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THE CONNECTION BETWEEN SELECTED ANTHROPOMETRIC AND MOTOR VARIABLES AND THE COMPETITIVE SUCCESS OF YOUNG COMPETITORS IN ALPINE SKIING

POVEZANOST MED IZBRANIMI ANTROPOMETRIČNIMI IN MOTORIČNIMI SPREMENLJIVKAMI S TEKMOVALNO USPEŠNOSTJO MLADIH TEKMOVALCEV V ALPSKEM SMUČANJU

ABSTRACT

The dilemma about using a greater or smaller battery of tests has been present for a long time when it comes to the organisation of measurements for categories of younger competitors in Alpine skiing. Based on a model of potential and competitive success we tried to establish the connection between (individual) motor and anthropometric dimensions and a particular criterion on a sample of 30 competitors in the category of older boys in Alpine skiing. The criterion was success in competitions on the basis of points scored in the Argeta Cup in the 2009/10 season. With the help of multiple regression analysis we calculated the connection with the competitive success on the basis of four statistically significant connections in the space of anthropometry and 13 statistically significant connections in the space of motor functions. In both cases (anthropometry; R=0.801*, Sig.=0.032* and motor functions; R=0.806*, Sig.=0.046*), a statistically significant connection with competitive success was confirmed. This means that, in the future, the battery of tests for establishing the state of anthropometric and motor dimensions in young Alpine skiers could be optimised using a smaller number of variables.

Key words: Alpine skiing, anthropometry, motor functions, successfulness

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IZVLEČEK

Dilema glede uporabe večje oziroma manjše baterije testov se pri organizaciji meritev za mlajše kategorije tekmovalcev v alpskem smučanju pojavlja že dalj časa. Za vzorec 30 tekmovalcev v kategoriji starejših dečkov smo na osnovi modela potencialne in tekmovalne uspešnosti ugotavljali povezanost (posameznih) motoričnih in antropometričnih dimenzij s kriterijem. Kriterij je predstavljala uspešnost na tekmovanjih na osnovi doseženih točk v pokalu Argeta v sezoni 2009/10. S pomočjo multiple regresijske analize smo povezanost s tekmovalno uspešnostjo izračunali na osnovi 4 statistično značilnih povezav prostora antropometrije in 13 statistično značilnih povezav prostora motorike. V obeh primerih (antropometrija; R=0.801*, Sig.=0.032* in motorika; R=0.806*, Sig.=0.046*) smo potrdili statistično značilno povezanost s tekmovalno uspešnostjo. To pomeni, da bi v prihodnje baterijo testov za ugotavljanje stanja antropometričnih in motoričnih dimenzij pri mladih alpskih smučarjih lahko optimizirali v smeri uporabe manjšega števila spremenljivk.

Ključne besede: alpsko smučanje, antropometrija, motorika, uspešnost

INTRODUCTION

In Alpine skiing as well as in other sports disciplines, achieving good results depends on a variety of factors and the quality of planning and conducting the training process, including how well athletes are prepared for competitions (Bosco, 1997). In determining athletes' success, we can only come quite close to the objective reality if in the observation process we can take into account and measure all dimensions which in one way or another may influence the achievement of the individual's end result. Since we know this is not possible, we are working on the development of a reduced model of success. This is divided into a model of potential success and a model of competitive success. The mutual connection of the results of the potential and competitive models of success is an indicator of the suitability and quality of the two models that have been developed. Regarding the connection between the dimensions measured and competitive success, we can select the contents of training; checking the psychomotor status of individuals and groups of competitors is, however, clearer and more rational if we only measure the set of selected variables typically connected with success.

Alpine skiing requires basic muscular power, aerobic and anaerobic abilities as well as a wide movement programme of specific motor abilities. In the past, the emphasis was laid on the training of leg power (Maffiuleti, Jordan, Spring, Impellizzeri, & Bizzini, 2009; Neumayr et al., 2003). Nowadays, it can be said that the training process, besides various manifestations of the power of the whole body, is primarily oriented to acquiring a broad spectrum of motor information with the emphasis on different kinds of co-ordination. In the past few years, the battery of tests for categories of younger competitors has consisted of variables (motor, anthropometric, psychological and other) which, according to the results of studies (Dolenec, 1996; Lešnik, 1996; Reid, Johnson, Kipp, Albert, & White, 1997; Rosenhagen et al., 2009), can be good predictors of success in Alpine skiing.

