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Original Investigation

Tennis performance priorities for all-court player using the Analytic Hierarchy Process method

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Purpose: Above all, a wealth of research into the game of tennis has failed to provide an answer to the question of how to measure the overall performance of a top tennis player under competitive conditions. The aim of this study was to investigate the priorities for all-court tennis players on offence and defence.
Methods: The relative importance coefficients related to the style of all-court tennis players were determined for eighteen criteria for evaluating overall performance based on the expertise conducted by seven tennis experts. In this study, the priorities for "all-court" style were analysed using the Analytic Hierarchy Process method. From each given matrix, the vectors of importance coefficients defined by each of the experts were calculated using the geometric mean method and used to form a matrix of importance coefficients for an all-court player. The vectors of the arithmetic mean and standard deviations were calculated.
Results: The top of the defensive hierarchical structure indicates that the quality of movement/defensive tasks and the quality of the first serve-return have a high importance; the quality of performance in long rallies has a medium to high importance. The top of the offensive hierarchy structure indicates that playing with multiple styles and the quality of the first serve have a high importance; the quality of taking the initiative in rallies and the quality of the offensive forehand have a medium to high importance.
Conclusions: The results of this study can be used by coaches to select the optimal technical and tactical solutions.

Keywords: performance assessment, top tennis players, tennis experts, hierarchical structure in sport, sports performance

Introduction

Numerous scientific studies based on mathematical models have been carried out on the basis of data from the most important tennis tournaments[1-7] The articles dealt with the mathematical modelling of the tennis system and possible alternatives, the prediction of winners, the most effective strategies and research related to the validation of tennis paradigms[8-15]. The resulting algorithms provided numerous answers, but not the answer to the question of how to measure the overall performance of a top tennis player under competitive conditions. Modern computerised tennis match recording technologies provide comprehensive analysis for coaches and players. However, these sources of information still require competent and sophisticated evaluation and interpretation and are therefore of less value for comparing and analysing play between individual player types. In order to explain the structure of indicators, construct performance prediction models and test tennis paradigms, the standardised statistics of the world's biggest tournaments should be analysed in detail[16-21]. Furthermore, when defining the criteria system, any form of contamination (criteria from team sports) should be avoided and it is necessary to define a specific system of tennis criteria for the evaluation of the performance of the players themselves[22-23].
This study is a continuation of the research work that deals with the development and evaluation of methods for assessing the overall quality of top tennis players[24-26]. In modern tennis, coaches and scientists can clearly distinguish four dominant types of motor behaviour[27].
In this study, the priorities for "all-court" style were analysed using the AHP (Analytic Hierarchy Process) method. Observation of today's elite tennis players shows that the number of specialists who prefer the all-court" style is relatively high[28]. It may sound overly ambitious to ascertain that the development of methods for evaluating the overall quality of top tennis players (qualitative research) could include all factors of real quality assessed by experts, but there is a possibility for the mentioned model, with the implementation of objectively measured official statistics (quantitative research), to represent the overall performance of tennis players during the game[29]. The presented model for assessing the overall quality of top tennis players may find application in scouting reports as well as in planning, programming and control of the training process. In fact, according to the statements of numerous coaches, the models for assessing the overall quality of water polo[23,26] and basketball[22,30] players are a very useful tool in scouting reports as well as in planning, programming and control of the training process.

Methods

Participants
Tennis experts/judges (seven) were defined in this study as coaches who fulfilled at least one of the three required conditions: I. one of the first four places in a global competition (Fed Cup, Davis Cup, Grand Slam, Hopman Cup); II. one of the first four

places in a tournament of the ITF Pro Circuit; III. one of the first two places in a national championship as head coach. Informed Consent Statement: Informed consent was obtained from all participants involved in the study.

