IDENTIFICATION, STRUCTURE AND VALIDITY OF TESTING OF MOTOR ABILITIES

by

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The aim of the study was to establish elementary structure of motor abilities based on structural — energetic principles and validity of indirect testing using various types of motor tests. The examined group included 243 persons (91 women and 143 men aged 21–23) — students of Univ. School of Phys. Educ., not practising competitive sports. This group can be characterised as having fully developed motor potential and relatively uniformed level of motor skills. 104 tests involving elementary parameters characterising muscle work (speed of involvement, maximal values and rate of strength decreasing) during isometric and dynamic contractions were run in laboratory conditions. Additionally, 13 motor fitness tests were conducted to check testing validity as a measures of particular abilities. Three — stage factor analysis and taxonomic method of Ward were applied to reduce the number of parameters and to select the most representative ones: they were selected for the stage III and treated as "golden standards". Markers and Ward analysis were used to establish further tests validity by their individual confrontation with the whole "area" of motor abilities.

It was found that all the parameters can be grouped into 7 main abilities: global strength, local strength, anaerobic alactacid and lactacid power, speed of muscles mobilisation, maximal oxygen uptake and muscles resistance to tiredness. They have common biological backgrounds and cover all "potential side" of motority having structural — energetic roots ("health – related fitness"). The tests of highest validity are: "medicine ball throw backward" (global strength), "arm bent" (local strength), "standing long jump" (MAP), "shuttle run 4 x 10 m" (speed of muscles mobilisation), "300 m run" (lactacid MAP), "Cooper Test" (maximal oxygen uptake) and "sit – ups" (muscle resistance to tiredness).

Key words: Motor abilities, Motor tests validity, Multivariate analysis

Introduction

The research into the motority structure conducted in Poland last years allow to make a considerable progress in identification, defining and categorisation of human motority (Szopa 1988, 1989, 1993, Szopa and Wątroba 1993, Szopa and Latinek

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. . . Szopa et.al. 1996, Juras et.al. 1998, Waśkiewicz et.al. 1998). Broad discussion enabled us to formulate the common opinion, and main differences refer mainly to the problem of scale and criteria of dividing motor abilities, as an indirect "floor" between the really existing biological traits (predispositions) and motor performance. This discussion reveals both the problem of complexity of particular abilities (strength, speed, endurance) and an attempt to co-ordination abilities (complexes of different abilities or predisposition).

Moreover, the earlier research was based on limited sets of tests, which may lead to limitation of the number of distinguished factors (abilities), as the multidimensional statistical analysis was applied. When the relevant requirements are met, therefore, it might be possible to identify still more abilities. We can expect, that in this case they will be closer to their biological root, which should enable more precise separation of "potential" and "effective" aspects of motority.

In the light of our methodology, the assumption are as follows:

- As many elementary traits as possible should be examined, by means of precise measurements
- tested population should be in the period of full biological development (adult persons with considerable physical activity); with uniformed motor skills (to minimise, even partially, their impact on motority structure)
- application of multidimensional statistical analysis, treated as a complementary tool and carried on "step by step", in the purpose of eliminating of those aspects which result from the specificity of these methods.

The present work is an attempt to fulfil those assumptions and its main objectives are:

1. Establishing the structure of "structural — energetic" motor abilities by searching for the "higher level connections" between 104 parameters characterising the elementary functional predispositions — i.e. "golden standards". They are necessary for establishing the validity of motor fitness tests.
2. Qualifying the validity of most frequent fitness tests based on particular types of abilities (verification of the thesis assuming a possibility of testing "potential side" through "motor effects").

The analysis covered three groups of abilities: strength, speed and endurance abilities (during the introductory phase of our investigations we tried to do it for the total number of parameters, but the obtained models were very complicated, not coherent and impossible to interpret in terms of logic).

Material and methods

The investigated group included 234 persons of both sexes (143 men and 91 women), students of the University School of Physical Education in Cracow, aged 21–23. Investigations were carried out during the period 1993–1995, (the competitive sportsmen were excluded): population under study presented a uniform level of training experience and motor skills. Standardised conditions of examination were assumed (bio-mechanical laboratory, the same team of researchers).

The investigations involved two main groups of parameters:

I. Laboratory tested "primary" values characterising three basic properties of muscle work:

- 42 parameters of static strength measured in isometric contraction. Maximal moments of strenght of 18 main muscle groups (table. 1) and sums of maximal and relative (to body mass) torques for extensors, flexors, and all the groups were examined using dynamometers, connected to the computer line.

Table 1. Characteristics of measurements positions

Joint	Measured muscles	measurent position	Angle between adjoin bones
knee	extensors, flexors	sitting	90^0
elbow	extensors, flexors	staying	90^0
hip	extensors, flexors	lying, on the back	90^0
shoulder	extensors, flexors	staying	0^0
extensors and flexors of trunk		sitting	90^0

- 53 parameters of speed of muscle mobilisation (time of achieving the maximal strength or power) and alactacid MAP, investigated on dynamographic platform and during 50 m run (speedography).
- 9 parameters of muscular resistance to tiredness and aerobic power ($VO_{2\,max}$). HR eff. was recording by Sport — Tester as well as the value of the strength decline in 40 sec' in an isometric contraction (tg of the right angle $f = F_{(t)}$).