The starting point for designing a model of potential success was objective reality, which is too wide to be encompassed. We therefore limited our study to certain aspects of treatment which ensure a holistic insight into the state of a competitor. In the 1980s, the authors of the first specification equation sought to define the factors that have an effect on success in competitive Alpine skiing (Petrović, Šmitek, & Žvan, 1984). In Slovenia, expert modelling has subsequently represented an important part of planning and training and analysing the effects of training of different categories of competitors in Alpine skiing. The initial models of successfulness were formed on the basis of a heuristic approach. Their purpose was to classify children in different sports according to their individual psychosomatic status (Jošt, 1992; Leskošek, Bohanec, & Rajkovič, 2002; Šturm et al., 1992). Even today's expert model is composed of hierarchically arranged dimensions of a specification equation which have a multi-dimensional character. Individual variables are joined in a hierarchical tree where the potential successfulness of an individual within a group of test subjects can be calculated on the basis of a criterion function (normalisers) and weights. Reduced training prognostic models were formulated using the "expert system" method. They obtain a predicted value for each racer on all levels of the decision tree and evaluate the linear correlation between all the variables and compare each of them with the actual successfulness. They calculate the linear correlation between the predicted and actual successfulness (points). The obtained coefficient value shows a high correlation and enables us to confirm the validity and quality of the reduced training prognostic model of successfulness (Lešnik, 1996; Dolenec, 1996).

Monitoring a competitor over a longer period can reveal the trend in their development and indirectly also show the quality of the sport training process (Černohorski & Pustovrh, 2008). In the last 20 years, many researchers have tried to establish the connection between particular potential dimensions and success in competitions by basing their research on various samples. It has been scientifically proven that, for young competitors, among all potential dimensions the subsystems of the selected motor and anthropometric variables are most connected to success in competitions. Many researches demonstrate a high level of connection between the results of the selected variables and the results scored in competitions (Jošt, Pustovrh, & Ulaga, 1998; Spitzenpfeil, Niessen, Rienacker, & Hartmann, 2005; Ulaga, 2001; Von Duvillard, 2005). Consequently, we formulated a reduced model of anthropometric characteristics (Figure 1) and a reduced model of motor abilities (Figure 2) for categories of younger competitors in Alpine skiing. These two models are based on experience and formed in accordance with the possibilities.

ANTR(anthropometric characteristics)
- *AT(body weight)*
- EKSGEOR(external geometric dimensions of the body)
  - DOLRAZ(longitudinal dimensions of the body)
    - *AV(body height)*
    - *ADN(length of the lower extremities)*
  - PRAZSO(transverse dimensions of the body)
    - *APKOLL(diameter of the left knee)*
    - *APSSL(diameter of the left ankle)*
  - OBSNOG(circumferences of the lower extremities)
    - *AOSL(circumference of the left thigh)*
- INTGEOR(internal geometric dimensions)
  - *AKGT(stomach skin fold)*
  - KGNOG(skin folds of the lower extremities)
    - *AKGSL(skin fold of the left thigh)*

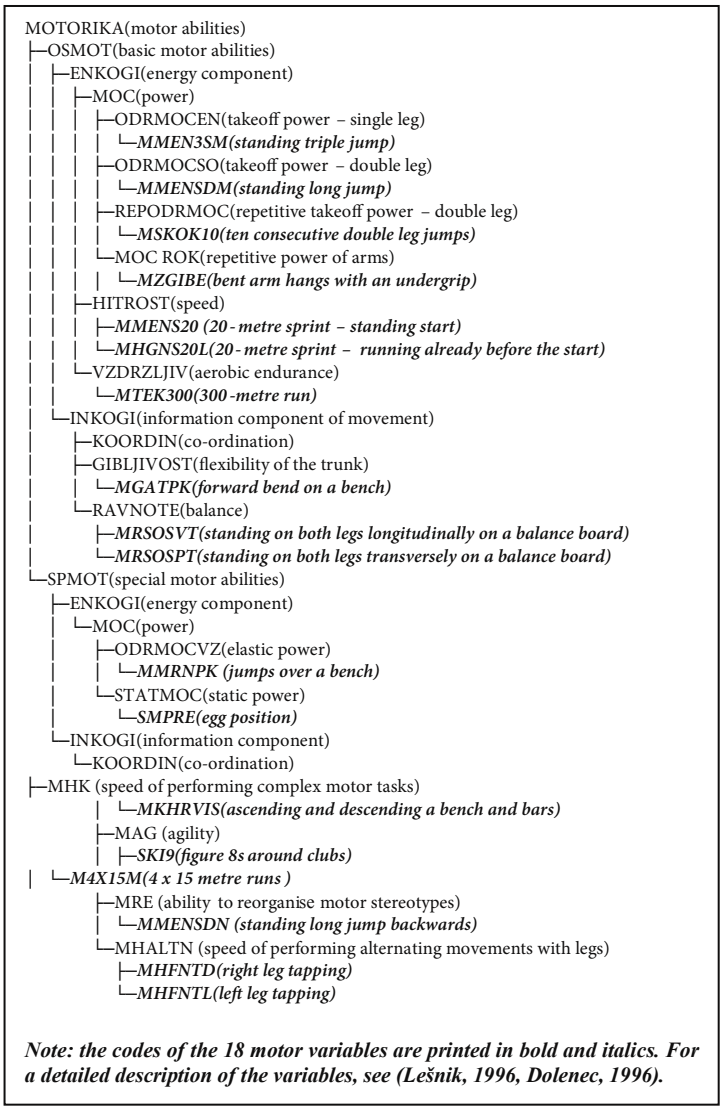
Note: the codes of the 8 anthropometric variables are printed in bold and italics. For a detai led description of the variables, see (Lešnik, 1996, Dolenec, 1996).

