

Janez Pustovrh**ANALYSIS OF THE CORRELATION
BETWEEN THE VARIABLES DETERMINING
COMPETITION PERFORMANCE
IN CROSS-COUNTRY SKIING****ANALIZA POVEZANOSTI MED
SPREMENLJIVKAMI, KI DOLOČAJO
TEKMOVALNO USPEŠNOST
V SMUČARSKEM TEKU****Abstract**

An analysis of some of the potential criteria of a competitive performance was made on a sample of young cross-country skiers aged between 13 and 14 years. The analysis covered all six races of the 'Žito Cup' and three conventionally defined criteria of a competitive performance: FIS points, the POZ criterion (average time behind the winner in % in all races of the cup series) and the K-1 criterion. By applying Hotelling's method of principal components and the Kaiser-Guttman criterion we extracted the first principal component (vector K-1) from six races of the Žito Cup, with which we succeeded in explaining 83% of the variance of young cross-country skiers' performances. In this case the fifth race contributed the least to the total subject of measurement. The results of the correlation analysis show a high correlation between individual conventionally defined criteria of a competitive performance (FIS, POZ and K-1). The correlations between the variables also show that the competitive performance of the measured subjects is not highly correlated with the cross-country skiing technique. Owing to the methodological advantages established, the application of the FIS-points variable was confirmed as a priority criterion of competition performance in both professional work in practice and in scientific research work.

Key words: cross-country skiing, competition performance, FIS points, professional practice, scientific research activity

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Izvleček

Na vzorcu mlajših smučarjev tekačev, starih 13 in 14 let, smo opravili analizo nekaterih možnih kriterijev njihove dejanske tekmovalne uspešnosti. V analizi smo upoštevali vseh 6 posamičnih tekmovalnih tekmovalnega sistema Žito in tri konvencionalno definirane kriterije tekmovalne uspešnosti: FIS-točke, kriterij POZ (povprečni zaostanek za zmagovalcem v % na vseh tekmovalnih tekmovalnega sistema) in kriterij K-1. Na osnovi Hotellingove metode glavnih komponent in uporabe Kaiser-Guttmanovega kriterija smo ekstrahirali prvo glavno komponento (vektor K-1) iz 6 tekmovalnih za pokal Žito, s katero smo uspeli pojasniti 83 % variance uspešnosti mladih smučarjev tekačev. Še najmanj je k skupnemu predmetu merjenja v tem primeru doprineslo peto posamično tekmovalje. Rezultati korelacijske analize kažejo na visoko povezanost med posameznimi konvencionalno definiranimi kriteriji tekmovalne uspešnosti (FIS, POZ in K-1). Povezave med spremenljivkami kažejo tudi na to, da tekmovalna uspešnost merjencev ni v večji odvisnosti od tehnike teka. Zaradi ugotovljenih metodoloških prednosti je bila potrjena uporaba spremenljivke FIS - točk kot prednostnega kriterija tekmovalne uspešnosti tako pri strokovnem delu v praksi kot znanstveno raziskovalnem delu.

Ključne besede: smučarski tek, tekmovalna uspešnost, FIS-točke, strokovna praksa, znanstveno-raziskovalna dejavnost

INTRODUCTION

Competition performance in cross-country skiing can be determined on the basis of the analysis of one single or several competitions. It is relatively simple to determine competition performance directly, i.e. on the basis of an analysis of a single competition. Such a single competition, also at the highest levels such as the Olympic Games and World Championships, does not allow the large influence of random factors that may occur during an event. In addition, performance in this competition depends largely – above all in top-level competitors – on the efficient programming of the development of the sports form (Pustovrh, 1991). This directly expressed competition performance is shown in the competition result, the time attained in an individual cross-country skiing competition.

