must first be determined amount of arm volume of the players, racket mass and ball. To determine the volume of arms, it can be seen by the weight segment, then analyzed in terms of percent (%) of the principal segments of the total weight.

Table 8. Sleeve Volume Analysis Based on Total Weight

Body Segments Weights	
Main Segment as % of Total Body Weight	**Individual Segment as % of Main Segment**
Head and Neck = 8.4 %	Head = 73.8 % Neck = 26.2 %
Torso = 50 %	Thorax (chest) = 43.8 % Lumbar = 29.4 % Pelvis = 26.8 %
One Total Arm = 5.1 %	Upper Arm = 54.9 % Fore Arm = 33.3 % Hand = 11.8 %
One Total Leg = 15.7 %	Thigh = 63.7 % Shank = 27.4 % Foot = 8.9 %

Based on the table above, analysis to determine the athletes' arm volume using the formula: Body Weight (kg) X One Total Arm (5.1%) + Diskus Mass (2 Kg).

Table 9. The Results of Athletes' Arm Volume Analysis

No	Name	*Body Weight (Kg)*	*One Total Arm (5.1%)*	*Discus Mass (Kg)*	Total
1.	Zulkarnaen	85	0.051	2	6.335
2.	Iskandar	45	0.051	2	4.295
3.	M. Al Munawir	75	0.051	2	5.825
4.	Khairullah	75	0.051	2	5.825

Having known the total of arm volume and the ball mass of each player, they were then connected with the results of acceleration using the formula:

$$F = m.a$$

F = Force (N)
m = Mass of the Object (Kg)
a = Acceleration of the Object (m/s^2)

Analysis of Force of the First Athlete

The results of the acceleration in of the first athlete can be seen in the graph below.

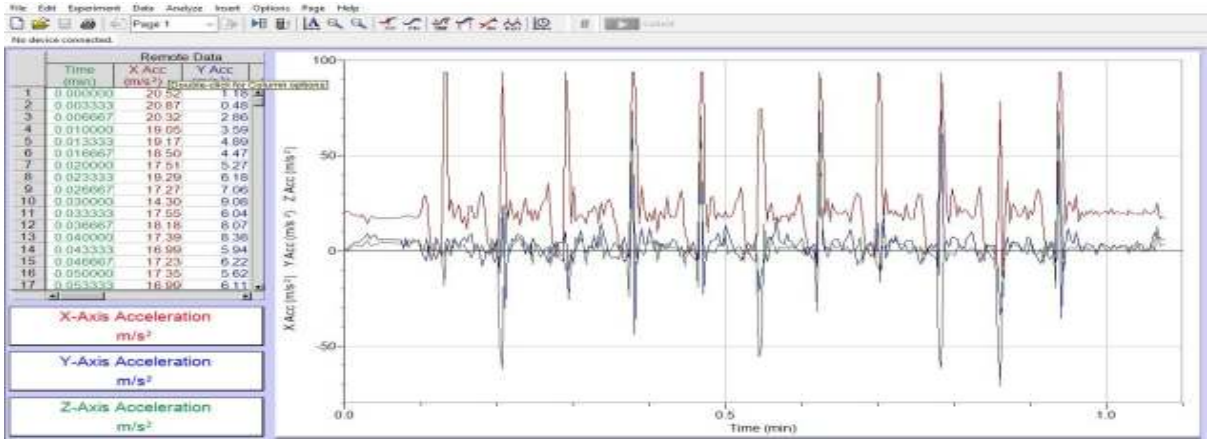

Fig. 3. Acceleration Graphics of the First Athlete

$F = m.a$
$= 6.335Kg \cdot 94.1\ m/s^2$
$= 696.16\ N.$

So, the acting forces of the first player of the PELTI athlete of Aceh province was 696.16 N.

Analysis of Force of the Second Athlete

The results of acceleration of the second athlete can be seen in the graph below.

