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ANALYSIS OF CORRELATION BETWEEN SCORES OF PERFORMANCE FACTORS IN CROSS-COUNTRY SKIERS OBTAINED BY VARIOUS METHODS OF DETERMINATION OF WEIGHTS IN EXPERT MODELLING

ANALIZA POVEZANOSTI OCEN DEJAVNIKOV USPEŠNOSTI SMUČARJEV TEKAČEV DOBLJENIH NA PODLAGI RAZLIČNIH METOD DOLOČANJA UTEŽI PRI EKSPERTNEM MODELIRANJU

Abstract

In the research, two universal reduced models of potential competition performance in cross-country skiing were constructed. The MMPS model covers the motor, morphological, psychological, and sociological subspace of the psychosomatic status of competitors, while in the MFMPS model, a functional subspace has also been added. Within both models, we wanted to establish a degree of correlation between the scores of some important levels of psychosomatic status obtained by the SMMS procedure of expert modelling by the method of dependent and independent determination of weights. On a sample of 14 competitors (older juniors) the agreement between the scores of variables obtained by the two different methods of weight determination was established. We found that the final score of both models (URMPU) is highly correlated with their subspaces, except with the sociological one. The degree of interrelations between individual subspaces varies; however, the highest correlation exists between the motor and psychological subspaces in the method of dependent determination of weights. Both methods of determination of weights are in a statistically highly significant agreement. Somewhat better and more predictive results are yielded by the method of dependent determination of weights, while the utility of the method of independent determination of weights is larger.

Key words: cross-country skiing, potential competition performance, expert modelling, methods of determination of weights

Izvleček

V raziskavi smo izgradili dva univerzalna reducirana modela potencialne tekmovalne uspešnosti v smučarskem teku. Model MMPS zajema motorični, morfološki, psihološki in sociološki podprostor psihosomatičnega statusa tekmovalcev, v modelu MFMPS pa je dodan še funkcionalni podprostor. Znotraj obeh modelov smo želeli ugotoviti stopnjo povezanosti med ocenami nekaterih pomembnih ravni psihosomatičnega statusa, dobljenih po postopku ekspertnega modeliranja SMMS z metodo odvisnega in neodvisnega določanja uteži. Na vzorcu 14 tekmovalcev (starejših mladincev) smo v obeh modelih ugotavljali tudi skladnost ocen spremenljivk, dobljenih po različnih metodah določanja uteži. Ugotovili smo, da je končna ocena obeh modelov (URMPU) v visoki povezanosti s svojimi podprostori, razen s sociološkim. Stopnja medsebojnih povezav posameznih podprostorov je različna, najmočneje pa se povezujeta motorični in psihološki podprostor pri metodi odvisnega določanja uteži. Obe metodi določanja uteži sta v veliki statistično značilni skladnosti. Nekoliko boljše, prediktivnejše rezultate daje metoda odvisnega določanja uteži, medtem ko je uporabna vrednost metode neodvisnega določanja uteži večja.

Ključne besede: smučarski tek, potencialna tekmovalna uspešnost, ekspertno modeliranje, metode določanja uteži

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INTRODUCTION

The theory of sport as a complex, interdisciplinary theory tries to encompass all important and essential issues in the field of sport. To better learn the laws that govern live systems, we use models by which the structure of the system and/or processes are analysed. The purpose of modelling is advance information on how the system would in all probability behave, if the initially selected, limiting conditions of the model happened (Mulej, 1996).

Based on the concept of psychosomatic status, a general potential model of competition performance in Nordic skiing was set up (Jošt, Dežman, & Pustovrh, 1992). This also includes cross-country skiing. The intent was to discover the essential laws of successful guidance of the transformation process, which should lead to high-level competition performance. It could be argued that performance of an athlete depends on the state of all model dimensions which represent a linear combination of performance (equation of performance-specific action). According to up-to-date scientific knowledge, the quality process of preparation of athletes can be guided only by a model. The model should thus start out from the actual athlete's (competition) result, as well as from the impacts of all individual and interrelated dimensions of the psychosomatic status. When we speak about an athlete, we have in mind an integral personality defined by the essential abilities, characteristics and traits on which the athlete's performance in the chosen sport depends. These most predictive factors affecting the structure of a competition result are studied in the so-called reduced model of potential performance. Limitations occur also in terms of methodology. This is precisely why in 1985, experts working at the Institute of Kinesiology and the Laboratory of Artificial Intelligence at the Jožef Stefan Institute in Ljubljana came together to develop an information system of initial selection and advising of children in choosing sports (Šturm et al., 1992). A weakness of the multivariate methods (which are, however, still indispensable) is, in fact, their limitedness as regards the nature of variables (linear correlation, normality of distribution, etc.), and especially number of subjects subjected to measurements. In some sports, a small base of athletes makes it difficult to elaborate a study by applying multivariate methods; cross-country skiing also belongs to such sports. The use of a large number of variables and dimensions of the psychosomatic status is often questionable as well. Decisions on the management of transformation processes, however, cannot be based on partial findings. Application of expert knowledge and methods solves these shortcomings in a satisfactory manner.

