

2012

Relationships between Chosen Motor and Morphological Characteristics of Young Men and Women: Longitudinal Research

Marek Drozdowski

University School of Physical Education in Poznan, Poland Department of Anthropology and Biometry,
marekdr@wp.pl

Ewa Ziolkowska-Lajp

University School of Physical Education in Poznan, Poland Department of Anthropology and Biometry

Follow this and additional works at: <https://www.balticsportscience.com/journal>



Part of the [Health and Physical Education Commons](#), [Sports Medicine Commons](#), [Sports Sciences Commons](#), and the [Sports Studies Commons](#)

Recommended Citation

Drozdowski M, Ziolkowska-Lajp E. Relationships between Chosen Motor and Morphological Characteristics of Young Men and Women: Longitudinal Research. *Balt J Health Phys Act.* 2012; 4(3): 155-163. doi: 10.2478/v10131-012-0016-x

This Article is brought to you for free and open access by Baltic Journal of Health and Physical Activity. It has been accepted for inclusion in Baltic Journal of Health and Physical Activity by an authorized editor of Baltic Journal of Health and Physical Activity.

Relationships between Chosen Motor and Morphological Characteristics of Young Men and Women: Longitudinal Research

Abstract

Background: Disadvantageous tendencies bound with a growing distance between the somatic development and motor condition of children and youth raise well understood anxiety, as these phenomena endanger health and fitness of future generations. The aim of this work is to verify if the above-mentioned phenomenon may be referred to youth groups for whom physical activity and motor development are important elements of everyday life. Material/Methods: Between 1983 and 2009 data on a total of 7,663 men and 7,368 women from Poznan AWF (University School of Physical Education) were collected annually at the same time each year. Information was collected on the body height and mass, and the vertical jump test. The maximum anaerobic work was calculated. Results: In both men and women there was a tendency for a negative association between body dimensions and fitness. A correlation analysis revealed a strong relationship between body height and mass, directly proportional tendencies, at $p < 0.05$ significance level, and better performance on the vertical jump test associated with higher maximum anaerobic work. Conclusions: Summing up, it is possible to suppose that along with stabilization of the economic situation of the state one should expect maintaining the progress of the secular trend in the case of somatic features; unfortunately, at the same time we will probably observe a slump in motor development.

Keywords

secular trend, physical activity

Creative Commons License



This work is licensed under a [Creative Commons Attribution-Noncommercial-No Derivative Works 4.0 License](https://creativecommons.org/licenses/by-nc-nd/4.0/).

Relationships between Chosen Motor and Morphological Characteristics of Young Men and Women: Longitudinal Research

Authors' Contribution:

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

Marek Drozdowski (A, B, C, D, E), **Ewa Ziolkowska-Lajp** (A, B, C, D)

University School of Physical Education in Poznan, Poland
Department of Anthropology and Biometry

Key words: secular trend, physical activity

Abstract

Background: Disadvantageous tendencies bound with a growing distance between the somatic development and motor condition of children and youth raise well understood anxiety, as these phenomena endanger health and fitness of future generations. The aim of this work is to verify if the above-mentioned phenomenon may be referred to youth groups for whom physical activity and motor development are important elements of everyday life.

Material/Methods: Between 1983 and 2009 data on a total of 7,663 men and 7,368 women from Poznan AWF (University School of Physical Education) were collected annually at the same time each year. Information was collected on the body height and mass, and the vertical jump test. The maximum anaerobic work was calculated.

Results: In both men and women there was a tendency for a negative association between body dimensions and fitness. A correlation analysis revealed a strong relationship between body height and mass, directly proportional tendencies, at $p < 0.05$ significance level, and better performance on the vertical jump test associated with higher maximum anaerobic work.

Conclusions: Summing up, it is possible to suppose that along with stabilization of the economic situation of the state one should expect maintaining the progress of the secular trend in the case of somatic features; unfortunately, at the same time we will probably observe a slump in motor development.