Design

A model for evaluating the overall quality of defensive baseline players, offensive baseline players and serve-volley style of play in tennis was proposed and described in detail in researches using AHP method[23-26,31]. The used approach is gender-independent. Suggested criteria for evaluating the overall quality of tennis players who primarily play the following styles of play: serve-volley, defensive baseliner, offensive baseliner and all-court player (Figure 1 and Figure 2):

I. Ten criteria for assessing the overall quality of top tennis players on offense:
1. quality of first serve; 2. quality of second serve; 3. quality of net game movement; 4. quality of net game shots; 5. quality of baseline movement / offensive tasks; 6. quality of offensive forehand; 7. quality of offensive backhand; 8. quality of taking initiative in rallies; 9. quality of transition attack; 1. quality of playing multiple styles.
II. Eight criteria for assessing the overall quality of top tennis players in defence:
1. quality of first serve return; 2. quality of second serve return; 3. quality of passing shots; 4. quality of baseline movement / defensive tasks; 5. quality of defensive forehand; 6. quality of defensive backhand; 7. quality of performance in long rallies; 8. quality of uncommonly situation shots.

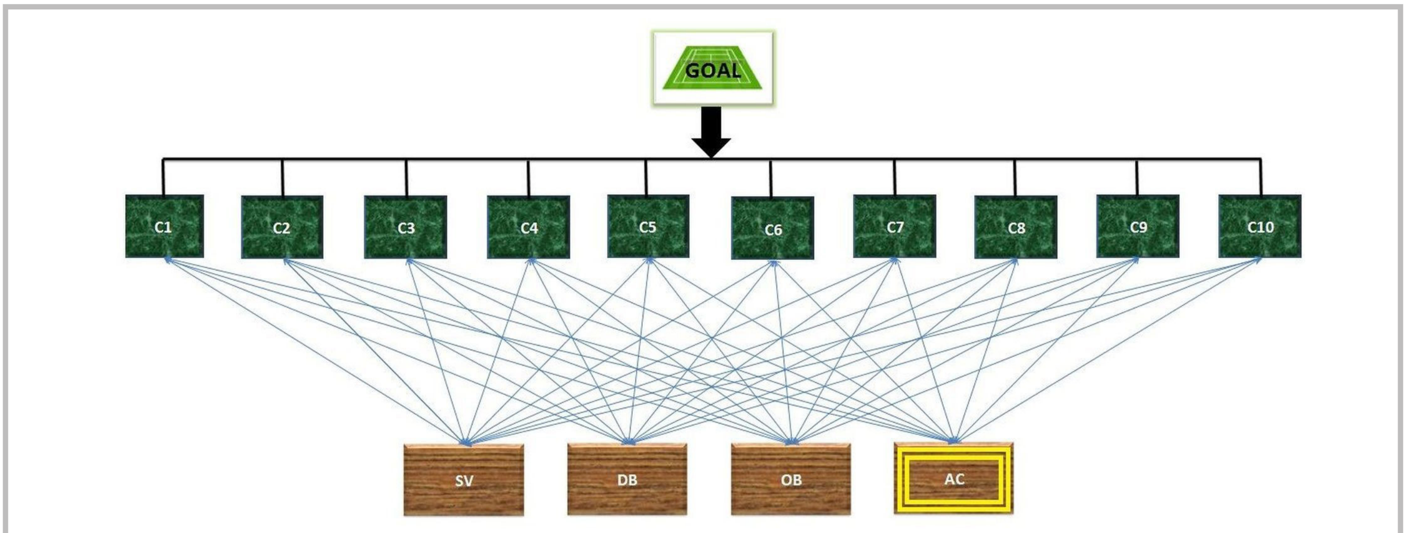

Figure 1. Structuring an AHP Model for offense (SV – service-volley player; DB – defensive baseliner player; OB – offensive baseliner player; AC – all-court player).