Of course, the reliability of evaluating the competition performance of an athlete on the basis of a single competition is reduced due to the influence of random factors normally present during the competition (bad mood on the competition day, momentarily low level of motivation, wrong selection of the glide, grip wax, bad starting number, unforeseen fall during the competition, difficulties with equipment, poor competition conditions etc.). Therefore, competition performance can be more reliably evaluated indirectly through an analysis of a larger number of competitions at the same competition level (e.g., cup competitions at the highest level for the World Cup) (Sharkey, 1984). These evaluations are made possible by an analysis of the model of competition performance (Jošt & Pustovrh, 1995). In this way, the mark of the overall performance of a competitor over a longer period (e.g. in the whole competition season, in half of the competition season etc.) is also obtained. The results also point indirectly to the development of the sports form and provide a superficial evaluation of the global efficiency of the training process in a given period. At the same time, these are also the data that are of use to the coach in the in-depth conception and execution of the plan and programme, and in the control of the transformation process (Ušaj, 1989, 1997).

For evaluating the competition performance of competitors over a longer period, the scoring of the rank in individual competitions of a given competition system is used in practice (World Cup, Intercontinental Cup, Alpine Cup etc.). However, since all male and female competitors in the competition system do not reach for points, the criterion of FIS points is mainly used as an addition. Theoretically there are also other criteria. The selection of a valid criterion of the competition performance of competitors is very important not only in immediate professional work, but also in scientific research work. In the study of the connections between the various dimensions of the psychosomatic status of competitors and their competition performance, the validity of the results obtained depends to a large extent on the very selection of a suitable criterion of the subject's competition performance.

The objective of our research was to establish mutual associations between individual criteria of competition performance. On the basis of the established mutual correlation between the criteria, it will be possible to accept or refuse the use of certain criteria in professional practice as well as in scientific research work.

METHOD

Participants

The sample of subjects consisted of 13 active cross-country skiers in the age category of older boys (13 or 14 years of age at the end of the competition season). All competitors took part in all six races of the Žito Cup held in Slovenia.

Instruments

The research included the following variables:

Individual competitions:

Race1 – freestyle technique

Race2 – classic technique

Race3 – classic technique

Race4 – classic technique

Race5 – freestyle technique

Race6 – classic technique

FIS points: the criterion represents the mark of the competition performance of a competitor in the competition season. It is expressed as a number of points. A lower number of points indicates a more successful performance.

POZ: average lag behind the winner in per cent in competitions for the Žito Cup

K-1: componently-defined performance criterion

Procedure

FIS points

The points that the measured subjects achieved in the current competitive season were taken from the official bulletin of the Ski Association (Tekmovalna komisija, 2002). The points were calculated using the following method (FIS, 2001):

a) Calculation of FIS points for the competition season and an individual competitor

The average of the four most successful competitions, expressed in FIS points, is taken into account. In the case of non-participation in the season due to illness or injury, the points gained so far to which an additional 22% of points are added (the maximum number of points that can be added is 14 and the minimum number is four) are taken into consideration. If a competitor took part in less than four competitions in the season, the average of the points they scored in the competitions and an addition of 50 points are used for the calculation.

b) Calculation of FIS points for a single competition

FIS points (single competition) = competition points + competition addition

Competition points (TT): $TT = F \times T_t / T_z - F$

Where:

F - factor: 540 - classic technique, 550 - free technique, 570 - pursuit event, 600 - mass start

T_t - time of the competitor in the competition for which FIS points are calculated

T_z - time of the winner in the competition.

c) Competition addition (TP)

From the valid total list of FIS points for the first five ranked competitors in a competition their respective actual FIS points are determined. The highest and lowest values are cancelled out (the best and worst results), while the remaining three results are added and the sum then divided by 3.75.

d) Individual competitions

All six competitions of the Žito Cup were taken into account. Four competitions were carried out in the classic, and two in the free cross-country skiing technique. The actually achieved time (in secs) of the subject in an individual competition is included as the result.

POZ: average lag behind the winner in per cent in the competitions of the Žito Cup For each competition of the Žito Cup in which a subject took part, the lag behind the winner in per cent is calculated. The obtained percentage figures are added and divided by the number of competitions.

K-1: componently-defined criterion of performance

All competitions of the Žito Cup in the season were condensed, by component analysis, into a first principal component – into only one common dimension, i.e. the vector K-1. This variable comprises the largest total variance of individual competitions (in Z - values).

The association between individual criteria of competition performance was determined by using Pearson's correlation coefficient.