Word count: 3,350

Tables: 2

Figures: 10

References: 19

Received: April 2012

Accepted: August 2012

Published: October 2012

Corresponding author:

Marek Drozdowski, Ph.D.
Department of Anthropology and Biometry
University School of Physical Education in Poznan
Ul. Królowej Jadwigi 27/39, 61-871 Poznan, Poland
e-mail: marekdr@wp.pl

Introduction

Young people taking up education at the academic level constitute the germ of future elites of the country. In the case of young people undertaking studies at colleges of physical education these future elites are supposed to be the model of pro-healthy and active lifestyle for the rest of society. Therefore, all worrying and negative phenomena occurring in this group should constitute an alerting signal about the possibility of copying them to the society as a whole, in particular when these changes have a long-term or even a secular character.

The secular trend is a sequence of changes in the phenotype occurring in consecutive generations, hence an interchangeable term for this phenomenon is "generation changes" and "long-term tendencies of transformations", while originally it was understood as a sequence of changes happening in the course of a century, i.e. 100 years [1, 2]. It is assumed that reversals of the secular trend are determined by changes in the economic situation and welfare of social groups on whose basis analysis is carried out and conclusions come. The direction of the trend, its dynamics and power are determined with the help of differences between mean values of the analyzed characteristics in the course of years or decades [3]. It is generally acknowledged that economic crises, wars or political transformations curb the trend, and inversely – economic development, long-term improvement in the trade boom support its hastening.

Long-term studies conducted in perspective of decades revealed a tendency for growing body dimensions with a simultaneous decline in activity and functions of younger generations. These adverse tendencies associated with an increasing gap between the somatic development and the motor condition of children and teenagers arouse understandable anxiety, as these phenomena threaten the health and the condition of future generations [4].

In Poland research on candidates for studies as well as students has been conducted in many centers of higher education and their results confirm the appearance of changes in the morphological characteristic of these groups. This research mainly concerns measurements of strongly genetically determined features (body height) and more ecosensitive features (body weight) [5]. Findings of research by Pilicz [6, 7] confirm the appearance of secular trends in other morphological features. Phenomena with a similar characterization were also substantiated in studies conducted in research centers of Gdansk [8, 9], Krakow [10], Poznan [11, 12], Warsaw [6, 7] and Wrocław [13]. In many of the above-mentioned studies attention is drawn to a reduction in the pace of the secular trend depending on the social status of families from which students came, which may have been caused by a gradual and slow process of leveling differences in incomes, particularly of lower social classes.

Concentrating further deliberations on candidates and students of physical education colleges, one should consider whether changes in the enrolment process for studies have not affected the image of changes in the trend. One should clearly underline that in successive decades requirements as for the generally understood physical fitness and condition of future students of physical education (as well as of other fields of studies at AWF – University School of Physical Education) were gradually reduced, and the "pass" criteria of entrance exams were constantly lowered. The result of such activity for many years has been to abandon fitness examinations during the process of recruitment to college by the majority of physical education universities. On the one hand, this is understandable due to competition on the market of education; on the other hand, this causes a drastic fall in the fitness level of young people, which is clearly confirmed by the results presented in this paper.

Aim of the work

The purpose of this work is to check whether it is possible to relate the above-described phenomena also to youth groups for whom physical activity and motor development constitute an element of everyday life. The paper also attempts to answer the question: what can cause a reversal in the direction of trends in the case of morphological features and its slump in the case of physical fitness tests.

Material and Methods

The material used in this study was taken from the Archives of the Department of Anthropology and Biometry of Poznan AWF. It comprises the results of anthropometric measurements and attempts in physical fitness tests of candidates for physical education studies at AWF in Poznan. Measurements of candidates at this college have been conducted for almost half a century; however, for the purposes of this study material gathered in the course of the last quarter of a century, in years 1983-2009, was used. These examinations were performed every year in the run-up period to entrance exams running in stages, and each time particular measurements were carried out by teams of employees of the Department of Anthropology and Biometry and of the Department of Gymnastics, throughout the majority of years in the same line-up and with keeping the same staff of test posts. In total 7,663 men and 7,368 women were examined.

Tab. 1. Candidates' numbers in subsequent years of research.

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
M	239	303	304	296	229	293	238	935	249	232	130	378	274	256
W	95	139	144	81	105	136	114	171	119	61	53	177	130	113
Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
M	233	220	205	321	364	457	489	490	274	190	190	114	208	
W	111	115	99	145	158	139	220	204	133	84	54	45	118	

In the study, candidates' body height and body weight and an attempt of the jumping ability measuring the dynamic power of lower limbs were analyzed (it was a test of height of the vertical jump) and a flexibility attempt measuring the range of motion in joints, determined by the depth of forward bend. Using measurements of the body and results of the vertical jump, the maximum level of anaerobic work was calculated – MAW [10, 14, 15].

