POTENTIAL AND COMPETITIVE SUCCESSFULNESS OF YOUNG TENNIS PLAYERS

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Abstract:

The partial potential successfulness of the sample of 42 tennis players, aged between 12 and 14 years, was evaluated in some chosen spaces of the psychosomatic status, using regression analysis and the Tennis Expert System.

The model of potential successfulness of young tennis players was designed on the basis of the existing research work and its findings. The model consisted of motor, morphological and functional dimensions. The model was tested by both methods at the highest level and also at individual levels.

Regression analysis was performed separately on the motor, morphological and functional parts of the tree of partial potential successfulness model. By means of morphological predictor variables 37% of the criterion variable was explained, by means of functional variables 38% and by means of motor variables 66%. Using standardized predicted estimations for individual areas, regression analysis was also performed at the highest level of the three dimensions that explained 74% of the criterion variable.

The association among the values of the partial potential successfulness obtained through the Tennis Expert System and the criterion variable is somewhat lower as is the case in regression analysis. The value at the highest level of the model of partial potential successfulness as correlated was at its highest 0.63, the value in the space of motor dimensions 0.65, the value in the space of functional dimensions 0.53 and the value in the space of morphological dimensions 0.45.

A congruity of the results obtained by the Tennis Expert System and regression analysis turned out to be 0.69 with the morphological dimensions, 0.70 with the motor dimensions and 0.88 with the functional dimensions. At the highest level of the model of partial potential successfulness of young tennis players the congruity of results turned out to be 0.78.

Key words: tennis, success, regression analysis, expert system

MÖGLICHE UND WETTBEWERBLEISTUNG DER JUNGEN TENNISSPIELER

Zusammenfassung:

Mit Hilfe von Regressionsanalyse und "System der Expertise in Tennis" wurde an einer Stichprobe von 42 Tennisspielern im Alter von 12 bis 14 Jahre die mögliche Teilleistung auf bestimmt ausgewählten Gebieten des psychosomatischen Standes eingeschätzt. Das Modell der Teilleistungseinschätzung der jungen Tennisspieler wurde auf Grund der vorherläufenden Untersuchungen und ihrer Auswertung aufgestellt. Das Modell besteht aus motorischen, morphologischen und funktionellen Dimensionen. Die beiden Zugänge wurden zur Überprüfung des Modells auf der höchsten allgemeinen Ebene wie auch auf Einzelebenen angewandt. Die Regressionsanalyse wurde parziell für motorischen, morphologischen und funktionellen Teil der Modellhierarchie von möglichen Teilleistung durchgeführt. Über die morphologisch-prädiktiven wurde 37%, über die funktionell-prädiktiven 38% und über die motorisch-prädiktiven Variablen wurde 66% der Kriteriumvariable erklärt. Durch die Anwendung von standarden prädiktiven Einschätzungen (Ergebnisse) für Teilgebiete wurde die Regressionsanalyse alle drei Dimensionen auf höchster Ebene durchgeführt und damit 74% der Kriteriumvariable erklärt. Die Zusammenhänge zwischen den Werten der parziellen möglichen Teilleistung die aus "System der Expertise in Tennis" und Kriteriumvariable erfolgen ist ja niedriger als bei der Regressionsanalyse. Die Korrelation auf der höchsten Ebene des Modells von parziellen möglichen Teileistung erreichte nur 0,63% und die Werte in den motorischen Dimension betragen 0,65%, in den funktionellen 0,53% und in den morphologischen 0,45%. Es stellte sich heraus, dass die Übereinstimmung der Auswertung von Ergebnissen des "Systems der Expertise in Tennis" und der Regressionsanalyse auf dem Gebiet der morphologischen Dimensionen 0,69%, auf dem Gebiet der motorischen Dimensionen 0,70% und auf dem Gebiet der funktionellen Dimensionen 0,88% beträgt. Auf der höchsten Ebene des Modells von partiellen möglichen Teilleistung der jungen Tennisspieler stimmen die Ergebnisse zu 78% überein.

Schlüsselwörter: Tennis, Leistung, Regressionsanalyse, System der Expertsystem

Introduction

The theory of successfulness tries to establish an athlete's successfulness. It deals with the different aspects of athletes' successfulness, factors of successfulness and their influence on performance and methods of ascertaining successfulness.

The successfulness of an athlete can be evaluated directly or indirectly. Direct successfulness is called competitive or playing successfulness, whereas indirect successfulness is called potential successfulness (Filipčič, 1996).

The factors of successfulness can be divided into three major groups: internal (micro), external (meso) and general social (macro) factors. The main problem in the present study was to define the dimensions of the internal factors, especially motor, morphological and functional dimensions. For each dimension, motor and functional tests and anthropometric measurements were carried out. A regression

analysis and decision (expert) system were performed on the motor, morphological and functional part of the model of potential successfulness of young tennis players. The competitive successfulness of the selected tennis players was used as the criterion variable. In the main part of the current research we present a comparison and association, i.e. a correlation between the values of partial potential successfulness obtained by regression analysis and the Tennis Expert System and competitive successfulness (Filipčič, 1996).

