THE RELATIONSHIP BETWEEN ANTHROPOMETRIC MEASUREMENTS AND PHYSICAL CHARACTERISTICS WITH THE LEVEL OF PERFORMANCE FOR TENNIS PLAYERS

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Abstract
The aim of the study was to examine the factors that helped in predicting the level of performance among Tennis players in Jordan. The sample for this study consisted of 15 tennis players from the national team of Jordan. The results of multiple stepwise regression indicated that there were nine anthropometric factors contributing to the explained variance in serving accuracy variable and forehand and backhand strokes. Age was the most important factor in the prediction model. Moreover, seven physical characteristics contributed to the explained variance in the serving accuracy, and there are physical factors in the explained variance in forehand and backhand stroke. Arms endurance was the most important predictor. It was recommended to take advantage of the results of this study in developing the characteristics related to the sport of Tennis which contributes in increasing the performing accuracy.

Key words: physical characteristics, skills, performance, tennis, Jordan

Introduction
Physical and body measurements considered to be one of the most important factors for sports performance requirements. Many researchers and scientists agree that each sport has its own specific physical requirements to reach the challenging levels. In this regard, a lot of studies showed the necessity and importance of recognizing the variables of physical growth in the body which include height, weight, body structure, body surface area and body mass index and how those are related to the physical characteristics and the indication that can be predicted, and the positive results a player will achieve. In addition, these measures are considered to be one of the contributing and specifying motor and physical performance, and an important indicator to find out their relationship with different skills (Wagner, 2005; Ogden et al., 2008; Sharon & Denise, 2014; Fernandez et al., 2014; Tremblay & Williams, 2000; Gregory & Shala, 2005; Al-Sheishani, 2007). Prediction of physical measurements could be in the same level of the physical and psychological characteristics due to their impact on the ability to perform and the basic physical attributes are considered to have the most affective effect. (Hillel & Zughayyar, 2013; Mohsen, 2011; Girard & Millet, 2009; Lohman, 1989). Each quality of these can be developed where the needed size for each quality depends on the needed demands related to each kind of sport. Researches and studies on tennis showed that there are many challenges and problems faced this sport (Clarke & Norman, 2012; Abramitzky et al., 2012). Other researchers spoke about the contribution of teaching aids and means used that helps in teaching the skills of Tennis. (March-Crespo et al., 2013; Caserta & Singer, 2007; Ali & Abdullah, 2013; Zughayyar, 2014). Tennis is a special sport in terms of muscular endurance, and that the need of both player and coach to know the most important and the most used muscles in motor performance.

Many researchers conducted studies on the anatomical and biomechanical factors related to muscular move that helps to improve the good performance in this sport (Hassan, 2012; Sanchis-Moysi et al., 2010; Elliott, 2006; Jensen, 2007; Landlinger, et al., 2010). These studies recommended taking into consideration the rapid growth in improving the performance in this particular sport. Excellence and high achievement in competitive sports require special physical and physiological requirements (Wong et al., 2014; Mohsen, 2011; Kleinwachter & Raschka, 2009; Jabari, 2011; Abbas, 2008). The study of these characteristics and requirements is considered to be one of the most important factors relied upon in determining the ideal Specifications that a player should have when chosen or directed to exercise a certain type of physical activities. The accuracy in serving in tennis is considered as a very critical factor in winning the highest number of points since it is considered to be one of the effectual offensive skills, where many researchers in Tennis pointed to the fact that the power of aiming depends on accuracy (Hillel & Zughayyar, 2013), (Hassan, 2012), (Abed Al Mohsen 2012), (Mohsen 2011), (Ali & Musa, 2009) noted that there is a direct relationship between the power and accuracy of the forehand and backhand with performance. Fernandez et al., (2014) developed a valid and reliable fitness test to study and measure the capabilities of tennis player in order to get the best performance for both beginners and the elite.