II. Motor fitness tests (14) aimed at examining their validity, chosen in consideration of reliability, theoretical validity, biological backgrounds, type of movement and "frequency" of their using in various test batteries:

- 6 tests based on strength abilities — "push–ups", "bent arm hanging", "medicine ball throw forward" and "backward", "grip strength", "sit–ups".
- 5 test based on speed abilities ("standing broad jump", "envelope run", "8-track run", "50 m run", "300 m — run").
- 3 test based on endurance abilities: 1500 m run — men and 800m run — women, "shuttle run" (Eurofit), "Cooper Test".

The statistical analysis involved:

1. Fundamental characteristics ($\bar{x}$, SD).
2. Z — normalisation of each parameters ($\bar{x}$ = O, SD=1).
3. Calculating of correlation matrices in all the groups of parameters using Z — values.

4. Two — stages factor — analysis (exploration version EFA) and taxonomic method of Ward. It enables "dimension reduction" and choosing factors most representative to the final stage of analysis.
5. The final (3-rd stage) factor and taxonomic analysis for determining the structure of particular motor abilities.
6. Markers and Ward's analysis applied to establish connections between motor fitness tests and the "space" of components (factors) of motor abilities. These procedures enabled establishing the validity of tests as an indirect method of testing motor abilities.

Calculations were made using STATISTICA v.5.0, AAD, Excel v.7.0. as well as some programs developed by us.

Results and discussion

1. I and II stage of analysis

From among strength abilities (36 variables), in the first stage nine factors were distinguished — both in men and in women. They explain 70,9 % and 65,7 % of common variance, respectively. Basing on the logic of particular factors, the values of factor loads and their reliability, 16 variables (in women) and 18 (in men) were selected , to the second stage of analysis (Chwała 1997). It is worth noting the variables of maximal absolute and relative strength moments were excluded from the first stage of the analysis because they strongly depend on other parameters describing particular groups of muscles. They were used in the second stage of analysis.

As far as speed parameters (53 variables) are concerned, the analysis enabled us to distinguished 15 factors in both sexes, explaining 77,3 % of common variance in women and 70 % in men. 19 parameters having greatest factor loads were selected for the second stage.

The structure of endurance abilities was the simplest: four factors were distinguished explaining more then 87 % of common variance, from which five variables were chosen for the second stage.

The second stage of analysis was the continuation of the process of separating the most representative variables characterising particular types of abilities. Results of factor analysis were complemented by Ward taxonomic method, according to the presumption that this stage should enable us to choose variables most closely connected with the "essence" of particular factors.

In the consequence of this stage four factors of strength abilities were distinguished for men and women, from which the most representative were found: the sum of all strength moments, sum of all flexors, sum of all extensors, maximal and relative moments of extensors of knee and elbow joints.

The structure of speed abilities proved to be more complex: during the second stage five factors were distinguished explaining 69 % (men) and 65 % (women) of common variance. The final set chosen for third stage included: time of achieving the maximal running speed (50 m), maximal velocity, alactacid MAP, time of achieving the maximal isometric strength and values of maximal time derivatives of strength for the muscles of knee and elbow joints. These were the factors with most weight (highest values of factor loads).

In the group of endurance abilities the most representative parameters were:

- in women — muscle resistance to tiredness in extensors of knee and elbow joints, as well as effort HR (84 % of common variance)
- in men — muscle resistance to tiredness in extensors of knee joint (left extremity), elbow joint (right extremity), effort HR (85 % of common variance).

The second stage of analysis allowed us to limit the number of factors to eleven, as well as enabled us to determine which variables were most representative for the particular type of abilities. At the same time, application of two methods allowed to eliminate variables of a complex nature (involving several factors).

2. **The final (3-rd) stage of the analysis**

a) Strength abilities.

In the case of men (table 2, Fig.1) four factors were distinguished, describing 90% of common variance.

Table 2. Factor loads in finally structure of strenght abilities in men

Parameters	Factor 1 Absolutly muscular strenght	Factor 2 Strenght of lower extremities	Factor 3 Relative muscular strenght	Factor 4 Strenght of upper extremities
Sum of Tmax	0.94	0.12	0.27	0.18
Sum of Tmax. Flex.	0.83	0.00	0.35	0.20
Sum of Tmax. – ext.	0.91	0.18	0.19	0.14
Sum of Trel.	0.32	0.17	0.90	0.24
Sum of Trel. flex.	0.23	0.00	0.83	0.22
Sum of Trel. – ext.	0.31	0.25	0.74	0.20
Tmax of lower extr.	0.36	0.85	0.04	0.10
Trel of lower extr.	–0.05	0.91	0.19	–0.03
Tmax of upper extr.	0.50	0.03	0.10	0.86
Trel of upper extr.	0.03	0.03	0.31	0.95

They involve two main abilities: absolute static strength (factors 1 and 3) and local static strength (factors 2 and 4). Absolute strength is expressed both by maximal and relative moments of strenght, while local strength — by maximal and relative strength of knee and elbow joints. The most valuable measurements (the highest values of factor loads) are respectively:

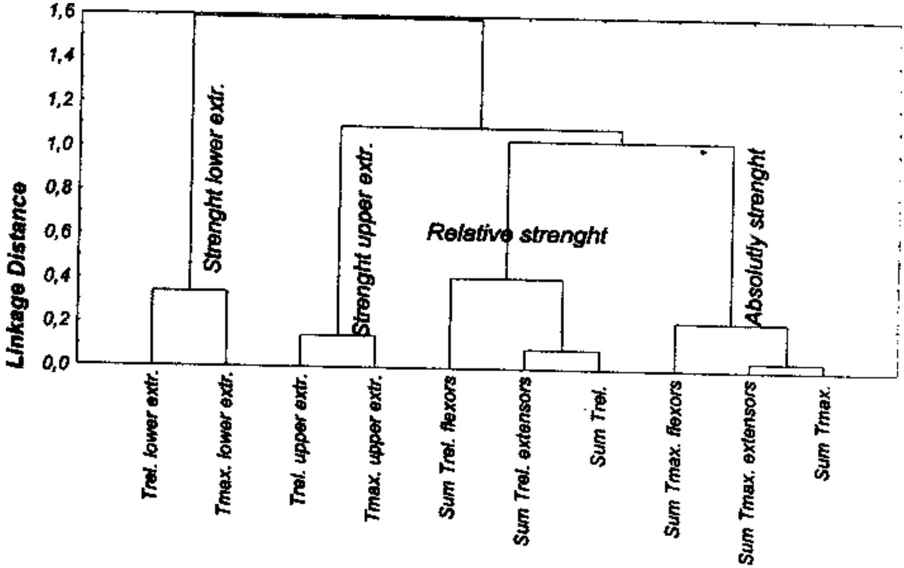

Fig. 1. Tree diagram for 10 Variables (strenght abilities — men) — Ward's method

- the sum of maximal strength torques of all muscles
- the sum of relative strength torques of all muscles
- values of relative strength torques of lower and upper extremities.

Identification of local strength suggests this ability will yield a varied distribu tion in extremities and in the trunk. Similar results were obtained by Fleishma (1964) and Sulisz (1975): this phenomenon can be explained by assuming the mod fying influence of environmental factors, i.e. the movements in the gravitation area sport training, life style — on particular groups of muscles. At the same time, thi fact confirmed the thesis whereby two independent factors of muscular strength ar present: "general" and "local".

In the Figure 1 we can see the relations between the variables according t Ward's method. It is worth noting, local strength of upper extremities displayed th stronger connection with "absolute" and "relative" strength. The relation betwee sum of all muscles strength and sum of extensors turned out to be the strongest: i can be the result of their more considerable contribution to general strength (anti-gravitational functions).

The same factors were found for women. They explained 89 % of commo variance (table. 3). In the case of men, the first factor — "the absolute strength" differs in one aspect only: the maximal moments of strength were found in lower — not upper extremities.

The second factor ("relative strength") explained 17 % of common variance. I involved three weighted variables: the sum of all relative moments of force, all the

Table 3. Factor loads in finally structure of strenght abilities in women

Parameters	Factor 1 Absolutly muscular strenght	Factor 2 Relative muscular strenght	Factor 3 Strenght of upper extremities	Factor 4 Strenght of lower extremities
Sum of Tmax.	0.92	0.25	0.13	0.24
Sum of Tmax. – ext.	0.84	0.18	0.15	0.36
Sum of Tmax. flex.	0.90	0.35	0.08	- 0.04
Sum of Trel.	0.25	0.91	0.20	0.22
Sum of Trel. ext.	0.21	0.78	0.22	0.40
Sum of Trel. flex.	0.26	0.90	0.11	- 0.13
Tmax. of lower extr.	0.59	0.04	- 0.03	0.68
Trel of lower extr.	0.21	0.27	0.09	0.74
Tmax. of upper extr.	0.38	0.09	0.87	- 0.07
Trel of upper extr.	- 0.08	0.29	0.90	0.13

extensors and all the flexors. The maximal factor load was presented by value of sum of all relative strength moments.

The further two factors, explaining together 20 % of common variance described "local strength", of upper and lower extremities, respectively. The taxonomic analysis confirmed the structure of thus distinguished factors (Fig. 2). Is interesting, however, that the strength of upper extremities is less connected with absolute strength. That may be due to the fact that muscles of upper extremities are distinctly weaker

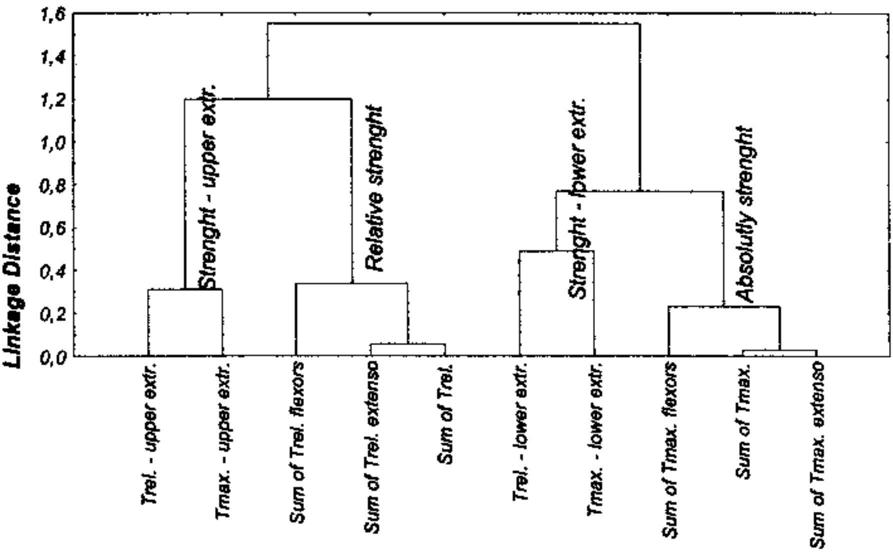

Fig. 2. Tree diagram for 10 Variables (strenght abilities — women) — Ward's method

in women than in men (differences of about 43 % — Ruchlewicz et.al. 1996), while in the case of lower extremities these differences are only about 10 %. An additional argument is that the term "local strength" covers both maximal and relative moments of force. These facts suggest a stronger relationship existing between these variables than the "main groups", i.e. absolute and relative global strength.