Method

Subjects

The research was conducted on 42 tennis players in the category boys over 12 and boys under 14 years of age. The research included players fulfilling the following conditions:

- they were born in 1981, 1982 or 1983
- they were placed on the STA ranking list in 1995
- they engaged in the process of regular training
- they were healthy during testing
- they were measured with all the relevant tests important for this research.

The sample of variables

The sample of morphological variables

Based on previous studies in tennis, the following sample of morphological variables was selected:

Code	Name of measure	Latent dimension	Number of items
ATV	Body height	longitudinal dimension	1
ADSPO	Length of lower limb	longitudinal dimension	1
ASM	Width of pelvis	transversal dimension	1
APKOL	Diameter of the knee	transversal dimension	1
APKOM	Diameter of upper arm	transversal dimension	1
AOP	Circumference of forearm	voluminosity	1
AOPMA	Maximal circumference of chest	voluminosity	1
ATT	Body weight	voluminosity	1

The sample of motor variables

Based on previous studies in tennis, the following sample of motor variables was selected:

Code	Name of test	Ability	Number of items
MSARG	Sargent jump	explosive strength	3
MM2	Throwing 2kg ball	explosive strength	3
MSKOK	The quadruple jump	explosive strength	3
MDT60	Sit-ups in 60 seconds	Repetitive power	1
MT20	20m run	Speed	3
MT9X6	Nine-by-six-metre run	Speed	3
MTAPR	Tapping	Speed of alternate movements	3
MTPK	Bend and touch	flexibility	3
MIZPK	Falling step	flexibility	3
MPAH	Fandrill	agility	3
MHEK	Hexagon	agility	3
MHST	Speed of stepping	agility	3
MPOL	Polygon backwards	co-ordination	3
MOZL	Rebounding tennis ball with the racket	co-ordination	3
MOSMI	Figure-of-eight run with bending down beneath the band	co-ordination	3
MHOJA	Walk on the beam and rebounding the tennis ball	balance	3
MPRIS	Side steps on a small beam	balance	3

The sample of functional variables

Based on previous studies in tennis, the following sample of functional variables was selec .ed:

Code	Name of test	Capability	Nui ıber of items
FRE6T	relative consumption of 0_2 at the speed 6 km/h (rel. $V0_2$ max. ml 0_2/kg/min)	aerobic function	1
FRAZD	Distance run	aerobic function	1
F2400	2400m run	aerobic function	1

The criterion variable

In the tree model of competition successfulness for boys under 14 years of age, all tournaments from June 1994 to July 1995 were included. Hence, 16 tournaments were used (national championships, masters and 13 open tournaments A and B).

Based on the achieved points in the tournaments in the 1994/95 season, the coefficient of successfulness was calculated for each tennis player. The procedure for calculating was the same as used for the ranking list of the Slovenian Tennis Association (STA). For further evaluation, the criterion variable was used (i.e. coefficient of STA).

Method of data processing

Data was processed with the statistical programme package SPSS for Windows (release 6.0), program Peta and Tennis Expert System (both were developed at the Faculty of Sport; Leskošek, 1991, 1995). The following was done:

- calculation of basic descriptive statistical parameters
- testing of normalcy of distribution of the variables
- test of linearity of correlation of the individual predictor variables with the criterion variable
- test of reliability of motor tests.

To determine the partial potential successfulness of tennis players, regression analyses and the Tennis Expert System were used.

Results and interpretation

The predictive value of the results of the partial potential successfulness of tennis players obtained with regression analysis

Regression analysis was first performed for each measurement space (morphological, motor and functional dimensions) and secondly for all three spaces together (the highest level of the three dimensions).

Table 1: Results of regression analysis in the space of morphological dimensions

Multiple R	.61048
R Square	.37268
Adjusted R Square	.22060
Standard Error	1.53088
F =	2.45061
Signif F =	.0334

	B	SE B	Beta	Correl	Part Cor	T	Sig T
ATV	.202129	.129101	1.067538	.474300	.215868	1.566	.1270
ADSPO	-.163952	.164512	-.524773	.406914	-.137406	-.997	.3262
APKOL	.106332	.871434	.029587	.354626	.016824	.122	.9036
ASM	.040650	.241496	.041797	.416250	.023208	.168	.8674
APKOM	-.075670	1.147350	-.015696	.434300	-.009093	-.066	.9478
AOP	.416767	.343512	.413612	.419266	.167278	1.213	.2336
AOPMA	-.099830	.046836	-.418245	.068359	-.293879	-2.131	.0406
ATT	-.040318	.121811	-.195939	.438961	-.045636	-.331	.7427
(konstanta)	-18.102400	12.272665				-1.475	.1497

Results of regression analysis in the space of morphological dimensions

Statistical significance shows an important connection between the criterion variable and the system of anthropometric measures (Signif F = .0334). The coefficient of determination (R Square = .37268) shows that the system of anthropometric measures explains 37% of the variance of the criterion variable. The coefficient of multiple correlation (Multiple R = .61048) shows that the association of the system of predictor variables with the criterion variable is 0.61.

