THE PARTIALIZATION AS A METHOD FOR DECONTAMINATION OF MOTOR TESTS AND DISCRIMINATION OF VARIOUS FORMS MANIFESTATION OF MUSCULAR FORCE

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Abstract:
The aim of this study is to define partialization as a method for determining and monitoring of measuring muscle force and the development of different forms of force under the influence of the curriculum of Special Physical Education (SPE). In the paper the partialization (corrections) of all variables was made of the measured (raw) data. In this way, the differences among the respondents in the morphological area are neutralized and the results obtained in the performed tests are brought to a level of force. Based on the corrected values it can be concluded that the applied partialisations of the measured dimensions for decontamination of morphological impact on the manifestation of various forms of muscular force indicated the obtaining of a clean structure of motor space and that the applied curriculum of SPE significantly influenced the changes in size of various forms of force. Determination of development tendencies and resizing of forces at the individual level helps optimize and adequately manage sports training.

Keywords: *Special Physical Education, muscular force, partialization, training management*

INTRODUCTION

Measuring physical quantities implies their comparison. Naturally, not any two physical quantities can be compared but only those which are homogeneous, of the same kind. For example, we cannot compare the length of the jump and the number of repetitions of a test task (Milosevic, 1985; Peric, 1994; Amanovic, 2003). Therefore, to measure a quantity is to compare it with the standard, or the standard of the same species, i.e. with the adopted unit of measure of that quantity. Findings about the level of development of motor skills can be obtained with the evaluation of various movement tasks, and they are registered with the appropriate tests and called the measuring instruments (Kostovski at. al. 2013). Since the motor skills of a man are measured indirectly, the complete measurement process must be standardized, and motor tests (measuring instruments) must have satisfactory metric characteristics such as validity, reliability of objectivity, etc. (Kostovski et al. 2012). In such cases, the results obtained from a sample of individuals in a particular motor skill can be compared with the results that are determined in another sample of respondents for the same motor ability (Kostovski & Georgiev, 2009).

It is frequent in practice that the results which are said to measure some kind of force are measured and expressed in linear measures, or time, number of repetitions, etc. iInstead of being expressed in units of measurement for force (N). This is the first issue that needs to be addressed, in other words that all test results are reduced to the level of force (Milosevic, 1985: Milosevic, Ivančević, Gavrilovic 1989, Milosevic et al., 1996; Milosevic, Amanović, Mudric 2003; Amanovic, Milosevic, Mudric, 2004, Milosevic et al., 2005; Amanovic, Kostovski, Blazevic et al., 2013; Milosevic and Milosevic, 2014). Previous studies of the morphological, functional and motor space have established that there is an undisputed connection of the manifestation of the muscle force with the morphological characteristics, primarily body weight (mass) (Gredelj, 1976; Blaskovic 1979, Milosevic, 1985 Momirovic, Hosek et al., 1989; Amanovic 2003 ; Milosevic et al., 2005; Milosevic & Milosevic, 2014). Traditional (outdated) diagnostics, ignoring this connection, does not provide valid information required for the programming of the training for the development of various types of force. Specifically, the variability of the results achieved in motor tests is influenced both by the force and morphological characteristics that either damp down or enhance the test results (Milosevic, 1985 Milosevic et al. 1989; Momirovic et al., 1989; Amanovic, Milosevic, Mudric, Dopsaj, Peric, 2006; Milosevic & Milosevic, 2014). Therefore, the second problem that needs to be addressed is the decontamination of motor tests from nonlinear influence of morphological characteristics. The third problem is related to programming of training because trends from various tests emerge as means of training the results of which are shown in different measuring units (Milosevic, 1985 Milosevic et al. 1989; Milosevic et al., 2003; 2004b Zatsiorsky, Kramer, 2006; Milosevic & Milosevic, 2013a, b, 2014 a, b; Milosevic et al., 2014).