In expert systems, application of methods of artificial intelligence is the essential feature. One of the most important characteristics of expert systems is their capacity to explain the solution whereby the system becomes transparent or comprehensible to the user (Urbančič, Lavrač, & Filipič, 1988). Despite the fact that in dealing with expert systems we do not underestimate an active use of knowledge, and hence the solving of the problem (inference mechanism), and that we cannot ignore the user interface facilitating a dialogue between an expert and the expert system, the essential work of experts is only associated with the modulation of the knowledge base. The quality of an expert system is basically the function of the scope and quality of its knowledge base. This contains the knowledge related to a given, specific problem field; in our case, performance of cross-country skiers. In setting up the knowledge base, it is first necessary to acquire knowledge in the field of performance in sport and to present it appropriately in a formalism. This encompasses three inseparably connected components (Ulaga, 2001): the referenceability of the knowledge base (criteria tree), the dimensional configuration of the knowledge base (decision rules or weights), and the positional configuration of the knowledge base (normalisers). Once it has been constructed the knowledge base must be embedded into the shell of the expert system consisting of the said mechanism for making inferences and of the user interface. A SMMS program (Sport Measurement Management System, Version 1.0), developed at the Faculty of Sport in Ljubljana, is a computer application intended to longitudinally monitor the results of the measurements carried out in athletes. In this program, two different methods of dimensional configuration (the method of dependent and the method of independent determination of weights) will be tested in assessing the competition potential of the subjects measured. The obtained different scores on the factors of competition performance will be analysed in terms of interrelations.

METHOD

Participants

The sample of subjects encompassed 14 competitors, i.e. cross-country skiers in the competition category of older juniors (born in 1984 and 1985). All ranked into the final list of SLO–FIS points in the 2001/2002 season.

Instruments

The MFMPS model of potential competition performance and the MMPS model included 70 and 64 variables, respectively. A detailed description of the variables and the measurement protocol are available from the authors at the Faculty of Sport in Ljubljana.

Variables of the motor subspace: MMENSDM – long jump from standing, MTRSK – triple jump from standing, MSRKF – balance frontally, MSRKS – balance sagitally, MTAPRO – tapping with hand, MSCT – Cooper's test (2,400 m), MEMTEK – 20-m sprint (high start), MMENS60 – 60-m run, MPON – polygon backwards, MKAOSP – eight with bending, MKVS – side steps, MSMIZT – hang with elbows bent, MSDTSK – trunk lifting on Swedish gymnastic bench, MSPSK – jumps over Swedish gymnastic bench, MSSNB – bent hangs on parallel bars, MTPK – bending forward on bench, MEMMED - heavy ball throw.

Variables of the functional subspace: VO_2max_LP – oxygen consumption at lactate threshold, VO_2max_ANP (4 mmol l^{-1}) – oxygen consumption at anaerobic threshold, VO_2max_ABS – maximal oxygen consumption, WATT_LP – load at lactate threshold, WATT_ANP (4 mmol l^{-1}) – load at lactate threshold, WATT_ABS – maximal load. VO_2max was measured relatively in ml min^{-1} kg^{-1} of body weight. Relative loading WATT (WATT kg^{-1} of body weight) was calculated according to the instructions (Mijnhardt, 1991). A standardised test for cross-country skiers on a Woodway treadmill was carried out. The subject walked on the treadmill with skiing poles at a speed of 7 km h^{-1} in the first 9 minutes, and then carried on at a speed of 7.5 km h^{-1} until the end of the test,. The inclination of the treadmill was increased every 3 minutes.

Variables of the morphological subspace: ATV – body height, ATT – body weight, ADZGO – length of upper limbs, ADSPO – length of lower limbs, AON – circumference of relaxed upper arm, AOPR – chest circumference, AOS – thigh circumference, APKOM – elbow diameter, ASR – shoulder width, ASM – pelvis width, APKOL – knee diameter, AKGT – abdominal skin fold.

Variables of the psychological subspace: Special psychological abilities were measured with a 10-minute series test (TN–10-A; Pogačnik, 1994) and a Test of concentration and achievement

(TKD; Bele-Potočnik, 1976): FLUIDINT – fluid intelligence, FUNVZPOD – function of encouragement, FUNKONTR – function of control. Motivation or dynamic component of personality was measured by Costello's performance motivation questionnaire (Costello, 1967), Willis' competitive motivation questionnaire (Willis, 1982), and by the self-motivation questionnaire (Dishman, Ickes, & Morgan, 1980): USPEZDEL – performance (success) based on work, USPNGDEL – performance (success) irrespective of work, MOC – motive of power, POZITIVN – positive competition motivation, NEGATIVN – negative competition motivation, SAMOMOT – self-motivation. Personality traits were measured by the Freiburg personality questionnaire (FPI questionnaire – 76; Bele-Potočnik, Hruševar, & Tušak, 1990), by a perseverance questionnaire (Černohorski & Železnik) and by Spielberg's anxiety scale (Spielberg, 1970): NEVROTIC – neuroticism, SPONTAGR – spontaneous aggressiveness, DEPRESIV – depressiveness, RAZDRAZL – irritability, DRUZABN – sociability, OBVLADAN – self-control, REAKTAGR – reactive aggressiveness, ZAVRTOST – inhibition, ODKRITO – sincerity, EKSTRAV – extroversion, EMOCLAB – emotional lability, MASKULIN – masculinity, VZTRAJNO – endurance, TEKMANKS – competition anxiety, ANKOSLAS – anxiety as personality trait.