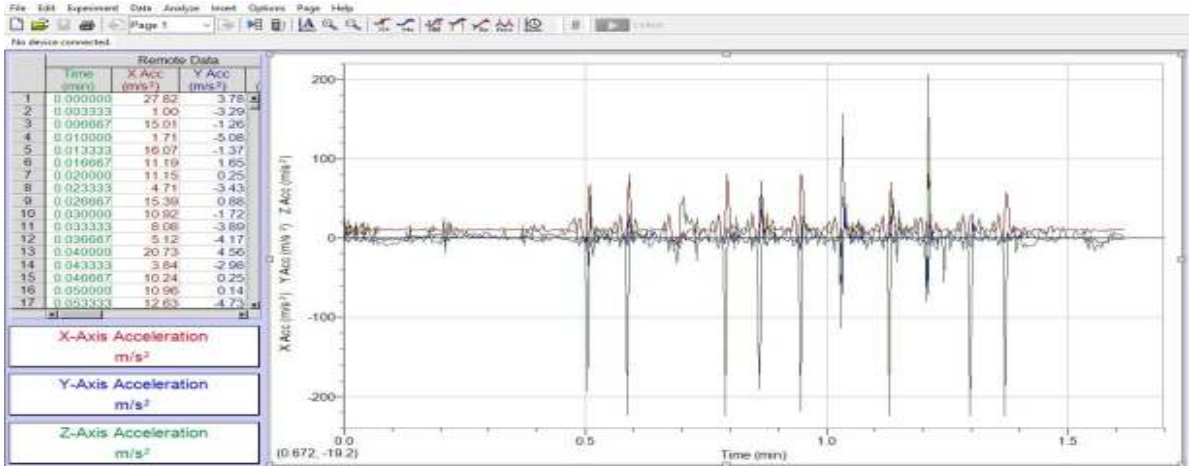

Fig. 4. Acceleration Graphics of the Second Subject

$F = m.a$
$= 4.295\ Kg \cdot 81.6\ m/s^2$
$= 350.47\ N$

So, the acting forces of the second player of the PELTI athlete of Aceh province was 350.47 N

Analysis of Forces of the Third Athlete

The acceleration results of the third athlete can be seen in the chart below

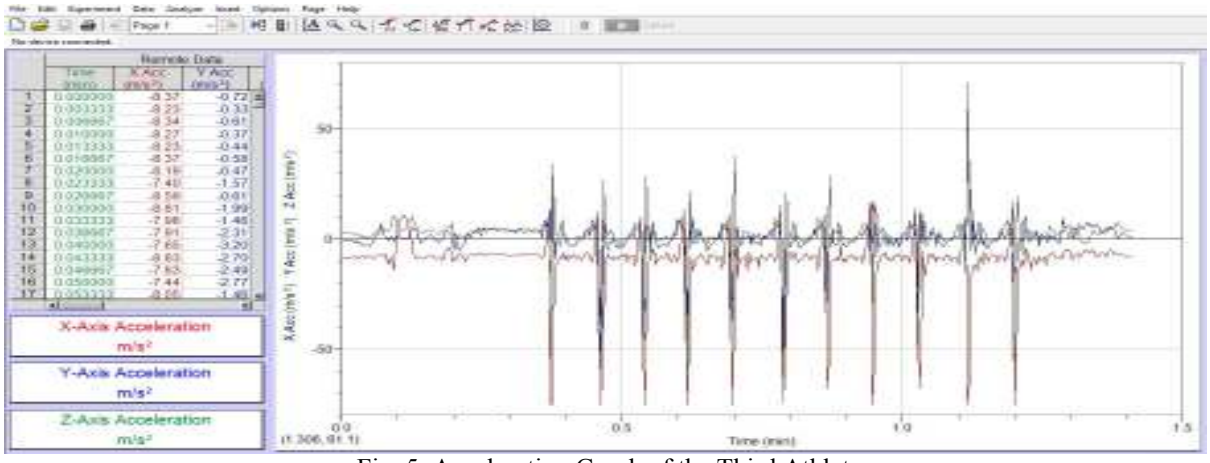

Fig. 5. Acceleration Graph of the Third Athlete

F = m.a

= 5.825 Kg . 34.4 m/s^2

= 200.38 N

So, the acting forces of the third player of the PELTI athlete of Aceh province was 200.38 N.

Analysis of Forces of the Fourth Athlete

The acceleration results of the fourth athlete can be seen in the graph below.