Figure 1: Reduced model of anthropometric characteristics for categories of younger competitors in Alpine skiing

One's body constitution is very important for top athletes as well as younger competitors to achieve good results in competitions. Although the latter holds true of adults, this is particularly noticeable in children's competitions where more corpulent competitors can achieve greater speeds. Since the body weight variable is closely connected to all dimensions of the morphological and anthropometric status of competitors, it is treated separately in the model of success (Figure1). Within the model of anthropometric dimensions, the highest level consists of external geometric characteristics (EKSGEOR), internal geometric characteristics (INTGEOR) and body weight (AT), which is classified at this level as an independent variable. Competitive Alpine skiing, in particular, is a sports discipline which involves the motor activity of the whole body. A competitor should master the mass of the body and the additional load of the skiing equipment to the greatest possible extent. Skiing therefore involves mastery of one's own body and body weight, which is also why we believe that in comparison with all other variables the body weight variable is the most important for success. Within the framework of external geometric dimensions of the body (EKSGEOR), we have focussed on the longitudinal (DOLRAZ) and

transverse (PRAZSO) dimensions and circumferences of the lower extremities (OBSNOG) due to the specific characteristics of skiing as a competitive sports discipline. All the mentioned dimensions can play a decisive role in bearing the loads in the age period of categories of younger skiers, which may determine an individual's (un)successfulness in competitions.

In the model discussed, the internal geometric dimensions of the body (INTGEOR) are encompassed in the form of skin folds of the body. Consequently, when studying the categories of younger skiers we were interested in studying the skin folds of the trunk (AKGT) and lower extremities (AKGNOG and AKGSL). The variables treated are an indicator of the ratio of the fatty tissue on the trunk and legs.



Note: the codes of the 18 motor variables are printed in bold and italics. For a detailed description of the variables, see (Lešnik, 1996, Dolenec, 1996).

Figure 2: Reduced model of motor abilities for categories of younger competitors in Alpine skiing

The basic and special motor dimensions of the reduced model of motor abilities (Figure 2) enable an insight into the state of primary special potential dimensions which may represent the key element in top sport which is a precondition for successfulness in Alpine skiing (Klika & Malina, 1997: Lešnik, 1996; Raschner et al., 2005).

In a potential model of the successfulness of motor dimensions, the nodes of the basic motor abilities (OSMOT) and special motor abilities (SPMOT) are at the highest level. Both are hierarchically divided into the ability to regulate energy (ENKOGI – the energy component of movement) and the ability to regulate movement (INKOGI – the information component of movement). In terms of the manifestation of power in Alpine skiing, the basis is represented by the single leg takeoff power (ODRMOCEN), double leg takeoff power (ODRMOCSO) and the repetitive power of the legs and arms (REPODRMOC and MOCROK). This is why we decided to define the extensive and well-researched area of power on the basis of four basic motor variables of the abovementioned types of power (MMEN3SM, MMENSDM, MSKOK10 and MZGIBE). Speed (HITROST) appears as the second node of the energy component of movement and is defined with the variables MMENS20 and MHGNS20L in the model. Endurance (VZDRŽLJIV) represents the last node of the energy component of movement (ENKOGI) of the basic motor dimensions and is used to measure the ability of a long-lasting performance of movement without a reduction in movement effectiveness. The test (MTEK300) is a physiological approximation of the duration of the activity on the course for the age group treated. In basic motor dimensions, the ability to regulate movement (INKOGI – the information component of movement) is closely connected to the functioning of centres in the central nervous system whose function is the formation, performance and control of motor actions. Areas that exert an important influence on successfulness in Alpine skiing are: co-ordination (KOORDIN), flexibility (GIBLJIVOST) and balance (RAVNOTE). These basic motor abilities were measured with the help of three variables (MGATPK, MRSOSVT and MRSOSPT). The group of special motor abilities (SPMOT) occupies the same level as the basic motor dimensions (OSMOT). This group of abilities comprises the ways of movement that resemble movements in Alpine skiing from the point of view of the structure of movement and how demanding the movement is. Within the framework of special motor functions, the energy component of movement (ENKOGI) is defined only by two forms of power (MOC) which also represent two leaves on the penultimate level of our model. This is the form of endurance in takeoff power (ODRMOCVZ) which was defined by variable jumps over a bench (MMRNPK) and static power (STATMOC) which was measured with the help of the egg position test (SMPRE). In special motor abilities, only the area of co-ordination (KOORDIN) was classified under the mechanism for the regulation of movement (INKOGI). The ability to perform elements in skiing that are demanding in terms of co-ordination is not important because of easier learning – the ability to perform complex motor tasks is an essential dimension that enables competitors to develop a refined feeling for the technique of skiing around the gates. The speed of performing complex motor tasks (MHK) was measured with the variable MKHRVIS, agility (MAG) with the variable SKI9, the ability to reorganise motor stereotypes (MRE) was measured with the variable MMENSDN and the speed of a co-ordinated performance of alternating movements with the leg was measured with the MHFNTD and MHFNTL tests.