If the results of the regression analysis obtained in the space of morphological dimensions are inspected more closely, the following can be established:

Both representatives of the longitudinal anthropometric measures (ATV, ADSPO) are highly correlated with the criterion variable. We can explain this by the positive influence of the body height and length of the extremities on the execution of shots. Suitable body height of a tennis player has an important influence on the execution of the service and smash and indirectly also on the execution of other shots, since high values mean a higher contact point, longer levers, catching more distant balls etc. (Filipčič, 1993).

An important share to the explanation of the criterion variable was also contributed by the measures of voluminosity (AOPMA, AOP). In our case this is reflected in the speed of the execution of individual shots (e.g. in the service, smash, etc.). It was established on the basis of the functional - anatomical analysis of tennis shots that the musculature of the trunk (abdominal and chest) affects to a large extent the speed of the execution (Jošt, 1992) and the possibility of acceleration of the speed of the racket through the point of the hit (higher acceleration of the racket through the hitting point).

The measures of the skeleton are represented by the variable APKOL. The test measuring the diameter of the knee is important for successful performance in tennis. It is a known fact that pronounced transversal dimensions enable

Table 2: Results of regression analysis in the space of motor dimensions

Multiple R	.81402
R Square	.66264
Adjusted R Square	.42367
Standard Error	1.31643
F =	2.77293
Signif F =	.0110

	B	SE B	Beta	Correl	Part Cor	T	Sig T
MT20	-2.875682	2.309717	-.270620	-.617682	-.147613	-1.245	.2251
MT9X6	-.228400	.463209	-.104425	-.530111	-.058461	-.493	.6264
MTAPR	-.068165	.067179	-.191111	.108154	-.120302	-1.015	.3204
MPOL	.216396	.187295	.217806	-.217833	.136983	1.155	.2593
MOZL	-.009152	.042522	-.046146	.374642	-.025517	-.215	.8314
MOSMI	.553295	.991868	.109642	-.291162	.066137	.558	.5821
MPAH	-.528886	.433256	-.282256	-.585292	-.144731	-1.221	.2340
MHEK	-.335978	.236177	-.270923	-.461037	-.168662	-1.423	.1677
MHST	-.194715	.378268	-.098269	-.386731	-.061030	-.515	.6114
MPRIS	.076111	.156030	.114276	-.178653	.057834	.488	.6301
MHOJA	-.006060	.066670	-.024954	-.424705	-.010777	-.091	.9283
MIZPK	-.006593	.029975	-.040901	.211858	-.026076	-.220	.8278
MTPK	.060184	.049566	.236619	.290267	.143961	1.214	.2365
MSKOK	.003800	.005873	.152652	.539276	.076705	.647	.5238
MSARG	.052376	.071400	.159575	.455131	.086971	.734	.4703
MM2	4.92387E-04	.002837	.039335	.591687	.020575	.174	.8637
MDT60	-.018639	.035888	-.081567	-.011205	-.061577	-.519	.6083
(Constant)	16.704746	13.978434				1.195	.2437

good attachment for the action of tendons and muscles, respectively. The massiveness of the skeleton can also have an indirect effect on a decreased occurrence of injuries (Agrež, 1976; Pustovrh, 1994).

Results of regression analysis in the space of motor dimensions

Statistical significance shows that the system of motor tests is statistically significantly connected with the criterion variable (Signif F = .0110). The coefficient of determination (R Square = .66264) shows that the system of motor tests explains 66% of the variance of the criterion variable. The coefficient of multiple correlation (Multiple R = .81402) shows that the association of the system of predictor variables with the criterion variable is 0.81.

A more detailed explanation of the results of regression analysis obtained in the space of motor dimensions shows the following:

The 20m run (MT20) and 9 x 6m run (MT9x6) tests belong to the group of very important variables whose common basis is the functioning of the mechanism for synergetic regulation. The speed of movement as well as the starting speed are by all means the abilities which have a special place in tennis. Namely, they have a decisive effect on the efficiency of movement of tennis players since the start and the first few metres of the run are the very factors which play a decisive role in executing a tennis stroke. In a game of tennis a large number of short sprints over a distance between 5 and 11 metres is repeated all the time (Schönborn, 1993).

Filipčič (1993) came to a similar finding. Within the battery of eight tennis tests, the T20 test (run over 20 metres) is, with its variance, the only one which statistically significantly explained the successfulness of tennis players.

The second cluster of variables of the information component of movement belongs to the field of regulation of movement. Among these variables the variable MPAH (fandrill) stands out. It belongs to the best tests of agility and measures the speed of the execution of a specific tennis movement on the designated polygon. The MPAH test does not approach the playing situation only with regard to content (nature of movement), but also with regard to the duration and intensity of movement.

The sub-space of agility was already singled out several times as the one having a very important influence on competitive successfulness of tennis players (Müller, 1989; Dlouha et al., 1990; Filipčič, 1993). Agility is the ability which belongs to the field of regulation of movement where above all mechanisms for movement structuring are decisive.

The group of variables (MPOL, MOZL, MOSMI) from the field of regulation of movement measures co-ordination. For the MOZL variable (bouncing the ball with the racket) a relatively high coefficient of correlation can be established. The MOZL test is a very specific test of co-ordination between the hand and eye, which is the only one having a slightly higher association with the criterion variable.