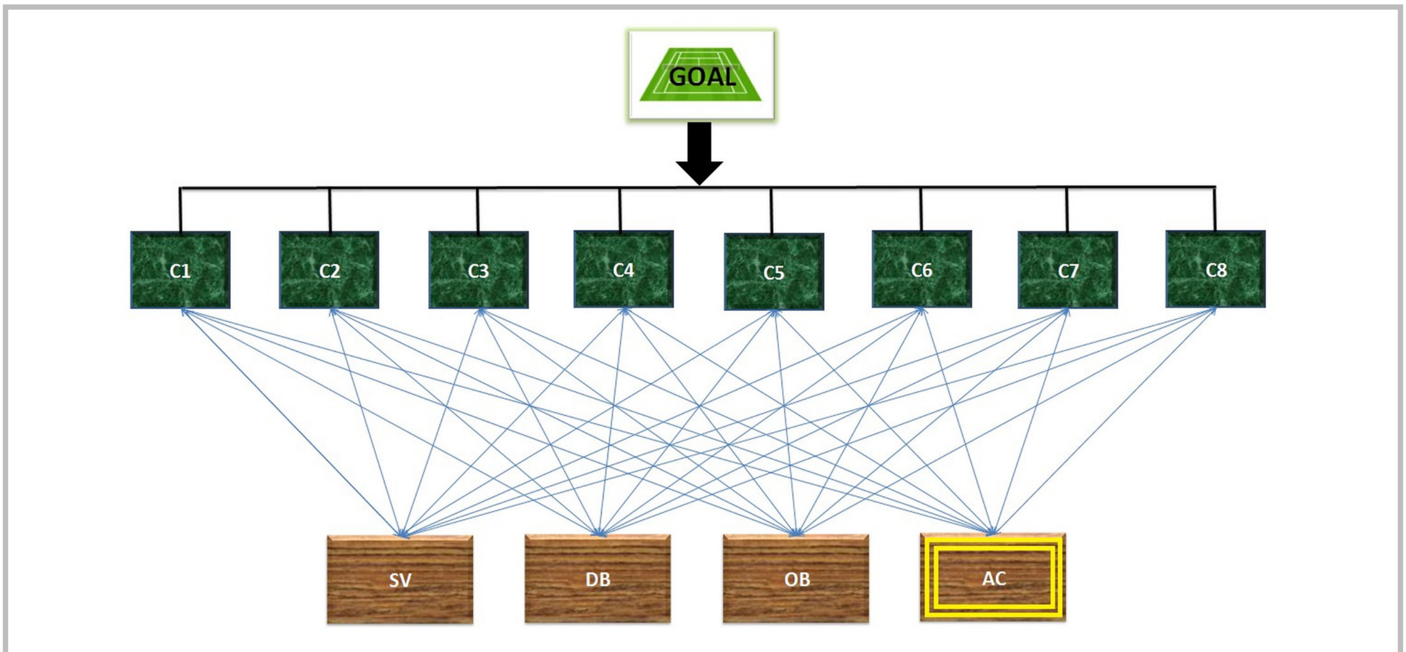

Figure 2. Structuring an AHP Model for defence (SV – service-volley player; DB – defensive baseliner player; OB – offensive baseliner player; AC – all-court player).

Methodology

Respecting the rules for application Analytic Hierarchy Process method (AHP method) for multi-criteria decision making, importance coefficients were determined within the defined criteria catalogue for the overall quality of "All Court" players in defence and offence[23,27]. The application of the AHP method was carried out in the following four steps:

1. Each tennis expert numerically rated the importance of each criterion by comparing it in pairs with the others and registering the relative importance for the serve & volley player. For example, if criterion »A« is twice as important as criterion »B«, then in the matrix of pairwise comparisons the value 2 was

assigned to position AB and ½ to position BA. In this way, each tennis expert created a square reciprocal matrix of scores for all court players;
2. From each matrix, the importance coefficient of the criterion was completed by applying the geometric mean method (GMM). In this way, a vector of importance coefficients for each criterion was obtained from each expert and the matrix of importance coefficients was formed for all court players;
3. From the matrices obtained, the vectors of arithmetic means and standard deviations of importance coefficients were then calculated for that particular style of play (1 vector for defence, 1 vector for offence).
4. The vectors of the arithmetic means of the importance coefficients were then rescaled so that their sum equalled one.

Statistical analysis
The reliability of the determined importance coefficients (i.e. weights) of the performance criteria for all-court player style was determined by calculating the correlation of mean values of the expert agreement (RMV – rank mean values) (agreement between the observers) and the Cronbach alfha (α). Apart from determining the criteria weights, the eigenvector method can be used as the basis for one of the most popular decision-making methods, the so-called Analytic Hierarchy Process (AHP). In this method, a decision maker (DM) is asked to assess the relative importance of two criteria and compare the importance of all possible pairs of criteria. The number of judgments that the decision maker has to make corresponds to the number of combinations without substitution of the second order from n elements.