The sample of variables comprises the dimensions used in practice for checking the motor and anthropometric status of competitors. In the past few years, the battery of variables used in a particular period to measure the most important dimensions of young competitors' success has been adapted to changes in the technique of performing competitive turns in different disciplines

of Alpine skiing (Supej, 2008). Already in the past, we strove to include sets of dimensions which importantly influence the achievement of good results from the energy as well as information aspects when studying different categories of subjects.

The basis for establishing an athlete's success is the results achieved in competitions. In Alpine skiing as well as in other sports disciplines, the results in competitions are the best criterion for the quality of the training process in the transition, preparatory and competitive periods. The model of competitive success (Figure 3) ranks each individual competitor according to a predetermined system of points at competitions (disciplines: giant slalom - GS, slalom - SL, super giant slalom - SG and downhill - DH) within the competitive category.

COMPETITIVE SUCCESS (POINTS)
- **INTERNATIONAL COMPETITIONS**
- **DOMESTIC COMPETITIONS**
  - **3RD DEGREE COMPETITIONS** (Argeta Cup; 16 competitions; 6xGS, 6xSL, 4xSG, 0xDH)
  - **2ND DEGREE COMPETITIONS** (regional competitions)
  - **1ST DEGREE COMPETITIONS** (interclub competitions)

Figure 3: Reduced model of competitive success for categories of younger competitors in Alpine skiing

The basic aim of this study is to evaluate the potential and competitive success of young skiers. At the same time, we wish to find a level of connection between the anthropometric as well as motor variables and the competitive success of young competitors. The findings could help us form a basis for selecting success predictors so as to enable a smaller and more rational structure of the model of dimensions to establish the positive and negative effects of training.

MATERIALS AND METHODS

In the past few years, measurements of anthropometric and motor dimensions of categories of younger competitors in Alpine skiing have been carried out twice a year at the Faculty of Sport (University of Ljubljana). The testing carried out in spring shows the state of motor abilities and anthropometric dimensions after the end of the skiing season (the beginning of the transition period), whereas the testing performed in autumn represents the starting point for fitness before the start of the competitive period.

The research included 30 competitors in the category of older boys who took part in the Argeta Cup competitions in the 2009/10 season. In the measurements performed in autumn (7 November, 2009), they had to fulfil the following requirements: that they were born between 1995 and 1996, were registered as competitors in Slovenian skiing clubs and had actively taken part in the regular training process in the previous year, and had no physical injuries or other complaints.

Taking the basic goal of our study into consideration, we intended to check the validity of the established model of success. For this reason, we had to determine the criterion which is (based on the calculation of points scored) represented by the subjects' actual success in the Argeta Cup competitions.

The criterion variable is represented by a total sum of points scored in competitions within the Argeta Cup in the 2009/10 season (Table 1). We tried to increase the objectivity of the results by

determining the criterion variable (actual competitive success) on the basis of the system of points of the Ski Association of Slovenia (SAS) for the 2009/10 season. There were 16 competitions for young categories in that season: 6 x GS, 6 x SL and 4 x SG. The points for Argeta Cup competition wins only classified racers from first to 24th place. According to the SAS rules, for taking first place a competitor receives 150 points, for second place 135 points, for third place 120, for fourth 108, for fifth 96 points etc. On the basis of the obtained values (sum of achieved points), the competitors were ranked from best to worst (SAS, 2010).

Table 1: Classification of the sample of test subjects based on the total points scored in the Argeta Cup competitions (criterion variable)

Rank	Com	POINTS
1.	O	1185
2.	Z	1035
3.	AA	999
4.	AC	720
5.	E	562
6.	R	546
7.	P	514
8.	AE	488
9.	AB	477
10.	L	461
11.	AH	446
12.	G	442
13.	F	343
14.	J	337
15.	AD	316
16.	V	311
17.	AF	245
18.	C	236
19.	K	220
20.	S	215
21.	AI	208
22.	B	146
23.	I	139
24.	H	99
25.	A	98
26.	M	77
27.	D	55
28.	N	12
29.	AG	10
30.	U	4

Legend: Rank – competitor's rank; Com – competitor; POINTS – Total points scored (criterion variable)

Statistical data processing was carried out by SPSS and based on the calculation of the basic statistical parameters (mean, standard deviation, lowest result and highest result) for the 8 variables of anthropometry and 18 motor functions. The codes and names of the variables are printed in bold and italics in Figures 1 and 2. Regarding the goals set, the next step was to employ Pearson's correlation coefficient (r) to determine the correlations between the results of individual tests and the points scored in the Argeta Cup competitions. Because of the relatively small number of subjects (30 competitors), we also accounted for the possibility of the non-linearity of the calculated connections.

In the second part of the study, the batteries of anthropometric and motor variables were further reduced on the basis of the obtained results. With the help of multiple regression analysis (R), the connection between only the statistically significant connections of the space of anthropometry and the statistically significant connections of the space of motor functions and competitive success was calculated (partial coefficients of correlation, beta stand. coefficients, coefficient of multiple correlation, the share of explained variance and statistical significance of multiple correlation).