Variables of the sociological subspace: SIZOBR_M – education of mother, SIZOBR_O – education of father, PDOBPOG – conditions for training, PDOBSTDE – good expert work, PDOBORG – good organisation of club, PSPAKT_M – involvement of mother in sport, PSPAKT_O – involvement of father in sport, IKLFUN_M – function of mother in club, IKLFUN_O – function of father in club, IDELMS_M – position of mother at work, IDELMS_O – position of father at work.

Procedure

Measurements were carried out at the Faculty of Sport in Ljubljana in March 2002. The subjects underwent the tests of motor abilities in a sports hall and on an athletic running track; the functional test protocol was performed in the laboratory for sport physiology. Data were processed with the SPPS software package and SMMS program. In line with the objectives and hypotheses, the research consisted of the following phases.

Two models of potential competition performance of cross-country skiers were set up in the form of a decision tree. The MMPS model covered the motor, morphological, psychological, and sociological subspaces of the psychosomatic status of competitors. In addition to the above subspaces, a functional subspace had also been included in the MFMPS model.

Normalisers for all elementary variables (tests) in the MFMPS model were set up, representing the points that determine the utility function v, which for a given measured (raw) result x on the base criterion determines its value or utility (Chankong & Haimes, 1983). The function is determined in such a way that in the variable for raw results, an arbitrary number of points is defined. The expert thus gives only the explicit, numerical and attribute values of the utility function for some points, while for other points, the values are determined by computing the straight line between two points by means of interpolation.

An example of normalisers for the MSPSK variable – jumps over Swedish gymnastic bench (see Table 1: e.g. 31 : 8 means that 31 repetitions in the test received the numerical score 8 – very good).

Table 1: An example of setting up the normalisers for the MSPSK variable

Value of variable	**8**	**24**	**26**	**27**	**29**	**31**	**33**	**42**
Score of variable	**0**	**2**	**4**	**5**	**7**	**8**	**9**	**10**

Numerical and descriptive values of scores: 0-1.99 = unsatisfactory, 2-3.99 = satisfactory, 4-6.99 = good, 7-8.99 = very good, 8.99-10.00 = excellent.

What experts have before their eyes when evaluating individual variables is a vision of top-level creativity in this sport (champion model) and at the same time the features of long-term developmental characteristics of an athlete. Thus, expert's evaluation becomes far-reachingly useful. In this way, longitudinal treatment of an athlete and the associated universal model of potential performance are attained. Namely, athletes go through various developmental, age and competition periods in their transformation process.

Decision rules for all nodes in the MFMPS and MMPS models were set up. They represent the value of a hypothetical contribution (in %) of each variable to competition performance at the respective node of individual model. The decision rules (weights) were determined by two methods: the method of dependent and the method of independent determination. In the method using dependent determination of weights (Šturm et al., 1992), total contribution of the weights of all variables of lower order that constitute a variable of higher order is, in relative terms, 100 at any individual node. In absolute terms, the sum total of the weights of all variables of lower order (tests) in the MFMPS model is 100. By the method of independent determination of weights (Ulaga, 2001), however, the absolute contribution of each variable to the score of competition performance is determined in such a way that for each basic and each derived variable a weight from 0 to 100 is determined. Hence, the weights are determined independently of other variables at the node.

With the SMMS program, scores for all variables at all levels in the MFMPS and MMPS models were calculated for each subject. First, for elementary variables (tests) and then gradually for all composite variables at higher nodes, up to the highest node (URMPU), the so-called prognostic score of competition performance of the subject. The calculation was made according to the following formula (Jošt, Dežman, & Pustovrh, 1992):

$$Svr = (Snr_1 \times P) + (Snr_2 \times P) + \ldots + (Snr_n \times P)$$

Svr – normalised value of a higher-order variable
Snr – normalised value of a lower-order variable
P – weight of a lower-order variable (decision rule, weight).

The data were processed at the Institute of Kinesiology at the Faculty of Sport in Ljubljana. The SPSS program package and SMMS program were used. To establish the correlation between the scores of variables in the MFMPS and MMPS models, the Pearson's correlation coefficient was used.

RESULTS

An example of the construction of the MFMPS model

Table 2 shows the structure of the MFMPS model at the highest levels and also part of the structure of the motor subspace (energy component of movement). There is also an example of the score of potential competition performance of the subject at the shown levels of the MFMPS model according to the method of dependent and independent determination of weights.