Force measurement is carried out by standard instruments (dynamometers, tensiometers), as a direct method of force measuring. However, it is possible to measure the force indirectly, as the load in one batch (in kilograms or tonnes), the duration of the series, the number of repetitions, as in our study using the method of partialization, obtaining the index of adjusted relative amount of force (Milosevic, 1985 Milosevic et al . 1988; Milosevic et al., 2003; Milosevic et al., 2005 Milosevic and Milosevic, 2014). Therefore, the muscle force (strength) during contraction should be analyzed in linear and square equalities in order to adapt training to individual characteristics, in accordance with the current condition and development possibilities of each individual and the requirements of Special Physical Education or sports activities. Previous studies so far have used different terminology for this phenomenon (Vanderburgh, Crowder, 2006; Jaric, Ugarkovic, Weeds, 2002). In our paper we use the term partialization (Lat. *parcellatio*) as a method for decontamination (correction) of raw test values from nonlinear influence of morphological characteristics (Milosevic, 1985 Milosevic et al., 2003; Amanovic et al., 2004; Milosevic and Milosevic, 2013a, b, 2014). Therefore, the aim of this study is to review and assess partialization as a method for discrimination against individual indicators of manifestation of various forms of muscular force.

Methods

All data were collected on a sample of 105 male subjects, the I-year students of the Police Academy in Zemun. The first measurement was made at the beginning and the second (retest) measurement was carried out at the end of treatment. The experiment included the application of a set of two morphological variables (body height expressed in meters, body mass expressed in kg) and nine motor variables (maximum force of knee extensors, quadriceps, back and hand grip, number of push-ups per 10", number of torso flexions in 30", long jump distance expressed in meters, high jump with a sweep of his hand by Abalac, running 20 meters flying start and run 20m high start). Anthropometric measurements were carried out by the method recommended by the International Biological Program (IBP). Muscular force - Fmax of knee extensor, back extensor and finger flexor was measured by the Belt method of isometric dynamometry using specially developed hardware-software system for measuring force - Software Engineering, Belgrade (Milosevic et al., 2003, Milosevic, 2004a). Other motor variables were measured using standardized tests (Milosevic, 1985).

Before calculating the factor models the data were prepared for processing. This preliminary analysis included the partialization of morphological impacts. For all used measures the correction of the measured data was performed so that the influence of morphological variables was eliminated and the result obtained in the primary process (measured value) was brought to the indicators of mean muscle force which exists in the size of the impulse force using mathematical functions proposed by Milosevic (Milosevic , 1985). It is known that the force is proportionate to the cross-sectional area of a muscle, and muscle cross-sectional area is equal to the square of linear dimensions (S^2). The transverse cross-sectional area is increased by increasing the volume (muscle mass). Therefore, the index of relative muscle force cannot be obtained by simply dividing with the weight, but it is necessary to reduce the weight in order to reduce the size of the volume with which body weight is directly proportionate to. Thus volume represents the third root of linear measures, so the reduction is carried out as follows:

$$Gr = Gr^{2/3}$$

where Gr - reduced value of weight, G - body weight expressed in newtons (body mass multiplied by 9.81). Getting the index of relative forces can now be done as follows:

$$Fr = F/G^{2/3}$$

- where Fr-the relative amount of force expressed in newtons. G-body weight expressed in newtons and the F-measured force expressed in newtons.

Therefore, in this case morphological and motor tests actually represented only individual items. Namely, the measured (raw) results, where the muscular force informs about vertical motion or movement at an angle to the horizontal, then for pushups, lifting the hull and running, are partialized in relation to height and body weight, and on that basis we have a corrected value of the force expressed in Newtons (N) as follows (Milosevic, 1985):

Body surface area

$$P = TV^2$$

where P - body surface area expressed in square meters (m^2), TV-value of body height expressed in meters (m).

Reduced value of body weight

$$Rt = G^{2/3},$$

where Rt - relative value of body weight expressed in newtons (N), G-body weight expressed in newtons (N).

