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ENDURANCE FITNESS AND PERSISTENCE FITNESS. GENETIC CONTROL AND TRAINING POSSIBILITIES

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The results indicate that endurance fitness is more susceptible to training than persistence. The latter is the more difficult to train, as more numerous muscle groups are concerned and the motor actions involved are more dynamic.

1. PROBLEM

The aspects of motorics in man have been the subject of discussion for more than half a century. International commissions founded at Olympic Congresses (cf. Larson and Michelman 1973) or appointed by the World Health Organization (cf. Shephard 1968) have reached certain conclusions which are neither obvious to all concerned nor consistent with each other. This indicates how difficult it is to measure objectively the different manifestations of human motorics and to set apart precisely their components. The major part of motor functions involved in various activities of life (nutrition, i.e. providing, preparation and consumption of food; employment; travelling; recreation; finding a partner and sexual intercourse; etc.) require various motor properties to be efficient. Prior to undertaking an analysis of the differences between endurance fitness and persistence fitness, it is necessary to specify their place among the overall manifestations of motorics as well as to determine their relationship to other aspects of motorics so far mentioned.

Some years ago (Wolanski 1958, 1963) I reflected on the meaning of physical fitness and suggested a definition close to that applied in physics, i.e. considering this trait as the relation between the results achieved and the subject's predisposition. This time (cf. Wolanski and Parizkova 1976) I want to add to the above concept the question whether man ought to strive for attainment of maximal fitness (to the limits of the body's possibilities) or only try to achieve optimum fitness) i.e. keeping some reserves, so as not to reach the limit entailing a risk for health and even for life). This question is, in a particular way, related to the problem of certain components of motorics; these components are the subject of the present analysis.

Considering motorics, attention has to be given to the relation of the organism to space and time. This relation is not simple. Some time ago the question arose whether time was an appriopriate measure of speed in running (Mydlarski 1932). This is only one illustration of the fact that the speed of covering a certain distance ought to be referred to e.g., the stature and/or body weight of the runner, that the style of running should also be taken into account etc. Motorics is manifestation of the function of several organs and systems of the organism, and depends on their co-operation; in particular, motorics is related to (Table 1): nervous conduction, muscle cross-section and structure, lever system, and to a great extent the functions of the senses, e.g. feeling of balance, visual control, tactile and proprioceptive sensation, chronognosis (sensation of time, especially rhythm) etc. The above traits can be expressed in terms of some definite physiological structures and functions, among which prevail the structure and functions of the muscle, with its ability to overcome resistance, movement speed, energy cost, precision of movement realization, movement range and internal and external possibilities of movement realization (duration and effects of movement).

In connection with this list the need arises for the description of the most frequently mentioned (Hebbelinck 1984) components of motorics: strength, speed, agility (it is controversial to what extent the component of co-ordination is a distinct trait), endurance and persistence. There is no agreement as to what degree agility (fitness in gross motor functions, flexibility in movement) differs from co-ordination (fitness in fine motor functions, neuro-muscular effects); distinguishing between endurance and persistence is an even more controversial question. Not all investigators feel the necessity for distinguishing between these components! In English dictionaries or encyclopedias these notions are defined almost identically. However, long time ago some components of motorics have been distinguished intuitively. Most often these two have been referred to as „endurance", with addition of the terms: „muscular" or „circulatory" (cf. Clarke 1959, p. 222). According to this approach, muscular endurance is defined as „ability to continue muscular exertion of submaximal magnitude; Example: chinning". Circulatory endurance is interpreted as „moderate contractions of large muscle groups for relatively long periods of time, which require an adjustment of the circulatory and respiratory system to the activity; Example: distance running or swimming". Several years later, the same author has extended these definitions by stating that: „muscular endurance"... „is the lasting power of a single muscle or group of muscles", and „circulatory-respiratory endurance — involves the continuous activity of the entire organism, during which major adjustments of the circulatory and respiratory systems are necessary" (Clarke and Clarke 1963, p. 116). In more recent papers distinction is made between „cardiorespiratory or general endurance" with a division into aerobic and anaerobic endurance which enables dynamic work, and „local muscular endurance" which leads to exhaustion (Hebbelinck 1984). In my opinion, these components can be distinguished very clearly. The former (for which I propose the term „endurance fitness") is related to working capacity, dynamics and amount of work, and rather concerns aerobic „power" (oxygen debt); the latter (which I propose to refer to as „persistence fitness") is related to the causes of fatigue and to duration of work, and it rather concerns anaerobic „power" (availability and utilization of nutrient reserves in the active tissues). Their distinction can most generally be argued by considering the energy cost of work (endurance) and the possibility of its continuation (persistence). Doubtless, the energy cost influences the possibility of work continuation, but viewing through the reserve exhaustion and/or production of metabolites and energy. However, the fatique associated with production of metabolites in muscles is related to energy cost (aerobic) to not a greater extent than the effect of strength or speed manifestation, attained in the course of body displacement. Yet, there is no tendency for identification of working capacity and energy cost of work performed, on the one hand, with muscular strength and/or speed of movements on the other.

Thus, in my opinion, (cardiorespiratory) *endurance* ought to be interpreted as a physical manifestation of motorics, expressed by muscle ability (determined by the overall state of the organism) to perform movements of considerable intensity (over 60% of maximal – voluntary intensity), lasting at least 60 sec, with full efficiency, i.e. without signs of its decrease. Persistence (= „muscular endurance") expresses tissue tolerance to work-induced changes, including the concentration of lactic and non-lactic acid metabolites. Thus, it is the tissue adaptive capacity of prolonged realization of work. This is how I defined these notions some years ago (Wolanski and Parizkova 1976).

In my opinion, factor analysis applied in the past 2 decades aiming at learning more about the „structure of physical fitness" (Fleishman 1964, Mekota 1966, 1978) demonstrates that both above-described traits (endurance represented by the pulse frequency increase and step-test, as distinguished from persistence represented by the „hanging in arm-flexed position" test – Zara 1970) are uncorrelated latent factors, in the same way as strength is not correlated with speed or with agility of movements (Matsuura 1980, Reilly and Thomas 1980).

In this connection, endurance fitness and persistence fitness will be considered in the present paper consistently with the above explanation. Endurance fitness will be represented by the increase in the pulse rate at work and by maximal oxygen uptake (MOU, max V_{0_2}), and persistence fitness by the hanging in arm-flexed position test (per time), Knaus-Weber muscular test and Burpee squat-thrust test.

In my opinion, in the future these two groups of evidently „physical" tests ought to be extended with tests for „neuropsychical endurance" measuring psychical fatigue (psychic resistance) as distinguished from biological fatigue (physical resistance = persistence). Since motivation is an important element of the motor effects (work, sport), this component of motorics should also be measured.

2. MATERIAL AND METHODS

The results presented in this study are the result of several sets of examinations, performed between 1960–1967 in Polish villages of the Suwalki and Kurpie districts, between 1971–72 in Polish settlements in low mountains and in villages situated close to an industrial region, between 1973–74 in a Yugoslavian mountain town (Cetinje), industrial town (Ivangrad) and seaside towns (Kotor and Bar), and between 1975–77 in a highly industrialized Polish area (Silesia). In these studies the maximal oxygen intake was evaluated by step-test in 2736 subjects, 14–85 years of age, and also in 183 families where parents and offsprings were examined, in Polish rural areas only.