In the analysis of metric features and attempts of physical fitness, arithmetic means and average standard deviation were estimated for individual series of examinations and arithmetic weighted means for the entire analyzed period of time. Shaping of the features in the time function was described graphically, and curves depicting the direction of trends were outlined with the method of polynomial approximation of appropriately selected ranks [16].

Results

Figures from 1 to 10 present tendencies of transformations of the analyzed characteristics and the MAW index in the course of years 1983-2009. Arithmetic means calculated for individual series of examinations are presented in the form of points, and then in every case a polynomial curve of an appropriately selected rank was estimated, while the straight line presents the weighted arithmetic mean.

Figures 1 and 2 present the changeability of young persons' body height. A phenomenon of regression (or of stagnation) appears in both the examined groups: in the first decade in the case of the male group, while in the group of women such a situation is noticeable in the first five years of examinations. In consecutive years one can observe a progress of the average body height of male and female candidates, all the way till 2007, when a considerable slump in the direction of the trend line takes place in the male group and a bit weaker one in the group of women. One should also pay attention to the fact that in the group of candidates, except for two series of examinations (2004 and 2006), all averages fluctuated around the long-term average, while women's mean body heights were far more dispersed around the weighted average in the course of the entire analyzed period.

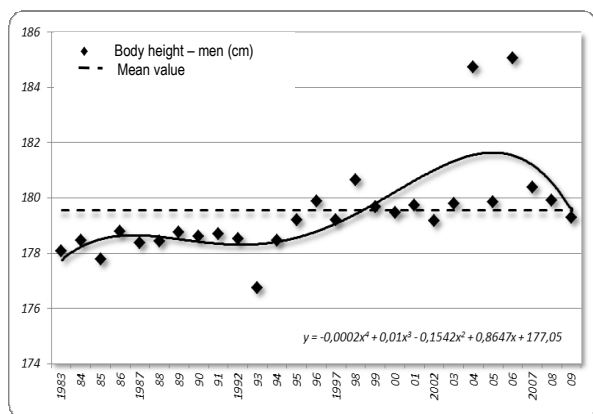


Fig. 1. Body height of the examined men

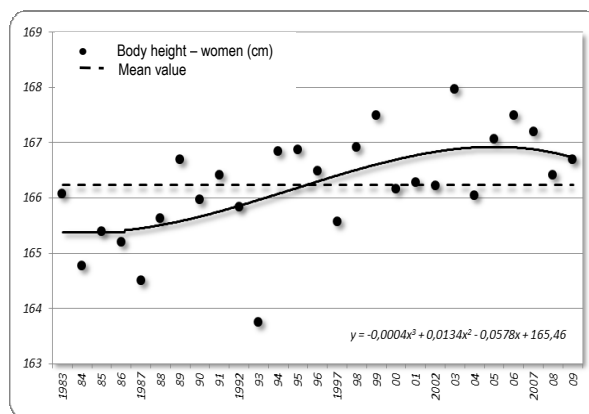


Fig. 1. Body height of the examined women

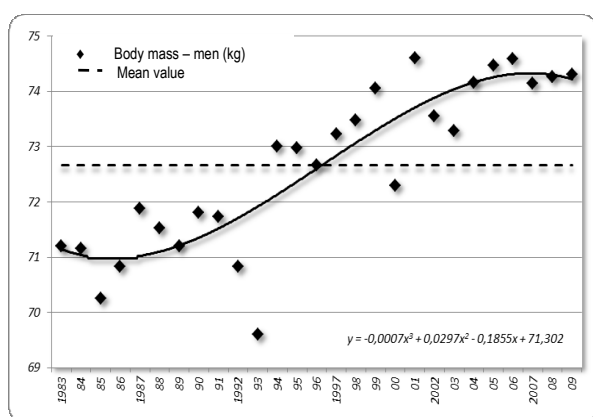


Fig. 3. Body mass of the examined men

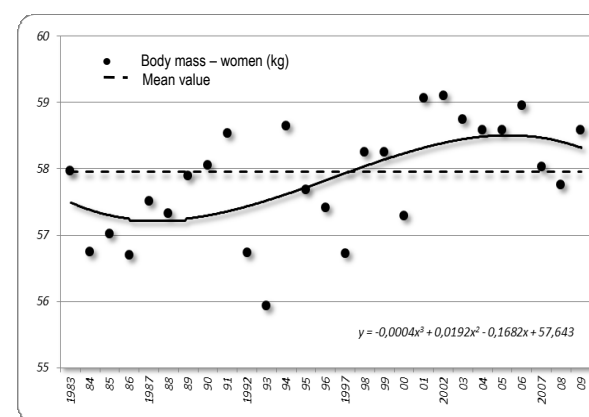


Fig. 4. Body mass of the examined women

Body weight of men and women in the course of years 1983-2009 is presented graphically in Figures 3 and 4. In both groups the course of changes of these characteristics looked alike, and both lines of polynomial trends have the same course. In the first five years one can observe a slight reduction in the average body weight, but already since the turn of years 1987/88 there is a long stretch of progress, lasting uninterruptedly in both groups till the half of the first decade of the current century. One should only pay attention to the fact that in the case of men this phenomenon took a far more dynamic form than in the group of women. A fact that polynomial curves of both teams crossed the line of the long-term average precisely in the same year (1997) is also worth attention.

In the case of physical fitness tests, the tendencies of transformations appear totally differently from anthropometric features. In Figures 5 and 6 we can see the course of changes of the first of the studied features, i.e. flexibility. In the group of candidates throughout the first five series of examinations the average range of motion in joints was at a very similar level (also at the level of the long-term average). As we can see, throughout the next decade, mean values from individual series of examinations were above the average level only to assume values below this level in the next decade. However, curves of long-standing trends (in both groups) demonstrate progress in the mobility of joints from 1983 up to the early 1990s only to slump, i.e. achieve worse test results in the depth of the forward bend, in the consecutive years and decades. Differences between groups of men and women are observed only in the last three years of examinations, when in the group of male candidates a reversal of the trend line direction takes place, while in the group of women this tendency gets deeper.