Table 2: Part of the structure of the MFMPS model, weights, normalisers and an example of evaluation of potential competition performance by both methods of determination of weights

Variables and test's codes	WEIGHTS		NORMALISERS	Competitor "A"			
				Dependent		Independent	
	D	I		RES	f(x)	RES	f(x)
URMPU	100	100			7.55		7.41
Morphology	12.5	80			6.34		6.65
Functional dimensions	30	100			8.70		8.87
Sociological characteristics	10	70			7.67		7.38
Psychology	17.5	85			7.80		7.27
Motor abilities	30	100			6.70		6.72
Energy comp. of movement	20.4	100			6.99		7.08
Excitation duration	12.8	100			8.38		8.56
Endurance power	5.6	75			7.48		7.88
Repetitive power	4.2	70			6.95		6.86
MSPSK	1.6	80	8:0, 24:2, 26:4, 27:5, 29:7, 31:8, 33:9, 42:10	33	9.00	33	9.00
MSSNB	1.2	65	1:0, 10:2, 14:4, 16:5, 18:7, 20:8, 22:9, 25:10	12	3.00	12	3.00
MSDTSK	1.4	70	0:0, 12:2, 15:4, 17:7, 19:9, 21:10	18	8.00	18	8.00
Static power	1.4	60			9.06		9.06
MSMIZT	1.4	60	0:0, 56:2, 65:4, 85:7, 102:9, 120:10	103	9.06	103	9.06
Running endurance	7.2	100			9.08		9.08
MSCT	7.2	100	480:10, 492:9, 504:8, 515:7, 530:5, 537:4, 554:2, 820:0	491	9.08	491	9.08
Excitation intensity	7.6	70					

Legend:
URMPU – universal reduced model of potential performance, D – dependent, I – independent,
RES – raw test results, f (x) – numerical score, SCORE – attribute score

Numerical and descriptive values of scores: 0-1.99 = unsatisfactory, 2-3.99 = satisfactory, 4-6.99 = good, 7-8.99 = very good, 8.99-10.00 = excellent

Correlation between scores of variables

Correlation between the final score of the universal reduced model of potential performance (URMPU) and the scores of individual subspaces in the MMPS model (motor, morphological, psychological, and sociological subspaces) is shown in Tables 3 in 4. In the method of independent determination of weights, the final score of the model (URMPU) is slightly less correlated with the motor and psychological subspaces than in the method of dependent determination of weights. Correlation between the final score and the morphological and sociological subspaces is, however, higher than in the method of dependent determination of weights. In the method of dependent determination of weights, the relation between the final score and the sociological subspace is statistically insignificant.

Table 3: Correlation between the scores of subspaces and individual subspaces with the final score (URMPU) in the MMPS model built by the method of dependent determination of weights

	URMPU	Motor abilities	Morphology	Psychology	Sociology
URMPU	1.00				
Motor abilities	0.91**	1.00			
Morphology	0.64*	0.36	1.00		
Psychology	0.65*	0.56*	0.07	1.00	
Sociology	0.31	0.10	0.45	-0.04	1.00

Legend:
** p ≤0.01, * p ≤ 0.05

In the method of dependent determination of weights, the degree of interrelation between individual subspaces of the psychosomatic status of cross-country skiers is in the range from low to medium high (see Table 3). The highest, statistically significant correlation is between the motor and psychological subspace.

Table 4: Correlation between the scores of subspaces and individual subspaces with the final score (URMPU) in the MMPS model built by the method of independent determination of weights

	URMPU	Motor abilities	Morphology	Psychology	Sociology
URMPU	1.00				
Motor abilities	0.83**	1.00			
Morphology	0.67**	0.26	1.00		
Psychology	0.55*	0.43	0.01	1.00	
Sociology	0.57*	0.25	0.54*	0.09	1.00

Legend:
** p ≤0.01, * p ≤ 0.05

In the method of independent determination of weights (see Table 4), the trend and direction of correlations remained more or less unchanged, if compared with the method of dependent determination of weights. In general, only the power of correlations between individual subspaces changes and is slightly smaller in this method. Only the correlation between the morphological and the sociological subspaces is statistically significant, however, it only slightly exceeds the level of statistical significance.

In the MFMPS model (motor, functional, morphological, psychological, and sociological subspaces), we focused slightly more on the motor and functional subspaces, which are the most important in terms of potential performance of cross-country skiers. An examination of correlations between the scores of variables obtained by both methods of determination of weights revealed only minimal differences (see Tables 5 in 6).

Table 5: Correlation between the scores of variables at different levels in the MFMPS model, obtained on the basis of dependent determination of weights

Dimensions and variable's codes									
					Motor.	Funct.	Morph.	Psych.	Socio.
URMPU (MFMPS model)					0.84**	0.86**	0.50	0.51	0.29
					Motor.	Funct.	Morph.	Psych.	Socio.
Motorabilities					1.00	0.54*	0.36	0.62*	0.20
			ENKOGI	INKOGI					
ENKOGI			1.00	0.57*	0.96**				
	TRAEKS	INTEKS							
TRAEKS	1.00	0.07	0.87**	0.29	0.77**				
INTEKS	0.07	1.00	0.56*	0.64*	0.65*				
INKOGI			0.57*	1.00	0.77**				
	REGSIN	KOORD							
REGSIN	1.00	0.72**	0.50	0.91**	0.69**				
KOORD	0.72**	1.00	0.55*	0.94**	0.74**				
Functional					0.54*	1.00	0.24	0.17	0.15
			VO2max	WATT					
VO2max			1.00	0.49	0.38	0.92**			
WATT			0.49	1.00	0.60*	0.80**			
Morphology					0.36	0.24	1.00	0.06	0.54*
Psychology					0.62*	0.17	0.06	1.00	-0.00
Sociology					0.20	0.15	0.54*	-0.01	1.00

Legend:

** $p \leq 0.01$, * $p \leq 0.05$

ENKOGI – energy component of movement, TRAEKS – excitation duration, INTEKS – excitation intensity, INKOGI – information component of movement, REGSIN – regulation of synergists, KOORD – coordination, VO2max – relative oxygen consumption, WATT – loadings at thresholds

Table 6: Correlation between the scores of variables at different levels in the MFMPS model, obtained on the basis of independent determination of weights

Dimensions and variable's codes					Motor.	Funct.	Morph.	Psych.	Socio.
URMPU (MFMPS model)					0.78**	0.84**	0.67**	0.32	0.38
					Motor.	Funct.	Morph.	Psych.	Socio.
Motorabilities					1.00	0.51	0.29	0.43	0.25
			ENKOGI	INKOGI					
ENKOGI			1.00	0.51	0.92**				
	TRAEKS	INTEKS							
TRAEKS	1.00	0.09	0.83**	0.20	0.67**				
INTEKS	0.09	1.00	0.62**	0.63*	0.71**				
INKOGI			0.51	1.00	0.81**				
	REGSIN	KOORD							
REGSIN	1.00	0.67**	0.31	0.84**	0.60*				
KOORD	0.67**	1.00	0.54*	0.97**	0.82**				
Functional					0.51	1.00	0.47	-0.03	0.26
			VO2max	WATT					
VO2max			1.00	0.51	0.33	0.89**			
WATT			0.51	1.00	0.57*	0.85**			
Morphology					0.29	0.47	1.00	0.01	0.54*
Psychology					0.43	-0.03	0.01	1.00	0.09
Sociology					0.25	0.06	0.54*	0.09	1.00

Legend:
** $p \leq 0.01$, * $p \leq 0.05$

The largest differences between both methods are exactly at the highest level of the model, i.e. between the URMPU score and the scores of individual subspaces. In the method of dependent determination of weights, the final score of the model is highly statistically significantly correlated with the motor and functional subspaces. In the method of independent determination of weights, the degree of correlation of the URMPU increased in the case of morphological and sociological subspaces, and decreased in the case of psychological and motor subspaces.

If we look at the final score of motor abilities, we can see that it statistically significantly correlates with both directly subordinated components (ENKOGI, INKOGI). The score of motor abilities is the most strongly correlated with the energy component, and slightly less with the information component of movement. In the method of independent determination of weights, a slightly lower correlation between the score of motor abilities and the score of the energy component of movement should be mentioned as well as a higher correlation with the score of information component, compared to the method of dependent determination of weights.

In the motor subspace, we also wanted to establish a correlation between all four hypothetical latent dimensions that emerge in numerous researches. Correlation between the energy component of movement (ENKOGI) and both directly subordinated mechanisms is high in both methods of dimensional configuration, especially with the duration of excitation (TRAEKS). The duration of excitation and the intensity of excitation (INTEKS), which belong to the superordinate node of the energy component of movement, turned out to be poorly correlated dimensions in our sample of subjects. The information component of movement (INKOGI) is also statistically significantly correlated with its hypothetically subordinated components (KOORD and REGSIG), which are again mutually statistically significantly correlated (0.72 in the method of dependent and 0.67 in the method of independent determination of weights), which could not be noticed in the case of TRAEKS and INTEKS. The information component of movement is also statistically significantly correlated with the energy component of movement; however, only in the method of dependent determination of weights. The correlations between both components of movement (ENKOGI, INKOGI) and the remaining two opposite mechanisms are important and two of them are even statistically significant (ENKOGI with KOORD and INKOGI with INTEKS) in both methods of determination of weights.

The correlation between the final score of the functional subspace and the score of oxygen consumption (VO_2max) is slightly higher than with the score of the ability of overcoming loads (WATT) in both methods of dimensional configuration, although in both cases correlation is high and statistically significant ($p \leq 0.01$). Both nodes are to a rather low extent interrelated in both methods of weight determination (0.49 and 0.51).

From the aspect of a predominant impact of motor abilities on performance in sport, we are mainly interested in correlations between this subspace and other subspaces. In the method of dependent determination of weights, the score of motor abilities has the highest and also statistically significant correlation with the score of the psychological subspace, while in the method of independent determination of weights this correlation is slightly smaller and statistically insignificant. Correlations between the score of motor abilities and the score of functional subspace are just above the limit of statistical significance in the method of dependent determination of weights and statistically insignificant in the method of independent determination of weights. It has also been found that there are no statistically significant correlations between the score of motor abilities and the score of morphology. The correlation between these two subspaces is slightly smaller in the method of independent determination of weights. There are no statistically significant correlations between the score of motor abilities and the score of sociological subspace.

Among all other correlations between the studied subspaces we should mention a statistically significant correlation (just above the limit of statistical significance) between the scores of the morphological and sociological subspaces in both methods of dimensional configuration.

The agreement, i.e. the correlation between the scores of variables obtained by various methods of determination of weights was established by the Pearson's correlation coefficient.

Table 7: Agreement between the scores of variables obtained by different methods of weight determination in the MFMPS and MMPS models.