Many authors (Fleishman 1964, Reilly and Thomas 1980, Pilicz 1986, Malacko 1986, Szopa 1989) distinguished the factor called "static strength" (MVC — maximal voluntary contraction"), closely connected with somatic traits (mainly the body mass and LBM). They point out to the better diagnostic value of "relative strength" which eliminates the effects of body size. It is probably connected with dominating position of "relative strength" factor in most of the movements dependant on gravitation forces (running, jumping, gymnastic). At the some time in many sport activities "absolute strength" is the dominating factor (weight — lifting, wrestling, throws). We can suppose then, that these two parameters should be treated as a measure of strength abilities treated as a distinguished factor.

Attempts were made to measure the maximal moment of strenght in isokinetic conditions (Fidelus 1971, Bober and Hay 1990, Kędzior 1992), which was named "dynamic strength". It seems that they should be related to dynamic conditions of muscle work rather than qualitative "elements" described by classical mechanics. The same opinion was expressed by Bober and Hay (1990): they pointed out the significant likeness of strength torques in isometric and isokinetic contraction at the same "angle position" and suggested that the static strength moments should be used as the most valuable technique for testing muscular strength.

The results obtained by Sulisz (1975) confirmed our conclusion, that "local strength" of upper and lower extremities are independent factors. Apart from that the Author did not express it directly.

Distinguishing two main factors of strength abilities has a significant practical meaning, especially while choosing the best parameters characterising strength distribution in men and women. This fact is confirmed by taxonomic method (Fig. 1 and Fig. 2), which indicates a very strong relation between the sum of all maximal moments of force and the sum of Mmax of all extensors. Therefore, we can recommend measurements of these muscles which are involved in the global strength in a larger degree (Vi.e. anti-gravitational complexes), simultaneously with the measure of smaller muscle groups of extremities.

b) Speed abilities

As already mentioned, the views on interpretation and classification of speed abilities are rather diverse. Some reserachers pointed out the complexity of this group (Raczek 1991, Czajkowski 1993), emphasising their dependence on ... "optimal connection between energetic potential and neurosensoric processes of movement steering"... A slightly different concept was presented by Szopa at.al. (1996). According to their classification, speed abilities belongs to the group of energetic abilities closely connected with nervous — muscle co-ordination (speed of muscles contraction). Most significant predispositions of these abilities are: structure of muscles fibres (FT/ST), efficiency of anaerobic enzymatic processes reaction time, frequency of movement and inertia of particular parts of the body.

In our analysis of speed abilities in men four factors were distinguished, explaining 72% of common variance (table. 4).

Table 4. Factor loads in finally structure of speed abilities in men

Parameters	Factor 1 Anaerobic power	Factor 2 Speed of strenght developing	Factor 3 Time of muscle contraction	Factor 4 Run acceleration
Reaction force of platform	0.87	–0.13	0.14	0.07
MAP	0.86	0.13	0.09	0.04
Vmax. in 50 m run	0.21	0.58	–0.27	–0.12
Time of Vmax reaching	–0.06	–0.04	–0.04	–0.98
Velocity of strenght increasing – upper extr.	–0.17	0.74	0.08	0.12
Velocity of strenght increasing – lower extr.	0.08	0.69	0.29	0.04
Muscle contraction time – upper extr.	0.38	0.09	0.87	–0.07
Muscle contraction time – lower extr.	–0.18	–0.09	–0.77	0.01

As far as the anaerobic alactacid performance is concerned, two variables were identified: MAP (calculated from parameters of vertical jump on the dynamographic platform) and forces of platform response during this jump.

The second factor (velocity of strength developing) seems to be a natural complementation to the factor 1: it loads variables determining “maximal speed of running” and “maximal values of derivatives of strength” of muscles of upper and lower extremities. Undoubtedly, these variables together describe the ability to generate maximal strength in a possible shortest time — alactacid MAP.

Factor 3 and 4 (“time of muscle contraction” and “acceleration ability”) are complementary, too. The parameters describing both times of maximal strength achievement and time of achievement of maximal speed make up the second main component of speed abilities (this time of an related to co-ordination abilities) — the possibility of maximal acceleration of the body.

The same factors (groups) were distinguished using Ward’s method (Fig. 3). We can assume that this structure was very stable, what agrees well with our introductory assumptions.