Another group of examinations, performed in Poland between 1976–77, involved 1819 subjects aged from 5 to over 85 years. These studies were carried out in a highly urbanized area (Lodz – a big industrial city), in a densely populated region of highly developed heavy and mining industries (Silesian Coal Basin – towns of Strzemieszyce, Slawkow, Bukowno and Olkusz), in a slightly industrialized region (Belchatow Industrial Region – BOP), in villages with experimental coal mines (Lublin Coal Basin – LZW), and in a agricultural region (Suwalki district). In each case, the whole population of a given age or families, determined as a random sample were examined.

The methods of assessment used were reported in publications describing other traits in the investigated population and properties of the geographic regions studied as well (Wolanski and Pyzuk 1973, Wolanski 1975, Pawlak and Sarna 1982, Wolanski and Siniarska 1982, Ivanović, Wolanski and Szemik 1984).

The population of Montenegro (Yugoslavia) represented a higher income level and better nutritional state, as compared with the Polish populations (Ivanović and Wolanski 1974). Among the populations studied, people from the Pieniny and Bieszczady regions endured the greatest manual work load, and those from the vicinity of the Katowice steelworks (Silesian Coal Basin) endured a smaller work load, while the Montenegro population had the smallest manual work load. The inhabitants of the village of Wronow represented a specific case, being employed both at the Nitrogen Works and on their own farms, and thus seemed greatly overworked, especially in summer.

The cardiac function of the population of Pieniny, Kurpie and Wronow was evaluated by taking the pulse rate at work by palpation; the remaining population was examined by recording the cardiac activity on a Simplicard electrocardiograph. Maximal oxygen intake (MOU) was read from an Astrand and Ryhming (1954) nomogram, multiplied by a correction factor related to the subject's age, and expressed as BTPS. Subjects performed submaximal work, stepping on and off a 40 cm high stool at a rate of 25 ascents and 25 descents per min, for a 5-min period. The final effect (max V_{O_2}) was expressed in ml O_2 per 1 min and per 1 kg body weight.

In the Burpee squat-thrust test (BSTT) performance lasted 1 min in a four-motion cycle: normal erect posture, with arms stretched out and hands clapping once over the head; squat with front support; front prop up, with backward thrust of legs; squat with front support; return to starting position, with hands clapping once over the head. The number of cycles per 1 min was counted accurately to 1/4 of a cycle.

In the test of hanging in arm-flexed position (HAFP) the subject maintained a flat sitting position under a bar situated at the level of his chin. With arms flexed, the subject reached the bar so as to touch it with his chest, whereupon he straightened his body forward to form one line. Thus, he maintained his body weight on flexed upper extremities, with support on heels only. The duration of time elapsed between maintaining the described position and dropping from the bar was measured accurately to 1 sec.

The Kraus-Weber muscular test of the psoas and abdominal muscles (KWAT) was carried out in the dorsal position on a hard mattress. The subject put his hands on thighs, lifted his legs – with knees set straight – by about 15 cm over the mattress and tried to keep this position as long as possible; the time was measured exact to 0.1 sec.

The heritability of endurance and persistence applying above described tests was calculated in two ways: applying Fisher's formula (1918):

$$H = \frac{2r_{pp}}{1 + r_{pp}}$$

and applying our own formula (Wolanski and Siniarska 1977, Wolanski 1984):

$$Her = \frac{1}{\frac{3r_{ss} - r_{po}}{r_{po}}}$$

where: r_{po} = parents-offspring correlation coefficient,
r_{pp} = father-mother correlation coefficient,
r_{ss} = sib-sib correlation coefficient.

The heritability thus calculated seems to express the intensity of genetic control of the development of the investigated traits; the value occuring in the denominator of the formula for Her is a measure of the trait's eco-sensitivity (Eco), in our case, of the trait's susceptibility to training.

3. RESULTS

3.1. Heritability of endurance and persistence

The results of the tests applied, as compared with the results obtained for other traits determined in the present Polish materials (Pawlak and Sarna 1982, Wolanski and Siniarska 1982), are recorded in Table 2.

The similarities in endurance and persistence fitness between parents and offspring are quite different, despite dealing with a large number of subjects and application of age- and sex-independent T-scores. The coefficients of correlation are, as compared with other traits, medium for KWAT and BSTT, less than medium for the pulse rate at work and HAFP, and very low for MOU (Fig. 1). A higher correlation is obtained for speed of movement, and an intermediate one for strength and reaction time.

The similarity in endurance and persistence fitness between siblings, as compared with other traits, is medium for HAFP and KWAT, and for endurance (pulse rate at work), and low for BSTT (Fig. 2). A correlation lower than that for BSTT is obtained only for the feeling of balance and movement accuracy. A correlation exceeding that for HAFP, KWAT and pulse rate at work, is obtained for movement speed and grip strength.

The heritability of endurance and persistence fitness, determined by Fisher's and our own method, is – as compared with that of other motor traits – different depending on the test used. Heritability evaluated by both methods is of similar low value for endurance (pulse rate at work) and HAFT; a lower one is obtained only for grip strength. Heritability assessed by both methods is medium for KWAT. For the Burpee test (Fig. 3), it is high according to our own method, and less than medium, when evaluated by Fisher's method. Consequently, the susceptibility of endurance and persistence fitness to training is also different. When measured by the value of Eco (Table 2), training susceptibility – as compared with that of other traits – is low for persistence evaluated by the Burpee test, less than medium for persistence assessed by KWAT, and medium for endurance (puls rate at work) and persistence evaluated by HAFP (Fig. 4).

Therefore, the heritability of persistence measured by static tests (HAFP and KWAT) is similar to the heritability of endurance and muscular strength, whereas persistence evaluated by the dynamic Burpee test is higly inheritable similar to speed of movements. Thus the results of genetic studies suggest that endurance and persistence are not clearly set apart with respect to heritability, while they may largely differ in dependence on the muscle groups and nature of movement, involved in a given test.

3.2. Development in ontogenesis and interpopulational differentiation

Endurance measured by MOU increases with age to about 20–25 years (with big inter-populational variation), whereupon it shows a regression (Fig. 5). In the period of peak development of MOU, the endurance is the lowest in populations of greatly industrialized Silesia and highest in the inhabitants of Swedish cities and in the primitive tribe Masai (Sudan) — (di Prampero and Cerretelli 1969, Shephard 1969); at older age (over 50 years), it is the highest in rural population and mountain raftsmen, and the lowest in populations of highly industrialized countries (Wolanski 1980, Shephard 1969). The regression rate of MOU is also different in agreement with the rule stating that the earlier the occurence of the peak value of a trait's development, the more rapid the subsequent regression (Wolanski 1973, 1984).

