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Original research papers

TIME SERIES APPROACH TO ATHLETES MOTOR POTENTIAL

Time series approach to motor potential

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Abstract

Introduction. The aim of this study was to determine the dynamics of changes in selected motor abilities of javelin throwers and to determine predictors of javelin throw distances. ***Material and methods***. Research material included the results obtained from a group of 60 competitors from the Silesia Region of Poland, aged 14 – 15 years. In order to answer the research question, the following statistical analysis were employed: Pearson's linear correlation coefficients, vectors R0 and R1, time series analysis, distributed lag analysis and Almon distributed lag analysis and coefficient of concordance ^{2}. ***Results***. The correlation analyzes allowed for a selection of two variables for further analyses: specific strength of arms and trunk (SSAT) and specific strength of shoulders girdle and trunk (SSGT). Calculated indexes revealed that the level of SSAT showed a constant upward tendency (+15%). The highest rise in SSAT level was recorded in the 4th and 5th quarter (+9%). The level of SSGT showed an upward tendency nearly (+6%). In this case, the highest rise was observed in the 7th and 8th quarter (+4.5%). ***Conclusions***. The standardized regression analysis revealed that the variable of specific power of arms and trunk (SOBT) is the most important predictor for javelin throw distance with a full approach run.

Key words: javelin throw, time series analysis, regression analysis, motor abilities, predictors

Introduction

The problems with the determination of personal predispositions for achieving high sport performance have been tackled for many years. One approach is the application of successive phases of training with different selection criteria, to determine the athletes chances of achieving high performance [1]. Statistical and mathematical prediction methods [2] are becoming increasingly significant in this area.

To determine factors influencing sport results in 14-15 year old javelin throwers, these factors must include the specific strength of chosen muscles groups. However, strength measurements in the investigated group seem to be less important and less accurate than the specific power of javelin throwers measurements (tests). More importantly, other indexes have demonstrated a varied dynamics of changes in the process of body development, which translates into prospects of athlete's achievements [3, 4, 5, 6, 7].

The investigation was intended to determine the dynamics of changes in selected motor abilities of 14-15 year-old javelin throwers, using time series and to determine best predictors of dependent variable Y-distance of javelin throw.

Material and methods

Participants

The study group consisted of 60 javelin throwers, aged 14-15 year old, from the Silesian Macro-region. The subjects participated in training three times a week. Written informed consent was obtained from all participants. Participants were free from any known cardiovascular or metabolic diseases as reported in a health questionnaire. They were informed of the aim and experimental risks of the study. Additionally, they were non-smokers and were not on medication. This project was approved by the Bioethics Committee for Scientific Research at the Academy of Physical Education in Katowice.

Measures

The research problem was solved using empirical and predictive investigations, with the following model of statistical research: dependent variable Y (the distance of the javelin throw from a full run-up, after 12 months of training) and polytomic independent variables $Xn^{n} Y^{n}$.

The data from the measurement period from December 2005 to October 2007, based on the assumptions for the experimental model that was built to time series.

The descriptive statistics of the group of 14-15 year old javelin throwers were shown in Table 1. The results of the trials and tests were used as the 10 explanatory variables (Body height, Body mass, Body Mass Index, Body Cell Mass Index, Specific strength of arms and trunk, Specific strength of shoulder girdle and trunk, Specific strength of shoulder girdle, Specific strength of abdominal muscles, Grip power and the cross step) and one dependent variable Y – the distance of the javelin throw.

Table 1. Mean ± SD values of descriptive statistics of the investigated group of 14-15 year old javelin throwers

No	Variables			$\bar{x}$	S	V	A_s	K_u-3
1	H	Body height	cm	167.31	6.48	3.32	-1.44	2.19
2	BM	Body mass	kg	57.01	7.89	11.35	-1.27	1.76
3	BMI	Body Mass Index	kg/m^2	18.00	1.40	6.69	0.45	1.14
4	BCMI	Body Cell Mass Index	kg/m^2	8.68	1.92	18.01	0.02	0.16

To find the relationships between all investigated features a correlation matrix was calculated, while the statistical significance of particular explanatory variables (X) with respect to the explained variable (Y) was found by determining the vector of correlation. To determine the optimal set of predictors, the vector R0 was determined for the explanatory variables and the vector R1 for the correlations generated by the vector R0 of variables showing significant correlation with the explained variable Y. The functional relationships between the variables were found by means of computer graphic techniques and midpoint quadratic approximation.