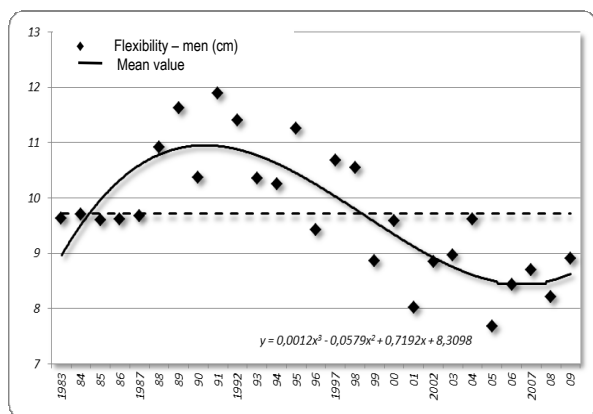


Fig. 5. Flexibility of the examined men

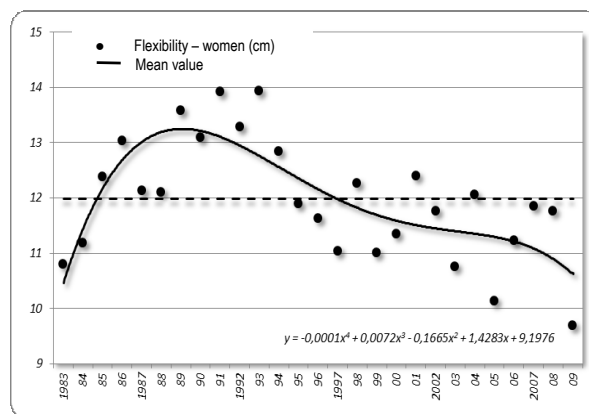


Fig. 6. Flexibility of the examined women

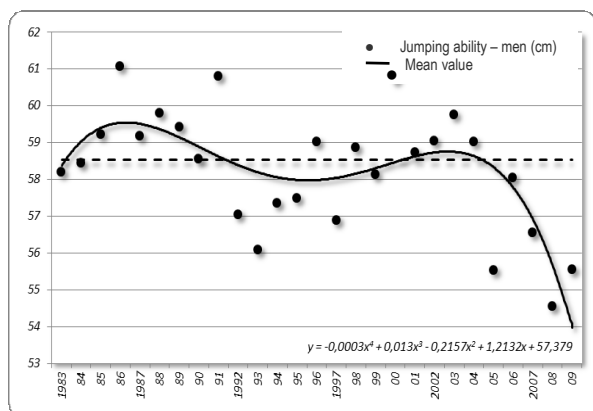


Fig. 7. Jumping ability of the examined men

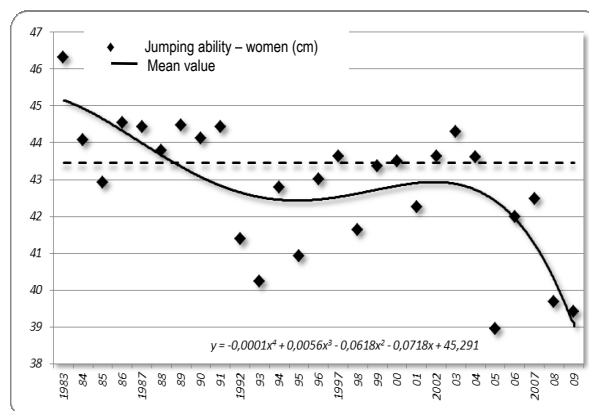


Fig. 8. Jumping ability of the examined women

Tendencies of transformations of the test measuring explosive strength of lower limbs are depicted in Figures 7 and 8. These figures show a slightly different image from the previously observed feature, and they are also more diversified for both sexes. Since the beginning of the analyzed period till the beginning of the 1990s there is a slump in the group of candidates; simultaneously, only at the beginning of this period mean values from individual series of examinations regularly placed themselves above the long-term average. After 1994 some leveling of the average height of the vertical jump takes place; unfortunately, in three out of five last series of examinations the mean values are much below the long-term average, which causes a considerable “break-down” of the trend line and a deep slump. However, female candidates for physical education studies demonstrate a slightly more stable level of the dynamic