Force of leg extensors

$$Fkn = F/G^{2/3}$$

where Fkn - the relative amount amount of leg extensors force expressed in newtons, F - measured value amount of leg extensors force expressed in newtons, and G – the value of body weight expressed in newtons.

Back extending force

$$Fkl = Fl/G^{2/3}$$

where Fkl - relative amount of the back extensor muscles force expressed in newtons, Fl - measured value amount of leg extensors force expressed in newtons, and G - the value of body weight expressed in newtons.

Hand grip strength

$$Fkš = Fš/G^{2/3}$$

where Fkš - relative amount of handgrip force expressed in newtons, F - measured value of handgrip force expressed in newtons, and G - the value of body weight expressed in newtons.

Force of hands and shoulder griddle implemented by push-ups in 10 seconds

$$Fkr = S2.\ G^{1/3} \cdot TV$$

where Fkr - relative value of force of hands and shoulder griddle implemented by push-ups per 10 seconds expressed in newtons, S - number of push-ups per 10 seconds, G - body weight expressed in newtons, TV -body height expressed in meters.

Torso flexor force

$$Fkt = P^2 \cdot G^{1/3} \cdot TV$$

where Fkt- relative value of torso flexors expressed in newtons, P - number of torso flexions in 30", G - body weight expressed in newtons, TV - body height expressed in meters.

Leg extensor force during long jump

$$Fksd = G^{1/3} \cdot SD / TV$$

where Fksd - relative value of leg extensors force expressed in long jumps expressed in newtons, G - body weight expressed in newtons, D - long jump distance expressed in meters, TV - body height expressed in meters.

Force implemented in the VRT + test

$$Fksv+ = G^{1/3} \cdot Abl+ / TV$$

where Fksv+- relative value of leg extensors force expressed in Abl + test expressed in newtons, G - body weight expressed in newtons, Abl+ - height depth jump with arm swings expressed in meters, TV - body height expressed in meters.

Body and leg extensors force during 20 meters run with flying start

$$Fk20l = G^{1/3} / t^2$$

where Fk20l - relative value of leg extensors force expressed during 20 meters run with flying start expressed in newtons, G - body weight expressed in newtons, t - time of 20 meters distance run with flying start expressed in meters.

Body and leg extensors force during 20 run with standing start

$$Fk20V = G^{1/3} / t^2$$

where Fk20l - relative value of leg extensors force expressed during 20 meters run with standing start expressed in newtons, G - body weight expressed in newtons, t - time of 20 meters distance run with standing start expressed in meters.

Results and discussion

Applying the methods of primary data processing, we have processed all the variables and presented them in Table 1. When the obtained values (raw variables) are corrected the variability measures for all variables indicate a relatively high degree of homogeneity of distribution. Error of the estimate of the average value is quite small for all monitored variables in the first and second measurements, indicating that the sample monitored in this paper represents well the student population. A significant difference in arithmetic means of the measured variables was confirmed for the adjusted variables between the first and second measurements in a positive sense, which is statistically confirmed as well on the one-percent level of risk at all observed variables. The highest increase in force production was found in the variables the characteristics of which are that the results achieved by the respondents depend on muscular force implemented in dynamic mode (corrected value of the number of raising the torso flexions in 30" and the corrected value of the number of push-ups per 10 seconds.). Both variables are characteristized by cyclic quality and creation of various levels of force per unit of time when shortening or elongating muscles.

In order to quantify the relationship (connection) between the variables and define the appropriate structures, the methods of factor analysis were used. For this purpose the procedures were used to transform the initial coordinate axis, orthogonal rotation (Varimax Rotation) and inclination (Oblimin Rotation) with the classic Kaiser's criteria for factor extraction (Peric, 2006). The analysis of the main components in the area of corrected variables at the first measurement resulted in four extracted components. Also in unrotated factor matrix the same relationship was formed, which gives the system of four co-ordinate axles. The same relationship that was given by the unrotated factor matrix was given by the orthogonal transformation of the coordinate system using Varimax solution. Manifest variables are grouped around four stable latent dimensions, in other words around four factors (Table 2).