Variable Y (the distance of a javelin throw from a full run-up – averages of three throws after a 30-minute warm-up) was selected as the model's explained variable.

To define the dynamics of changes in selected variables, the calculations of the indexes and the values of moving average were determined. In order to verify the level of adjustment of trends function to empirical data, coefficients of concordance ^{2} were calculated. Moving average was determined using eight quarterly measurements for selected variables value. Moving average is a predicting method using the average volume achieved in several recent sales periods to predict the volume likely to be sold in the next period.

For the purposes of the regression analysis, the results of a javelin throw from full approach run (measurement period of October 2007) were used. In order to obtain the aim of the study, the following tools of statistical analysis were employed: time series analysis, distributed lag analysis and Almon distributed lag analysis.

To determine which variable was the best predictor of javelin throw results, a standardized regression analysis was carried out. To sum up, in order to obtain the answers to the research problems, the methods of statistical data analysis and tools of direct observation were employed.

All statistical analyzes were carried out on a PC using the statistical package STATISTICA 9.1, STATISTICA Neural Networks Module (Data mining module – STATISTICA 8.0) and Excel 2010 from the Microsoft Office 2010.

Results

Measurements and analysis approach allowed for determining ten predictors which significantly improved the model's explained variable Y – the distance of the javelin throw (descriptive statistics in Table 1 and Table 2). However, eight variables were removed from the model following statistical testing: height, body mass, cross step with assuming the throwing stance Body Mass Index, Body Cell Mass Index, specific power of the shoulder girdle, specific power of the abdominal muscles and grip power (hypothesis testing – significance testing and statistical verification of structural parameters of regression equation for dependent variable Y – within the meaning of the equation: sign $(r(x_i,y))=\text{sign}(a_i)$).

Ultimately, the regression equation was re-estimated with the remaining two explanatory (statistically significant) variables:

- Specific strength of arms and trunk: medicine ball (2 kg) forward throw (with accuracy of 10 cm) – SSAT variable expressed in [m].
- Specific power of the shoulders and trunk: medicine ball throw (2 kg) from a sitting position (with accuracy of 5 cm) – SSGT variable expressed in [m].

Table 2. Mean ± SD values of explanatory variables of the investigated group of 14-15 year old javelin throwers

No	Variables			$\bar{x}$	S	V	A_s	K_u-3
1	SSAT	Specific strength of arms and trunk	m	17.74	2.57	13.72	-0.20	-1.34
2	SSGT	Specific strength of shoulder girdle and trunk	m	6.07	0.52	7.34	0.33	-0.96
3	SOB	Specific strength of shoulder girdle	n	17	3.45	29.30	0.12	-1.26
4	SSMB	Specific strength of abdominal muscles	n	18.00	3.60	24.79	0.04	-1.10
5	FCH	Grip power	N/kg	40.28	6.79	13.99	-0.54	-0.58
6	CSTP	The cross step	s	1.35	0.09	7.87	0.81	-0.02
7	Y	Result of javelin throw	m	50.77	4.73	6.20	-0.60	0.20

Considering the results of the calculated indexes, the level of SSAT in the analyzed period showed a constant upward tendency. The level of studied variable rose by 15%. At the same time the highest rise in SSAT level was recorded in the 4th and 5th quarter (9%). The level of SSGT showed an upward tendency and rose in the period by nearly 6%. In this case, the highest rise was observed in the 7th and 8th quarter (4.5%).

Based on moving average values (Tab. 3 and 4), the trend functions were selected; they adopted different forms depending the variables. The trend function for changes in the level of SSAT in the studied period was: $f(t_1) = 15.94+0.30*t_1$, SSGT: $f(t_2) = 7.18+0.06*t_2$.

However, further calculations revealed that variability coefficient for SSAT equaled ^{2}= 0.06 and SSGT ^{2}= 0.01.