Dimensions and variables	MFMPS	MMPS
URMPU	0.988**	0.981**
├ **Motor abilities**	0.985**	0.979**
├ Energy component of movement	0.989**	0.982**
├ Excitation duration	0.990**	0.987**
└ Endurance power	0.910**	0.879**
└ Repetitive power	1.00	1.00
└ Excitation intensity	0.980**	0.989**
└ Fast power	1.00	1.00
└ Information component of movement	0.961**	0.965**
├ Regulation of synergists	0.788**	0.787**
├ Balance	0.972**	0.987**
└ Speed	0.947**	0.977**
└ Coordination	0.999**	0.993**
├ **Functional dimensions**	0.997**	
├ Relative oxygen consumption	0.999**	
└ Loadings at thresholds	0.999**	
├ **Morphology**	0.954**	0.976**
├ **Psychology**	0.929**	0.968**
└ **Sociological characteristics**	0.961**	0.926**

Legend:
** $p \leq 0.01$

Table 7 shows that the agreement between the scores of both dimensional configuration methods is statistically significant, at a probability level of $p \leq 0.01$ in both models (MMPS and MFMPS). Only the correlations at the nodes of both universal reduced models of potential performance are given.

The values of correlations at the level of elementary variables are complete (1.00) since in both methods of determination of weights, identical normalisers were used for raw results (tests).

Where the relationship between weights of both methods of determination of weights is the same or very similar, the agreement between the scores of the variables in the model is also complete, hence 1.00 (repetitive power, fast power). The lowest agreement (although highly statistically significant) between the variables obtained by both methods of determination of weights was recorded in the aggregated criterion of the mechanism of regulation of synergists. To explain this smaller agreement, the trend of scores of the mechanism for the regulation of synergists in relation to the URMPU score is given in Figure 1 and Figure 2 for all subjects. A detailed examination of the scores in the coordinate system (correlation of the URMPU with the mechanism for regulation of synergists) in both methods shows that the scores of subjects 3, 6, 8 and 14 vary the most.

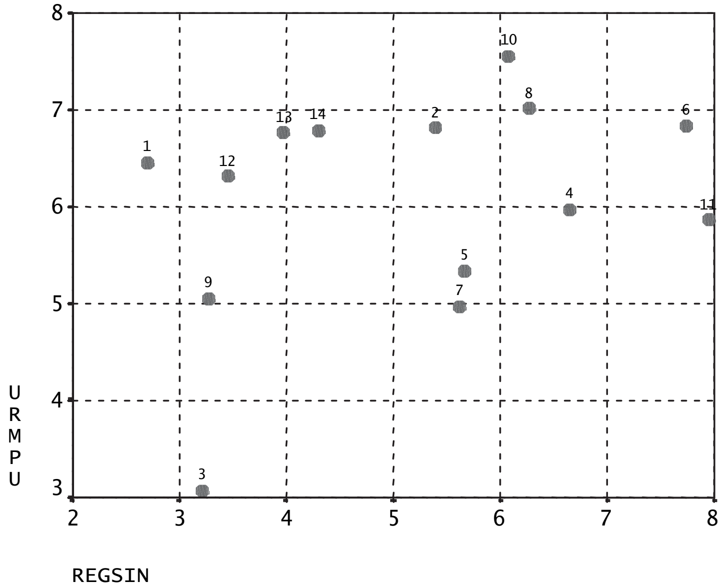

Figure 1: Correlation of the scores of the regulation of synergists with the final score (URMPU) in the method of dependent determination of weights (MFMPS model)

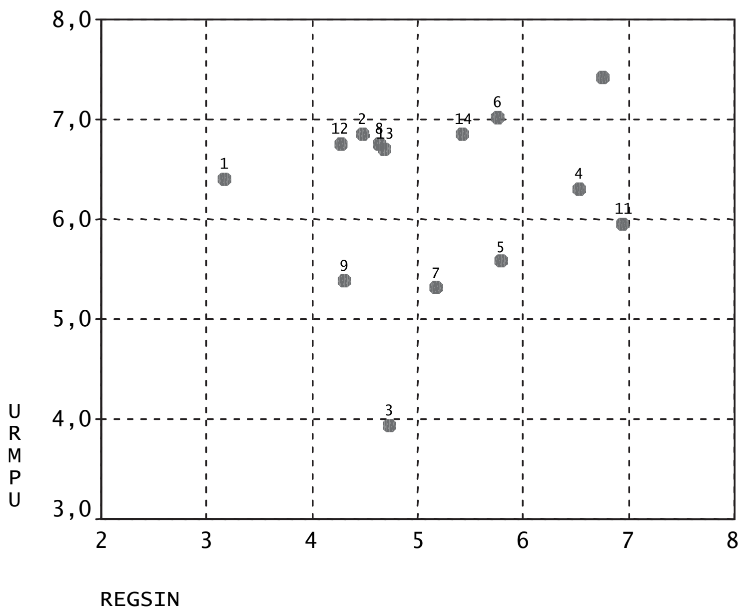

Figure 2: Correlation of the scores of the regulation of synergists with the final score (URMPU) in the method of independent determination of weights (MFMPS model)

In Table 8, the scores of the mechanism of regulation of synergists and its respective variables are shown for the mentioned subjects. The largest disagreements between both methods occur in the score of the speed node. In the score of the balance node, this disagreement is smaller, while in the score of the flexibility node, it is the same, due to the fact that the said node contains only one elementary variable.

