TAXONOMIC STRUCTURE OF ENTITIES IN THE TAKE-OFF POWER SPACE

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TAXONOMSKA STRUKTURA ENTITET V PROSTORU ODRIVNE MOČI

Abstract

A taxonomic analysis can provide an efficient toll to study a structure of motor abilities, as well. The aim of the present study was to employ taxonomic analysis to observe the latent dimensions that describe subjects as entities in a take-off power space. A sample of 118 proficient sportsmen from the Slovenia, participating in six different sports, was measured with 13 tests of take-off power and 14 anthropometrical measures. In the take-off power space, two taxonomic dimensions emerged: an ability to perform vertical jumps with a counter movement and an ability to perform multiple jumps, where the dominant factor appeared to be one-legged horizontal take-off. After the partialization of the influence of anthropometrical measures, the taxonomic dimension »horizontal multi-jumps« emerged clearer, while at the dimension »vertical jumps« one-legged jumps were more pronounced, pointing to a demand for a greater take-off power and good take-off technique. The obtained dimensions can be interpreted mainly as complex abilities for performing jumps of a certain type. On the other hand, the abilities at the lower level that are responsible for their execution could not be identified reliably.

Key words: motor abilities, jumping, taxonomic analysis

Izvleček

Strukturo motoričnih sposobnosti je mogoče proučevati tudi s pomočjo taksonomske analize. Namen te naloge je bil uporabiti taksonomsko analizo za opis latentnih dimenzij, ki opisujejo merjence v prostoru odrivne moči. Sodelovalo je 118 kategoriziranih športnikov Slovenije iz šestih športnih panog, ki so bili izmerjeni s 13 testi odrivne moči in 14 antropometrijskih mer. V prostoru odrivne moči sta bili identificirani dve taksonomski dimenziji: sposobnost izvajanja vertikalnih skokov z nasprotnim gibanjem ter sposobnost izvajanja mnogoskokov, kjer se je kot dominantni element pojavil enonožni horizontalni odriv. Po parcializaciji antropometrijskih mer se je taksonomska dimenzija horizontalnih mnogoskokov še dodatno utrdila, v strukturi druge taksonomske dimenzije pa so dobili večji poudarek enonožni vertikalni skoki, kar kaže na zahteve po večji odrivni moči in dobri tehniki odriva. Dimenzije je bilo mogoče interpretirati predvsem kot kompleksne sposobnosti izvajanja skokov določenga tipa. Sposobnosti nižjega ranga, ki so odgovorne za njihovo izvajanje, ni bilo mogoče zanesljivo identificirati.

Ključne besede: motorične sposobnosti, skoki, taksonomska analiza

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Introduction

As in many areas of human activity, more functional types of jumpers in take-off power space can be expected, as well. That is why the questions of how many jumpers' types and of which kind may be very actual.

According to the previous research works in a field of motor abilities (7), it was possible to conclude that taxonomic procedures may be equally applicable as factor or component analysis for a determination of a structure of motor abilities. There is an important distinction between two approaches. Factor analysis determines a structure of observed space as defined by measured variables. Since a subject always acts as a unity, it seems reasonable to treat him in that way. This does not include only the differences at a single motor test (a particular jump) but also and especially the differences that appear at all motor tests included into an analysis. According to a set of jumping tests, it would be possible to talk about jumper's types or dimensions that define them, respectively.

A take-off power is a manifest motor ability that in the area of action's defined motor abilities fits into a speed-power (9). According to a neuro-muscular function, the speed-power can be divided into two categories: a speed-power at concentric contraction and a speed-power at stretch-shortening cycle. Čoh (3) analyzed the structure of a take-off power space on selected population of sportsmen of different sports. He attained three factors which preserved their structure after a partialization of anthropometric variables, as well. Sprints formed a distinctive factor. More important were the other two factors: elastic power and explosive power. The structures of these two factors were not possible to connect with the findings of Buehrle and Schmidtbleicher (2) of two distinctive forms of the speed-power.