The prepared predictions (for next quarter and half a year) using trend function was as follows:

- SSAT-($f(t_1)=15.94+0.299*9 = 18.63\text{m}\pm0.34\text{m}$;
  $f(t_1)=18.05+0.299*10 = 18.93\text{m}\pm0.12\text{m}$
- SSGT- $f(t_2) =7.18+0.06*9 = 7.72\text{m}\pm0.54\text{m}$;
  $f(t_2) =7.18+0.06*10 =7.78\text{m}\pm0.63\text{m}$

Table 3. Mean ± SD values of specific strength of arms and trunk (SSAT)

Quarter	True Results [m]	Moving Average [m]	$F(t_1)$ [m]
I	15.93	-	16.24
II	16.85	16.51	16.54
III	16.74	16.96	16.84
IV	17.29	17.18	17.14
V	17.51	17.51	17.44
VI	17.74	17.73	17.73
VII	17.95	17.99	18.03
VIII	18.28	18.28	18.33
SUM:	138.28	122.16	138.28

Table 4. Mean ± SD values of specific strength of shoulder girdle and trunk (SSGT)

Quarter	True Results [m]	Moving Average [m]	$F(t_2)$ [m]
I	7.25	-	7.24
II	7.30	7.30	7.30
III	7.36	7.36	7.36
IV	7.42	7.42	7.42
V	7.47	7.47	7.48
VI	7.52	7.52	7.54
VII	7.58	7.59	7.60
VIII	7.66	7.65	7.66
SUM:	59.56	52.31	59.56

The results of distributed lag analysis showed maximal values of t for quarter-based and half-year lag: SSAT $(t_1)=1.169$ for quarter lag (equal 1), SSGT $(t_2)=0.90$ for half-year lag (equal 2), (Tab.5).

Table 5. Mean ± SD values of distributed lag analysis. Regression coefficients - SSAT.

Lag	Regrssion Coeff.	Standard Error	t_2 (3)	*p*
0	2.067	2.394	0.863	0.451
1	1.594	1.363	1.169	0.326
2	-1.016	1.511	-0.672	0.549

Lag: 1 R=0.999 R-Square= 0.998

A verification of existence of lag was made based on the Almon distributed lag method, the following maximal values *t* for individual variables were obtained: SSAT $(t_1)=62.44$, SSGT $(t_2)=46.17$. The values of *t* for SSGT variable were obtained for quarter lag (equal 1), (Tab. 6). The standardized regression analysis of the variables SSAT and SSGT and the results obtained (R=0.993; R2=0.988; R^2=0.983; F(2.5)=205.77; p=002) revealed that the variable of arms and trunk strength performance is the most important predictor for javelin throw distance with full approach run. It obtained a statistically significant value of B=8.39 and Beta=1.06 (Tab. 7).

Table 6. Mean ± SD values of Almon distributed lag method. Regression coefficients - SSGT.

Lag	Regrssion Coeff.	Standard Error	t_2 (3)	*p*
0	2.087	8.671	0.241	0.825
1	2.090	0.045	46.175	0.000
2	2.093	8.760	0.238	0.826

Lag: 1 R=0.998 R-Square= 0.997

Table 7. Mean ± SD values of structural parameters of standardised regression analysis for the variables: specific strength of arms and trunk (SSAT) and specific strength of shoulder girdle and trunk (SSGT)

Variables	Beta	St. error B	Beta	St. error B	t	*p*
Intercept			14.436	7.242	1.993	0.102
SSGT	0.070	0.210	0.103	0.311	0.333	0.753
SSAT	1.061	0.210	8.387	1.661	5.048	0.004

Discussion

The distributed lag analysis revealed occurrence of delay in rise in motor potential in both variables, however, due to a low number of observations, they were not statistically significant (SSAT p=0.055, SSGT p=0.046). Based on the results obtained one can assume that the level of specific strength of arms and trunk showed an upward tendency, with quarter trend rise at the level of 0.3 points. At the same time, specific strength of shoulders and trunk also had a rising tendency; however, in this case, a quarter trend rise amounted to 0.06 points.

It was also observed that linear function of trend showed a good match with empirical data since only 6% of variability of the level of specific strength of arms and trunk (SSAT) and 1% of specific strength of shoulders and trunk (SSGT) were not explained by the function.