RESULTS

Table 2: Basic statistics and (multiple) connections between the selected variables of anthropometry in a statistically significant relationship with the competitive success

ANT.VAR.	N	M	SD	Min	Max	r	r part	beta	R	R Sq	R(Sig)
1. AT	30	54.39	10.141	35.00	81.50	***0.465****	0.497	1.325			
2. AV	30	163.31	5.853	147.00	175.00	***0.572****	-0.115	-0.17			
3. ADN	30	95.45	4.682	86.00	104.00	***0.552****	0.253	0.277			
4. APKOLL	30	8.98	.294	8.40	9.60	0.041	-0.502	-0.452	**0.801***	**0.642**	**0.032***
5. APSSL	30	6.94	.498	6.10	7.90	0.35	0.345	0.262			
6. AOSL	30	47.34	4.234	39.10	57.00	***0.383****	-0.249	-0.417			
7. AKGT	30	12.74	7.799	4.10	34.20	-0.04	-0.202	-0.321			
8. AKGS	30	16.88	6.632	8.40	33.10	-0.016	-0.144	-0.198			

Legend: ANT.VAR.-anthropometric variables, M-mean of results, SD-standard deviation, Min-the lowest result, Max-the highest result, r-Pearson's coefficient of the correlation between variables and the criterion variable, r part-partial coefficients of the correlation between anthropometric variables and the criterion variable, beta-stand.beta coefficients, R-coefficient of the multiple correlation between selected predictors of the space of anthropometric variables (AV, AOSL, ADN and AT) and the criterion variable, R Sq-the share of explained variance; R (Sig)-statistical significance of the multiple correlation, **-correlation is significant at the 0.01 level (2-tailed); *-correlation is significant at the 0.05 level (2-tailed)

Table 2 shows that half of the eight chosen variables of anthropometry are connected with the young competitors' success in Alpine skiing in a statistically significant way. Interestingly, the highest calculated value of Pearson's correlation coefficient between the variables of anthropometry and the criterion variable was established in the variable body height (AV) amounting to r=0.572**. Besides this variable, the length of the leg (ADN; r=0.552**), body weight (AT; r=0.465**) and the circumference of the thigh (AOSL; r= 0.383*) are connected with the criterion variable in a statistically significant way.

In contrast, our study showed no statistically significant relationship between the transverse body dimensions (APPKOLL; r=0.041, APSSL; r=0.35) and the points achieved in the Argeta Cup as well as no statistically significant relationship between the internal geometric dimensions of the body (AKGS; r=-0.016, AKGT; r=-0.04) and the points achieved in the Argeta Cup. The better competitors did not have high values of the diameter of the knee and ankle (APPKOLL and APSSL), which may be conditioned by the contents of training.

Table 3: Basic statistics and (multiple) connections between the selected variables of motor functions in a statistically significant relationship with the competitive success

MOT.VAR.	N	M	SD	Min	Max	r	r part	beta	R	R Sq	R (Sig)
1. MMEN3SM	30	613.80	61.317	528.00	753.00	***0.553*****	0.336	0.993			
2. MMENSDM	30	212.13	21.820	170.00	250.00	***0.486*****	0.208	0.494			
3. MSKOK10	30	20.72	2.340	16.70	25.32	***0.496*****	0.133	0.441			
4. MZGIBE	30	6.93	3.936	.00	15.00	***0.399****	0.215	0.39			
5. MMENS20	30	3.63	.251	3.16	4.11	***-0.384****	-0.331	-0.418			
6. MHGNS20L	30	2.93	.243	2.51	3.49	***-0.427****	0.02	0.019			
7. MT300	30	52.02	5.329	43.72	64.60	***-0.495*****	0.472	0.668			
8. MGATPK	30	48.60	5.275	36.00	56.00	0.18	0.06	0.08			
9. MRSOSVT	30	3.03	1.110	1.75	7.41	0.251	-0.109	-0.136	**0.806***	**0.650**	**0.046***
10. MRSOSPT	30	3.14	1.205	1.65	7.31	0.047	-0.062	-0.074			
11. MMRNPK	30	50.16	6.813	28.00	59.00	***0.411****	-0.264	-0.324			
12. SMPRE	30	120.96	61.062	38.00	300.00	0.021	-0.146	-0.171			
13. MKHRVIS	30	14.73	2.875	10.10	23.90	-0.233	-0.282	-0.425			
14. SKI9	30	31.55	1.631	28.20	33.90	***-0.582*****	0.269	0.316			
15. M4X15M	30	13.79	.776	12.53	15.37	***-0.483*****	0.421	0.461			
16. MMENSDN	30	119.00	19.755	74.00	160.00	***0.404****	-0.102	-0.126			
17. MHFNTD	30	23.20	1.788	20.00	27.00	***0.442****	0.07	0.212			
18. MHFNTL	30	22.00	1.597	20.00	25.00	***0.460****	0.359	1.036			