The penultimate sub-space of the information component of movement is represented by the tests whose common functional basis are mechanisms for the regulation of the muscle tone. Among the variables, also called tests of mobility (MIZPK, MPTK), only the MTPK variable (bending forward on the bench) is associated slightly with the criterion.

Among other variables (MPRIS, MHOJA) of the information component of movement it is necessary to mention the MHOJA test (walking on the beam and rebounding) whose association with the criterion is higher. The importance of balance in tennis shows above all in the execution of certain shots (service, basic shots) and the catching of very difficult balls by the player while jumping.

In the field of the energy component of movement we should mention the sub-area which is defined by the mechanism for regulation of the intensity of excitation. The tests measuring elastic strength (MSKOK) and speed strength (MSARG, MM2) belong to this sub-space. The importance of the tests of strength in tennis is evident in the influence on the initial acceleration of the movement of the player, in the execution of the service and smash and in saving very distant balls (Filipčič, 1993).

Results of regression analysis in the space of functional dimensions

Statistical significance shows that the system of functional tests is statistically significantly correlated with the criterion variable (Signif F

Table 3: Results of regression analysis in the space of functional dimensions

Multiple R	.61945
R Square	.38372
Adjusted R Square	.33507
Standard Error	1.41400
F =	7.88690
Signif F =	.0003

	B	SE B	Beta	Correl	Part Cor	T	Sig T
FRE6T	.058843	.044733	.172940	.281632	.167516	1.315	.1963
FRAZD	.002106	9.1108E-04	.316571	.470458	.294328	2.311	.0263
F2400	-.007260	.002531	-.381798	-.487391	-.365318	-2.869	.0067
(Constant)	-1.306738	2.843529				-.460	.6485

= .0003). The coefficient of determination (R Square = .38372) shows that the system of functional tests explains 38% of the variance of the criterion variable. The coefficient of multiple correlation (Multiple R = .61945) shows that the association of the system of predictor variables with the criterion variable is 0.62.

The FRE6T variable measures the consumption of O_2, more precisely the absolute relative maximal oxygen uptake at a running speed of 6 km/h (rel. O_2 max. ml O_2/kg/min). As implied by the name of the variable itself, the FRE6T variable determines the maximum oxygen consumption at initial lower load. In the calculation of the consumption of O_2 the body weight of the respective test subject is also taken into account. This is particularly important when dealing with such an age category, since the differences in body weight between individual subjects are large.

The reason that the majority of the variables (FRAZD, F2400) which measure aerobic functions explain competition successfulness very well can be sought in the time parameters of the tennis game, which indirectly determine the intensity of play in younger age categories (boys up to 14 years of age). These parameters are at least 30% higher than the parameters applying to the absolute category. This means that the speed of the hit projectiles is lower, which decreases the intensity of the game and usually also lengthens the duration of points.

The F2400 variable belongs to the field of running endurance. However, this test - also known as the Cooper test - measures aerobic endurance well. In research dealing with tennis (Filipčič, 1993) a similar test (T2000 - running over 2000 metres), only shorter, also statistically significantly explained the successfulness of tennis players. The T2000 test also measured the running endurance or aerobic capacities.

The importance of the mentioned mechanisms is reflected in a tennis game above all in longer contests which can last up to three hours and in overcoming long and strenuous tennis training sessions. Highly

Table 4: Results of regression analysis at the highest level of the tree of partial potential successfulness of young tennis players.

Multiple R	.85810
R Square	.73633
Adjusted R Square	.71551
Standard Error	.92490
F =	35.37290
Signif F =	.0000

	B	SE B	Beta	Correl	Part Cor	T	Sig T
REG_MOTO	.984827	.198170	.567934	.814025	.413963	4.970	.0000
REG_ANTR	.324753	.179268	.187280	.610477	.150901	1.812	.0780
REG_FUNK	.447014	.169868	.257785	.619455	.219205	2.632	.0122
(Constant)	-.400358	.142715				-2.805	.0079

developed aerobic capacities enable tennis players to preserve a high level of playing performance throughout the match. This means that the quality and intensity of the execution of movements and shots are at a suitably high level all the time (Schönborn, 1993).

In addition it is necessary to stress the high correlation of the state of good fitness level, to which running or aerobic endurance also belongs, with some motor abilities (co-ordination, accuracy, balance, etc.), tennis technique and some psychological abilities (concentration, anticipation, reaction abilities etc.).

Results of regression analysis at the highest level of the tree of partial potential successfulness

In regression analysis standardized predicted marks of the criterion at the highest level of the individual parts (motor, morphological and functional dimensions) of the tree of partial potential successfulness of young tennis players were included. Table 4 shows the results of regression analysis at the highest level of the tree of partial potential successfulness of young tennis players.

Statistical significance shows that the standardized predicted marks at the highest level of partial potential successfulness of young tennis players are statistically significantly correlated with the criterion variable (Signif F = .0000). The coefficient of determination (R Square = .73633) shows that the standardized predicted marks explain 74 % of the variance of the criterion variable. The coefficient of multiple correlation (Multiple R = .85810) shows that the association of the system of the standardized predicted marks with the criterion variable is 0.86.