power of lower limbs throughout the entire analyzed period. The line of the trend presents alternating periods of progress and regress, which still invariably oscillate around the mean height of vertical jump for the entire period. Unfortunately, in the five last series of examinations we observe the same phenomenon as in the group of men, i.e. a significant and simultaneously very much worrying phenomenon of the breakdown of the trend.

The last figures (Fig. 9 and Fig. 10) present the level of the maximum anaerobic work, calculated on the basis of the height of vertical jump, which results in a strong correlation between both characteristics; therefore, tendencies of transformations in this case exactly reflect the described above image.

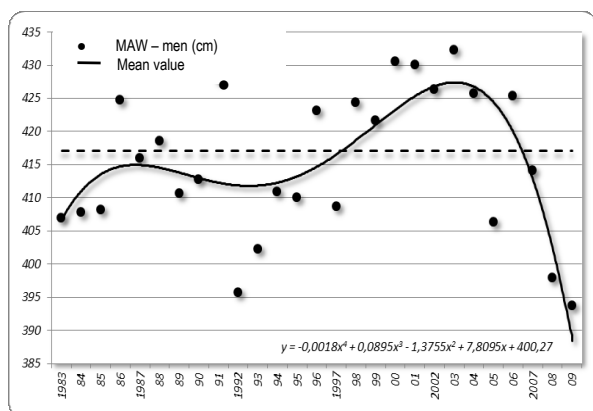


Fig. 9. Maximal anaerobic work MAW of the examined men

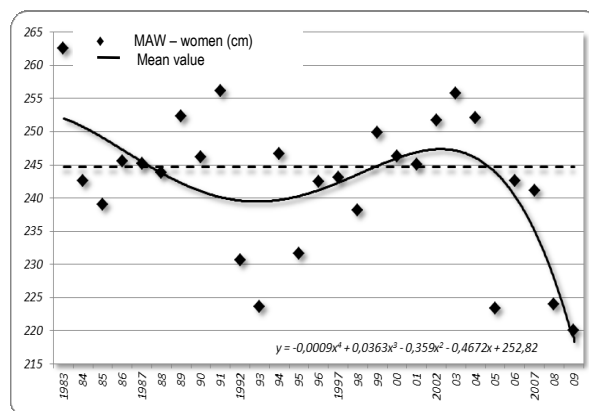


Fig. 10. Maximal anaerobic work MAW of the examined women

Also the calculated correlation coefficients between the discussed features were analyzed (Tab. 2). As we can observe at a statistically significant level ($p=0.01$), body height and body mass were interrelated in both the group of men and women. These relations had a directly proportional character and were very strong.