In order to find out when and how large lag in development of motor potential level occurs in the studied variables, analysis of that data for both variables was carried out in consideration of lag. It can be determined that the javelin throw result is a function of a rise in the value of the thrower's motor abilities (variables). However, the possibility of delays of these variables must be assumed. Due to differences in the biological development of 14-15 year old athletes, the investigation of lags was assumed for a period of quarter or half-year.

The results for the distributed lag analysis and their verifi-cation (likelihood of occurrence of collinearity effect was re-jected) revealed that all of variables show tendencies towards quarterly lags with possibility of half-year lags during rise in specific power of arms and trunk.

Time series analysis allowed for prediction of the values at the next quarter: specific strength of arms and trunk SSAT=18.63m and specific strength of arms and trunk SSGT=7.72m.

The nature of the athlete recruitment and selection processes consists of finding a vector of the candidate's abilities with respect to each stage of sports training. Therefore, an athlete selection process can be optimized by creating a possibly large resource of information on the candidate's sports abilities with as few examined features as possible, using a time series and a regression model [5, 8]. Because a large number of cases with optimal resources of information on an dependent variable Y (sports result) can be created using only a few variables, it is not necessary to make multiple measurements of numerous of features, many of which do not tell us anything new on variable Y because of their co-linearity [6].

Therefore, in the group of 14-15 year old javelin throwers, the regression analysis determined the vector of two variables that were most strongly related to javelin throwing distance. The final set of model variables was selected, with estimators which could play the role of athlete selection criteria (in 14-15 year old javelin throwers): specific strength of arms and trunk (SSAT) and specific strength of shoulder girdle and trunk (SSGT).

These variables significantly determine throwing distances in the analyzed group of javelin throwers. When the model's parameters for the young javelin throwers were being interpreted, it was found that increasing SSAT by a unit extended the throwing distance by nearly 10 centimeters (±0.31m), while the specific power of arms and trunk improved the result by approximately 8.38 meters (±1.66m).

Analysis of regression revealed best predictor for javelin throw from a full run-up, which is specific strength of arms and trunk (Beta=1.06), explaining 98% of variability of the phenomenon (Tab. 5.).

The analysis results were consistent with the sports theory view. The studied group was young, thus javelin throw distance mainly depends on the arms and trunk performance [9]. Other predictors of throw distance were still at the training phase and were not statistically significant. Therefore, the analysis results half-confirm findings by other authors [9, 10, 11], which reported statistically significant correlation between javelin throw distance, throw angle or javelin flight trajectory and arms and trunk performance, particularly in young athletes.

The results of the analyzes are also consistent with the results of the researchers who analyzed correlation between the position of elbow joint during the throw and positive twisting position of trunk to arms and trunk throwers strength. Best et al. (1993) revealed that these relationships are not significant at the initial phase of javelin thrower's training, which is caused by lack of skills to use specific strength of both trunk and arms properly [8].

This research problem was indirectly but closely connected with the optimization of an athlete selection process, based on predictions that determine future successes of athletes. The analytical tools employed in this investigation had many applications.

However, problems as we encounter, become progressively more complex and new methods will be needed. Naturally, we can always use hybridization to construct a method using a local algorithm or methods based, for instance, on the neural-genetic algorithms.

Conclusions

The results of the investigation into the group of 14-15 year old javelin throwers showed that the optimal set of two variables (specific strength of arms and trunk – SSAT and specific strength of shoulder girdle and trunk SSGT) was the most informative and usable as the explanatory variables of the regression models. The created regression model revealed that the specific strength of arms and trunk is the most important predictor for javelin throw from a full run-up in the investigated group. These models, built using results achieving from simple tests of young javelin throwers, could be helpful for instructors and coaches to determine level of athletes motor potential.

The research results indicate that the time series models are a useful and potentially superior tool that offers correct optimization possibilities in predicting sports results and an athlete recruitment and selection processes. The results of analysis and comparisons obtained using trend lines and moving average and allowed creation of realistic models of sports results based on time series technology, which predicted future performance reasonably accurately based on prior measures of performance and specific strength.

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