Persistence measured by the Burpee test (BSTT) rises with age till the pubertal period, in girls from different populations until about 11 (Lodz) to 14 (Belchatow Industrial Region) years of age, and in boys until about 13 (Strzemieszyce) to 18 (Lodz) years of age (Fig. 6). The period of peak development is followed by a regression being most rapid in women from the Belchatow Industrial Region and men from Bukowno, and the slowest in inhabitants of both sexes in the Lublin Coal Basin. At about 45 years of age, the persistence once again reaches the level characteristic of 5 year old children.

The age-dependent changes in the results of the test in hanging in arm flexed position (HAFP) and of the test for abdominal muscles (KWAT) are less clear-cut. This is probably due to the fact that in this case the weight of child's body is changed; yet, the relation of muscle cross-section area and also strength of lever system between various body parts and body weight varies in the course of ontogenesis. Thus, in general, particularly in girls and mainly in tests of abdominal muscles, the persistence increases in the pre-school period, drops in the pubertal period, once more rises during adolescence and again diminishes in adulthood, particularly at old age.

Persistence evaluated by HAFP increases till the pre-pubertal period, and after a temporary drop it once again rises until adolescence (Fig. 7). The peak of development is attained earliest by women from Lodz and Bukowno (at about 16 years of age) and men from Slawkow (at about 15 years), and latest by women from Olkusz and Belchatow Industrial Region (at about 20 years) and men from Lodz and Suwalki district (after 20 years). The regression is most rapid in women from the Belchatow Industrial Region and Bukowno and in men from Lodz and Olkusz, whereas it is slowest in women from Olkusz and inhabitants of the Suwalki district of both sexes. Old women exhibit persistence typical of 7 years old girls, and old men typical of 12 years old boys.

Persistence measured by KWAT drops with age till the pubertal period and then increases. The peak value is attained earliest (at about 15 years of age) by women from Lodz and men from the Belchatow Industrial Region, and latest (after 50 years of age) by women from Bukowno and men from the Belchatow Industrial Region and Lodz (Fig. 7). The regression of this trait after the developmental peak is most rapid in women from Lodz and men from Strzemieszyce, whereas it is slowest in women from Bukowno and men from the Lublin Coal Basin. A value of the test typical of 5 years old children is attained for the second time at about 20 years of age and for the third time after 80 years of age, with big inter-populational differences in the dynamics of the progressive and regressive changes.

As compared with other traits investigated in the same materials, the endurance measured by MOU exhibits a peak value during asolescence, while persistence evaluated by the above-mentioned tests displays this peak value from puberty till adolescence; for movement accuracy and flexibility, the analogous period is earlier (Fig. 8). As compared with persistence, other traits: aim accuracy, movement speed of hands, static strength of muscles and endurance fitness (MOU), display a later peak of development.

Persistence evaluated by the above-mentioned tests is highest in the inhabitants of industrialized regions and lowest in rural populations (Table 3), probably on account of the nature of work and mode of life of these population groups. Urban population assumes an intermediate place between both above mentioned populations. The endurance is highest in urban populations and lowest in inhabitants of industrial regions.

4. DISCUSSION

In the present study it is of importance to specify whether the traits evaluated by a certain group of tests measuring „cardiorespiratory and muscular endurance" only represent distinct tests assessing the same component of human motorics or whether in fact they are different. In my opinion endurance fitness is only one of the several manifestations of motor activity in man. It exhibits a low correlation with some traits, e.g. with duration of short- and medium-distance races (100—1000 m), and a high one with other traits, e.g. with duration of 60—m dash. (Wolanski, Kozlowski and Firsowicz 1973).

There is a strong correlation between the duration of 10—50 m dash, on the one hand, and static persistence (HAFP — stronger correlation) and dynamic persistence (BSTT — weaker correlation) on the other. Persistence fitness is also strongly corre lated with the duration of shuttle run and with explosive power, but not with grip strength (Fleishman 1964, Brudzynski 1985).

The above-mentioned factor analysis affords important information about the different components of motorics (Table 4). Obviously, the results depend on the tests analysed. However, it can generally be stated that the first principal component (F 1) is formed by body size and weight, and to some extent by muscular strength as well. The second principal component (F 2) is formed by adipose tissue and/or static strength, the third principal component — by endurance fitness and overall physical fitness, the fourth principal component — by persistence, the fifth principal component — by agility, and the sixth principal component — by speed of movements. In our opinion it is of importance that the tests representing the cardiorespiratory system and energy changes, i.e. endurance fitness, form a separate principal component (latent factor), not correlated with that formed by the tests concerning long-term static efforts, i.e. persistence fitness.

An analysis of the age at the peak value of development of the traits measured by various tests also indicates that the developmental peak is attained earliest by persistence measured by the dynamic Burpee test, and later by the static tests of persistence (HAFP and KWAT). The peak of development is reached by MOU the latest, being most representative of endurance fitness.

Only heritability sets apart the dynamic test for persistence (Burpee squat-thrust test), and endurance measured by an increase in the pulse rate at work and persistence evaluated in hanging position (HAFP).

In the light of the present results it seems obvious that within physical fitness two traits have to be distinguishes. One of them reflects the cardiorespiratory properties and expresses the energy changes; I propose to refer to this trait as endurance. The other trait corresponds to the possibilities of work continuation and expresses tissue tolerance to the metabolites formed during work; I propose to refer only to this trait as persistence fitness. Factor analysis indicates that these two components of motorics are evidently distinct from strength (particularly the static one), agility and speed of movements. It seems that the traits listed in order of decreasing importance for physical fitness of the body assume the following sequence: body weight and static muscular strength; endurance fitness and explosive power; persistence fitness; agility; speed of movements.

The present results indicate that endurance fitness is more susceptible to training than persistence. The latter is the more difficult to train, as more numerous muscle groups are concerned and the motor actions involved are more dynamic.