Table 1.
Descriptive and comparative statistical indicators adjusted variables

Variables		X	SX	SD	R	Min	Max	Kv	t	P
$VT^2 (м^2)$	1	3.27	0.01	0.21	1.13	2.78	3.92	0.06	-7.36	0.00
	2	3.30	0.01	0.21	1.09	2.82	3.92	0.06		
$G^{2/3}$(N)	1	17.89	0.14	1.58	7.9	15.32	23.23	0.08	-7.07	0.00
	2	18.39	0.16	1.75	9.47	15.32	24.79	0.9		
F_{kn}(N)	1	8.77	0.09	1.08	4.88	6.08	10.96	0.12	-11.05	0.00
	2	10.56	0.18	2.03	11.17	5.48	16.66	0.19		
F_{kl}(N)	1	8.08	0.1	1.12	5.52	5.57	11.09	0.13	-10.3	0.00
	2	9.44	0.15	1.66	8.6	6.18	14.78	0.17		
Fkš (N)	1	3.15	0.03	0.4	2.02	2.04	4.06	0.12	-4.5	0.00
	2	3.31	0.04	0.48	2.62	2.03	4.65	0.14		
F_{ks}(N)	1	1921.71	49.76	542.88	2341.69	591.9	2933.59	0.28	-11.58	0.00
	2	2616.15	67.30	734.19	3810.92	996.64	4807.56	0.28		
F_{kt}(N)	1	18430.95	425.73	4644.17	21681.64	9048.66	30730.3	0.25	-9.53	0.00
	2	23256.07	528.65	5766.92	35344.33	10319.09	45663.42	0.24		
F_{kd}(N)	1	938.82	11.45	124.99	740.3	689.5	1429.8	0.13	-8.03	0.00
	2	1001.28	12.19	132.99	741.57	721.61	1463.19	0.13		
F_{ksv}(N)	1	19178.16	275.13	3001.34	17952.3	12262.5	30214.8	0.15	-10.49	0.00
	2	22238.37	354.59	3868.16	20180.89	12563.3	32744.19	0.17		
F_{20l}(N)	1	4217.44	69.74	760.85	4707.76	2858.35	7566.12	0.18	-6.01	0.00
	2	4610.27	67.74	738.97	3488.52	3337.28	6825.8	0.16		
F_{20v}(N)	1	2876.69	42.5	463.63	2253.76	1757.59	4011.35	0.16	-10.83	0.00
	2	3228.56	41.73	455.24	2431.84	2322.99	4754.84	0.14		

The first factor, which is explained in terms of contribution to the variability 34.34%, is determined by the following variables: adjusted value of running 20 m high start - adjusted value of running 20 m flying start, the corrected value of the long jump distance, the corrected value of the high jump with a sweep of the hand by Abalac and the corrected value of the body mass.Variables saturated by first Varimax factor can be divided into two groups. The first group consists of variables whose common generator of variability is in the ability to quickly engage muscles, the ability to implement force at high speeds of muscle contraction and the ability for efficient and synchronous engagement and disengagement of antagonistic muscle groups. The second group consists of variable of adjusted value of the body mass, in this way transformed value functionally related with the corrected values of directly measured (raw) muscle strengths. Here the body weight (bulking) is observed thorugh the corrected values expressed in Newtons (N). Based on the structure this factor can be defined as the factor of force manifestation speed. The second factor that carries 20.75% of the total variability previously explained is determined by the following variables: adjusted value of body height and corrected value of maximum force of back extensors. The first variable saturated bu the second factor is identical to the cross-sectional area of a muscle. The second variable is characterized by the results achieved by the participants which depend on the maximum muscle force realized in the already explained isometric mode. Therefore, the extracted factor can be defined as the factor of maximum muscle force. The third factor carries 12.77% of the explained variability, and it is explained by the following variables: adjusted value of maximal hand grip force and corrected value of maximum force of the knee extensors. For both variables saturated by the third factor there is a common feature that the results achieved by the respondents depend on maximal muscular force realized in isometric mode, therefore this factor also defines the maximum muscle force. Although these are two separate factors (of topological type) at the basis of which there are physiological mechanisms that determine the result in maximum muscle force, we can define them through a single factor as the factor of maximum force. The fourth factor that carries 10.25% of the total explained variance is defined by the following variables: adjusted value of raising the number of torso flexions for 30 seconds and the adjusted value of the number of push-ups in 10 seconds. From previously defined dimensions on which the creation of forces depends that determines the result of variables saturated by the fourth factor suggests that we define it as a factor of repetitive forces