The basic goal in motor activities described in terms of the speed-power is equal in all occasions: explosiveness. For that reason, it seems that a term explosive power may not be used to describe a special ability, since the explosiveness of the motor actions is the main characteristic of all forms of the speed-power. A term elastic power may be even more disputable. Elasticity of muscles and tendons (muscle potentiation) is only one of the mechanisms to emerge at the stretch-shortening cycle. A neural potentiation must also be considered (1). For that reason, a term žreactive ability' has been adopted to describe this phenomenon.

The differences among subjects in the take-off power tests may originate from the anthropometrical characteristics of the subjects, as well. So, the second part of the paper will try to answer on a question about the influence of the anthropometrical characteristics on a formation of jumpers' types.

According to this, the subject matter of this paper was as a study of the take-off power and the problems to solve: (1) establishing a taxonomic structure of entities in a take-off power space and (2) establishing an influence of anthropometric variables on the taxonomic structure in the take-off power space.

Methods

Subjects. A sample of 118 proficient sportsmen from Slovenia volunteered in the study. They participated in the following sports: athletics, ski jumping, basketball, handball, volleyball, and football. The mean age was 22.3 years, range from 16 to 37 years, and the mean training participation was 7.6 years, range from 2 to 20 years. In time of measurements, all the subjects were healthy and without injuries.

Variables. The following test were employed to assess the take-off power: standing broad jump (SBJ2), one-legged standing broad jump (SBJ1), sargent jump (SARG2), one-legged sargent jump (SARG1), sargent jump from dropping height of 75 cm (SARG75), abalak jump without a help of hands (ABALNO), abalak jump with a help of hands (ABALHA), standing broad triple jump (TRIP), broad triple jump started from dropping height of 50 cm (TRIPDR), broad triple jump with 3 steps run (TRIP3), broad five jump with a single leg (FIVE), drop-broad jump (DRBR), and one-legged drop jump from 45 cm (DROP). A result in horizontal jumps was a distance, in vertical jumps the maximal height of the jump. Each jump was repeated three times. More detailed description of tests was provided by Čoh (3). The following tests were used to assess the anthropometrical characteristics: body height (BH), arm length (AL), leg length (LL), foot length (FL), shoulder width (SW), pelvis width (PW), ankle diameter (AD), knee diameter (KD), thigh circumference (TC), thigh circumference – vastus (TCV), calf circumference (CC), upper arm skinfold (AS), abdomen skinfold (BS), thigh skinfold (TS), and calf skinfold (CS). These measurements were performed in accordance with the international biological program (6).

Statistics. For all take-off variables (2nd repetition) and anthropometrical variables the basic statistical parameters were calculated. The results of single tests (three repetitions) were transformed into the parallel projections to the first principal component and used in further analysis. A taxonomic structure of the entities was established by the algorithm TAXON (11). A partialization of take-off variables with anthropometrical variables was performed with a multiple regression analysis. The partialized results of entities in single take-off variables were presented as the students' residuals. After the partialization, the second taxonomization was performed in the take-off power space.

Results

Table 1 presents the basic statistical parameters of the jumping tests. Results in all observed variables were normally distributed. The differences between the lowest and the highest results were big in all variables. The basic statistical parameters of the anthropometric variables are shown in Table 2. All results' distributions, except in BS, were normal. The distributions in the skinfold variables, except TS, were asymmetric in direction of higher values.

Table 1. Basic statistical parameters of jumping variables

Variable	XA	SD	SKE	ASSI	DIS	TEST
SBJ2	265,4	17,2	,003	,245	,07	,49
SBJ1	225,3	18,2	-,491	,058	,04	,95
SARG2	57,4	6,3	-,323	-,044	,05	,80
ABALNO	54,5	7,5	,073	,213	,07	,46
TRIP	769,8	57,7	-,333	-,259	,06	,65
TRIPDR	802,8	66,1	-,361	,037	,03	1,00
ABALHA	66,1	8,1	-,247	,048	,07	,51
SARG75	57,8	7,5	-,107	,009	,05	,90
DRBR	283,8	27,7	,142	-,007	,05	,88
SARG1	60,0	5,6	-,673	,124	,09	,28
TRIP3	946,4	80,1	,293	,114	,06	,73
FIVE	1308,2	98,6	-,446	-,069	,07	,51
DROP	57,3	5,8	,145	-,028	,06	,69