References

1. Astrand P.O., Rhyming J. 1954. Nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during sub-maximal work J. Appl. Physiology 7:218–221
2. Brudzynski T. 1985. Types of intercorrelation between various motorics components in subjects differing by sex, age and environmental conditions. Progress Report, Warszawa
3. Clarke H.H. 1959. Application of measurement to health and physical education. Prentice-Hall Inc., Englewood Cliffs. N.J.
4. Clarke H.H., Clarke D.H. 1963. Developmental and applied physical education, Prentice-Hall Inc., Engewood Cliffs, N.J.
5. Elzanowska D., Siniarska A. 1982. Physical fitness of populations from areas under various degree of industrialization. In „Ecology of human populations", ed. by N. Wolanski and A. Siniarska, p. 667–705, Ossolineum, Wroclaw
6. Fisher R.A. 1918. The correlation between relatives on the supposition of Mendelian inheritance. Trans. royal Society (Edinborough), 52:399–433
7. Fleishman E.A. 1964. The structure and measure of physical fitness. Prentice Hall, Englewood Cliffs, N.J.
8. Hebbelinck M. 1984. The concept of health related to physical fitness. International Journal of Physical Education 21(1):9–18
9. Ivanović B., Wolanski N. 1974. Some morphological properties in 16–80 years old inhabitants of seaside and mountain areas in Poland and Yugoslavia. Glasnik Druzstva za Nauku i Umjetnost Crne Gore, Titograd 1(1):189–208
10. Ivanović B., Wolanski N., Koziol R. 1984. Respiratory and cardiovascular traits of some mountaineous and seaside populations in Montenegro, Studies in Human Ecology 6:179–199
11. Larson L.A., Michelman H. 1973. International guide to fitness and health. Çrown Publishers Inc., New York
12. Matsuura Y. 1980. Multivariate assessment of physical fitness. In: Kinanthropometry II:161–175, University Park Press, Baltimore
13. Mekota K. 1978. Strukturnoje issledovanije w antropomotorike w Czechoslovakii do 1975 goda. In „Voprosy Antropomotoriki w fiziczeskom vospitanii i sportie": 85–118, Karlov Universitet, Praha
14. Mydlarski J. 1932. Czy czas jest odpowiednia miara sprawnosci w biegu. Wychowanie Fizyczne, 13:36–41
15. Pawlak K. Sarna J. 1982. Instruction for research of human psychomotorics in main project 10.2. In „Ecology of human populations", ed. by N. Wolanski and A. Siniarska, p. 707–719. Ossolineum, Wroclaw
16. Prampero di P.E., Cerretelli P. 1969. Maximal muscular power (aerobic and anaerobic) in African natives. Ergonomics 12:51–59
17. Reilly T., Thomas V. 1980. The stability of fitness factors over a season of professional soccer as indicated by serial factor analysis. In „Kinanthropometry II": 247–257, University Park Press, Baltimore
18. Shephard R.J. at al. 1968. Standardization of submaximal exercise tests. Bull. World Health Organization 38:765–775
19. Shephard R.J. 1969. Endurance fitness. University of Toronto Press, Toronto
20. Wolanski N. 1958. Connected with measure of movement fitness. Kultura Fizyczna 8:593–596
21. Wolanski N., 1964. The multiaspect method of comparative research on motor development of children and adults. FIEP-Bulletin, 34(1–2):33–41
22. Wolanski 1973. Rate of involutional changes in the Polish rural populations. Studies in Human Ecology, 1:163–166
23. Wolanski N., 1975. Methods of control and standard values of development of children and youth. Polish medical Publ. House, Warszawa
24. Wolanski N. 1975. Physical fitness, its development and regression in the light of genetic and ecological studies. Zeszyty Naukowe AWF we Wroclawiu, 18:21–46
25. Wolanski N., 1980. Genetic and ecological components in the development of endurance fitness. In „Kinanthropometry II"; 88–103, University Park Press, Baltimore
26. Wolanski N. 1984. Further studies on the rate of involutional changes in Man. Studies in Human Ecology, 6:245–256
27. Wolanski N., Ivanović B., Szemik M. 1984. Secular changes in the populations of Kotor and Cetinje during the past 80 years. Studies in Human Ecology 6:101–126
28. Wolanski N., Kozlowski S., Firsowicz M. 1973. Adaptative changes in some somatic and physiological traits of soldiers during one year of military service. Wychowanie Fizyczne i Sport 2:33–55

29. Wolanski N., Parizkova J. 1976. Physical fitness and human development. Sport i Turystyka, Warszawa
30. Wolanski N., Pyzuk M. (eds) 1973. Studies in Human Ecology, vol. 1, Polish Scientific Publishing House, Warszawa
31. Wolanski N., Siniarska A. 1977. Genetische bedingungen der Menschlichen motorische Entwicklung. In „Motorische Entwicklung", 275–302, Technische Hohschule, Darmstadt
32. Wolanski N., Siniarska A. (eds) 1982. Ecology of human populations. Ossolineum, Wroclaw
33. Zara J. 1970 – after Mekota 1978.

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Table 1

Nominal traits of the organism with a potential effect on the motor properties, and expected „predetermination" of the components of motorics in man

Nominal traits of organism	Component of motorics
Nerve impulse conduction	speed
Cross-section and type of muscle	strength, speed, agility
Lever transposition	strength, agility
Aerobic and anaerobic power	endurance
State of vestibular organ	agility
State of visual organ	agility, co-ordination
State of taction (inc. proprioceptive) organ	co-ordination, agility, speed
Chronognosis (feeling of time, rhythm	co-ordination, agility
Continued work capacity	persistence

Nominal properties of muscle	Component of motorics
Overcoming resistance	strength
Contraction rate	speed
Precision of movement	co-ordination, agility
Range of movement	agility
Energy cost of movement	endurance
Possibility of movement realization in time	persistence

Table 2.

Correlation coefficients of somatic and psychomotor traits in combinations: parents – offspring (r_{po}), sib-sib (r_{ss}), husband-wife (r_{pp}), heritability index H (Fisher), ecosensitivity (Eco) and heritability (Her) estimated by an own method. Correlation coefficients significant at level 0,05*, and 0,01**

Trait	r_{po}	r_{ss}	rpp	H	$3r_{ss}-r_{po}$	Eco	Her
Grip strength							
right hand	0,15**	0,30**	0,06	0,28	0,75	5,00	0,20
left hand	0,13**	0,27**	0,08	0,24	0,68	5,23	0,19
Back lift strength	0,28**	0,23**	0,22**	0,46	0,41	1,46	0,68
Explosive power of upper extrem. (med. ball throw)	0,17**	0,16**	0,13**	0,30	0,31	1,82	0,55
lower extrem. (vertical jump)	0,20**	0,23**	0,15**	0,35	0,49	2,45	0,41
Simple reaction time							
hand	0,17**	0,18**	0,16**	0,29	0,37	2,18	0,46
foot	0,16**	0,17**	0,16**	0,28	0,35	2,19	0,46
Movement speed							
right hand	0,34**	0,33**	0,33**	0,53//	0,65	1,91	0,52
left hand	0,36**	0,30**	0,35**	0,54	0,54	1,50	0,67
feet (max.)	0,45**	0,46**	0,59**	0,57	0,93	2,07	0,48
feet (cycling)	0,39**	0,28**	0,36**	0,57	0,45	1,15	0,87
Persistence (hanging in arm flexed pos.)	0,17**	0,25**	0,15*	0,30	0,58	3,41	0,29
Abdomen muscles (persis.)	0,26**	0,25**	0,15**	0,45	0,49	1,88	0,53
Persistence (Burpee test)	0,23**	0,17*	0,31**	0,35	0,28	1,22	0,82
Endurance (pulse increase under work)	0,18	0,25	0,26	0,29	0,57	3,16	0,32
Endurance (max V_{O_2})	0,12	–	–0,22	0,20	–	–	–

Table 3.
Maximal (best = max), average (a) and minimal (worst = min) values of some psychomotor traits in 5 populations recognized as rural, urban and industrial in Poland

Trait	Rural	Urban	Industrial
Agility and co-ordination			
Spine flexibility	min	min	max
Turning balance	a	min	max
Standing balance	min	a	max
Hand movement accuracy (proprioceptive feel)	min	max	max
Space orientation	min	—	max
Throw at a target for accuracy	a	max	min
Agility run (shuttle run)	max	min	a
Strength and power			
Grip strength	max	min	a
Back-lift strength	max	—	min
Upper extremity explosive power (ball throw)	a	min	max
Lower extremity explosive power (vert. jump)	min	a	max
Speed			
Simple reaction time of hands and feet	max	a	min
Hand movement speed	max	a	min
Legs movement speed	min	a	max
Persistence fitness			
Burpee squat thrust test	min	a	max
Abdomen muscles persistence	min	a	max
Hanging in arm flexed position	min	a	max
Endurance fitness			
Maximal oxygen uptake (aerobic power)	a	max	min

Table 4.
Principal components (latent factors) identified by various authors using different tests connected with human physical fitness and/or psychomotor efficiency. Principal components according to Krapkova 1973, Žara 1970 and Havliček 1972 after Mekota 1978.