Table 2.
Matrix of factor loadings adjusted variables - the first measurement.

	Oblimin Rotation					Varimax Rotation			
Variables	**F1**	**F2**	**F3**	**F4**	**h**	**F1**	**F2**	**F3**	**F4**
VT^2	0.168	0.197	0.862	-0.166	0.827	0.301	0.841	0.081	0.152
$G^{2/3}$	0.810	-0.191	0.194	-0.024	0.876	0.841	0.293	-0.267	0.103
Fmaxkn	-0.081	0.541	-0.341	-0.214	0.602	-0.128	-0.391	0.612	0.241
Fmaxkl	0.110	0.247	-0.760	-0.076	0.710	-0.001	-0.753	0.352	0.135
Fmaxkš	-0.020	0.924	0.050	0.049	0.831	-0.086	-0.014	0.908	-0.009
Fks	-0.071	0.107	0.007	-0.796	0.641	0.062	-0.047	0.188	0.774
Fkt	0.092	-0.133	0.070	-0.800	0.685	0.251	0.049	-0.069	0.784
Fkd	0.844	-0.206	-0.201	-0.177	0.850	0.848	-0.096	-0.214	0.275
Fksv	0.834	-0.125	-0.016	-0.019	0.742	0.831	0.085	-0.174	0.115
$Fk_{20}l$	0.877	0.162	0.086	0.080	0.761	0.850	0.175	0.083	0.030
$Fk_{20}v$	0.915	0.171	0.004	0.025	0.812	0.885	0.096	0.108	0.093
Explained variance	4.160	1.709	1.985	1.783	8.336	3.804	1.574	1.535	1.423
Proportion %	39.680	17.888	9.467	8.748	75.783	34.579	14.310	13.953	12.940

Note: Marked with a load factor that exceeds 0.55

When it comes to inclined Oblimin transformation the level of explained variability is the same, the number of the produced factors is also four but the order is changed and the intensity of some of the factors (Table 2). Specifically, the second Oblimin factor corresponds to the third Varimax factor, and the third to the second Varimax factor. Finally, we can conclude that all four factors of the stable dimension explain 75.78% of common variability.

Factor analysis of corrected variables in another (repeated measurement), after defining the initial coordinate system of the manifest variables and then its orthogonal transformation by the Varimax solution, extracted four factors (Table 3). The first factor whose contribution to the explained variability is 34.34% can be labeled as a speed factor of force manifestation, since it mostly projected at five measured dimensions (corrected value of the long jump, the corrected value of body weight, the adjusted value of running 20 m high start and 20 m flying start and the corrected value of the high jump with a sweep of the hand by Abalac). The second factor had a share of 20.75% in the explained variability and showed significant projection at variables (adjusted value of maximum force of the back extensors, maximal hand grip force and maximum force to the knee extensors). Considering the variables which it is determined by, it may be characterized as a factor of the maximum force. The third factor, whose contribution to the explained variability is 12.77%, showed significant projections at the variables (corrected value of of torso flexions for 30 seconds and a corrected value of a number of push-ups performed for 10 seconds) and can be labeled as a factor of repetitive forces. The fourth factor whose contribution to the explained variability is 10.25%, showed significant projections at the remaining variable corrected value of body height, while the muscle cross-sectional area corresponds to the square of linear dimensions (VT^2), and therefore it is possible to mark it as a factor of muscle cross-section. All four factors are stable dimensions, explain 78.13% of the variability of the joint action of all manifest variables and can independently exist in the analyzed area.