XA – means, SD – standard deviation, SKE – skewness, ASSI – asymmetry, DIS – maximal distance from theoretical distribution, TEST – Kolmogorov – Smirnov test, Variables – for variable names see Methods

Table 2. Basic statistical parameters of anthropometric variables

Variables	XA	SD	SKE	ASSI	DIS	TEST
AV	1822,9	77,3	-,613	,278	,06	,61
AT	761,9	83,1	-,097	,486	,10	,17
AL	794,4	39,7	-,265	,124	,05	,79
LL	1043,0	58,9	-,688	,065	,06	,73
FL	268,8	14,1	,828	,436	,04	,93
TC	563,9	27,1	-,344	,219	,10	,12
TCV	483,3	29,8	,041	,062	,08	,32
CL	384,4	18,5	-,413	-,120	,11	,07
SW	399,1	19,9	-,227	-,071	,06	,65
PW	275,3	16,0	,372	,309	,06	,74
AD	76,0	4,3	1,303	,688	,09	,25
KD	98,6	4,4	1,031	,718	,10	,14
AS	55,0	16,9	1,326	,990	,10	,13
BS	76,6	26,6	2,926	1,542	,15	,09
TS	95,7	28,8	-,401	,257	,08	,35
CS	68,1	27,0	4,858	1,768	,11	,08

XA – means, SD – standard deviation, SKE – skewness, ASSI - asymmetry, DIS – maximal distance from theoretical distribution, TEST – Kolmogorov – Smirnov test, Variables – for variable names see Methods

The analysis of correlation coefficients (Table 3) showed that the group of variables including TRIP, TRIPDR, TRIP3, and FIVE were those with the highest connections. It was possible to assume that the origin of their common variance might be found in a similar inter-muscular co-ordination. The differences in a neuro-muscular function (which mechanisms and to what extent, respectively), what would have the most relevance, were not possible to determine for this group of tests. The second group of connected variables, presenting the vertical jumps, displayed much lower correlation coefficients than the first group. A central position in this group belonged to SARG75, which had the highest connec-

Table 4. Uniqueness and commonalties of jumping variables

	UNI	COM
SBJ2	,184	,816
SBJ1	,388	,611
SARG2	,243	,757
ABALNO	,288	,712
TRIP	,126	,874
TRIPDR	,168	,832
ABALHA	,293	,707
SARG75	,209	,791
DRBR	,251	,749
SARG1	,394	,606
TRIP3	,190	,810
FIVE	,182	,818
DROP	,467	,533

UNI – uniqueness, COM – communality

Table 5A. Principal components of correlation matrix of jumping variables

PCOM	LAM	%
1	7,99	61,5
2	1,62	12,5
3	,71	5,5
4	,52	4,2
5	,46	3,6
6	,35	2,7
7	,30	2,4
8	,29	2,3
9	,21	1,7
10	,17	1,4
11	,15	1,2
12	,11	,9
13	,06	,5

PCOM – principal component, LAM – lambda value, % – relative share of variance of the system

Table 3. Correlation coefficient matrix of jumping variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 SBJ2	1,00												
2 SBJ1	,64	1,00											
3 SARG2	,75	,50	1,00										
4 ABALNO	,52	,28	,58	1,00									
5 TRIP	,85	,63	,69	,49	1,00								
6 TRIPDR	,77	,60	,56	,43	,90	1,00							
7 ABALHA	,61	,38	,59	,66	,49	,40	1,00						
8 SARG75	,75	,45	,80	,63	,71	,63	,62	1,00					
9 DRBR	,58	,63	,36	,20	,68	,71	,25	,43	1,00				
10 SARG1	,62	,60	,59	,33	,64	,64	,43	,60	,53	1,00			
11 TRIP3	,62	,58	,43	,19	,78	,80	,25	,47	,72	,57	1,00		
12 FIVE	,68	,69	,50	,36	,83	,81	,38	,55	,72	,58	,79	1,00	
13 DROP	,61	,54	,51	,38	,59	,57	,39	,57	,49	,69	,49	,57	1,00

Numbers in matrix presents a pearson correlation coefficient for pairs of variables. For variable names see Methods.