Author and tests used	F 1	F 2	F 3	F 4	F 5	F 6
Fleishman 1964, strength	static persist.	static streng.	agility + speed	dynamic persist.	dynamic persist.	
Fleishman 1964, agility etc	agility	balance	speed	balance	flexib.	speed
Žara 1970 general	body w. + VC	grip streng.	explos. power	persistence	endurance	speed
Havliček 1972 general	agility	body w.	explos.	persistence	flexib.	speed
Krapkova 1973, artis. gimnastics	flexibil.	flexib.	streng. + flexib.	streng. + coordin.		
Mekota 1975, track and field	throw	jump	run			
Matsuura 1980 general	body w. + statura	adipose tissue	static streng. + VC	persistence	agility	flexib.
Reilly and Thomas 1980, general	body w. + streng.	adip. tis. + VC	endurance	streng. low extr.	explos. power	agility
Brudzynski 1985, general	body w. + streng.	agility	persistence	speed		
MOST FREQUENT SEQUENCY (and important for motorics in man?)	muscle mass	static streng. + adipose tissue	endurance (+ general) fitness	persistence fitness	agility	speed

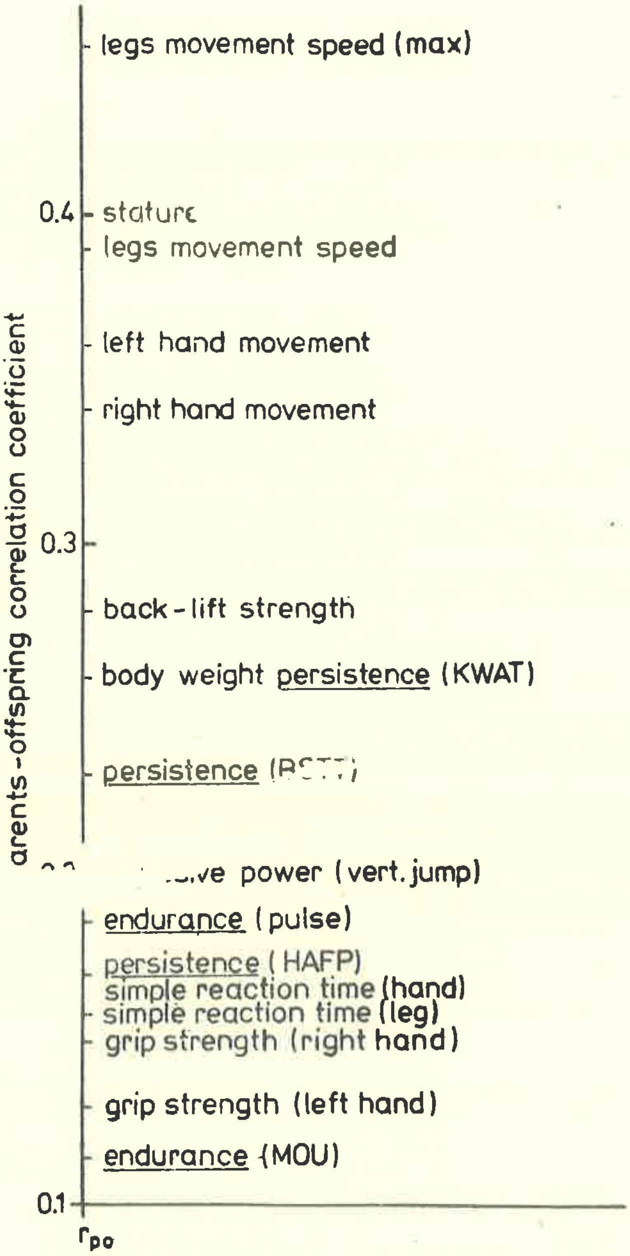


Fig. 1. Parents-child mean correlation coefficients for endurance and persistence fitness, and for numerous other motor traits in Man

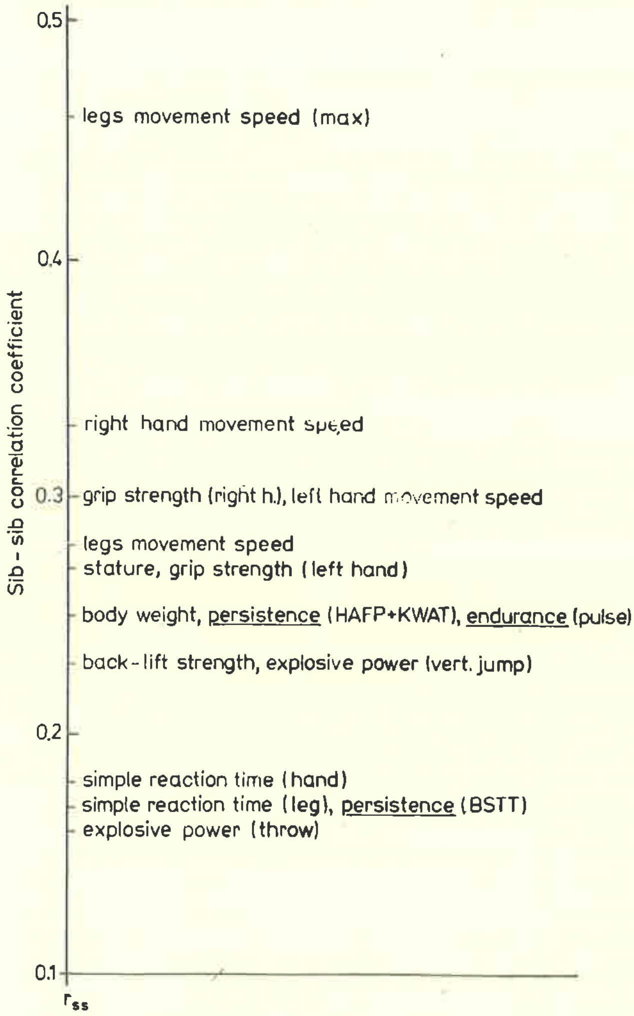


Fig. 2. Sib-sib mean correlation coefficients for endurance and persistence fitness, and for numerous other motor traits in Man