Table 8: Comparison between the scores of the mechanism for regulation of synergists and its variables, obtained by both methods of determination of weights for subjects 3, 6, 8 and 14.

Variable's and test's codes	WEIGHTS		SCORES OF DEPENDENT METHOD				SCORES OF INDEPENDENT METHOD			
	D	I	3	6	8	14	3	6	8	14
URMPU	100	100	3.07	6.83	6.62	6.79	3.93	7.01	6.76	6.85
└ **Information component of movement**	12	85	2.30	6.54	5.17	4.62	2.98	5.65	4.41	5.11
├ **Regulation of synergists**	4.8	65	3.21	7.74	6.28	4.30	4.74	5.75	4.63	5.43
├ **Balance**	0.8	55	3.88	7.05	4.67	4.08	3.70	6.26	4.57	3.84
├ MSRKS	0.3	50	2.88	2.75	4.13	2.75	2.88	2.75	4.13	2.75
└ MSRKF	0.5	60	4.38	9.19	4.94	4.75	4.38	9.19	4.94	4.75
├ **Speed**	3.4	75	2.32	9.00	7.57	3.74	3.69	8.41	6.82	4.69
├ MTAPRO	0.8	55	7.00	7.00	5.00	7.00	7.00	7.00	5.00	7.00
└ MMENS60	2.6	85	1.54	9.33	8.00	3.20	1.54	9.33	8.00	3.20
└ **Flexibility**	0.6	60	7.00	1.95	1.95	7.80	7.00	1.95	1.95	7.80
└ MTPK	0.6	60	7.00	1.95	1.95	7.80	7.00	1.95	1.95	7.80

DISCUSSION

When searching for interrelations between the scores of individual subspaces in the MMPS model, it is necessary to mention the correlation between the score of motor abilities and psychology despite the fact that in the method of independent determination of weights, the degree of correlation is no longer statistically significant. The correlation is quite understandable; however, it is difficult to tell what the cause is and what the effect. To trust in his own abilities (including the motor ones), it is necessary that a cross-country skier forms a stable self-image. Marentič Požarnik (1988) says: "It is a whole of opinions and attitudes that a young person holds of himself – his mental and physical capacities." However, in the developmental period of adolescence, rapid changes occur and the competitor's self-image tends to vary considerably. On the other hand, Marsh and O'Neill (1984) found that self-image is significantly affected by the environment (external factors). Actively involved are those who deal with the adolescent every day. In addition to the family and friends, sport also plays an important role here. Sport should contribute to the development of personality by transforming socially less acceptable reactions. In this way, the foundations for a grown-up personality are being constantly upgraded.

In the MFMPS model, an extremely low correlation between the dimensions of the duration and the intensity of excitation, belonging to the energy component of movement, is particularly evident. The TRAEKS variable involves the ability of persisting in the elevated state of excitation despite the inhibitory tendencies in the peripheral and central structures; the INTEKS variable, however, involves the ability of activating a large number of motor units in short time intervals. In accordance with some researches we would expect a higher (positive) correlation; especially owing to the fact that in these age categories, the effects of specific training can be rather general (Dykstra, Demetriou, Copay, & Boileau, 1996); the progress in one structure is followed by the progress in another one. On the other hand, the reason for statistically insignificant correlation between the TRAEKS and the INTEKS variables can also be sought in the theoretical bases of the motor subspace structure. Theories speak about specific adjustments produced by training of the explosive power and endurance, as otherwise the hypothetical hierarchically arranged motor subspace would not point to two different latent dimensions (Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975). It is necessary to add here that these scores are derived from the raw results (they are transformed) and do not permit any overall generalisation to the theories derived from standardised values of variables.

In the functional subspace we should mention a rather low correlation between both directly subordinated nodes of this subspace, which points to the fact that two relatively independent dimensions of the functional subspace are involved, despite the fact that loading (WATT) indirectly results from energy processes at different intensity levels (VO_2max).

For a more thorough analysis of the correlations between individual subspaces, additional multivariate data processing and, above all, a larger sample of measured subjects would be necessary. Despite that and the fact that derived (transformed) scores are concerned, we can give a basic evaluation of directions of the said correlations, primarily for motor abilities. This evaluation has the highest correlation with the score of the psychological subspace (in the method of dependent determination of weights). This subspace consists of special psychological abilities (intelligence, concentration) and motivational and personality dimensions. If greater motor efficiency is taken as an indicator of greater competition performance and this is connected with the dimensions of the psychological subspace, then the obtained correlation can be compared with the results of some researches. More successful athletes are, as a rule, more dominant (Thakur & Thakur, 1980) and emotionally more stable (Butt, 1987); more successful athletes have a lower degree of pre-competition anxiety (Martens & Gill, 1976), and a smaller degree of neuroticism has a positive impact on coordination and balance (Ismail, 1976). Researches (e.g., Kirkendall & Gruber, 1970; Mejovšek, 1976) also showed no correlations between intelligence and simple motor movements. However, we can agree with the opinion of Adams (1981) that in carrying out the motor tasks, cognitive factors are more important until the movement becomes automated. The questions that arise here are: how long does the elimination of faults in the movement technique take and how fast is the adaptation to new disciplines, if the level of cognitive factors is lower? Responses to training are triggered, determined and dictated by the brain. If for certain reasons we dedicate insufficient attention to the encoding of exact movement patterns, the cross-country skier has difficulty in focusing on more important factors during the race itself.