All three standardized predicted marks have high coefficients of correlation with the criterion variable. In examining the Beta coefficients the mark of motor dimensions stands out, it is followed by the mark of functional dimensions, while the mark of anthropometric dimensions has a lower value. The same applies also to the coefficients of partial correlation where the occurrence of suppressor effect can be noticed. Both the mark of motor dimensions and the mark of functional dimensions take the variance from the mark of anthropometric dimensions. This can be explained by the indirect effect of certain anthropometric measures (longitudinal and transversal measures, circumferences) on the execution of certain motor and functional tests.

Results obtained by the Tennis Expert System and their explanation

By means of the computer program KISS 1.2 Tennis Expert 1 we calculated the partial potential successfulness of young tennis players. The partial potential successfulness was calculated for 42 test subjects involved in the research. Due to the large number of subjects we selected only three different subjects for explanation. The results for these players are given in linear representation 1.

Analysis of the results of the selected subjects (linear representation 1) was started at a higher level, i.e. the level of partial potential successfulness of tennis players. The next step was the analysis of the marks or the level of individual larger clusters (motor, morphological and functional dimensions). Then we proceeded to the level of individual abilities or characteristics. At the end, we also carried out an examination of the marks at the lowest level, i.e. the individual tests.

The player A received 3.87 (very good) at the highest level, in the motor space 4.16, in the morphological space 3.26 and in the functional space 3.97. More precisely, an inspection of the motor part shows that the tennis player also received a high mark in the information component of movement (4.31) and energy component of movement (3.62). Within the field of the information component of movement, the subject achieved excellent results in the MT20, MHEK, MHST, and MHOJA tests. All these tests are measures of abilities (speed, agility and balance) whose influence on performance in tennis is very high.

Analysis of the tests assessing the energy component of movement shows an excellent result in the MM2 test measuring explosive strength of the shoulders. This test is in a high correlation with successful performance of the serve (the kinematic chain).

Analysis of the morphological characteristics shows very good and good results in the longitudinal and transversal body measures. Almost all marks are higher than 3.50. The lowest marks were established in the body height (ATV) and body weight (ATT). This can be explained by the excessive height and

Linear representation 1: Marks of partial potential successfulness of the selected players obtained by the Tennis Expert System