In the group of women (table. 5) identical four factors were distinguished, which explained 72 % of common variance — though in a different sequence. The first

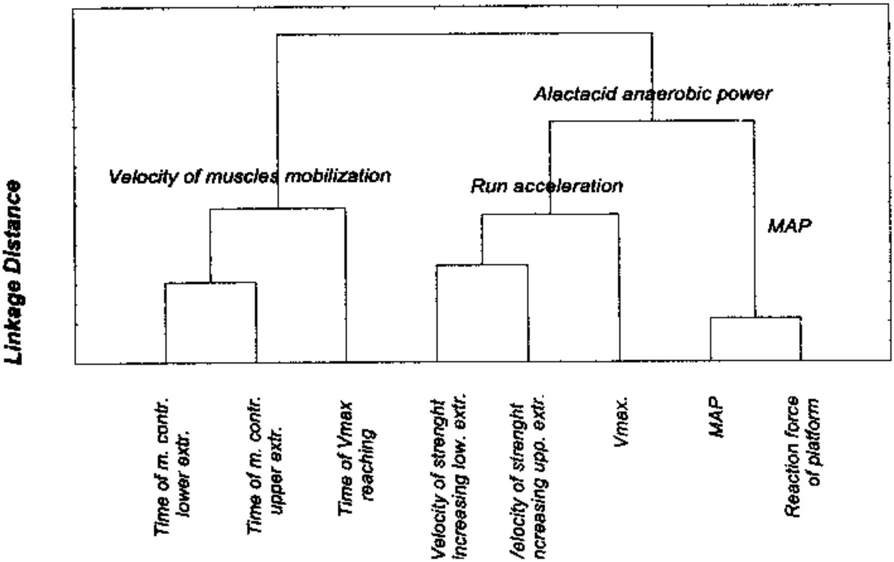

Fig. 3. Tree Diagram for 8 Variables (speed abilities — men) — Ward's method

factor was the "time of muscle contraction" loading two variables describing the time required for reaching the maximal strength developed by muscles of upper and lower extremities.

The second factor was identified as alactacid MAP and was expressed as the maximal power in vertical jump and platform reaction force.

Table 5. Factor loads in finally structure of speed abilities in women

Parameters	Factor 1 Time of muscle contraction	Factor 2 Anaerobic power	Factor 3 Speed of strenght developing	Factor 4 Run acceleration
Reaction force of platform	0.02	0.87	–0.01	0.02
MAP	0.01	0.88	0.80	–0.03
Vmax. of 50 m run	–0.05	0.00	0.91	0.05
Time of Vmax. reaching	–0.40	–0.27	0.13	–0.62
Velocity of strenght increasing – upper extr.	–0.30	–0.13	0.78	0.09
Velocity of strenght increasing – lower extr.	0.47	0.19	0.59	–0.13
Muscle contraction time – upper extr.	–0.82	0.05	0.04	0.05
Muscle contraction time – lower extr.	0.82	0.05	0.07	–0.07

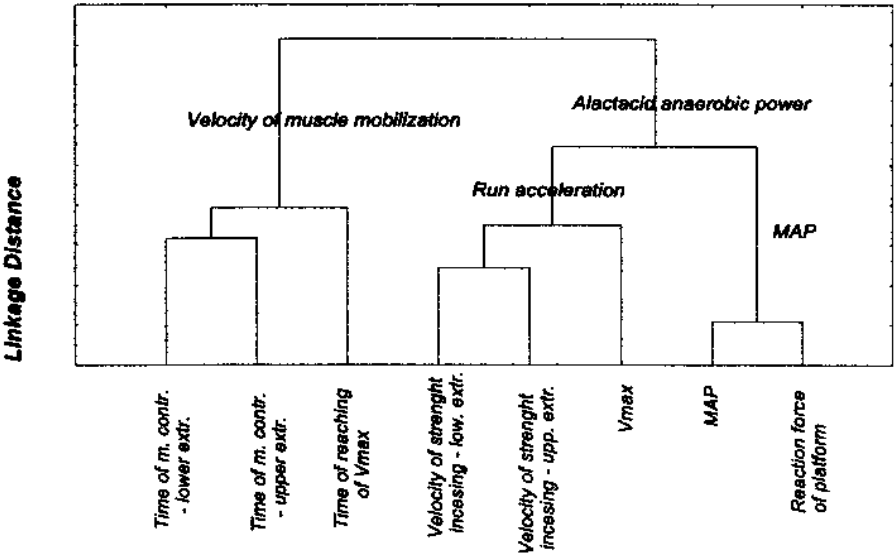

Fig. 4. Tree diagram for 8 Variables (speed abilities — women) — Ward's method

Further factors "the speed of developing of maximal strength" and "time of achievement of maximal velocity" (co-ordination elements) were divided. As the correlation between them can only be assumed, the structures of a higher level are obtained in taxonomic analysis (Fig. 4). Indeed, in the diagram displaying levels of connections between variables three main groups can be seem: "alactacid MAP", "the ability of fast muscle mobilisation" and "the ability of run acceleration". Two of them yield a higher level connection.

The "twin" structures obtained in both groups under investigation further confirm the correctness of these analysis.