RESULTS

Table 1: Results of the principle component analysis of the variables of individual competitions (Race1 - Race6)

COMPONENT	EIGENVALUE	% OF EXPLAINED VARIANCE
1	4.98	83.00
2	0.53	8.9
3	0.25	4.2
4	0.17	2.9
5	0.04	0.7
6	0.01	0.3
VARIABLES	COMMUNALITIES	LOADINGS (1. COMP.)
Race1	0.89	0.94
Race2	0.88	0.94
Race3	0.89	0.94
Race4	0.90	0.95
Race5	0.59	0.77
Race6	0.83	0.91

On the basis of Hotelling's method of principal components and the application of the Kaiser-Guttman criterion, the first principal component was extracted; it accounted for 83% of the common variance of young cross-country skiers. 13 competitors participated in all six competitions of the cup system.

Basic statistical characteristics of variables

Table 2: Coefficients of basic statistical characteristics and of testing the normality of the distribution of variables

	M	SD	V	MIN	MAX	KUR	SKEW	K-S Z	p(K-S Z)
Race1	989.77	79.26	8.0	877.00	1180.00	1.80	1.17	0.89	0.40
Race2	931.23	57.35	6.2	872.00	1078.00	2.54	1.41	0.54	0.93
Race3	841.62	37.56	4.5	781.00	932.00	1.94	0.92	0.64	0.81
Race4	1201.15	69.95	5.8	1127.00	1382.00	2.79	1.54	0.92	0.36
Race5	1268.77	56.59	4.4	1189.00	1372.00	-0.24	0.69	0.76	0.60
Race6	1097.08	100.62	9.2	980.00	1395.00	7.01	2.31	0.94	0.34
FIS	440.41	37.72	8.6	383.40	536.75	2.90	1.29	0.62	0.83
POZ	15.25	6.69	43.9	7.22	33.71	4.54	1.83	0.74	0.64
K-1	0.00	1.00		-1.19	2.71	4.03	1.72	0.67	0.76

Legend:

M mean

SD standard deviation

MIN minimum value

MAX maximum value

V coefficient of variability

KUR kurtosis

SKEW skewness

K-S Z K-S Z value

p(K-S)Z two-tailed testing of the significance of the K-S Z value

The results of the subjects varied the most in the POZ variable. Among the measures of asymmetry and kurtosis, the variable Race6 stands out. It has a pronounced leptokurtic and positively asymmetric distribution (i.e., in the direction towards lower, better values) of the test results.

Correlations between the variables

Table 3: Matrix of correlations between the variables defining the competition performance of the subjects

	Race1	Race2	Race3	Race4	Race5	Race6	FIS	POZ	K-1
Race1	1.00								
Race2	0.84**	1.00							
Race3	0.95**	0.88**	1.00						
Race4	0.84**	0.92**	0.81**	1.00					
Race5	0.70**	0.59*	0.61*	0.78**	1.00				
Race6	0.80**	0.86**	0.87**	0.83**	0.59*	1.00			
FIS	0.95**	0.93**	0.96**	0.91**	0.71**	0.91**	1.00		
POZ	0.94**	0.94**	0.94**	0.94**	0.76**	0.92**	0.99**	1.00	
K-1	0.94**	0.94**	0.94**	0.95**	0.77**	0.91**	0.99**	0.99**	1.00

Legend:

* P < 0.05

** P < 0.01

The correlation coefficients between the variables lie in the range between 0.59 and 0.99 and are statistically significant (at a 5% risk level) in all mutual associations. The correlations between the criteria (FIS, POZ and K-1) show how the variables denoting the measured subjects' general competitive performance correlate. We were also interested in how the criteria of a one-off race (Race1 – Race6) correlate with each of the criteria of general competitive performance.

DISCUSSION

The analysis of the K-1 criterion showed that the variable Race5 was the most distinctive among all individual races. This variable evidently contributed the least to the total subject of measurement (communality of 0.59) among all variables of a one-off race. The analysis of correlations between the variables of a one-off race and the first principal component showed similar results, with the respective variable $r=0.77$. Race6 is the next in a row of variables contributing the least to explaining the total variance, however its values are quite higher (communality of 0.83, $r=0.91$). The remaining variables (Race1, Race2, Race3 and Race4) are relatively equal in terms of their contributions to the first principal component.