When it comes to inclined Oblimin transformation the level of explained variability is the same, the number of the produced factors is also four factors. High correspondence of the results of orthogonal and oblique solutions is an indicator of the stability of isolated factors and the possibility of independent existence in the analyzed latent space. This assumption was confirmed by the matrix of intercorrelation of isolated factors. If we compare the results of the factor analysis of this study with the results obtained by Milosevic in 1983 (Milosevic, 1985), we can conclude that the variables in the system of corrected values grouped around similar factors that integrate common regulatory mechanisms.

Table 3.
Matrix of factor loadings adjusted variables - the second measurement

	Oblimin Rotation					Varimax Rotation			
Variables	**F1**	**F2**	**F3**	**F4**	**h**	**F1**	**F2**	**F3**	**F4**
VT^{2}	0.267	-0.119	0.009	0.820	0.864	0.335	-0.181	0.018	0.848
$G^{2/3}$	0.881	-0.135	-0.112	0.193	0.886	0.876	-0.201	-0.026	0.280
Fmaxkn	0.054	0.822	0.088	-0.131	0.745	0.009	0.831	0.147	-0.180
Fmaxkl	0.070	0.877	-0.080	-0.195	0.823	-0.009	0.873	-0.011	-0.247
Fmaxkš	-0.096	0.873	0.007	0.275	0.793	-0.124	0.856	0.048	0.206
Fks	-0.034	0.079	0.812	0.093	0.677	0.097	0.152	0.798	0.087
Fkt	0.056	-0.088	0.825	-0.088	0.699	0.186	-0.007	0.812	-0.073
Fkd	0.892	0.031	0.083	0.037	0.850	0.897	-0.007	0.180	0.116
Fksv	0.822	-0.000	0.022	-0.348	0.712	0.790	-0.018	0.116	-0.272
$Fk_{20}l$	0.823	0.039	0.070	0.112	0.750	0.831	-0.002	0.159	0.184
$Fk_{20}v$	0.845	0.059	0.022	0.174	0.794	0.849	0.008	0.114	0.246
Explained variance	4.043	2.405	1.730	1.310	8.595	3.778	2.283	1.405	1.128
Proportion %	38.290	21.789	10.202	7.852	78.132	34.349	20.752	12.776	10.254

Note: Marked with a load factor that exceeds 0.55

CONCLUSION

Above all variables in both measurements partializations (corrections) were made of raw data, namely, in this way the differences among the respondents in the morphological area are neutralized and the results obtained in the performed tests brought to the level of force. Further were made descriptive, correlation and factor analyses on the basis of which it can be argued that the analyzed data are reliable and can be validly interpreted. After completing the experimental procedure, based on the results obtained, we can conclude the following:

Applied partialisations of the measured dimensions, in order to eliminate morphological impact on the expression of various forms of muscular force, indicated the obtaining of the clearer structure of motor space, in other words, the reduced variability in comparison with the variability of the series of directly measured data.

The intensity and character of the connections between the observed parameters enables a qualitatively different interpretation of the motor space in relation to the interpretation given based on non-partialized data. Further, the corrected data have produced factors that provide information about the manifestation of different forms of muscular force in time and space in a different mode (of static and dynamic character), which can be measured directly and indirectly, and which can be described using certain physical quantities, in other words that can be expressed numerically.

In the end, it is possible to conclude that the results we obtained in addition to theoretical are also of practical significance, contributing to the issue of programming and management of educational and training process in Special physical education and sport.

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