Tree of results

Results of individual players

Group: Tennis - Slovenia - 12.06.95

	PLAYER A STA ranking: 07 R: 82, tr. od: 92 Resul C dC Oc.	PLAYER B STA ranking: 23 R: 82, tr. od: 93 Resul C dC Oc.	PLAYER C STA ranking: 70 R: 83, tr. od: 90 Resul C dC Oc.
Successfulness	-3 3.87	31 2.58	45 1.93
+-Motorics	-0 4.16	50 2.15	49 2.18
¦ +-Infcompmov	-2 4.31	51 2.15	50 2.14
¦ ¦ +-Regsyn	-2 4.31	51 2.15	50 2.14
¦ ¦ +-Speedmov	0 4.59	75 1.27	57 2.22
¦ ¦ ¦ +-MT20	3.82 87 -2 4.84	4.31 9 76 1.57	4.16 31 54 2.48
¦ ¦ ¦ +-MT9X6	15.3 70 5 4.11	17.3 3 72 0.73	16.8 13 62 1.74
¦ ¦ +-Speedaltmov	21 2.96	66 1.36	68 1.30
¦ ¦ ¦ +-MTAPR	43 49 21 2.96	34 4 66 1.36	32 2 68 1.30
¦ ¦ +-Regmov	-4 4.41	47 2.36	50 2.07
¦ ¦ ¦ +-Co-ordin	1 4.01	37 2.67	62 1.46
¦ ¦ ¦ ¦ +-MPOL	9.2 75 -0 4.34	11.0 40 35 2.89	12.3 19 56 2.00
¦ ¦ ¦ ¦ +-MOZL	50 77 -7 3.79	38 32 38 2.52	25 4 66 1.37
¦ ¦ ¦ ¦ +-MOSMI	7.7 59 11 3.66	8.0 29 41 2.43	8.5 1 69 0.62
¦ ¦ ¦ +-Agility	-5 4.62	59 1.97	52 2.04
¦ ¦ ¦ ¦ +-MPAH	13.9 70 10 4.11	15.8 7 73 1.51	15.0 26 54 2.28
¦ ¦ ¦ ¦ +-MHEK	9.3 92-17 5.04	12.2 26 49 2.29	11.9 41 34 2.92
¦ ¦ ¦ ¦ +-MHST	6.8 88-13 4.87	8.5 25 50 2.25	9.1 6 69 0.85
¦ ¦ ¦ +-Balance	-10 4.55	29 2.92	21 3.27
¦ ¦ ¦ ¦ +-MPRIS	15.9 77 -7 4.42	20.7 15 55 1.84	18.1 45 25 3.08
¦ ¦ ¦ ¦ +-MHOJA	29.0 83-13 4.68	33.0 67 3 3.99	36.2 54 16 3.46
¦ ¦ +-Regmusctone	-7 3.85	4 3.56	25 2.85
¦ ¦ +-MIZPK	170 90-20 4.31	168 92-22 4.40	143 39 31 2.72
¦ ¦ +-MTPK	48 65 5 3.38	43 40 30 2.72	45 50 20 2.98
¦ +-Encompmov	5 3.62	48 2.15	42 2.31
¦ +-Intexc	-3 3.89	50 2.08	49 2.11
¦ ¦ +-Elast_strength	-23 4.44	55 1.81	48 2.13
¦ ¦ ¦ +-MSKOK	900 93-23 4.44	730 15 55 1.81	740 22 48 2.13
¦ ¦ +-Fast_strength	5 3.66	48 2.19	49 2.10
¦ ¦ +-MSARG	40 28 42 2.35	36 9 61 1.59	41 44 26 2.84
¦ ¦ +-MM2	925 96-21 4.59	630 36 39 2.62	500 9 66 1.58
¦ +-Traek	31 2.70	42 2.39	19 3.00
¦ +-Endur_strength	31 2.70	42 2.39	19 3.00
¦ +-Rep_strength	31 2.70	42 2.39	19 3.00
¦ +-MDT60	49 39 31 2.70	45 28 42 2.39	50 51 19 3.00
+-Morphol_dim	-11 3.26	-20 3.71	53 0.64
¦ +-Skeletdim	-16 3.36	-19 3.77	58 0.61
¦ ¦ +-Skeletlength	-16 2.71	-16 3.28	68 0.60
¦ ¦ ¦ +-Height	-14 1.57	-11 2.38	70 0.03
¦ ¦ ¦ ¦ +-ATV	175.1 99-14 1.57	168.9 96-11 2.38	144.0 15 70 0.03
¦ ¦ ¦ +-Lengtseg	-19 4.49	-23 4.69	65 1.63
¦ ¦ ¦ +-Leglength	-19 4.49	-23 4.69	65 1.63
¦ ¦ ¦ +-ADSPO	100.5 94-19 4.49	102.0 98-23 4.69	82.0 10 65 1.63
¦ ¦ +-Skeletwidth	-17 4.19	-22 4.41	46 2.17
¦ ¦ +-Legwidth	-3 3.61	-25 4.52	30 2.72
¦ ¦ ¦ +-APKOL	9.5 73 -3 3.61	9.8 95-25 4.52	8.9 40 30 2.72
¦ ¦ +-Trunkwidth	-24 4.49	-18 4.24	58 1.70
¦ ¦ ¦ +-ASM	26.3 94-24 4.49	25.0 88-18 4.24	21.8 12 58 1.70
¦ ¦ +-Armwidth	-25 4.54	-22 4.42	51 1.99
¦ ¦ +-APKOM	6.7 95-25 4.54	6.5 92-22 4.42	5.7 19 51 1.99
¦ +-Volumdim	-4 3.10	-23 3.60	45 0.70
¦ +-Circumf	4 3.64	-21 4.59	44 2.46
¦ ¦ +-Armcircumf	16 3.23	-22 4.62	38 2.67
¦ ¦ ¦ +-AOP	21.8 59 16 3.23	24.1 97-22 4.62	20.6 37 38 2.67
¦ ¦ +-Trunkcircumf	-8 4.05	-21 4.57	50 2.26
¦ ¦ +-AOPMA	84.4 83 -8 4.05	86.8 96-21 4.57	72.9 25 50 2.26
¦ +-Weight	-25 1.58	-28 0.82	49 0.25
¦ +-ATT	56.7 95-25 1.58	57.2 98-28 0.82	36.3 21 49 0.25
+-Funct_dim	5 3.97	58 2.02	12 3.69
+-Aerocap	5 3.97	58 2.02	12 3.69
+-Maxconsump	29 3.01	55 2.27	-16 4.59
¦ +-FRE6T	23.7 51 29 3.01	20.4 25 55 2.27	29.8 96-16 4.59
+-Distance	-28 4.65	39 2.49	57 1.73
¦ +-FRAZD	2530 98-28 4.65	1827 31 39 2.49	1625 13 57 1.73
+-Endur run	-1 4.57	73 1.52	16 3.88
+-F2400	589 81 -1 4.57	760 7 73 1.52	640 64 16 3.88

weight measures of the subject and furthermore, the combined relation between those measures and successfulness in tennis. All other assessments are over 3.00.

In the space of the functional characteristics the subject received an excellent mark in the FRAZD and F2400 test. The mark in the third test was good. Finally, it can be pointed out that the player A received high marks (very good) in all areas and, furthermore, that very good test results which have the highest value or influence on competition successfulness contribute to the high final mark.

The player B attained the mark 2.58 (good) at the highest level, in motor space 2.15, morphology 3.71, and in functional dimensions 2.02. A detailed examination of the motor part indicates that the player B achieved slightly below-average marks both in the information component of movement, i.e. 2.15, and in energy component of movement, 2.15.

Within the field of information component of movement, the subject achieved good results in the MPOL, MOZL, MHOJA, MIZPK, and MPTK test. In the majority of the remaining tests, the marks range between 0.73 and 2.43. The player B attained the worst marks in the MT9x6, MT20 and MTAPR tests. In the tests measuring the energy component of movement we can notice a good mark in the MM2 test (throwing the medicine ball), while the other marks are only satisfactory. If we once again take a look at the area of motor dimensions as a whole, we may conclude that the player B attained poor results in a large majority of the tests.