Legend: MOT.VAR.-motor variables, M-mean of results, SD-standard deviation, Min-the lowest result, Max-the highest result, r-Pearson's coefficient of the correlation between variables and the criterion variable, r part-partial coefficients of the correlation between motor variables and the criterion variable, beta-stand.beta coefficients, R-coefficient of the multiple correlation between selected predictors of the space of motor functions (SKI9, MMEN3SM, MSKOK10, MT300, MMENSDM, M4x15M, MHFNTL, MHFNTD, MMENSDN, MHGNS20L, MMRNPK, MZGIBE, MMENS20) and the criterion variable, R Sq-the share of explained variance; R (Sig)-statistical significance of the multiple correlation, **-correlation is significant at the 0.01 level (2-tailed); *-correlation is significant at the 0.05 level (2-tailed)

Table 3 shows that 13 of the dimensions of the basic and special motor functions have a statistically significant correlation with success. Especially strong connections can be observed in the variables that are indicators of special co-ordination and agility (SKI9; r= -0.582**, M4x15M; r= - 0.483**) and takeoff power - single and double leg (MMEN3SM; r= 0.553**, MSKOK10; r=0.496**, MMENSDM; r=0.486**) and speed endurance (MT300; r= -0.495**).

Among the basic motor abilities that belong to the energy component of movement, the variable of speed endurance (MT300; r=-0.495**) has a strong and statistically significant connection

with the criterion. A slightly lower but still statistically significant connection with the criterion variable is also shown in the ability to develop maximum leg speed (MMENS20; r=-0.384*, MHGNS20L; r=-0.427*), jumps over a bench (MMRNPK; r=0.411*) and the arm power test (MZGIBE; r=0.399*).

Among the variables used to measure the speed of a co-ordinated performance of alternating movements with the right and left legs (MHFNTD; r=0.442*, MHFNTL; r=0.460*), the speed of changing the direction of movement (M4x15M; r=-0.483**) has a statistically significant relationship with the criterion variable. It is especially interesting that the variable balance is has a low connection with the criterion (MRSOSPT; r=0.047, MRSOSVT; r=0.251).

The variables with which the forms of power are measured were only partially connected with the criterion. The test jumps over a bench (MMRNPK; r=0.411*) is quite strongly connected with the criterion, while the connection between the static power test and the criterion variable is low and statistically insignificant (SMPRE; r=0.021). Like in the balance tests (MRSOSPT and MRSOSVT), the reasons for this are also linked to the very high range of the measured results in this case. The greatest connection with the criterion was shown by the agility test (SKI9; r=-0.582**), with which the important ability to quickly change the direction of movement along the path determined in advance was once again confirmed. The variable used to measure co-ordination (MHK) is not connected to the criterion in a statistically significant way (MKHRVIS; r=-0.233). A high level of connection with the success was also shown in the test standing long jump backwards (MMENSDN; r=0.404*).

Regarding the results, the success of young competitors in the category of older boys in Alpine skiing was conditioned by a higher level of basic motor dimensions that belong to the energy component of movement as well as a high degree of the development of special motor abilities that belong to the information component of movement. The results confirm our assumptions, although it should be noted that out of the total number of 18 motor variables five of them were not statistically significantly connected with the success of the selected sample of competitors.

In the second part of the study, we proved the connection between the four statistically significant connections of the space of anthropometry (AV, AOSL, ADN and AT) and the competitive success as well as the connection between 13 statistically significant connections of the space of motor functions (SKI9, MMEN3SM, MSKOK10, MT300, MMENSDM, M4x15M, MHFNTL, MHFNTD, MMENSDN, MHGNS20L, MMRNPK, MZGIBE, MMENS20) and the competitive success. Tables 2 and 3 present the connection between the selected variables of anthropometry and motor functions that have a statistically significant relationship and the competitive success.

Based on the results of a multiple regression analysis of the connection between the criterion variable (POINTS) and anthropometry (ANT.VAR.) and motor functions (MOT.VAR.), a statistically significant connection with the competitive success was confirmed in both cases. The coefficient (R) of the multiple regression analysis between the dimensions of anthropometry (ANT.VAR.) and the criterion (POINTS) amounts to R=0.801*, and the level of connection is statistically significant (Sig.=0.032*). Four anthropometric variables that have a statistically significant relationship with the competitive success explain RSquare = 64.2% of the criterion variance. The coefficient (R) of the multiple regression analysis between the dimensions of the motor functions (MOT.VAR.) and the criterion (POINTS) is even higher than with anthropometry and amounts to R=0.806*, whereas the degree of connection is statistically significant (Sig.=0.046*). Thirteen

variables of the motor function that have a statistically significant relationship with the competitive success explain as much as RSquare = 65% of the entire criterion variance.

DISCUSSION AND CONCLUSIONS

In modern times the possibilities of achieving top results can only be increased by the expert and scientifically supported work of coaches and others who take part in the training process. In planning and conducting the training process, it is important to take account of the greatest possible number of those dimensions which exert a decisive influence on competitive success (Le Master, 2009). Taking the physiological, biological and sociological factors of the development of the age category treated into consideration, the proven levels of connection of individual dimensions of the model of success provide important guidance when planning and conducting the transformation process of 13 to 14-year-old competitors.