Problem
Physical and body measurement are considered to be an important factor in specifying the nature of the sport activity that forms the primary base in different fields. It can be used in comparing individual differences for players, and to be introduced to the similarities and also to distribute
the personal qualities (Abdullah et al, 2001). In addition, it is considered as a necessary indicator to identify its relation with other skills. Tennis in Jordan is one of the popular sports. Tennis, like other sports, is affected by players' body and physical measurements which affect performance. The researcher, while working with the Jordanian National Team of Tennis, noticed a weakness in the physical and body characteristics which are used when selecting the players to the team. In addition, there were no studies in Jordan about the physical and body characteristics of Tennis players. Therefore, the researcher was motivated to conduct this study in order to examine the relationship between some physical and body measurements and performance for Tennis players in Jordan.

Aim of the study

The purpose of this study is to examine the relationship between the physical measurements and body characteristics with the level of performance of tennis players in the national team of Jordan.

Methodology

Study Design

The researcher used the descriptive method.

Participants

The sample of the study has been chosen in an intentional way, the sample consisted of 15 players of the Jordanian national Tennis team. Their age's average is 21.5 years, with standard deviation 3.876.

Instruments

Tests and measurements have been used to conduct the study out according to the following: 1. Body measurements: weight, height, total length of the arm, body mass index, body fold's thickness in seven different areas of the body including: brachial triceps muscle, under the scapula, chest area, abdomen, thigh, lilac, midaxillary, body density, the proportion of body fat, parts of non-lipid weight, upper arm circumference (Taan, 2011; Al-Shishani, 2007; Jabari, 2011; Raya, 2010; Gregory & Shala, 2005); 2. Physical tests: fist strength test, flexibility, set ups, push-ups, legs strength, fitness test (T), Vo2 max (AL Hazza, 1993; Al-Shishani, 2007; Jabari, 2011; Raya, 2010; Filipic et al, 2010; Muyor et al, 2014); 3. Skill test: Serving accuracy test, forehand and backhand accuracy test have been made for Hewitt (Clayne & Cynthia, 1980).

Tools

Balanced medical titrated (Seca) type, Vernier scale for the nearest 0.5 cm, thickness of skin folds scale (Harpenden) type, tape measure to measure the upper arm circumference, Dynamometer device for legs' strength, flexibility box, dynamometer device for grip strength, cones, electronic stop watches, registration forms, tennis court, racket and tennis balls, a rope, chalks, running track and marker pen.

Procedures

The researcher coordinated with the Jordanian Tennis Federation in order to conduct measurements and tests for the study. Hiring a qualified team of assistant (master's and doctoral) Students in the College of Physical Education at the University of Jordan. Specifying study's variables. An exploratory experiment to make sure of the sincerity and constancy of the tests were conducted. Implementation of the main experience.

Data Analysis

Stepwise multiple regression analysis was used to identify the proportion of the contribution of each of physical characteristics and properties with the level of performance.

Results and Discussion

To achieve the objective of the study which refers to the percentage of the contribution of each of physical measurements & characteristics with the level of s performance for Tennis players. Tables (1 and 2) show the details. Table 1 shows that the value of correlation and dependence between internal physical variables in the regression equation that contributed in predicting the Serving accuracy which amounted to (0.999) that they are rates statically significant because the value of (F) reached (36511.78) and at the same level of indication to (0.001). There are also nine physical measurements effectively contributed in explaining the variance for the variable related to serving accuracy. And it's clear that the highest contributing value was for the Age variable that reached (0.404), then the thickness in skin folds in the Triceps reached (0.392), followed by thickness of skin folds in maxillary that reached (0.102), then the Height with (0.035), and the thickness of skin folds in the thigh that also reached (0.025), for the arm length the value was (0.016). After that we have thickness of skin folds in Abdominal that reached (0.015), followed by BMI with (0.008), and the last was for the contribution of weigh that reached (0.003), all of them are statistically significant. The relations between thickness of skin folds in different areas with the weight and serving accuracy skill were negative because (Beta) values that are corresponding to the contributed values were also negative whereas the positive correlation relations showed between other contributing variables (with the serving skill accuracy). With regard to the physical characteristics entered the regression equation that contributed in predicting the serving accuracy variable that reached (0.906) and it's also statically significant because the (F) value reached (25.290) with (0.001). There are also seven physical measurements contributed significantly in explaining the variance of the variable of serving accuracy. It's clear that the highest contributing value for the Right Grip Strength that reached (0.199) then the leg strength reached (0.164), the Push – Ups (0.124), then Set Ups (0.091) and Left Grip Strength that reached (0.085).
Table 1 The results of Stepwise Multiple Regression Analysis to the proportion of contribution of anthropometric measurements and characteristics in serving skill accuracy that a Tennis player has