In some of the already mentioned tests the player, however, also received good marks. He attained good marks in the tests not having a decisive influence on performance (lower weights). In the analysis of morphological characteristics we can notice a very good mark in the space of morphology (3.71) and very high marks in the majority of morphological dimensions. The player B achieved excellent results in the longitudinal measures of the skeleton (ADSPO), transversal measures of the skeleton (APKOL) and voluminosity (AOP, AOPMA). In the morphological part an unsatisfactory mark in the body weight (ATT) stands out, which indicates that the player in question is too heavy. The player attained satisfactory marks in all three measures in the space of morphology. He received a very poor mark in the F2400 run test. Our analysis may be concluded by the finding that the final mark in the space of morphology is very good, while in the space of motor and functional abilities it is satisfactory. The lower total mark at the highest level is the consequence of poor marks in the majority of motor and functional tests.

The player C attained the mark 1.93 (satisfactory) at the highest level, in motor space 2.18, morphology 0.64, and in functional dimensions 3.69. A more detailed examination of the motor part shows that the player received satisfactory marks both in the information component of movement (2.14), and in the energy component of movement (2.31). In the field of information component of movement, the subject achieved good results in the MHEK, MPRIS, MHOJA, MIZPK, and MTPK tests. In all other tests he received satisfactory or unsatisfactory marks. The player C received the lowest marks (below 1.00) in the tests measuring co-ordination (MOSMI) and agility (MHST). In the test measuring the energy component of movement, the player attained good marks in the MSARG and MDT60 (Sargent jump and sit-ups 60 seconds) tests. In the analysis of morphological characteristics we can notice an unsatisfactory mark (0.64). In the majority of morphological measures, the player C received very low marks (between 1.00 and 2.00). The player C received the lowest marks in body height and weight (0.03 and 0.25).

In the space of functional dimensions, the subject attained an excellent mark in the FRE6T test and a very good mark in the F2400 test. In the third test, the mark was only satisfactory. In the end we can establish that the player C achieved satisfactory marks in two spaces (motor, morphology). In the area of functional dimensions he attained a good mark. A strong deviation from the optimal model of a tennis player in the two spaces that are important for tennis (morphological and motor dimensions) is reflected at the highest level in a satisfactory final mark. A comparison between players A, B and C shows that by an individual analysis it is possible to obtain very fast a relatively clear picture of the partial potential successfulness of tennis players. As regards the selection of players,

Table5: The relationship between the criterion variable and values obtained for individual segments of the expert tree of partial potential successfulness by regression analysis and the Tennis Expert System.

REG_ANTR	1.0000 (42) P= .								
REG_FUNK	.3389 (42) P= .000	1.0000 (42) P= .							
REG_MOTO	.5913 (42) P= .000	.5251 (42) P= .000	1.0000 (42) P= .						
REG_SKUP	.7114 (42) P= .000	.7219 (42 P= .000	.9486 (42) P= .000	1.0000 (42) P= .					
EKS_ANTR	.6922 (42) P= .000	.2444 (42) P= .000	.4943 (42) P= .000	.5517 (42) P= .000	1.0000 (42) P= .				
EKS_FUNK	.2978 (42) P= .000	.8800 (42) P= .000	.4201 (42) P= .000	.6074 (42) P= .000	.2455 (42) P= .000	1.0000 (42) P= .			
EKS_MOTO	.3257 (42) P= .000	.6027 (42) P= .000	.7026 (42) P= .000	.7172 (42) P= .000	.4188 (42) P= .000	.5547 (42) P= .000	1.0000 (42) P= .		
EKS_USP	.5971 (42) P= .000	.5905 (42) P= .000	.7185 (42) P= .000	.7833 (42) P= .000	.8089 (42) P= .000	.5765 (42) P= .000	.8632 (42) P= .000	1.0000 (42) P= .	
CRITER	.6105 (42) P= .000	.6195 (42) P= .000	.8140 (42) P= .000	.8581 (42) P= .000	.4474 (42) P= .000	.5338 (42) P= .000	.5594 (42) P= .000	.6302 (42) P= .000	1.0000 (42) P= .
	REG_ANTR	**REG_FUNK**	**REG_MOTO**	**REG_SKUP**	**EKS_ANTR**	**EKS_FUNK**	**EKS_MOTO**	**EKS_USP**	**CRITER**

Legend:

CRITER - criterion variable (logarithmic coefficient of competition successfulness in the year 1994/95)

REG_ANTR - standardized predicted value of criterion obtained by regression analysis of morphological variables

REG_FUNK - standardized predicted value of criterion obtained by regression analysis of functional variables

REG_MOTO - standardized predicted value of criterion obtained by regression analysis of motor variables

REG_SKUP - standardized predicted value of criterion obtained by regression analysis at the highest level of partial potential successfulness

EKS_ANTR - tennis expert system value in the space of morphological extensions

EKS_FUNK - tennis expert system value in the space of functional extensions

EKS_MOTO - tennis expert system value in the space of motor extensions

EKS_USP - tennis expert system value at the highest level of partial potential successfulness

(n) - number of subjects

p= statistical significance of correlation coefficient (5 % significance level)

large differences between players are very obvious. The player A belongs to the group which attained the highest marks, the player B to those who achieved average marks, and the player C to the group of players with the lowest marks.