Generally, we can ascertain that our results lead to the conclusion that among speed abilities two fundamental abilities exist: the **level of alactacid MAP** and **velocity of muscles contraction** (co-ordination element). As a broad spectrum of parameters is analysed, we can suggest two — or three factors structure of speed abilities (lactacid MAP was not taken into consideration). All of these should be tested for scientific purposes — the tests recommended by us will be shown at the end of this work.

c) **Endurance abilities**

Though several papers dealt with the structure of endurance abilities (Zaciorski 1979, Klimek 1986, Raczek 1987, 1991, Kubica 1995),the methods of factor analysis was applied in only a few (Mekota and Blahuš 1983, Pilicz and Stawczyk 1987). They were based on the different principles: the Authors assumed, that every effort involving long — time muscles work has an clear element of endurance; fitness tests can be thus regarded as representative methods for testing these abilities (these give the greatest factors loads, often taken as their validity indices). In our earlier studies (Szopa et.al. 1996) we defined endurance abilities as "... possibilities of an organism to do long-time muscular work of submaximal intensity without tiredness". It points to "cardio — respiratory endurance" and "acidity tolerance" as two main physiological factors. That is why the main predispositions are: the number of mitochondria, erythrocytes, level of Hb, heart volume, muscle fibres ratio FT/ST, fat mass etc. Endurance abilities have therefore broader sense (maximal aerobic capacity) than "maximal aerobic power" measured by $VO_{2\,max}$. Raczek (1991) emphasised however, that "besides of high aerobic efficiency, the anaerobic factor plays significant role in different kinds of endurance ", connected with glycolytic processes. This division is determined by the time and intensity of effort.

Table 6. Factor loads in finally stucture of endurance abilities

Parameters	Factor 1 Muscular endurance		Factor 2 Aerobic power	
	men	women	men	women
Local m. endurance – upper extremities	0.81	0.98	0.23	–0.01
Local m. endurance – lower extremities	0.65	0.76	0.42	–0.03
$VO_{2\,max.}$	–0.06	–0.05	–0.90	0.75

Final structure of endurance abilities is presented in table 6. As we can see, two identical factors were distinguished, according to earlier expectations: "aerobic capacity" and "muscles resistance to the tiredness (muscle endurance)". The same results were obtained by taxonomic analysis (Fig. 5). This correspondence is partially caused by very limited number of analysed variables; also — by a very clear structure of endurance abilities.

Summing up, we can assume, that thus distinguished structure of all the "energetic — structural" abilities does not give a "sharp" division, but are able to intermingle. However, the predominant factor may differ depending on which variables are taken into consideration. Describing these "common areas" has however a great significance for utility — sports attempt ("speed endurance", "strength endurance", "endurance of short and long time" are commonly used terms).

In connection to the fact, that) motor abilities l distinguished in several tests have a complex nature, it would be too general to classify them in accordance with existing cathegories. It seems, that existing conceptions of motor abilities should be verified as far as their dependence on the **biological backgrounds**_is concerned, apart from their being related to motion aspects.

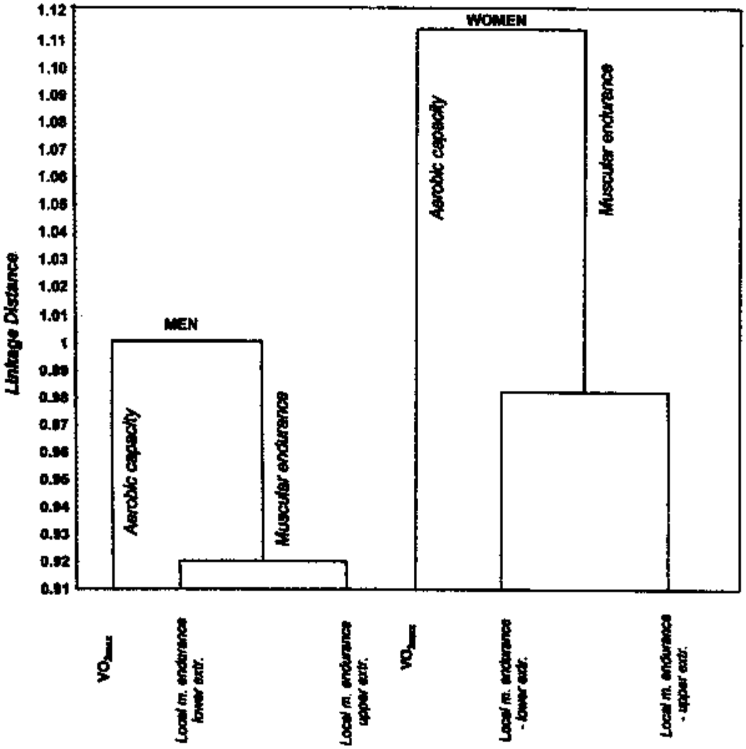

Fig. 5. Tree diagram for 3 Variables (endurance abilities — men) — Ward's method

3. Estimation of validity of motor fitness tests

The problem of the validity of motor fitness tests is of primary importance in physical education research. Separating abilities from skills is however impossible in movement tests, in the end we reach the following conclusion: we have to look for such kind of tests in which the presence of motor skills is eliminated as far as possible.

The criteria of test validity are related both to internal an external conditions. Positive opinion of the validity of test should included "... the rate of adequacy of measurement, the accordance between the essence of contents of the measurement with the assumed variables — with minimising the impacts of other components as far as possible" (Szopa et.al. 1996). The notions of internal and external validity are closely connected. External and internal validity coincides in the population where the results of particular tests should yield the normal distribution.

Osiński (1993) emphasised that "reliability is a necessary though not sufficient condition of validity. Unreliable tests cannot be valid, but reliable tests need not be valid".

An attempt to determine validity of tests is connected to the answer to some fundamental questions (Mekota 1988):

a) which feature of motority (ability, skills) is measured by given test?

b) what is the reliability and objectivity of this test?

c) which is the proof that the theoretical model represents the trait characterising (even indirectly) the distinct differences between individuals?