Results

Table 1 shows the means (M) and standard deviations (SD) of the scores given by the 7 judges for the relative importance of 18 criteria per all-court tennis player in offence and defence. The average Cronbach's alfha per offensive game is .856 and per defensive game is .787. The average correlation of the judges' scores per offensive game is .949 and per defensive game is .939. These results indicate a high degree of agreement between the observers. All-court player (defence) – QBM-DT quality of movement / defensive tasks and QFSR quality of first serve return have high importance (M .191; M .169), QPLR quality of performance in long rallies has medium to high importance (M .152), QSSR the quality of second serve return, QDF quality of defensive forehand and QDB quality of defensive backhand have medium importance (M .121; M .120; M .114), QPS quality of passing shots has low to medium importance (M .083) and QUSS quality of uncommonly situation shots has low importance (M .050). All-court player (offense) – QPMS playing multiple styles and QFS quality of first serve have high importance (M .150; M .136), QTIR quality of taking initiative in rallies and QOF quality of offensive forehand have medium to high importance (M .121; M .117), QTA quality of transition attack, QOB the quality of offensive backhand and QBM quality of baseline movement / offensive tasks have medium importance (M .109; M .100; M .100), QSS quality of second serve has low to medium importance (M .078), QNS quality of net shots has low importance (M .052) and QNM quality of net game movement has very low importance (M .038).

Discussion
The results obtained show that the all-court player is indeed a universal player. This fact can be deduced from the results of the experts for this player, who estimated that the quality of playing several styles is the most important criterion for offensive play. This criterion implies that the player has the ability to play both a defensive and an offensive game from the baseline and at the net efficiently and consistently. In addition, this player is characterised by his ability to execute a fast and precise first serve that can completely prevent or neutralise the opponent's return. The results of this type of player show a great balance of different criteria, with an emphasis on attacking play from the baseline (baseline movement/offensive tasks, offensive forehand, offensive backhand, passing shots, transition attack). This type of player must therefore have the special ability to exert maximum pressure on the opponent with powerful and efficient forehand and backhand shots. It is also assumed that this type of player has a high ability for efficient footwork on the baseline, which can ensure the continuation of the initiative to exert constant pressure on the opponent's game from the baseline and turn a difficult defensive situation into an efficient offensive situation that can secure a winner or the initiative to win the point later in the rally.
The results show a slight variation in the importance of the criteria in the defence phase, which is to be expected given the assumption that this is the most versatile type of player. Nevertheless, the emphasis for an all-round player in defence is on his ability to perform efficient footwork at the baseline that can maintain a continuous balance in the point while preventing the opponent's initiative by successfully neutralising the opponent's first serve, and on his aggressive play by enforcing a type of tennis characterised by long rallies.
Based on the overall results of the match, both on defence and offence, one can therefore confirm the assumption that an all-court player is the most versatile type of player in modern tennis. Looking at the details of the objective results[20] and the subjective assessments, they suggest that an all-court player is most likely to be successful in the future of modern tennis.
There are several limitations to this research. Several coaches pointed out that it was hard work, where the large number of criteria made it extremely difficult to maintain concentration. One limitation that may arise in future studies is the inconsistency ratio (CR ≤ .10). Previous studies in other sports

Table 1. Required expert conditions for participation in the research

Competition	Place	Role
Fed Cup	1-4	player or coach
Davis Cup	1-4	player or coach
Grand Slam	1-4	player or coach
Hopman Cup	1-4	player or coach
ITF Pro Circuit	1-4	player or coach
National championship	1-2	coach

Table 2. Means (M), standard deviations (SD), the relative importance coefficients of the grades given by experts for the relative importance of eighteen performance evaluation criteria, as well as the correlation means of experts (RMS) & Cronbach's alpha (α) per all-court tennis player on offense and defence.

