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INFLUENCE OF THE SELECTION OF MOTOR TEST SAMPLES ON THE PARSIMONY OF MOTOR SPACE

VPLIV IZBIRE VZORCEV MOTORIČNIH TESTOV NA PARSIMONIČNOST MOTORIČNEGA PROSTORA

Abstract

The present study assesses characteristics of the selection of motor test samples from the viewpoint of parsimony of motor space. The obtained results point to the need to respect elementary principles when defining the structures in an analysed sample of variables. Namely, a) every hypothetical factor should be evaluated by at least three motor tests with good metric characteristics and b) every hypothetical research model should be balanced, meaning that every factor should be evaluated by the same number of motor variables. Considering these principles, the relevant characteristics of the primary factor, as well as the highest order of a certain hierarchical factor model, can be obtained.

Key words: motor test, hypothetical factor model, parsimony

Izvleček

Pričujoča študija ugotavlja značilnosti izbiranja vzorcev motoričnih testov z vidika parsimoničnosti motoričnega prostora. Rezultati raziskave so pokazali, da je potrebno pri definiranju struktur analiziranih vzorcev spremenljivk upoštevati osnovna načela. Velja izpostaviti dve načeli: a) vsak hipotetični dejavnik mora biti preverjen z vsaj tremi motoričnimi testi z dobrimi merskimi značilnostmi in b) vsak hipotetični raziskovalni model mora biti uravnotežen, kar pomeni, da se vsak dejavnik preverja z enakim številom motoričnih spremenljivk. Z upoštevanjem teh načel lahko ugotovimo relevantne značilnosti primarnih faktorjev in faktorjev višjega reda izbranega hierarhičnega faktorskega modela.

Ključne besede: motorični test, hipotetični faktorski model, parsimoničnost

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INTRODUCTION

Amongst true kinesiologically-/methodologically-oriented researchers it is well-known and common that kinesiological research requires at least 3-5 variables for determining the factor structure of anthropological characteristics and abilities in order to gain a parsimonial solution of isolated latent variables (factors, dimensions) (e.g., Kurelić, Momirović, Stojanović, Šturm, Radojević, & Viskić-Štalec, 1975). Meanwhile, in practice, especially at the level of master's theses and doctoral dissertations, as well some research works produced by insufficiently experienced students, researchers or mentors, one finds cases where this methodological demand is neglected.

The selection of a sample of motor tests necessary demands an explicitly defined hypothetical model of motor abilities that is to be researched or confirmed. When defining a hypothetical model created on the basis of results of previous research works or based on practical experience, one needs to make it operative and express it at the manifest level, i.e. define the proper sub-sample of motor tests for each latent motor dimension (factor) and eventually form a sub-sample of all motor tests to be applied in the relevant kinesiological research (Gredelj, Metikoš, Hošek, & Momirović, 1975). With such a qualitative selection of motor tests it is not irrelevant how this problem will be resolved quantitatively, i.e. how many motor tests each sub-sample should comprise, that is how many measurement instruments should be used for the total sample.

The aim of this paper is to analyse the structures of motor factors, i.e. the parsimony of analysed motor space, based on a sample of motor tests selected in such a way that one, two or three relevant motor variables are used to define a single hypothetical motor factor. The motor factors will not be interpreted in detail because this paper is essentially methodological and has the purpose to illustrate theoretical demands concerning the number of motor tests and to determine the factor structure of motor space.

METHOD

Participants

The sample of subjects consisted of 260 first- and second-year male students of the Faculty of Physical Education in Novi Sad (Serbia) who were 18-22 years of age and selected according to their biological, health, motor and psychological development.