In this work the analysis of validity of chosen motor tests was done in two stages (see "*Material and Methods*"). Taking into account all the advantages and disadvantages of the mentioned — above methods of tests validity assessment, in the first stage we used two methods of multidimensional analysis: marker's factor analysis (Kline and Cooper 1984) and taxonomic analysis. The first conclusions about the nature of particular tests were utilised in the final stage, when analysis of each test allowed to distinguish the most representative "markers variables". The assumptions helped us to avoid any mistakes arising from the structural dependence between tests.

a) The first stage

In the first stage "markers variables", as distinguished earlier, were parameters characterising final constructions of particular structural — energetic abilities. Only those tests could be applied, which were related to particular abilities, as assumed by the Authors for the purpose of measurements. At the same time these tests which had a distinct different biological backgrounds or movements features were eliminated: it helped us to avoid incidental structures.

The purpose of the analysis was to determine the strength of the relation between the results of particular tests and motor abilities, including a greater number of parameters.

Localising the results of seven tests within the space of nine most representative parameters of strength abilities four factors explaining 72 % of total variance were distinguished for men. A relation was found between " the absolute strength" and results of tests: "medicine ball throw backward" and "forward", "grip strength" and "standing broad jump". The results of "bent arm hanging" and "arm push–up" tests were connected with "local strength of the upper extremities. These results were then confirmed by taxonomic analysis.

In a 8 — dimensional space of speed abilities **in men** all the tests conditioned by anaerobic energetic processes and co-ordination ones were localised. Five factors were distinguished in factor analysis (73 % of common variance). The tests of: "standing broad jump", "medicine ball throw", "300 m run", "envelope run" and "8-shape run" were connected with these markers of final structure of speed abilities — in taxonomic analysis, too.

From among the tests related to endurance abilities the "Cooper Test", "1500 m — run" and "shuttle — run test" are the best indicators serving as the measure of the "aerobic efficiency" factor. The "muscle resistance to tiredness" factor was involved mainly through the tests "bent hanging", "arm push-up. The results of "300 m — run" were distinguished as a local endurance of lower extremities.

Tests **in women** displayed a great similarity to the results obtained in men. A small differences arose in the group of tests of strength abilities: absence of "standing broad jump" and the presence of only one test (grip strength) in the space of "local strength. Six tests were related to the parameters describing speed abilities: alactacid MAW ("standing broad jump"), "envelope — run", "8–shape run", "medicine ball throw", and "300 m run". In taxonomic method the structure was more clear: "agility" runs were connected with "speed of muscle mobilisation" ability, and others — with alactacid MAP. In endurance abilities the "aerobic capacity" factor was represented in "Cooper Test", "shuttle run" and "800 m — run", but only results of "300 m — run" could be identified as the test of "muscles resistance to tiredness". Results of the first stage of analysis suggested rather validity of particular tests to the "high — level" factors than to primary abilities. For that very reason during the second stage the criteria were limited by localisation of the results of selected tests only in all the space of motor abilities. Furthermore, to this stage only one variable related to the given ability was chosen, the one best fit to their nature (highest factor load).

b) **The second stage of makers analysis**

Values of factor loads, presented in tables 7 and 8 determine the strength of the relation between the particular tests and theirs "standards". It must be clearly emphasised that the criteria of test validity of the tests were worked out individually, from among variables representing distinguished structures of abilities. Because they were the primary parameters related to mechanical values, their validity seems unquestionable.

Also their reliability was confirmed, mainly in the bio-mechanical studies. The introductory assumption, referring to limitation of variables representative for the given ability (only one) was fulfilled, too. It enables the concentration of factor loads to a limited number of tests — in our opinion only this assumption gives us the possibility of determining the relations between the markers (motor abilities) and theirs indirect tests.

In men (table. 7) Cooper Test, "1500 m — run", and "shuttle run" (Eurofit) passed the validity tests as the measures of aerobic efficiency. It should be emphasised that the presence of other abilities in these tests was minimal. It is worth noting, that the highest factor load was displayed by **Cooper Test** (both in men and in women), which confirmed results obtained by Cooper (1968), Mekota and Blahuš (1983), Sparling and Cureton (1983) and Wyndham (1971). Sufficient levels of validity were offered by "shuttle run test" developed by the Authors of Eurofit (1988), but its dependence on "relative strength" and "speed of muscles mobilisation" clearly deteriorates its application value.

From the tests measuring speed abilities (in accordance with the concept put forward by the author), "300 m — run" displayed **the highest level of validity** as

Table 7. Factor loads of particular tests in the "space of motor abilities" in men

Tests	Strenght abilities			Speed abilities			Endurance abilities	
	Absolut strenght	Relative strenght	Local strenght of upper or lower extr.	MAP	Speed of strenght develop.	Time of mm. contr.	$VO_{2\,max.}$	Muscular endurance
1500m run	0.09	0.02	0.02	0.02	0.07	0.05	0.84	0.18
Shuttle run	0.09	0.29	0.12	0.12	0.18	0.25	0.86	0.17
Cooper's Test	0.04	0.02	0.06	0.02	0.03	0.04	0.90	0.12
8-track run	0.16	0.34	0.20	0.48	0.22	0.40	0.08	0.24
„envelope" run	0.16	0.30	0.32	0.23	0.16	0.69	0.21	0.15
300m run	0.06	0.04	0.02	0.14	0.70	0.15	0.18	0.41
Pull-up on a bar	0.22	0.26	0.68	0.20	0.04	0.12	0.32	0.29
Push-ups	0.10	0.26	0.63	0.13	0.22	0.10	0.26	0.31
Sit-ups	0.12	0.19	0.27	0.48	0.32	0.26	0.17	0.29
Med. ball throw-forward	0.54	0.22	0.23	0.26	0.49	0.01	0.01	0.06
Med. ball throw-backward	0.81	0.18	0.22	0.19	0.20	0.03	0.02	0.07
St. broad jump I	0.30	0.17	0.28	0.38	0.77	0.16	0.00	0.06
St. broad jump II	0.48	0.12	0.25	0.63	-	0.17	0.03	0.10
Grip strenght	0.49	0.12	0.20	0.38	0.01	0.06	0.02	0.13