<table>
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<th>Variables</th>
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As for the agility, the contribution rate reached (0.083), and the least contribution was for Flexibility that reached (0.077), all values have statistical significance. The relations were positive between different physical variables with serving accuracy because the values of Beta are positive except the fitness factor where the relation was negative because the Beta value for contributing rate was negative. Table 2 shows the value of the correlation coefficient between internal physical variables in the regression equation that contributed in predicting the accuracy of both forehand and backhand that reached (1.000) that are statistically the value significant where the (P) value has reached (5405.099) and of a level indication (0.001), thus, there are (9) physical measurements contributed effectively to explain the variance of the dependent variable which is the accuracy in performing the forehand and backhand strike. The highest contribution was to the Age variable that reached (0.674) followed by Subscapular that reached (0.120-). The Thigh reached (0.095-) and Arm length (0.036) and then the Upper Arm Circumference that reached (0.023). Body folds height reached (0.001-) followed by Body Fat percentage with (0.019-) and then the thickness in abdominal area that reached (0.013), and finally the Triceps with a contribution percentage reached (0.001-), and all values were statically significant. The negative relationship between the skin folds in different areas and body fat percentage with the accuracy in performing the forehand & backhand strokes because the values of (beta) corresponding to the ratios have a negative contribution, while a positive link appears between relations of other contributing variables with precision of forehand and backhand strokes. It's clear from the table related to physical characteristics in the regression equation that contributed in predicting the accuracy in performing the forehand & backhand accuracy that reached (0.746) and it's statically significant because the (F) value reached (15.026) p ≤ 0.001. There were three physical measurements contributed
effectively to the explained variance of forehand and backhand strokes accuracy. It can be noted that the highest percent of contribution was for the Push-Ups that reached (15.026) then the Flexibility with (0.162) and Set-Ups (0.125) all ratios have statistical significance. The relationships which were positive among the variables of different physical performance skills with precision of forehand and backhand where (beta) values were positive with the exception of flexibility which showed a negative relationship. From these results, we note that the variables of (age, height, body mass index, thickness of fats in maxillary area, Triceps, Thigh, Abdominal, arm length and weight) significantly contributed in the serving accuracy skill, whereas the variables of (age, height, body mass index, thickness of fats in bottom of the board area, thigh, Upper arm circumference, abdomen, Triceps, muscle and the percentage of fat in the body) contributed statically effectively in the forehand and backhand accuracy. This result is considered to be reasonable, where the percent of contribution of the thickness of fats in different areas of the body and The percent of total fats in the body have had negative relations with serving and the forehand and backhand strokes accuracy which indicates that the less fat content whenever accuracy increased in performance skills and the greater the thickness of fat, it affects the performance skills accuracy, as the increase in the thickness of the fat at the expense of muscle blocks, directly affects the muscles labor force and affect the accuracy to guide strikes. Also, the increase in fatty lumps limits the movement of the joint and reduces joint flexibility and range of motor which affects the speed motor to perform detailed and accurate strikes. It agrees with the study of Sweeney et al. (2012) that showed a positive relationship between the body mass and the increase in torque, which in turn, will affect the ball speed in serving skill, and this result also agrees with the result of (Kleinwächter & Raschka, 2009) which indicated that the outstanding players group showed lower levels of fat as compared to the low level players. This result is in contrast with the study of Jabari (2011) which indicated a positive relationship between the thickness of the fat in the muscle area of Triceps with the level of performance skills. We also note a positive contribution to the age variable and to the performance of serving skill accuracy and the forehand and backhand strokes, this indicates that that whenever the age of the player increases, his experience also increases, which contributes to increase the accuracy in strikes. This result is in contrast with the study of Wong et al., (2014) which showed no correlation between the speed and the speed of the ball in the serving skill. The result is consistence with the result of the study of Hassan et al., (2009) which indicated a positive relationship between age and performance skills in volleyball, it is evident that whenever player’s training time increases, his physical ability increases however this does not mean that the player is capable of mastering all the skills at the same level may master some skills and fails in others. This depends on a number of variables which include age and weight. We also note the positive relationship between the height, the arm and the accuracy of the performance of two skills which is explained through that height incensement means an incensement in the length