Instruments

The sample of motor variables was obtained on the basis of the motor model according to Kurelić et al. (1975) and Gredelj et al., (1975):

1) *Mechanism for movement structuring*
   - I Functional co-ordination of primary motor abilities (C)
     - a) The test 'Agility on the floor' (CAGFLOOR)
     - b) The test 'Dragging and jumping over' (CDRAJUMP)
     - c) The test 'Co-ordination with stick' (CCOSTICK)
2) *Mechanism for tonus and synergetic regulation*
   - II Balance (B)
     - d) The test 'One foot cross balance – eyes open' (B1CROPEN)

e) The test 'One foot length-wise balance – eyes open' (B1LEOPEN)
f) The test 'Flamingo' (BFLAMING)

III Frequency of simple movements (FQ)
g) The test 'Two foot tapping' (FQ2FOOTT)
h) The test 'Plate-tapping' (FQTAPPIN)
i) The test 'One foot-tapping' (FQ1FOOTT)

IV Flexibility (FL)
j) The test 'Toe touching – sitting straddle' (FLTOESIT)
k) The test 'Toe touching – standing' (FLTOESTA)
l) The test 'Push off one leg – lying on the side' (FLPUSH1L)

3) *Mechanism for excitation intensity regulation*

V Explosive strength (E)
m) The test 'Standing broad jump' (ESTANJUM)
n) The test '20m dash' (E20MDASH)
o) The test 'Spring forward from front support on the floor' (EREFLOOR)

4) Mechanism for excitation duration regulation

VI General strength (S)
p) The test 'Bent arm hang' (SARMHANG)
r) The test 'Horizontal hold lying on the back' (SHORHOLD)
s) The test 'Sit-ups' (SSIT-UPS).

The coding of the motor tests was as follows: the first letter in the code name was according to a hypothetical motor factor while the others were according to the names of the tests. The reason for this was to make the interpretation of the analysed factors easier. This means that the first letter in the code name C was for co-ordination, B for balance, FQ for the frequency of simple movements, FL for flexibility, E for explosive strength and S for general strength.

Table 1: Reliability levels of the motor tests

test	α	test	α
a) CAGFLOOR	.92	j) FLTOESIT	.93
b) CDRAJUMP	.93	k) FLTOESTA	.94
c) CCOSTICK	.88	l) FLPUSH1L	.99
d) B1CROPEN	.76	m) ESTANJUM	.94
e) B1LEOPEN	.90	n) E20MDASH	.91
f) BFLAMING	.92	o) EREFLOOR	.95
g) FQ2FOOTT	.92	p) SARMHANG	.62
h) FQTAPPIN	.85	r) SHORHOLD	.97
i) FQ1FOOTT	.87	s) SSIT-UPS	.92

Legend: α – Cronbach's reliability coefficient

The conditions and techniques of measuring used in most of the tests were according to Metikoš, Prot, Hofman, Pintar and Oreb (1989); except the tests *flamingo* (Moravec, 1996), *push off one leg – lying on the side* and *spring forward from front support on the floor* (Madić, 1995, 2000). Every test was performed three times so that each of them was a composite test of three successive items.

The reliability of these tests was computed as Cronbach's α-coefficient (α). The reliability values are shown in Table 1.

It is obvious that all the motor tests have quite good reliabilities, except the tests *bent-arm hang* (SARMHANG) and *one foot cross balance – eyes open* (B1CROPEN).

The motor variables were assumed as the first principal component of the correlation matrix of every repetition result (three items) in the same composite test.

Procedure

The effect of applying different numbers of motor tests according to hypothetical factors can be seen in the final analysis of an explored motor space in a sample of subjects, in both quantitative and qualitative ways. This effect will be illustrated in the following cases:

1) the analysis of motor factor structures on a sample of motor tests which were selected so that one variable defines one hypothetical motor factor;
2) the analysis of motor factor structures on a sample of motor tests which were selected so that two variables define one hypothetical motor factor; and
3) the analysis of motor factor structures on a sample of motor tests which were selected so that three variables define one hypothetical motor factor.

In all three analyses, a promax transformation of the principal components of the corresponding correlation matrix of all variables was applied. The number of statistically significant principal components was obtained on the basis of the Guttman-Kaiser criterion.

RESULTS

a) One variable defines one hypothetical motor factor

The analysis of motor factor structures on the sample of these motor tests which were selected so that one variable defines one hypothetical motor factor gave the following results:

Functional co-ordination of primary motor abilities (C)

a) the test *co-ordination with stick* (CCOSTICK)

Balance (B)

b) The test *one foot length-wise balance – eyes open* (B1LEOPEN)

Frequency of simple movements (FQ)

c) The test *plate – tapping* (FQTAPPIN)

Flexibility (FL)

d) The test *toe touching – standing* (FLTOESTA)

Explosive strength (E)

e) The test *standing broad jump* (ESTANJUM)

General strength (S)

f) The test *sit-ups* (SSIT-UPS).