Tab.2. Pearson's simple correlation coefficients for the researched features

	Body height / Body mass	Jump A. / Body height	Jump A. / Body mass	Jump A. / MAW	Flexibility / Body height	Flexibility / Body mass
M	-0.670**	-0.003	-0.345	0.759**	-0.361	-0.615**
W	-0.736**	-0.139	-0.031	0.925**	-0.401*	-0.302

* $p = 0.01$ / ** $p = 0.05$

Observing the relation between the attempt of jumping ability and the body height, there is no value at the level of statistical significance; however, in all cases correlations assume negative values, which clearly shows that an increase in the two basic somatic features in these groups causes a reduction in the dynamic power of lower limbs. One should, however, point out that in the case of jumping ability and the body height within the male group and between the jumping ability and the body weight within the female group these relations are simply scarce, close to zero. However, the interdependence between the attempt of the jumping ability and the index of maximum anaerobic work is very strongly correlated in both the examined groups, also in both cases the values of the correlation coefficient were at the level of statistical significance ($p=0.01$).

In the case of relations between the flexibility test and the height of the examined men and women, one can see that in all the cases the relations were inversely proportional, that is increasing parameters of the body negatively influence the range of motion in joints. The strength of these correlations in all the cases fluctuates between an average and a strong strength of the interdependence.

Discussion

In the described analysis of test results collected in the Department of Anthropology and Biometry of Poznan AWF an attempt was made to answer a few questions, in the authors' opinion essential to describe the connections and relationships between motor development and the body composition of persons who aspire to undertake studies at a prestigious college of a sports profile as well as the causes and possible effects of such a state of affairs. These phenomena can intensify in the period of political transformation of the country as well as immediately following it even stormier transformation of lifestyle and eating habits. It is possible to suppose that in this case the transformation will particularly concern the generations who are growing up, being educated as well as already entering the production phase of their lives. The older generations, in the over-

whelming majority, already have defined nutrition habits and lifestyle, and changes are not a characteristic defining this group of society.

Mleczko and Januszewski [10] stated that an improvement in living conditions of the society is an agent of long-term tendencies of changes in specific environmental groups. In the studied subject matter there is a universal view that inter-generation changes appear much more firmly when a significant improvement in living conditions of the population takes place as a result of economic development of the country. Findings of many studies confirm this view, but, according to the present authors, it requires certain verification. The results presented above do not depict the discussed phenomenon in such a clear and transparent way. Findings presented by Dobosz [2] (period from 1979 to 1999) “confirm the long-known fact that successive generations of Polish youth are increasingly higher and grow and mature increasingly faster”. Here a question arises: how is it possible when the first decade of this study fell for a period of a deep economic crisis in Poland, the time of restrictions on the majority of food stuff and supply deficiencies practically in every aspect of everyday life, while the studied features are ranked as ecosensitive. The research on candidates for studies at Poznan AWF confirm this thesis. After all, in the course of the 1980s we can observe distinct slowing down of the secular trend in both body height and body weight. It is possible to state that we are dealing at least with the occurrence of stagnation of the trend. In the mid-1990s a significant improvement in economic conditions takes place for the majority of citizens in Poland, and ecosensitive features in the examined group react almost immediately.

One should also pay attention to the fact that till the end of the 20th century the recruited students were mainly from intellectual families, and the percentage share of this group in the society as a whole did not exceed 5%. Subjecting the state of Polish economy to evaluation, and in its light the situation of intellectual families, one should not expect that this group enjoyed exceptionally favorable economic terms. Interpreting the achieved results, one should take financial capabilities of the family into consideration – they guarantee a young person’s biological development – as well as a manner of their distribution by parents. Bielicki et al. showed in their study [1] that it is more advantageous for the development of youth in intellectual families [1].