of the parts, which provides a good elevator for players. Additionally, height helps to increase the height of the center of gravity of the body from the earth, providing the player suitable base for directing the strikes in sharp angles with the land base, which helps to increase the accuracy and strength in the strikes, as well as the arm with the racket, which helps the player to perform well. The researcher paying attention when choosing Tennis players to notice their Lower parts and upper body lengths which are important and attached to their physical style, (Whiteside, et al, 2013) pointed out that the speed of racket and arm length become more apparent after puberty, while the movements of the feet become more apparent later through skill development. According to Abbas (2008) the more the player is tall, the more the weight position increases, and thus the step’s length increases while running to the place of the fall the ball falls and return faster to the place of start. The researcher explains this in that the length of the upper limb has the most important role in almost all skilled performance the game of tennis necessitate the use of racket in all the skills, so it requires special specifications related to the arm of the player and this is in line with what was indicated by Amin (2007) that the arm is the element of primary use in the performance skills of different types. The results agree with the study of Kleinwächter and Raschka, (2009) which indicated that the length of players with higher level is greater than those with low levels and they have less weight and this contributes significantly to the motor speed and performance. This is in contrast with the result of the study of Abdullah et al. (2001), which indicated a positive relationship between the transitional speed and all of the body weight, and the area around the chest and upper arm circumference and thigh circumference, as the increase in body weight adversely affect and hinder the body in his movements and performance of the transitional speed. And heavy individual needs great strength to overcome the inertia in the cross-section at the beginning of jogging, this is consistent with the study of Wong et al., (2014), which indicated that body mass index correlates significantly with the speed of the ball in the skill and accuracy of Serving. Mohsen (2011) indicated that the weight has a negative correlation with performance. Moreover, there is a positive relationship between arm circumference and accuracy performance of the forearm and backhand strokes that the increase in arm circumference means an increase in muscle mass which contributes to increase the ability to control and direct the racket in the performance of the forehand and backhand strokes. Also increasing muscle mass helps to increase strength and muscular endurance of the arm, which helps to bear the burden of a repeated performance of the
injuries. This is consistent with what Filipi (2013) found that the work of the fist increases the strength and ability which in return increases the speed and the appropriate speed. Mahjoub (2001) pointed out that reaching to the kinetic accuracy in sports needs the power to be available, as the strength of the fist is important to support the wrist joint when performing the strikes, where the greater the power of the fist increases the player’s ability to control and direct the strokes, which increases performance accuracy. Ulbricht et al., (2013) found that increasing muscle mass increases the strength and ability which in return affects the Tennis skills and increases the speed of serving. As the strength of the upper limb and lower have a great importance to the game of Tennis that it is not only to improve performance, but also in the prevention and rehabilitation of injuries. This is consistent with what Filipi et al., (2010) found in their study. They said that moving muscle strength of the trunk among females, and compatibility between the eye and the hand that males have contributed to the performance skills of tennis. This result also agrees with the study of Rogowski et al., (2009), which indicated that the speed of the ball and the effectiveness of muscle are associated with weight of tennis racket, where the greater the weight, the greater the need to work the muscle to produce power, and this is strongly linked to the muscles and their stamina. Agility has a negative relationship with the serving accuracy. This result could be explained through the skill of the accuracy of the serving, which does not need fitness to a great extent. The performance of the individuals does not require repeated movements and change directions and it differs from the forehand & backhand strokes that require the player speed to move in different directions and short time to cover All parts of the court, where (Ulbricht, et al, 2013) refers to that the work of the feet in Tennis in general as important as that the player needs to cover the side of forehand and backhand strokes. This requires running along distance to reach the forehand stroke, this makes it clear that the speed of the short-run and change direction is one of the factors that determine performance in Tennis. this result agrees with the study of Gerard & Millet (2009), which pointed to the importance of the physical attributes in affecting the achievement among Tennis players as speed, agility and ability significant has a relationship with achievement. We notice the effect of flexibility on skill performance in Tennis, where the flexibility of the trunk is important in providing a range of motion to the joint to move to the ultimate distance that gives the opportunity to the arm to swipe, gain speed and power to direct the ball to the right place.