By applying the Kaiser-Guttman's criteria two factors were obtained which explained 46.21% of the common variance of the entire motor space, which consists of applied variables. After a promax rotation of the principal components and on the basis of the pattern and structure of two isolated factors, the following conclusions can be derived about the nature of the factors (the significance saturations are typed in bold) (see Table 2):

a) functional co-ordination of primary motor abilities which assumed the speedy use of trunk and leg muscles, and
b) factors which are saturated with variables for estimating balance, frequency of simple arm movements and flexibility, which pointed to the mechanism for tonus and synergetic regulation. Between these two motor factors there is a statistically significant correlation.

Table 2: Pattern and structure matrices of rotated factors and correlation coefficient of factors (one variable per factor)

Variable	Pattern		Structure	
	A1	A2	F1	F2
CCOSTICK	**-0.574**	-0.279	**-0.645**	-0.425
B1LEOPEN	-0.280	**0.828**	-0.070	**0.757**
FQTAPPIN	0.317	**0.484**	0.440	**0.564**
FLTOESTA	0.114	**0.560**	0.256	**0.589**
ESTANJUM	**0.569**	-0.059	**0.554**	0.085
SSIT-UPS	**0.765**	-0.109	**0.737**	0.086

r = 0.254

b) Two variables define one hypothetical motor factor

The analysis of motor factor structures on the sample of these motor tests which were selected so that two variables define one hypothetical motor factor produced the following results:

Functional co-ordination of primary motor abilities (C)

a) The test *co-ordination with stick* (CCOSTICK)
b) The test *dragging and jumping over* (CDRAJUMP)

Balance (B)

c) The test *one foot length-wise balance – eyes open* (B1LEOPEN)
d) The test *flamingo* (BFLAMING)

Frequency of simple movements (FQ)

e) The test *two foot tapping* (FQ2FOOTT)
f) The test *one foot – tapping* (FQ1FOOTT)

Flexibility (FL)

g) The test *toe touching – standing* (FLTOESTA)
h) The test *push off one leg – lying on the side* (FLPUSH1L)

Explosive strength (E)

i) The test *standing broad jump* (ESTANJUM)

j) The test spring forward from front support on the floor (EREFLOOR)

General strength (S)

k) The test *bent arm hang* (SARMHANG)

l) The test *sit-ups* (SSIT-UPS).

When the structure analysis of motor space was made according to the hypothetical model which was estimated with two motor variables per one hypothetical factor, four factors were isolated which explained 54.84% of the common variance of all 12 motor variables. With the same procedures as in the previous analysis, the interpretation of the structure for these motor factors was carried out (see Table 3):

Table 3: Pattern and structure matrices of rotated factors (two variables per factor)

Variable	*pattern*				*structure*			
	A1	A2	A3	A4	F1	F2	F3	F4
CCOSTICK	-0.257	**-0.606**	0.067	0.084	-0.449	**-0.671**	-0.206	0.107
CDRAJUMP	-0.325	-0.257	-0.203	0.078	-0.482	-0.434	-0.382	0.088
B1LEOPEN	-0.101	0.019	**0.852**	-0.094	0.177	0.265	**0.820**	-0.026
BFLAMING	-0.092	-0.001	**-0.723**	-0.227	-0.298	-0.272	**-0.768**	-0.271
FQ2FOOTT	**0.379**	0.352	0.054	-0.361	**0.544**	0.498	0.262	-0.386
FQ1FOOTT	**0.623**	-0.190	0.310	0.033	**0.651**	0.125	0.442	0.004
FLTOESTA	**0.767**	-0.032	-0.147	0.247	**0.691**	0.183	0.098	0.175
FLPUSH1L	**0.786**	-0.068	-0.087	0.010	**0.735**	0.171	0.135	-0.059
ESTANJUM	0.124	0.422	-0.146	**0.460**	0.186	0.418	0.064	**0.442**
EREFLOOR	0.102	0.029	0.116	**0.800**	0.084	0.106	0.213	**0.800**
SARMHANG	-0.192	**0.652**	0.260	0.141	0.100	**0.673**	0.426	0.178
SSIT-UPS	-0.194	**0.820**	-0.070	0.109	0.056	**0.732**	0.148	0.124