The correlations between the score of motor abilities and the score of functional subspace only indicate (as generally known) that through the activities which have the character of long-lasting cyclic movements it is possible to exert substantial influence on the oxygen transport system (ventilation, cardiac output and pulmonary diffusion capacity), which is one of the indicators of the energy capacity of the organism. Hence, the correlation between the score of motor abilities and the two scores of the dimensions of functional abilities is understandable and expected, despite the fact that in the method of independent determination of weights the association between these two subspaces is no longer statistically significant.

The interrelation between the motor and morphological subspaces has been the subject of many researches (Ambrožič, 1996). In our case, statistically significant correlations between the two subspaces were not established. The correlation is slightly smaller in the method of independent determination of weights. Despite that, in both methods of determination of weights and in both models (MMPS, MFMPS) the score of morphology is relatively highly correlated with the score of the entire model (URMPU).

The latent structures of the sociological and motor subspaces are fairly well investigated; however, the results of researches carried out on different samples are difficult to compare. In our group of subjects, statistically significant correlations do not occur. Perhaps we expected a somewhat larger correlation between both subspaces since the sociological subspace also consisted of the socialisation subsystem dimensions (education of parents), which could indirectly point to the influence of that subsystem on the development of motor abilities. The reason in all probability lies in the nature of the sport itself since execution of simple movements does not involve high cognitive demands (Planinšec, 1999), if they can be hypothetically considered as a transmittable hereditary factor of highly educated parents. Despite all, however, correlations between these two subspaces are not without importance, especially because this is the first attempt of this kind to set up a sociological model of performance in sport. Between the motor and sociological subspaces, the most consistent correlation can be seen with respect to the applied various methods of weight determination.

The correlation between the morphological and sociological subspaces is somewhat unexpected in both methods of dimensional configuration. Perhaps this points to the fact that athletes with well-ordered factors of the socialisation, institutional, and consequential subsystems have all of the primary conditions for a harmonious physical development.

We have found that the scores of variables obtained by different methods of determination of weights agree highly statistically significantly. A slightly lower (yet still highly statistically significant at the probability level of $p \leq 0.01$) agreement at the node of regulation of synergists (REGSIN) occurs because the relationships between the weights representing the degree of the variance in the significance of individual nodes are disproportionate. If we decreased (increased) the criterion of significance in the method of independent determination of weights and thus artificially attained a more appropriate relationship between both methods, a question would arise about suitability of placing the individual variables into the model and hence, about the informative value of the universal reduced model of potential performance. We would also undermine the applicability of the whole expert modelling by this method of weight determination, since according to both methods the dimensional configuration (determination of weights) should be independent.

The speed node (HITR) has the largest influence on smaller agreement of the superordinate node (REGSIN). Here the disproportion in the weights between both methods is the largest at the level of elementary variable of tapping with hand (MTAPRO) and 60-m run (MMENS60) (0.8 : 2.6 and 55 : 85), therefore the final scores at the speed node also differ the most in all four subjects (Table

8). A disproportion in weights between both methods can also be seen at the remaining two nodes of balance and flexibility, which is consequently carried over into the superordinate node.

By applying expert knowledge of individual scientific disciplines, we have constructed two universal reduced models of potential performance in cross-country skiing with the intent to discover the relationships and interactions between individual psychosomatic status dimensions. Information yielded by both models should veer towards treating each cross-country skier as a bio-psycho-social whole. However, models are not theories or laws; they are only a reduced form of the system-athlete (man) relationship. Success in sport depends on the concomitance of numerous factors, which must be perfectly intertwined. The model thus does not include the variables of the cross-country skiing technique and movement economics, representing essential variable factors of excellence in cross-country skiing. Despite the fact that in scoring individual dimensions and subspaces we proceeded from the transformed values and that it was difficult to generalise, connect and also compare them with the standardised ones, these values can, nevertheless, serve as an important aid from the aspect of practical and theoretical starting points in planning of transformation processes. Above all, the correlations between motor abilities and the functional and psychological dimensions established by us can be of great help in planning and monitoring of successful/unsuccessful competition performance and they often lead away from blind alleys in which those athletes practising sports with a strongly emphasised endurance component often end.

In both models, two methods of dimensional configuration were tested. The question that arises here is the question about the qualitative value and the utility of both methods of determination of weights. By the method of dependent determination of weights, slightly higher correlations between the elementary and derived variables of cross-country skiers' psychosomatic status were obtained in general. As regards the accuracy of determination of contributions to individual elementary variables, the method of dependent determination of weights seems to be more appropriate. However, this is not the only reason for the evaluation of appropriateness. In the method of dependent determination, expert modelling is much more focused on the urgent need for an interdisciplinary treatment of the cross-country skier's psychosomatic status. However, in the case of independent determination of weights, this is not possible to such an extent, as there is no division of weights on a given criterion. In the latter method, overvaluation or undervaluation of individual dimensions is also possible. The positive side of the method of independent determination of weights is its fast, simple, and unproblematic application when one wants to measure only a specific scope of the psychosomatic status dimensions. In such cases it is not necessary to rebalance the model and to set up anew the decision rules.

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