The presented results of study demonstrated opposite tendencies in secular changeability of somatic and motor development among a group of young people enrolling into studies at AWF. Comparing the tests from the beginning of political transformation period and almost two decades after its end, one can notice tendencies for a significant slump in the dynamic power of lower limbs, the range of motion in joints as well as the maximum anaerobic work. Similar trends on a much smaller scale were noticed earlier in studies on the general population of Polish students [17, 18] and secondary school youth [19]. One should ponder what the cause of such a direction of the trend can be, particularly in the case of young people choosing a physical education college. One could suppose that results of physical fitness tests in this group will be characterized by the opposite direction of changes. According to the present authors, causes of this phenomenon should be looked for not in the economic situation of the country – as in the perspective of the state it is undergoing a constant and significant improvement – but in the change of the structure of the society, eating habits and lifestyle. Before the change of the system, the prevailing part of the society lived at a similar level, incomes of families were settled top-down and the free market economy did not exist. After the transformation this situation underwent a diametric change; freeing the economy caused considerable lengthening of working hours and a significant diversification of incomes of families, which, as a result, caused neglecting the education process of the growing up generations. Simultaneously, a media and computer revolution took place, which, in turn, brought about a change of the preference of spending leisure time by the younger generation from outdoor games and the bicycle to the TV set and computer games. These phenomena were, of course, overlapped by a significant improvement in economic conditions, which resulted in the increase in obesity of young people.

In the last section of the analysis of the problem, it only remains to mention and to sum up that the calculated correlation coefficients confirm in all cases the presented statements, and they depict the appearance of the “opened scissors” phenomenon while comparing the dynamics of long-term transformations in the somatic and motor development of candidates for studies at AWF.

Conclusions

Summing up, it is possible to suppose that along with stabilization of the economic situation of the state one should expect maintaining the progress of the secular trend in the case of somatic features; unfortunately, at the same time we will probably observe a slump in motor development. It is a very pessimistic hypothesis, bearing in mind the fact that this regards a social group for which caring about motor development of next generations will be a target point in the future. The road chosen by the majority of colleges, which consists in a reduction in recruitment requirements for next generations of students, is dictated by economic factors which were necessitated by rules of the free market gained during the political transformation; simultaneously, the same free market can lead to a biological decline of the society, which probably was not a purpose of the transformation in itself.