For comparison between the marks of partial potential successfulness of tennis players and actual competitive successfulness (STA ranking) we also give the position of each competitor on the ranking list of STA in the 1994/95 competition season. A quick comparison between the marks of partial potential successfulness and actual competitive successfulness shows that the marks obtained by the Tennis Expert System agree with the position of the respective player on the ranking list of STA.

The congruity of the results obtained by regression analysis and the Tennis Expert System

The congruity of the results obtained by means of the Tennis Expert System and by means of regression analysis was evaluated on the basis of the correlation coefficient with the mark of competition successfulness (CRITER). Table 5 shows the association between the values obtained by regression analysis and the Tennis Expert System in the individual parts of the expert tree of partial potential successfulness.

Table 5 shows that in all parts of the expert tree of partial potential successfulness the predicted values at the individual levels of the expert tree obtained by regression analysis have a higher congruity with the criterion than the values obtained by the Tennis Expert System.

The high values of the correlation coefficients obtained by regression analysis can be explained by the fact that this procedure takes into account all the characteristics of the observed measured sample. By regression analysis, a comparison between the partial potential and total competitive successfulness (in the year 1994/95) within the category was obtained. The procedure of regression analysis attempts to establish the optimal (mathematical) agreement between the partial potential successfulness (system of predictor variables) and competition successfulness (criterion variable). Therefore, a high agreement between the standard predictor values obtained for motor, morphological and functional dimensions and the highest level of partial potential successfulness is completely understandable.

Values of the correlation coefficients obtained by the Tennis Expert System are not so high as in the case of regression analysis. The value at the highest level of the model of partial potential successfulness has the highest correlation of 0.63, the value in the space of motor dimensions is 0.56, the value in the space of functional dimensions is 0.53, and the value in the area of morphological dimensions is 0.45. All the correlation coefficients are on a 5% statistical significance level. The lower association between the values of partial potential successfulness obtained by the Tennis Expert System and the criterion variable can be explained with two reasons. Firstly, in the Tennis Expert System the level of influence of the individual variable was determined for partial potential successfulness. This is seen in the weight of the value for the individual test. Secondly, the characteristics of the samples were not considered completely. Namely, the relations between the individual tests were assumed on the basis of potential successfulness in tennis. It is also necessary to mention that it is possible that the expert makes a suggestive model (expert tree, weights, normalisers) for each group of different age (potential successfulness within the category) or for the whole category (absolute potential successfulness).

In addition to the mentioned reasons for the differences between partial potential and competitive successfulness, there are still many other reasons from different fields that were not used in the model.

The lower values of correlation between partial potential successfulness and the criterion variable do not diminish the value of the results obtained by the Tennis Expert System. We are certain that the obtained results and information can be used in practical work. Such information can, namely, be used in monitoring and development planning for young tennis players. Furthermore, such information can also be used as an additional and more objective method in the selection.

The analysis of individual data concerning the ten best tennis players (list of Slovenian Tennis Association) obtained by the Tennis Expert System shows that at present the most successful players have very high values of partial potential successfulness. Besides that, the decision system allows us to infer that some of the tennis players have very high potentials and will make a lot of progress in competition successfulness in the near future.

The congruity of the results obtained by the Tennis Expert System and regression analysis for morphological dimensions is 0.69, for motor dimensions 0.70, and for functional dimensions 0.88. At the highest level of the model of partial potential successfulness of young tennis players, the congruity of the results is 0.78.

The congruity of the results obtained by both methods at the highest level can be evaluated as very high. At this point it may be concluded that despite many differences between the different methods some similarities still exist.

Some of the reasons for the lower congruity have already been mentioned, while some reasons can also be sought in the fact that different methods were employed in order to achieve different objectives. In carrying out the regression analysis, attention was focused on the characteristics of the sample and their correlation with competitive successfulness in the current competitive season, while in the case of the Tennis Expert System attention was focused on the results of partial potential

successfulness of the subjects. This method was used from the perspective of the requirements in tennis in the category of boys below the age of 14.

The values of correlation coefficients at the lower level of partial potential successfulness (motor, morphological and functional dimensions) are correlated with the influence on a particular field of successfulness of tennis players and the level of variance. The particular field co-operates with the level of variance with the aim of explaining the criteria variables.

Applicability of the Tennis Expert System in practical work

The conclusions of the present research can enrich both the tennis practice and the theory with new insights and experiences. Based on more systematic approaches it will be possible to improve the efficiency and humanity of the tennis training process as well as to employ a more individual approach to the training of each tennis player. The Tennis Expert System has the following characteristics:

- quick data processing
- protection of a tennis player's personal data
- multifunctional use of the obtained information
- comparison of the obtained information between different groups of players
- more precise and more efficient training planning
- use of data in the process of selection
- possibility of upgrading the system with other criteria
- systematic obtaining, processing and editing of the tennis players' data
- simplicity in using the Tennis Expert System program.

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