In accordance with changes in the competitive technique, equipment and other factors, changes can also be observed in the methods of establishing how prepared young athletes are (Bloom,1985; Patterson, Raschner, Platzer, & Lembert, 2009). Constant improvements in the competitive techniques of Alpine skiing can best be ensured with the use of alternative forms of movement training as the most suitable motor approximation of the modern techniques used by top Alpine skiers (Roman, Miranda, Martinez, & Jesus, 2009). Apart from the large number of factors that influence success in Alpine skiing, it is impossible to take into consideration all the dimensions important to success when studying success. We therefore must pay attention to those variables which in practice as well as according to the results of research studies provide the greatest number of answers to the question of how prepared the organism is for the exertion experienced in Alpine skiing competitions (Le Master, 2009).

The results of this study enable the training process to be regulated with the aim of influencing the development of those abilities that are crucial for achieving top sports results. The method that enables an insight into the psychosomatic status of an individual competitor is based on a training process oriented to an individual, with the aim being to foster a positive young personality who develops in accordance with the rules of biopsychosocial development (Mueller, Benko, Raschner, & Schwameder, 2000; Von Duvillard, 2005).

Among younger boys aged 13 to 14, the latter is largely marked by a phase of unharmonised musculoskeletal development (Thompson, Humbert, & Mirwald, 2003). The consequences of such development are primarily shown in a reduced ability to regulate movement (information component) and that the dimensions of the basic motor functions play an important role (muscle strength, co-ordination, specific speed and speed endurance). In our case, the motor function represents 65% of the entire criterion variance (Table 3) and our findings are confirmed by the results of many researches examining skiing and other sports (Auersperger, Ulaga, & Škof, 2009; Kapidžić, Ismaili, & Bečirović, 2010; Mujanović & Krsmanovič, 2008; Pustovrh, 1994; Stepinski, Zwierko, Florkiewicz, & Debicka, 2003).

They represent the widest necessary part of the motor information which constitutes the basis for progression to a top racer. By no means should we neglect the role of mental factors, among which the ability to concentrate, competitive motivation and the need for constant mutual competition (competitiveness) are particularly in the foreground for this age group of Alpine skiers. Success in

professional Alpine skiing is not related to individual physiological variables. Power and muscle strength continue to be crucial for the best World Cup skiers (Neumayr et al., 2003).

This study is a step forward in evaluating the competitive success of young skiers. At the same time, we have established a different connection between the anthropometric and motor variables of young competitors and their success in competitions. On the basis of these findings we can reduce the number of predictors, thereby enabling a more rational structure of the model of dimensions with which the positive and negative effects of the training process are established. The dilemma about using a greater or smaller battery of tests has been present for a long time when it comes to organising measurements for categories of younger competitors. On hand, there are reasons for the tendencies to check a smaller number of variables due to a lack of money; on the other, a gap which can have negative effects on competitors can be created in the realisation of training due to a smaller quantity of data or a lack of information in connection with the state of individuals. Of course, the results of this research on a relatively small sample cannot constitute a definitive selection or ensure the total elimination of some variables from the complete spectrum of variables in future models.

The use of the reduced model of success was based on scientific findings as well as practical experience. Experience shows that the constitution of children plays an important role in faster gliding on skies. The speed of gliding as a result of gravitation, the gradient of the terrain and the opposing forces (air resistance, friction etc.) in an appropriate posture and of other factors increase more greatly among heavier competitors (AV, AT, ADN...). The results of our sample of test subjects confirm that success in Alpine skiing depends on the longitudinal body dimensions (AV and ADN) as well as voluminosity (AT and AOSL). This means that the best results in the Argeta Cup competitions were achieved by the taller and heavier competitors. In contrast, excess body weight as a result of too great a quantity of subcutaneous fat (AKGT, AKGSL...) can exert a negative influence on mastery of one's own body in space, which is one of the basic preconditions of good skiing. However, in bearing skiing loads it should be emphasised that in a young organism the diameters of the joints (APKOLL, APSSL) and circumferences of the lower extremities (AOSL) which must be large primarily due to a good ratio between muscular mass and subcutaneous fat are very important. The variables treated are an indicator of the ratio of the fatty tissue on the trunk and legs. This is primarily important due to the ratio between the fat and muscle tissue of the legs which bear the greatest load in skiing. It is perfectly clear that those test subjects with greater circumferences of their lower extremities due to a greater quantity of muscular mass are more likely to achieve better results. Those competitors with a greater quantity of fatty tissue have fewer chances of achieving good results despite the great circumferences of their lower extremities. The better competitors also did not have high values of the diameter of the knee and ankle (APPKOLL and APSSL), which may be conditioned by the contents of training. In children's categories, these contents are linked to overcoming one's own body weight rather than using additional weights and exaggerated loads which can exert a negative influence on the organism. Since we are dealing with the category of older boys who are on the verge of a period of rapid growth, we can presume that the subcutaneous fat established by means of the skin fold values does not exert a greater influence on success in competitions.