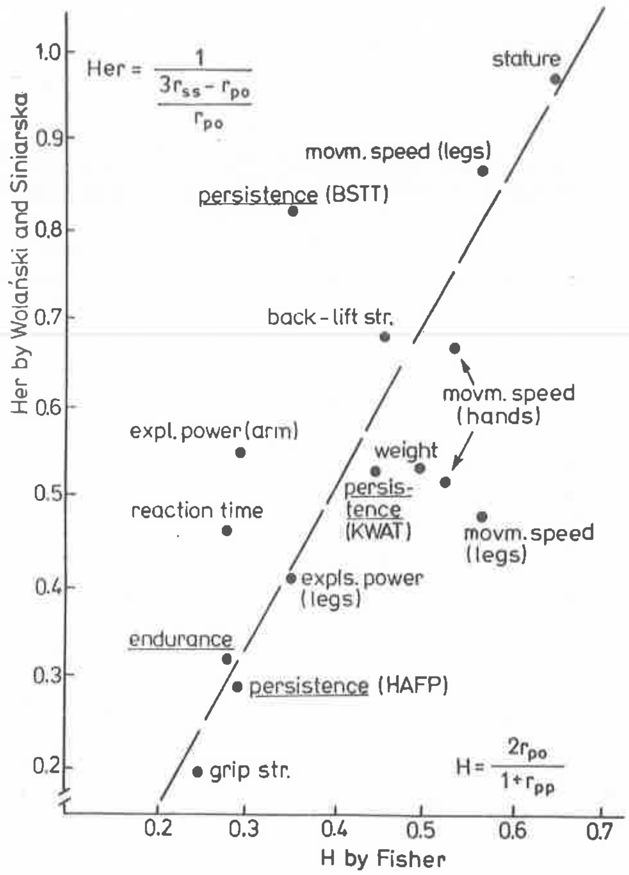


Fig. 3. *Heritability index as calculated by Fisher (1918) method (H) and by Wolanski and Siniarska (1984) method (Her) for endurance and persistence fitness and for some other motor and somatic traits in Man*

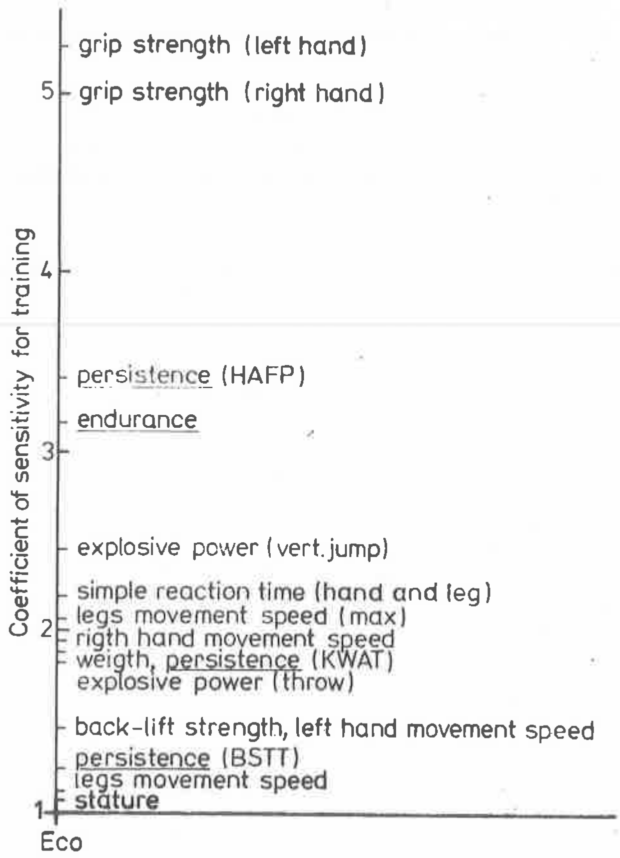


Fig. 4. *Ecosensitivity index (Eco) as calculated by Wolanski and Siniarska (1984) method for endurance and persistence fitness anf for some other motor traits in Man*

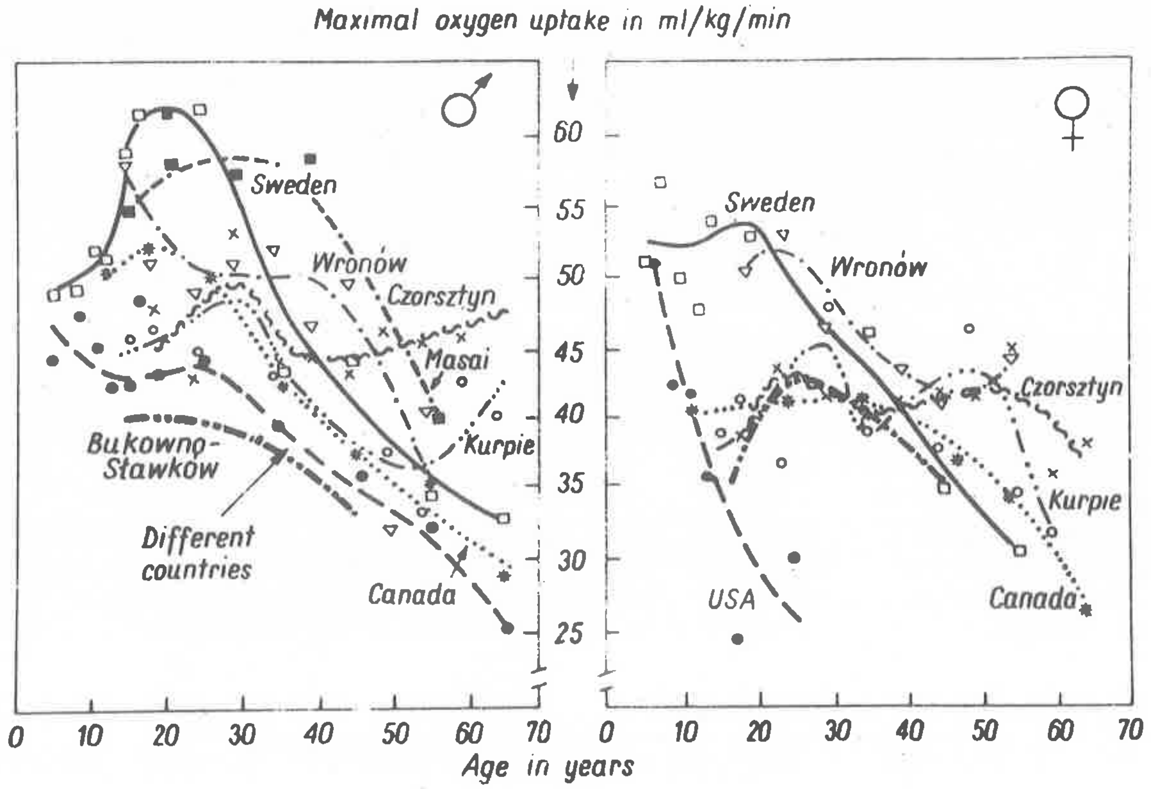
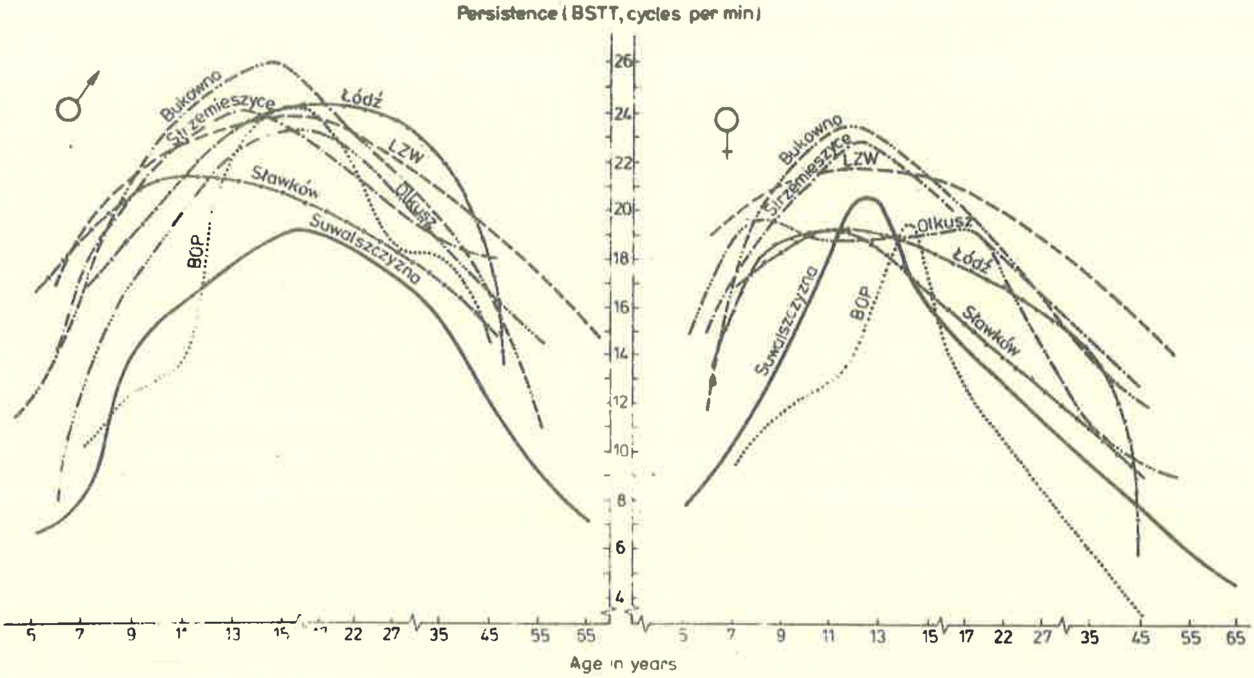