The conventionally defined criterion variables (FIS, POZ and K-1) denoting general competitive performance throughout the season show high and identical correlations ($r=0.99$). All variables almost identically denote the measured subjects' general competitive performance in a competitive season. Irrespective of a different methodology for calculating these individual variables, all variables in our example show almost identical results (the ranking of measured subjects according to their competitive performance). It is estimated that, in our scientific and research work, by using the same sample of measured subjects we could have applied any of these three criterion variables.

Among the variables of individual races (Race1 – Race6) the variable Race5 ($r=0.71, 0.76, 0.77$) shows the lowest correlation with the conventionally defined criterion variables (FIS, POZ and K-1). A similar trend was already established for this variable when we analysed the variable K-1 and found out that it contributed the least to the explanation of total variance. Race6 is the second in a row of variables showing a low correlation with the conventional criterion variables (FIS, POZ and K-1); nevertheless, all correlations exceed the correlation coefficient of 0.90. In the fifth race of the season the conditions were evidently slightly different compared to other races, which explains the established differences. The last, sixth race was held in March and it is known that competitive conditions may vary slightly at that time of the year.

The variables of individual races (Race1 – Race6) correlate in different ways, hence their correlation coefficients range from 0.59 to 0.95. By and large, the variable Race5 correlates with all other one-off race variables showing the lowest coefficients, and it was established for this variable that the impact of coincidental factors was the strongest during the fifth race. The lowest correlation coefficient ($r=0.59$) was established twice, first in the Race5–Race2 variable correlation and then in the Race5–Race6 variable correlation. The variable Race5 showed the highest correlation with the variable Race4 ($r=0.78$).

The fifth and sixth races were the only races in the season where the skating technique was used. Their correlation was 0.70. In spite of the fact that the competitors in both races used the same technique, i.e. the skating technique, their correlation was relatively low due to the reasons mentioned above. Among all one-off races the highest correlation was that between

the variables Race1 and Race3, in spite of the fact that in these two races different skiing techniques were used (the skating technique in the first race and the classical technique in the third race). As the variable Race1 also shows relatively high correlations with other races where the classical technique was used (Race2, Race3, Race4 and Race6), it may be concluded that the performance of cross-country competitors of this age category does not correlate significantly with the technique used in a race. Therefore, it is most likely that the cross-country skiing technique as such does not add significantly to the differentiation between the measured subjects in terms of their competitive performance. Competitors excelling in one technique also excel in another technique, and vice versa.

The results of our research show that, based on our sample of measured subjects, any of the variables denoting athletes' general competitive performance in a competition season (FIS, POZ and K-1) could be used for the purposes of scientific and research work. Correlations between these variables are identical ($r=0.99$); however, it has to be emphasised that our sample was relatively small (13 measured subjects). Considering the fact that as a rule all competitors do not participate in all races of a cup series in a given season for various reasons (illness, injury, competitions abroad etc.), the use of the K-1 criterion in practical as well as scientific and research work is problematic. As K-1 is only calculated for those competitors who participate in all races of the cup series, in such cases the sample of measured subjects may be considerably reduced notwithstanding the fact that, in elite sport, it is already relatively small. Similar is true for the POZ criterion, as the calculation of this variable is only correct if the same number of races in a season applies to all competitors.

The research also showed that conditions in individual races may vary too much (in our case, the fifth race) to allow the use of a one-off race as a criterion of general performance. Performance in a one-off race depends on an athlete's current form, which may vary during the season. Since all competitors do not take part in all races the size of the sample is again problematic.

It is a fact that in practice the FIS point criterion is applied as the criterion of general competitive performance. It denotes an athlete's form in a competitive season in general terms and reduces the impact of coincidental factors that may appear in individual races. For the purposes of maintaining a relatively high number of measured subjects, this criterion is very useful in scientific and research work and has, in its own way, a certain practical value compared to the other criteria included in our research. By all means, similar research should be conducted on a larger sample of athletes.

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