OFFENSE	M	SD	DEFENSE	M	SD
QPMS	.150	.032	**QBM-DT**	.191	.019
QFS	.136	.031	**QFSR**	.169	.043
QTIR	.121	.028	**QPLR**	.152	.030
QOF	.117	.022	**QSSR**	.121	.021
QTA	.109	.062	**QDF**	.120	.016
QBM-OT	.100	.014	**QDB**	.114	.025
QOB	.100	.015	**QPS**	.083	.026
QSS	.078	.026	**QUSS**	.050	.005
QNS	.052	.006			
QNM	.038	.002			
RMS	.856		**RMS**	.787	
α	.949		**α**	.939	

Legend: QPMS - quality of playing multiple styles; QFS - quality of first serve; QTIR - quality of taking initiative in rallies; QOF - quality of offensive forehand; QTA - quality of transition attack; QBM - quality of baseline movement - offensive tasks; QOB - quality of offensive backhand; QSS - quality of second serve; QNS - quality of net game shots; QNM - quality of net game movement; QBM-DT - quality of baseline movement - defensive tasks; QFSR - quality of first serve return; QPLR - quality of performance in long rallies; QSSR - quality of second serve return; QDF - quality of defensive forehand; QDB - quality of defensive backhand; QPS - quality of passing shots; QUSS - quality of uncommonly situation shots

Table 3. The relative importance of 18 criteria per all-court tennis player on offense and defence

Criteria	Importance weight	Criteria	Importance weight
QPMS	**High importance**	**QBM-DT**	**High importance**
QFS	**High importance**	**QFSR**	**High importance**
QTIR	**Medium to high importance**	**QPLR**	**Medium to high importance**
QOF	**Medium to high importance**	QSSR	Medium importance
QTA	Medium importance	QDF	Medium importance
QOB	Medium importance	QDB	Medium importance
QBM	Medium importance	QPS	Low to medium importance
QSS	Low to medium importance	QUSS	Low importance
QNS	Low importance		
QNM	Very low importance		
OFFENSE		DEFENSE	

Legend: QPMS - quality of playing multiple styles; QFS - quality of first serve; QTIR - quality of taking initiative in rallies; QOF - quality of offensive forehand; QTA - quality of transition attack; QBM - quality of baseline movement - offensive tasks; QOB - quality of offensive backhand; QSS - quality of second serve; QNS - quality of net game shots; QNM - quality of net game movement; QBM-DT - quality of baseline movement - defensive tasks; QFSR - quality of first serve return; QPLR - quality of performance in long rallies; QSSR - quality of second serve return; QDF - quality of defensive forehand; QDB - quality of defensive backhand; QPS - quality of passing shots; QUSS - quality of uncommonly situation shots

have shown diminished objectivity indicators for positions that are inadequate[29,30,32]. Furthermore, conventional methods of explaining success in sports games ignore the dynamic interactions that make up sports games[33]. The authors claim that current assumptions ignore the interaction between the player and opponents as an important source of variability in sports games. Future research could therefore investigate nonlinear, hybrid systems, neurotransmitter and hormonal factor detection, and motor programme diversity factors that determine individual differences in quality among elite players[34].

It is very important to design the training process in such a way that the most important offense criteria are brought together with the most important criteria, while at the same time working on specific psychosocial criteria[35].

Practical applications

These procedures of this research should provide the expert with an idea of how far their tennis player has progressed, based on an accurate assessment and interpretation of the results between the goals set and the goals achieved. This analysis should be carried out with the intention that the expert coaches will ultimately be able to redefine the goals by improving the training procedure.

Conclusions

Measuring the overall performance of a player in a tennis match is a challenge faced by scientists and coaches. The hierarchical AHP model for solving multi-criteria decisions helps to select the best solution among several alternatives with multiple criteria. The current research has revealed the all-court player's priorities for offence and defence.

By selecting technical and tactical knowledge and activities, the necessary training systems can be designed and applied, focusing on the criterion of selective disadvantage compensation. Indeed, since certain types of players do not always show the desirable high values of a certain criterion in a defined criteria system, it is of utmost importance to provide such a training system that allows them to reach their maximum competitive performance by maximising their personal skills.

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Ethical Committee approval

The use of these data did not require approval from an accredited ethics committee, as they are not covered by data protection principles, i.e., they are non-identifiable, anonymous data collected through an anonymous questionnaire.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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Author-s contribution

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