Regarding motor abilities, the greatest possible spectrum of the base of motor information is very important from the point of view of practice. This spectrum is based on a suitable quantity of basic motor abilities which are regarding the structure of movement in skiing upgraded with special motor abilities. When forming the subsystem of motor dimensions, we tried to take the

classification of the primary motor abilities into consideration. They represent the basis for constructing the reduced model of motor variables taking account of the coefficient of innate abilities and regarding the question of whether they are of an information or energy type. Due to the nature of skiing motor functions, success in mastering the technique as well as bearing great loads depends on the ability to develop certain forms of power that represent the basis for this sports discipline. It was estimated that, from the point of view of manifestation of power in Alpine skiing, the basis is represented by the single leg (MMEN3SM) and double leg (MMENSDM, MSKOK10) takeoff power and repetitive (MMRNPK) and static power (SMPRE). In terms of speed, the frequency of leg movement (MMENS20, MMENS20L) is important (e.g. in the skating step immediately after the start). As regards endurance, the performance of the test was oriented to the approximate duration of load in a race (MTEK300). In the age group treated, the slightly longer course can represent a great endurance problem in competitive Alpine skiing; this can often be the main reason for not achieving optimum results. The strong connections between various forms of the energy component of movement with the actual success in competitions show that in the category of older boys those competitors with a more pronounced takeoff power of the legs, leg speed and speed (anaerobic) endurance were more successful in competitions. The information component (M4X15M, MMENSDN, MHFNTL, MHFNTD) is closely connected with the functioning of centres in the central nervous system whose function is the formation, performance and monitoring of the motor activities. One of the important nodes of co-ordination (MHK) in the model of success is represented by the ability for the kinetic solving of space problems and the quick performance of complicated motor tasks. In competitive Alpine skiing, this is reflected as an upgrade of motor stereotypes that are a basis for a better performance along atypical course settings and a better handling of the configuration of the terrain. It is especially interesting that the variable balance has a weak connection with the criterion (MRSOSPT; r=0.047, MRSOSVT; r=0.251). The balance is one of the key dimensions of the modern competitive skiing technique and the reason for the weak connection in our study may lie in the very high range of measured results of our test subjects. It means that in the future we have to find new ways of balance measurements for Alpine competitors. The values of the connections between the variables of motor functions and the actual success (the criterion variable) show the structure of the most pronounced basic and special motor dimensions of competitors who achieved high positions in the total number of points in the Argeta Cup in the 2009/10 season. Regarding the results we obtained, we can say that the majority of connections between the motor dimensions and the criterion variable are statistically significant. This also implies that the variables used to determine the changes and the development of the motor potential of young competitors twice a year were well selected.

According to the coaches' experience and from the point of view of mastering the skiing technique and solving complex motor problems, the main abilities in Alpine skiing are balance and co-ordination. When skiing along technically more demanding courses, the ability to realise various rhythmic structures and the ability to reorganise motor stereotypes come to the fore. This involves the use of automated programmes of movement and their yield in performing (learning) new movements (motor transfer).

It is in the abovementioned dimensions of the motor model that the motor potential of young competitors is most strongly reflected. Coaches' considerations are therefore properly directed to improving those dimensions which enable a fast and effective solution to the motor problems along the course. Taking account of the developmental changes in the period after the age of 10

is vital in the organisation and conduct of the training process. The muscle growth which does not catch up with the accelerated growth of bones is reflected in unharmonised movement. The consequences of this are shown primarily in the decreased ability to regulate movement (information component) and an important role is played by the dimensions of basic motor functions. The latter represent the greatest necessary element of the motor abilities, especially in the age category treated, while the motor abilities represent the basis for progression to a top athlete. Apart from that, we should by no means neglect the role of psychological factors among which the ability to concentrate, competitive motivation and the need for a constant mutual comparison (competitiveness) are particularly relevant to Alpine skiers in this age group.

Nowadays, the possibilities of achieving top results can only be increased with the help of the expert and scientific work of coaches and others who take part in the training process. An optimum mix of theoretical and practical knowledge is a basis for the quality conducting of the training process. The use of the methods and means for monitoring the factors which exert the greatest influence on success is an integral part of planning and conducting the training process. Therefore, the choice of a suitable and effective battery of variables, which can help establish the progress of competitors, is particularly important. On one hand, this choice is the basic starting point for planning and conducting the training process and, on the other, it represents the basis for monitoring and controlling athletes' psychophysical state. In top sport, the results achieved in competitions are a reflection of how well the competitors are prepared and, at the same time, are a criterion of the quality of the entire training process. Regarding the results we obtained, the anthropometric and motor status of our sample could be established by using a lower number of variables without reducing the predictive value of the reduced model of success. It would be possible to save time and money if the measurements were to take place more frequently and within the framework of one measurement we could measure a greater number of competitors. In future, we will try to optimise the battery of tests for establishing the state of anthropometric and motor dimensions in young Alpine skiers with the aim of reducing the number of variables.

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