Table 5B. Correlation coefficients between jumping variables and principal components

	PC1	PC2
SBJ2	,89	,11
SBJ1	,74	-,23
SARG2	,77	,39
ABALNO	,57	,61
TRIP	,93	-,09
TRIPDR	,88	-,20
ABALHA	,61	,57
SARG75	,80	,37
DRBR	,73	-,45
SARG1	,77	-,04
TRIP3	,78	-,43
FIVE	,85	-,30
DROP	,73	-,00

PC1 – first principal component, PC2 – second principal component

tions with other variables from this group. The commonalties (Table 4) of motor variables were high to middle high. A high common variance of the take-off power space was very likely influenced by the fact that the subjects achieved more or less similar results in single tests (referring to the position in a distribution) or that the groups of better or worse subjects were relative stable, respectively.

Two principal components were extracted from the correlation matrix according to the lambda criterion (Table 5). The first principal component explained much as 61.5% of the whole common variance of included motor variables. According to the amount of the explained variance, it was possible to assume the first principal component as a general factor. The second principal component discriminated the variables. In general, the highest and positive projections to the second principal component displayed the variables presenting jumps with a counter movement. The variables presenting jumps with a very intensive stretch-shortening cycle had mainly negative projections.

Table 6 shows the parallel and orthogonal projections of the jumping variables to both taxonomic dimensions. The same projections, but after the partialization of the athropometrical variables, can be seen in the Table 7.

Discussion

The most important finding of the present study was that the set of analyzed jumping tests led to two well-defined taxonomic dimensions. The first taxonomic dimension was mostly determined by variables presenting the jumps with a counter movement. The variables (ABALNO, FIVE, TRIP3), in which the neuro-muscular mechanisms differed the most in any direction, had low and statistically non-significant projections. For that reason, it would be difficult to defend a thesis that the main characteristics to discriminate the subjects was the speed-power at concentric muscular contraction or jumping with a concentric muscle action, respectively (4). For this taxonomic dimension, the following mechanisms from the speed-power can be important: a capability to recruit as much as possible motor units in the shortest time, a capability to develop the highest possible firing rate of motor neurones, a good synchronization of motor units and muscles, bigger muscle transversal area, more fast motor units, etc., which are typical for a concentric contraction, but also the capability to include a myotatic reflex (neural potentiation), as well as elasticity of muscles and tendons (muscle potentiation), which are typical for the stretch-shortening cycle (8). So it seemed, that it would be possible to talk about a complex capability of jumping performance, which was close to performing jumps with counter movement.

Table 6. Complex and structure of taxonomic dimensions

	Complex		**Structure**	
	TAX1	**TAX2**	**TAX1**	**TAX2**
SBJ2	,69	,02	,70	,47
SBJ1	,71	,26	,88	,72
SARG2	,67	-,16	,57	,28
ABALNO	,35	-,07	,31	,16
TRIP	,64	,23	,79	,65
TRIPDR	,45	,47	,75	,76
ABALHA	,65	-,36	,41	,07
SARG75	,69	-,16	,59	,29
DRBR	,46	,40	,73	,71
SARG1	,78	,02	,79	,53
TRIP3	,13	,73	,61	,81
FIVE	,31	,65	,73	,85
DROP	,89	-,24	,73	,34

TAX1 – first taxonomic dimension, TAX2 – second taxonomic dimension

Table 7. Complex and structure of taxonomic dimensions after partialization

	Complex		**Structure**	
	TAX1	**TAX2**	**TAX1**	**TAX2**
SBJ2	,17	-,51	,57	-,64
SBJ1	-,12	-1,02	,68	-,92
SARG2	-,18	-,65	,33	-,51
ABALNO	,17	-,01	,18	-,15
TRIP	,68	-,22	,85	-,75
TRIPDR	,81	-,04	,84	-,68
ABALHA	-,43	-,70	,12	-,36
SARG75	,10	-,39	,40	-,47
DRBR	,70	-,14	,81	-,69
SARG1	-,13	-,82	,52	-,72
TRIP3	,79	-,12	,88	-,74
FIVE	,80	-,11	,88	-,74
DROP	,07	-,59	,53	-,64

TAX1 – first taxonomic dimension, TAX2 – second taxonomic dimension

The second taxonomic dimension was mostly defined with the horizontal multijumps with a preceding run (substantial horizontal speed at the beginning of jumping). The first common feature that discriminated the subjects could be a jumping technique. The second ones could be the differences in performing the stretch-shortening cycle. Next to the intra-muscular co-ordination, it should be mentioned that the horizontal jumps differ from vertical ones in an involvement of the muscle groups, as well. This means, that a topologic factors must also be encountered. The second taxonomic dimension can be defined as a complex capability responsible for a variability in the horizontal jumps.