a) frequency of simple movements and flexibility,

b) general strength and functional co-ordination of primary motor abilities,

c) balance, and

d) explosive strength. The correlation matrix between these four factors shows there is a statistically significant correlation among the first, second and third factors, as well between the second and third factors (see Table 4).

Table 4: Correlation coefficient matrix of factors

Factor	*1*	*2*	*3*	*4*
1	1.000	**0.341**	**0.310**	-0.080
2	**0.341**	1.000	**0.330**	0.005
3	**0.310**	**0.330**	1.000	0.070
4	-0.080	0.005	0.070	1.000

c) Three variables define one hypothetical motor factor

The analysis of motor factor structures on the sample of motor tests which were selected so that three variables define one hypothetical motor factor showed the following results:

Functional co-ordination of primary motor abilities (C)

a) The test *agility on the floor* (CAGFLOOR)
b) The test *co-ordination with stick* (CCOSTICK)
c) The test *dragging and jumping over* (CDRAJUMP)

Balance (B)

d) The test *one foot cross balance – eyes open* (B1CROPEN)
e) The test *one foot length-wise balance – eyes open* (B1LEOPEN)
f) The test *flamingo* (BFLAMING)

Frequency of simple movements (FQ)

g) The test *two foot tapping* (FQ2FOOTT)
h) The test *plate – tapping* (FQTAPPIN)
i) The test *one foot – tapping* (FQ1FOOTT)

Flexibility (FL)

j) The test *toe touching – sitting straddle* (FLTOESIT)
k) The test *toe touching – standing* (FLTOESTA)
l) The test *push off one leg – lying on the side* (FLPUSH1L)

Explosive strength (E)

m) The test *standing broad jump* (ESTANJUM)
n) The test *20m dash* (E20MDASH)
o) The test *spring forward from front support on the* floor (EREFLOOR)

General strength (S)

p) The test *bent arm hang* (SARMHANG)
q) The test *horizontal hold laying on the back* (SHORHOLD)
r) The test *sit-ups* (SSIT-UPS).

This case showed the most acceptable solution for the size and balance of a variable sample according to the hypothetical model of motor abilities. Common variance in the motor space of 18 motor variables accounted for 57.87%. With the same transformation of principal components, i.e. in the promax position, the isolated factors can be defined in the following way (see Table 5):

a) frequency of simple movements,
b) flexibility,
c) general strength,
d) balance,
e) functional co-ordination of primary motor abilities (dual factor), and
f) explosive strength (dual factor).

Table 5: Pattern and structure matrices of rotated factors (three variables per factor)