the measure of **lactacid MAP,** "envelope — shape run" – most closely connected with the **acceleration motion system and "standing broad jump" – being the measure of alactacid MAP?** "8 — shape run", which showed a great level of complexity (mingling co-ordination and energetic elements) did not meet the validity requirements.

As the tests most valid for measuring the level of absolute strength ability we can recommend "medicine ball throw backward": it displayed high factor load and simultaneously small influence of other components. "Bent arm hanging" seems to be the best indirect tests of "local strength".

The other tests displayed significant level of dispersion of factor loads between a few marker's variables, pointing to their complexity — and, at the some time, small validity. It should be emphasised that we did not find the tests fully sufficient to measure the level of relative strength and muscle resistance to tiredness.

The results obtained in the women's groups (table. 8) were similar to men's results only in the group of endurance abilities tests. "Cooper's Test" and "shuttle run" were found valid as the measure of aerobic efficiency. As far as speed abilities tests were concerned, the situation was less clear: "standing broad jump" (al. MAP) displayed a high level of validity as a measure of "speed of muscles mobilisation" as well as "8 — shape run" ("envelope" run was found to be more complex). 300 m run

Table 8. Factor loads of particular tests in the "space of motor abilities" in women

Strenght abilities				Speed abilities			Endurance abilities	
Tests	Absolut strenght	Relative strenght	Local strenght of upper or lower extr.	MAP	Speed of strenght develop.	Time of mm. contr.	$VO_{2\,max}$	Muscular endurance
800m run	0.01	0.16	0.19	0.04	0.19	0.02	0.78	0.12
Shuttle run	0.10	0.18	0.23	0.07	0.07	0.18	0.82	0.01
Cooper's test	0.07	0.08	0.23	0.07	0.08	0.09	0.86	0.13
8-track run	0.10	0.18	0.21	0.15	0.61	0.49	0.07	0.22
„envelope" run	0.21	0.28	0.26	0.31	0.21	0.57	0.14	0.29
300m run	0.29	0.42	0.07	0.21	0.52	0.12	0.35	0.34
bent hanging	0.14	0.23	0.30	0.49	0.01	0.02	0.42	0.38
Push-ups	0.14	0.15	0.37	0.41	0.17	0.24	0.37	0.39
Sit-ups	0.01	0.15	0.27	0.49	0.19	0.25	0.30	0.18
Med. ball throw-forward	0.56	0.26	0.17	0.41	0.33	0.28	0.01	0.02
Med. ball throw-backward	0.80	0.11	0.27	0.23	0.19	0.32	0.03	0.05
St. broad jump I	0.09	0.28	0.22	0.45	0.72	0.05	0.11	0.12
St.broad jump II	0.13	0.36	0.30	0.62	-	0.10	0.23	0.23
Grip strenght	0.16	0.14	0.49	0.38	0.07	0.01	0.07	0.16

was a relatively good measure of lactacid MAP , yet it was loaded by factors of "speed of muscles mobilisation" and "aerobic power", too.

The highest rate of validity was attributed to "medicine ball throw backward" as an indirect measure of "absolute strength". We were not able to identify any valid tests measuring "relative strength" and "local strength".

The other tests showed a distinct "complex" nature, without a clear dominating factor both in structure and energetic base of movement.

Conclusions

1. The assumed three — element structure of "energetic" abilities did not find any confirmation in the results of analysis. Seven factors (abilities), relatively independent, were therefore distinguished:

- ability of developing the maximal, global strength (maximal and relative value),
- ability of developing the maximal, local strength,
- ability of developing the alactacid MAP,
- ability of developing the lactacid MAP,
- ability of fast muscles mobilisation,
- ability of maximal oxygen uptake $VO_{2\,max.}$,
- ability of muscle resistance to tiredness.

2. Taking into account the factors presented above, further improvement of motority classification seems to be possible.

3. The structures of structural — energetic abilities presented in this paper make up a reliable qualification system for the assessment motor fitness tests validity. Among the analysed tests, "Cooper's Test", "medicine ball throw backward", "standing broad jump", "envelope run", "bent arm hanging", "300 m run" were found have a high level of validity. They can be used as an indirect method of measuring aerobic capacity, absolute strength, al — MAP, fast muscles mobilisation, local strength and l — MAP, respectively.

4. Complexity and low values of factors loads (in the space of marker's variables) of some tests proved their small validity ("8 — shape run" in men, sit–ups, "arm push up", "bent arm hanging" — in women).

5. It seems worthwhile to continue this research work, taking into consideration a greater number of motor tests and in populations of a more differentiated motor skills.

6. In the light of results presented in this work we can suggest a possibility of measuring the "potential side" of motority (abilities) by way of motor fitness tests (indirect methods), but under condition of its validity.

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