The first taxonomic dimension after the partialization of the anthropometrical variables (Table 7) was defined clearer as before. Its comparison with the factor of elastic strength (3) showed that the first taxonomic dimension differentiated the variables of take-off power more than the factor of elastic power. However, there were also much similarities between both. From a contents, it would be possible to characterize the first taxonomic dimension as a consolidation of a motor model to perform the horizontal multijumps. In any case, it was a fact that the multijumps, as a quite uniform motor structure, discriminated the subjects the most. It was possible to assume that this was a result of a specific training where in certain sports the multijumps presented one of the basic tools of preparation while in others were rarely present. After the partialization of the anthropometric variables this became even more obvious.

The second taxonomic dimension after the partialization did not correspond well to the first one before the partialization. However, even if the parallel projections were much different it was possible to conclude on similar mechanisms. A contents of the second taxonomic dimension could be defined as a capability to perform vertical jumps with an emphasis on a one-legged take-off. Although at the jumps, which results had the highest projections on that dimension, the concentric speed-power was considered as the main component, it had to be recognized, especially in a line with our experiences of measuring jumps with a force plate, that a basic movement pattern at that jumps included the stretch-shortening cycle.

It was also possible to recognize a significant homogenization of the variables which defined the first taxonomic dimension after the partialization. That was not observed to the same extent at the second taxonomic dimension. Nevertheless, it was possible to observe that both taxonomic dimensions discriminated employed variables much more after the partialization.

The results of the taxonomic analysis showed obviously that the existence of two taxonomic dimensions in a take-off power space was real. The parallel projections of the variables on both taxonomic dimensions formed a simple solution. Even so, it was difficult to define what was a unique variance of each dimension and what was a substance that connected or discriminated them, respectively.

The obtained taxonomic dimensions proved that the subjects, when observed for their jumping performance, should be analyzed in the terms of one-legged multijumps and vertical jumps separately. A take-off action in each of the observed jumps could be performed concentrically as well as a stretch-shortening cycle. Although there was not possible to assign directly any of the jumps to any of both neuromuscular actions, our experiences with measurements with force plate strongly suggested that no jump was performed purely concentrically.

A sportsmen specialization should also be taken into account. The specialization showed itself through the results obtained in the jumps which were close to those at competition. For that reason, the relations among obtained results in single jumps were under this influence. A group of the track and field athletes dominated in the horizontal multijumps while the volleyball players dominated in the vertical jumps.

The obtained results could also be observed through the optics of one- or two-legged jumps (5, 10). A bilateral deficit can be influenced by training. In the sportsmen experiencing more two-legged jumps (as in volleyball) this deficit is lower. That the uni-laterality had an important role (at least in this sample of subjects) showed the variables with the highest projections on both taxonomic dimensions simultaneously, which presented one-legged jumps. Inside the observed sample of the subjects, these variables could have a dominant role in a discrimination of the subjects. A high correlation between both dimensions could testify this.

What about the application of these results? In the take-off power space, the subjects could be differentiated according to two criteria. The first one was an ability to perform the horizontal multijumps and the second one an ability to perform the vertical jumps. A good results in one criteria did not exclude automatically a good result in another criteria. It can be said: nothing especially new, we already knew this without any arithmetic. And there is a lot of truth in this. So it seems that some other conclusions, which follow from the above, need to gain more attention for its consequences: how to tackle an experiment of such kind and a problem of relationship between the employed methods and obtained results or/and conclusions. As much as we approach to the elementary motor abilities, lesser is possibility for further explanation of a human function with complex results obtained with motor tests. The main problem in this is a control of the experimental conditions (control of movement conditions) and observing additional independent variables which are not included into complex results of the motor tests. A further step in this direction is to observe the biomechanical, physiological and neurological quantities that characterize the movement.

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