References

1. Bielicki T, Szklarska A, Kozieł S, Welon Z. Transformacja ustrojowa w Polsce w świetle badań antropologicznych 19-letnich mężczyzn [in Polish] [Political transformation in Poland in view of anthropological studies of 19-year-old men]. In: *Monografie Zakładu Antropologii PAN*. Wrocław: PAN; 2003.
2. Dobosz J. Trendy sekularne sprawności fizycznej młodzieży w Polsce [in Polish] [Secular trends in physical fitness of youth in Poland]. In: *Trendy sekularne na tle zmian cywilizacyjnych [Secular trends in view of civilisation changes]*. Warszawa: AWF; 2004, 55-74.
3. Bocheńska Z. Zmiany w rozwoju osobniczym człowieka w świetle trendów sekularnych i różnic społecznych [in Polish] [Changes in human personal development in view of secular trends and social differences]. *Prace monograficzne*, AWF Kraków, 1972; 5.
4. Pilicz S. Zmiany sekularne w rozwoju fizycznym i sprawności ruchowej studentów polskich [in Polish] [Secular changes in physical development and motor fitness of Polish students]. *Wychowanie Fizyczne i Sport* 1984;4:3-12.
5. Malinowski A. Trend sekularny i czasowa zmienność cech i standardów antropometrycznych Polaków w XX wieku [in Polish] [A secular trend and temporal change in anthropometric features and standards of Poles in the 20th c.]. In: Zagórski J, Popławska H, Skład M, eds. *Uwarunkowania rozwoju dzieci i młodzieży wiejskiej [Determinants of the development of rural children and youth]*. Lublin: Instytut Medycyny Wsi; 2004, 707-715.
6. Piechaczek H, Łaska-Mierzejewska T, Skibińska A. Trend sekularny wielkości ciała studentów Politechniki Warszawskiej w okresie 25 lat [in Polish] [The secular trend in the body dimensions among students of Warsaw Technical University]. *Wychowanie Fizyczne i Sport* 1986;4:39-48.
7. Pilicz S. Trend sekularny wysokości i ciężaru ciała studentów Politechniki Warszawskiej w latach 1954-74 [in Polish] [The secular trend in the body height and weight among students of Warsaw Technical University in years 1954-1974]. *Zeszyt Naukowy /WSI, Koszalin/* 1979;6:21-25.
8. Pilicz S. Zmiany w sprawności fizycznej i w rozwoju fizycznym studentów w czasie I i II roku studiów (1981-1983) [in Polish] [Changes in physical fitness and physical development of students during the first and second year of studies (1981-1983)]. In: Pilicz S, ed. *Tendencje zmian sprawności fizycznej młodzieży akademickiej [Tendencies in changes in physical fitness of academic youth]*. Warszawa: AWF; 1991, 6, 7-11.
9. Rogowska E. Trend sekularny wysokości i masy ciała młodzieży studiującej w Akademii Wychowania Fizycznego w Gdańsku [in Polish] [The secular trend in body height and mass among youth studying at the Academy of Physical Education in Gdańsk]. In: Rożnowski F, ed. *Biologia populacji ludzkich współczesnych i pradziejowych [Biology of contemporary and prehistoric human populations]*. Słupsk: WSP; 1992: 373-384.
10. Mleczo E, Januszewski J. Long-term trends in changes in physical and motor development observed among Cracovian students. *Antropomotoryka* 2009;46:65-79.
11. Deckert A, Kobielski B. Charakterystyka somatyczna oraz sprawność fizyczna studentów Akademii Medycznej w Poznaniu w latach 1974-75. [in Polish] [A somatic characteristic and physical fitness of students at Medical Academy in Poznań in years 1974-1975]. In: Drozdowski Z, ed. *Wartość biologiczna młodzieży akademickiej Polski. Materiały konferencyjne Poznań 27 września 1976*. Monografie nr 91. Poznań: AWF; 1977, 39-47.
12. Ziółkowska-Łajp E. Studia tendencji przemian cech morfologicznych uwarunkowania i skutki w świetle badań wieloletnich [in Polish] [Studies on tendencies in changes in morphological feature: determinants and effects in the light of long-term research]. Monografie, 336, Poznań: AWF; 1999.

13. Janusz A, Burdukiewicz A, Ignasiak Z, Sławińska T. Trend sekularny wysokości i masy ciała kandydatów na studia do AWF we Wrocławiu [in Polish] [The secular trend in body height and mass among candidates for studies at the Academy of Physical Education in Wrocław]. In: Gładykowska-Rzeczycka J, ed. *Człowiek w czasie i przestrzeni*. Gdańsk: AWF; 1993, 151-155.
14. Januszewski J. Przydatność wskaźnika maksymalnej pracy anaerobowej (MPA) w ocenie rozwoju fizycznego i sprawności motorycznej dziewcząt [in Polish] [The usefulness of the maximal anaerobic work (MAW) index in the assessment of girls' physical development and motor fitness]. *Antropomotoryka* 2001;22:105-114.
15. Szopa J. Zmienność ontogenetyczna oraz genetyczne i środowiskowe uwarunkowania pracy anaerobowej (MPA) – wyniki badań rodzimych [in Polish] [Ontogenetic changeability and the genetic and environmental determinants of anaerobic work (MAW) – results of native research]. *Antropomotoryka* 1989;1:25-38.
16. Bogucki Z. Elementy statystyki dla biologów. Statystyka opisowa [in Polish] [Elements of statistics for biologists. Descriptive statistics]. Poznań: UAM, 1979.
17. Milicer H, Skibiński A, Skład M. Trend sekularny wielkości i proporcji ciała młodzieży akademickiej [in Polish] [The secular trend in body height and proportions among academic youth]. *Wychowanie Fizyczne i Sport* 1974;4:63-71.
18. Milicer H. Zjawisko trendu sekularnego w populacji polskiej [in Polish] [The phenomenon of the secular trend in the Polish population]. *Wychowanie Fizyczne i Sport* 1966;X;1:3-17.
19. Przewęda R, Dobosz J. Kondycja fizyczna polskiej młodzieży [in Polish] [Physical condition of Polish youth]. *Studia i Monografie* nr 98. Warszawa: AWF; 2003.