Fig. 5. Maximal oxygen uptake (MOU) per 1 minute and per 1 kg of body weight in some Polish and Yugoslavian populations with comparison with Sweden, Canadian, USA and Masai populations (data by Ivanović, Wolanski and Koziol 1984, Wolanski 1975, di Prampero and Cerretelli 1969, Shephard 1969) in age 5 to 70 years in mililiters of O_2 in BTPS

Fig. 6. Burpee squat-thrust test (BSTT) in cycles per 1 minute in numerous of Polish rural, under industrialization, industrialized and urban populations in age 5–65 years (by Elzanowska and Siniarska 1982)



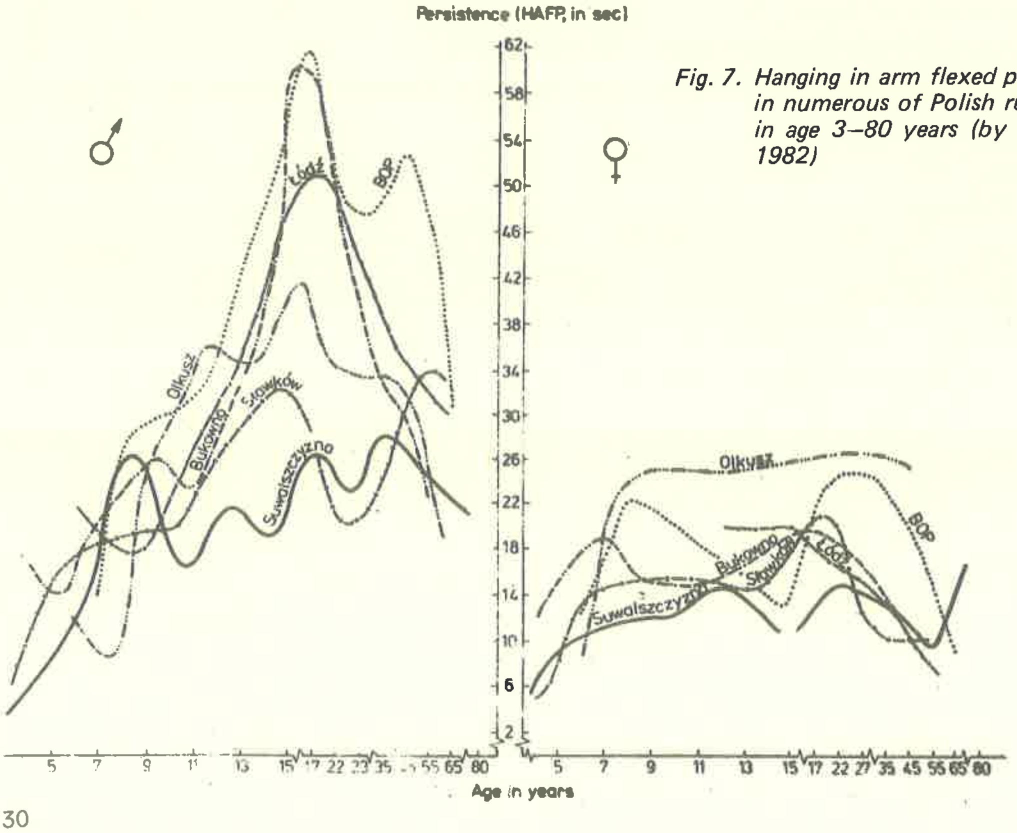


Fig. 7. Hanging in arm flexed position (HAFP) in seconds in numerous of Polish rural and other populations in age 3–80 years (by Elzanowska and Siniarska 1982)