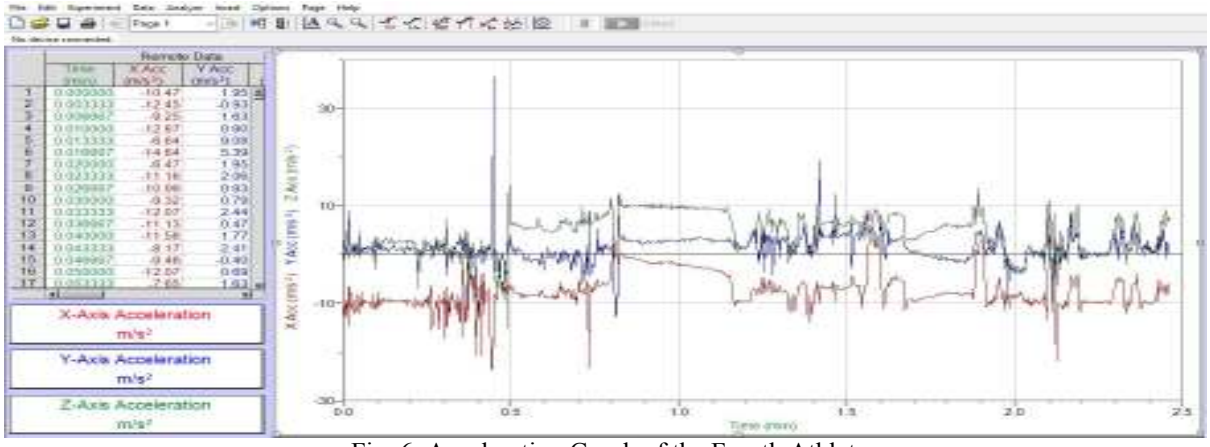

Fig. 6. Acceleration Graph of the Fourth Athlete

F = m.a

= 5,825 Kg . 36,8 m/s^2

= 214,36 N.

So, the acting forces of the third player of the PELTI athlete of Aceh province was 214.36 N.

Based on the force analysis above, to be more clearly, it can be seen table 10 below.

Table 10. Results of Force Analysis in Services of Lawn Tennis of Pelti Athletes of Aceh Province

No	Name	Results		
		Force (F)	Service Score	Category
1.	Zulkarnaen	696,16 N	18	Good
2.	Iskandar	350,47 N	19	Good
3.	M. Al Munawir	200,38 N	19	Good
4.	Khairullah	214,36 N	19	Good
	Total	1.461.37N	75	

Table 10 above shows that the first athlete had forces to hit the ball at 696.16 N resulting in a total score of 18 points and was categorized as good. The second athlete had forces to hit the ball at 350.47 N resulting in a total score by 19 points and was categorized as good. The third athlete had the forces to hit the ball at 200.38 N

resulting in a total score by 19 points and was categorized as good. The fourth athlete had the forces to hit the ball at 214.36 N, resulting in a total score by 19 points and was categorized as good. Overall, forces to hit was 1.461.37 N with an average of 365.34 N and scores service was categorized good and the total of service scores was 75 with an average of 18.75 and categorised as good.

Conclusions

1. Overall, the body position of the lawn tennis athletes of PELTI of Aceh province at the time of doing service based on the phase of body movement was considered as a good category.

2. Position of the service angle movement of the lawn tennis athletes of the PELTI of Aceh province referred to the best hits of ten services done by the athletes, the first athlete did the best service in the second hit with a score of 4. They details are as follows: (1). At the preparation phase, the angle of the front foot and the baseline formed an angle of 35^0, angle flexed arm handle of the racquet makes an angle of 143^0, front knee flexion angle formed an angle of 170^0 degrees, and the distance between the fulcrum foot of 0.22 meter, (2). The angle of take back phase when the racket swung right shoulder formed an angle of 128^0, left shoulder formed an angle of 127^0, right elbow formed an angle of 160^0, left elbow formed an angle of 127^0, the right knee formed an angle of 165^0, the left knee formed an angle of 176^0 and wrist angle that hold the racket formed an angle of 162^0. (3). The loading phase angle when throwing the ball, right shoulder formed an angle of 133^0, the left shoulder formed an angle of 170^0, right elbow formed an angle of 151^0, left elbow formed an angle of 69^0, right knee angle formed an angle of 151^0, left knee formed an angle of 170^0 and wrist that hold the racket formed an angle of 143^0, (4) The hitting phase angle, the right shoulder formed an angle of 139^0, the left shoulder formed an angle of 64^0, right elbow formed an angle of 159^0, left elbow formed an angle of 57^0, the right knee formed an angle of 151^0, left knee formed an angle of 179^0 and wrist that hold the racket formed an angle of 139^0, (5) Angle phase of contact point, angle of movement of hitting ball, where the right shoulder formed an angle of 80^0, the left shoulder formed an angle of 126^0, right elbow formed an angle of 63^0, the left elbow formed an angle of 152^0, left knee formed an angle of 175^0 , left knee formed an angle of and forming an angle 173^0 , and the wrist that hold the racket formed an angle of 180^0, and (6) Phase angle of follow-through where the right knee angle formed an angle of 170^0, the left knee formed an angle of 122^0 and wrist angle that hold the racket formed an angle of 148^0.

3. The amount of force exerted in the tennis service of the PELTI athletes tennis of Aceh province, based on the weight, a total of one arm, and the overall weight of the ball, hitting force was 1.461.37 N with an average of 365.34 N and was categorized good and the total scores of services was 75 with an average of 18.75 and categorised good, while good force to do the service was 6335 Kg and acceleration of 94.1 m / s2 so as to produce the forces of 696.16 N.

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