Variable	*pattern*						*structure*					
	A1	A2	A3	A4	A5	A6	F1	F2	F3	F4	F5	F6
CAGFLOOR	-0.01	-0.07	0.09	-0.05	**0.78**	-0.01	-0.20	-0.14	-0.17	-0.16	**0.77**	-0.10
CCOSTICK	-0.47	-0.05	-0.09	-0.03	0.16	0.00	-0.55	-0.22	-0.26	-0.23	0.29	-0.11
CDRAJUMP	-0.14	-0.07	0.04	-0.01	**0.78**	-0.01	-0.32	-0.18	-0.23	-0.17	**0.80**	-0.13
B1CROPEN	0.42	-0.06	0.16	**0.40**	0.21	-0.04	0.50	0.12	0.29	**0.52**	0.03	0.04
B1LEOPEN	-0.04	-0.01	-0.16	**0.87**	-0.04	0.00	0.18	0.10	0.09	**0.82**	-0.12	0.04
RFLAMING	0.01	-0.04	-0.05	**-0.74**	0.06	-0.01	-0.25	-0.16	-0.28	**-0.77**	0.19	-0.09
FQ2FOOTT	**0.74**	-0.13	-0.06	-0.11	-0.18	0.07	**0.70**	0.09	0.13	0.10	-0.30	0.17
FQTAPPIN	**0.74**	-0.03	0.02	-0.03	-0.04	0.06	**0.74**	0.20	0.21	0.20	-0.21	0.17
FQ1FOOTT	**0.55**	0.15	-0.04	0.10	0.10	0.06	**0.61**	0.33	0.12	0.27	-0.04	0.14
FLTOESIT	-0.09	**0.88**	0.06	-0.03	-0.04	0.14	0.21	**0.88**	0.19	0.11	-0.13	0.25
FLTOESTA	-0.05	**0.86**	0.00	0.07	-0.11	-0.01	0.25	**0.86**	0.15	0.20	-0.19	0.11
FLPUSH1L	0.41	**0.55**	-0.02	-0.07	0.05	-0.23	0.51	**0.63**	0.08	0.10	-0.05	-0.12
ESTANJUM	-0.10	0.11	0.10	0.03	-0.06	**0.81**	0.10	0.21	0.25	0.11	-0.18	**0.84**
E20MDASH	-0.27	0.09	0.07	0.03	-0.05	**-0.77**	-0.32	-0.07	-0.08	-0.07	0.07	**-0.78**
EREFLOOR	-0.03	0.11	**0.48**	0.01	0.22	0.11	0.09	0.16	**0.44**	0.13	0.06	0.17
SARMHANG	-0.05	-0.09	**0.59**	0.26	-0.20	-0.04	0.18	0.02	**0.69**	0.42	-0.38	0.08
SHORHOLD	0.03	0.08	**0.79**	-0.11	0.19	0.00	0.17	0.16	**0.73**	0.10	-0.04	0.11
SSIT-UPS	0.04	-0.08	**0.67**	-0.15	-0.27	-0.05	0.18	0.01	**0.70**	0.07	-0.44	0.08

It may be concluded that with the change to the motor test sample so that three motor variables define every hypothetical factor almost the entire hypothetical motor model was confirmed. Certain discrepancies were probably the result of the specificity of the subject sample, but also of some motor tests with poor metrical characteristics (validity and reliability). That was certainly the case with variable *co-ordination with stick* (CCOSTICK), which was a better estimator for frequency of simple movements, and with *spring forward from front support on the floor* (EREFLOOR) which had better validity for general strength. The correlation matrix showed it contains a large number of statistically significant elements (see Table 6)

Table 6: Correlation coefficient matrix of factors

Factor	*1*	*2*	*3*	*4*	*5*	*6*
1	1.000	**0.302**	**0.240**	**0.291**	**-0.219**	**0.144**
2	**0.302**	1.000	**0.134**	**0.154**	-0.090	**0.124**
3	**0.240**	**0.134**	1.000	**0.279**	**-0.295**	**0.162**
4	**0.291**	**0.154**	**0.279**	1.000	**-0.153**	0.075
5	**-0.219**	-0.090	**-0.295**	**-0.153**	1.000	**-0.125**
6	**0.144**	**0.124**	**0.162**	0.075	**-0.125**	1.000

DISCUSSION

The illustrated cases with different numbers of motor variables for defining the hypothetical models of motor abilities showed the need to respect elementary principles when defining the structures in an analysed sample of variables. To achieve the parsimony of motor space, i.e. the good and valid pattern and structure required for a meaningful logic interpretation, every hypothetical motor factor should be evaluated with at least three motor variables. All adequate motor tests, in fact the motor measurements, must have good metric characteristics. The third principal is that every hypothetical research model should be balanced, meaning that every factor should be evaluated by the same number of motor variables (an uneven number of variables could produce a biased situation). Assuming all principals are taken into consideration, it is possible to obtain the relevant characteristics of latent factors (motor dimensions, abilities) of the primary (first-order) factors, but also at the extraction of higher-order ones in some hierarchical model of motor abilities.

This paper illustrates that it is impossible to get latent dimensions (factors) with a meaningful logical interpretation by grouping variables on the basis of just one or two of them.

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