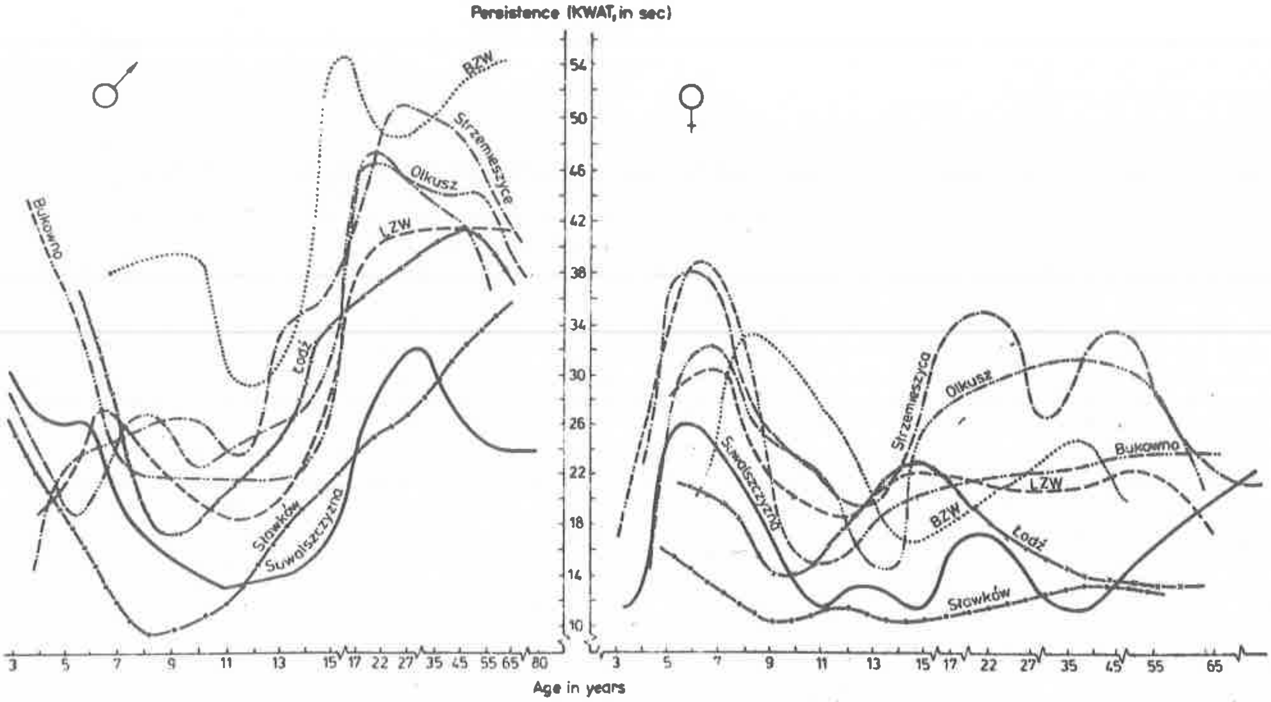


Fig. 8. Kraus-Weber muscular test of the psoas and abdominal muscles (KWAT) in seconds in numerous of Polish rurral and other populations in age 3–80 years (by Elzanowska and Siniarska 1982)

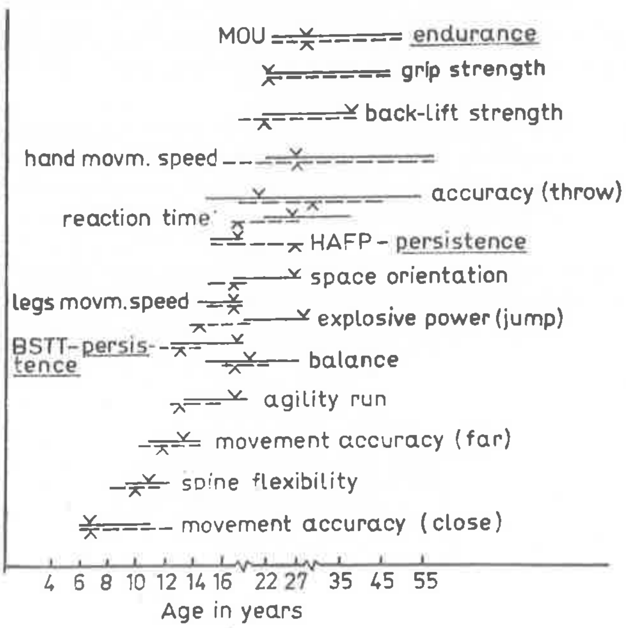


Fig. 9. Age at maximal (peak) value and high fitness of endurance, persistence and some other motor traits in Man (solid lines in men and broken linesin women, triangle = peak value)

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IZDRŽLJIVOST I USTRAJNOST. GENETSKA KONTROLA I MOGUĆNOST TRENIRANJA (VJEŽBANJA)

Učinjen je pokušaj razgraničenja pojmova izdržljivost i ustrajnost. Na temelju citirane literature autor smatra da se izdržljivost odnosi na radni kapacitet, dinamiku i količinu rada, a pobliže na tzv. aerobnu „snagu" (dug kisika), dok je ustrajnost povezana s uzrocima umora i s trajanjem rada i više se odnosi na anaerobnu „snagu" (dostupnost i iskorištavanje hranjivih rezervi u aktivnim tkivima). U svrhu utvrđivanja mogućih genetskih razlika između dvije tako definirane sposobnosti uspoređeni su rezultati velikog broja istraživanja, provođenih od 1960 godine u Poljskoj i Jugoslaviji, na ispitanicima u dobi od ranog djetinjstva do kasne starosti, koji su živjeli u krajevima s veoma različitim demografskim karakteristikama. Izmjerena je bila maksimalna potrošnja kisika, Burpee test, kosi vis u zgibu, i Kraus-Weberov test snage trbušnih mišića. Heritabilnost je određena na temelju Fisherove (1918) i posebno na temelju formule Wolanskog (1984) i Siniarske i Wolanskog (1977).

U svijetlu dobijenih rezultata čini se izvan svake sumnje da je potrebno unutar fizičke spremnosti razlikovati dvije osobine. Jedna odražava kardiovaskularna svojstva i izražava energetske promjene; autor predlaže da se ta osobina imenuje kao izdržljivost. Druga odgovara mogućnostima nastavljanja rada i izražava toleranciju tkiva na metabolite proizvedene tokom rada; autor predlaže da se ta osobina nazove ustrajnošću. Razmatrani rezultati ukazuju na to da je izdržljivost znatno više podložna procesu treninga od ustrajnosti. Ustrajnot je to manje podložna procesu treninga što je više mišićnih grupa uključeno, te što su motoričke akcije više dinamičkog karaktera.

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ВЫНОСЛИВОСТЬ И НАСТОЙЧИВОСТЬ, ГЕНЕТИЧЕСКИЙ КОНТРОЛЬ И ВОЗМОЖНОСТИ ТРЕНИРОВОК (УПРАЖНЕНИЙ)

Сделана попытка разграничения понятий: выносливость и настойчивость. На основе приведенной литературы автор считает, что выносливость относится к размерам работоспособности, динамике и объему труда и, в частности, к так называемой »аэробной« силе (долг кислорода), а то время как настойчивость связана с источниками усталости и продолжительностью труда и в большей степени относится к »анаэробной« силе (возможности использования питательных резервов активных тканей). В целях определения возможных генетических различий между этими двумя способностями, проведено сравнение большого числа исследований, которые проводились в Польше и Югославии на испытуемых в возрасте от раннего детства до поздней старости, при чем испытаемые жили в очень разнообразных демографических условиях.

Проведены измерение максимального потребления кислорода, Бюрпее тест, косой вис в подтягивании и тест силы мышец живота Крауса и Вебера. Геритабильность была определена при помощи формулы Фишера (1919), а также при помощи формул Воланского (1984) и Снарской и Воланского (1977).

На основе полученных результатов можно сделать вывод, что необходимо в рамках понятия физической готовности различать две характеристики. Одна из них отражает свойства сердечнососудистой системы и изменения энергетического состояния организма; автор предлагает назвать эту характеристику выносливостью. Вторая характеристика определяет возможности продолжительности труда и представляет собой отражение размеров допуска тканей по отношению количества метаболитов, выделяемых в течение работы; автор предлагает назвать эту характеристику настойчивостью. Рассматриваемые результаты указывают на то, что от характера процессов тренировок гораздо больше зависит выносливость, чем настойчивость. Чем больше групп мышец включается в работу и чем больше движение обладает динамическим характеристиками, тем менъше настойчивость зависить от особенностей процессов тренировок.