Conclusions

1. Nine Anthropometric measurements which are (Age, Thickness of the skin fold in the triceps, midaxillary, length, thigh area, arm length, the abdomen, body mass index and weight) had the contribution with statistical significance differences in the variable of serving skill performance. The highest contributing rate was for the age and the lowest was for the weight.

2. Seven physical variables which are (Right Grip Strength, leg strength, Set-Ups, Push-Ups, Left Grip Strength, agility, flexibility) had the contribution with statistical significance that differs in the performance of serving skill accuracy variable. And the top rated percentage contribution was to the variable of Fist Strength and the lowest was for flexibility.

3. Nine Anthropometric measurements which are (Age, Thickness of the skin fold at the bottom area of the scapula, Thigh, Arm length, Upper Arm Circumference, Height, Percentage of body fat, Thickness of the skin fold in the Abdominal area, and Triceps) had the Contribution with statistical significance in performance accuracy of the forehand and backhand strokes. The highest contribution rate was to the age and the lowest was for the thickness of the skin fold in the Triceps.

4. Three physical variables (push-ups, flexibility, and set-ups) contributed effectively with statistical significance in performance accuracy of front and back kicks. The top rated variable rate of contribution was for set-ups and the lowest was to the push-ups.

Recommendations

In light of the results of the current study, the researcher recommends the following: Conducting similar studies in taking into consideration the rapid development in performance with adding some other psychological and biomechanical variables compatible with the progress in the various training methods. Make use of the results of the current study in the development of the sport of Tennis that contributes in increasing the level of accuracy in performance characteristics.
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**ODNOS ANTROPOMETRIJSKIH MJERENJA I FIZIČKIH OSOBINA S RAZINOM IZVEDBE TENISAČA**

**Sažetak**

Cilj istraživanja bio je ispitati čimbenike koji su pomogli u predviđanju razine izvedbe među tenisačima u Jordanu. Uzorak za ovo istraživanje sastojao se od 15 tenisača iz reprezentacije Jordana. Rezultati stupnjevite regresijske analize pokazuju da postoji devet antropometrijskih čimbenika koji doprinose objašnjenju varijance u smislu točnosti forhend i bekend udaraca. Uzраст je najvažniji čimbenik u modelu predviđanja. Štoviše, sedam fizičkih obilježja pridonosi objašnjenju odstupanja u točnosti, a tu su i fizički čimbenici objašnjene varijance forhend i backhand udaraca. Izdržljivost kao sredstvo je najvažniji prediktor. Preporuča se korištenje rezultata ovog istraživanja za razvoj karakteristike vezanih za Tenis što pridonosi povećanju točnosti izvedbe.

**Ključne riječi:** tjelesne značajke, sposobnosti, izvedba, tenis, Jordan

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