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Biological and behavioural factors conditioning muscular power in men aged 30 to 60 years

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B Data Collection
C Statistical Analysis
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Abstract

Background & Study Aim: The increasing life span and sedentary lifestyle of the general population impose higher demands on functional fitness, including muscular power. The aim is determine biological and behavioural factors conditioning muscular power in adult males.

Material & Methods: A total of 175 healthy male subjects (aged 30-60 years; divided into three groups on the basis of age) were recruited, presenting different levels of past and present physical activity. In order to determine the level of maximal muscular power, two tests, which are considered appropriate for the population research, i.e. medical ball throw for upper limbs and long jump for lower limbs, were used as research method. Descriptive statistics, calculation of correlation between morphological variables and power, as well as measurement of the level of differences between the three age groups were made.

Results: Age, past and present level of physical activity are the factors significantly differentiating the level of muscular power. Among the morphological variables researched, only body mass, in particular lean body mass (LBM) is positively correlated with the results of the long jump test.

Conclusions: As the age increases, the influence of morphological variables on the level of muscular power becomes stronger. Muscular power is also conditioned by the past and present level of physical activity.

Key words: motor fitness • muscular power • transposition effect

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INTRODUCTION

Factors conditioning muscular power in professional sportsmen are subject of numerous researches. They are of particular concern in those sports in which muscular power is a major factor enabling best outcomes. 'Power' in physics is the time rate at which energy is used or transformed. In this study the tests were described as 'explosive strength'. Zaciorski described it as an ability to develop the maximal force in the shortest time possible [1]. Nowadays, it also synonymous with the term 'rate of force development' (RFD – rate of force development) [2]. It is therefore the ability of the neuromuscular system to overcome resistance with the highest possible velocity of muscle contraction [3]. Velocity, therefore, along power, determines motor effect.

Data on muscular power in adult persons who do not practise sport professionally, when exposed to maximum effort, are scarce. This is a shortcoming, since rapid and intensive physical efforts are inherent human physical behaviour (e.g. jumps, heavy lifts,

motor fitness is a term that describes man's ability to perform effectively when doing sport or other physical activity

muscular power – the ability to exert maximum muscular contraction instantly in an explosive burst of movements. The two components of power are strength and speed. (e.g. jumping or a sprint start)

transposition effect – high level of motor stimulation in the early age translates to a higher level of motor abilities in later life

etc.), constituting an important element of motor independence [4]. Moreover, the increasing life span makes the issue in question especially important in the light of all aspects associated with functional fitness becoming crucial in the later years of life.

The issue of the significance of muscular power has found its place within the concept of health-related fitness as an integral part of overall physical fitness, becoming one of the fitness factors according to HR-F [5]. All the before-mentioned arguments provide for conducting research in this field as it may provide important data for both educational and utilitarian purposes (medical, accident and injury prevention).

Each motor effect of human physical activity is conditioned by a number of factors, including structural and morphological ones, motor habits (experience), psychological predisposition and the influence of one's environment [5-7]. All of the above-mentioned variables are exposed to mutual, complex interactions. In the present study, an assumption is made that the effects of human physical activity may create a basis for drawing conclusions about the factors conditioning them [8]. The number of motor effect determinants suggests reduction model should be adopted. Therefore, the aim of the research is to determine biological and behavioural factors of maximal muscular power of adult males.

MATERIAL AND METHODS

A sample of 175 healthy male volunteers aged 30 to 60 years (x=41.6, SD 8.05) were studied. All the subjects were informed about the objective and the methodology of the research and gave consent to participate in the study, as required.

The research encompassed:

Biological factors – apart from age (the influence of involution), morphological and structural determinants we taken into consideration, such as: height, body mass, lean body mass, the length of limbs

The level of physical activity – both present and past above-average physical activity, related to professional sport practice.

Anthropometric measurements of body height, body mass and the length of the limbs were performed. Body fat percentage was evaluated using the method of bioelectrical impedance analysis (BIA). The Schoenhle analyser (SOEHNLE – Waagen GMBH&Co., Germany) was used for the before-mentioned study. According to the manufacturer's information, an accuracy of the measurement of body mass is of 0.1 kg and of body fat percentage is of 0.1%. On the basis of this measurement, lean body mass (LBM) was calculated, using the two-component model of body composition. The length of the limbs was also measured (with an accuracy of 0.01 m).

The present and past physical activity of the subjects was established in the course of interviews. An arbitrary criterion differentiating the subjects was introduced – a given individual was categorised as presently physically active when practising any sport systematically at least once a week for one hour. The criterion relating to past physical activity and being regarded as an ex-sportsmen was systematic training and taking part in tournaments, regardless of the sport, for at least 5 years. Taking into consideration both criteria: present and past physical activity, a division of the subjects into 4 groups was implemented:

Active ex-sportsmen (AES) n=51
(age: x=40.5; SD 8.2)

Active non-sportsmen (ANS) n=51
(age: x=42.0; SD=6.6)

Non-active ex-sportsmen (NAES) n=33
(age: x=40.2; SD=7.9)

Non-active non-sportsmen (NANS) n=40
(age: x=44.7; SD=8.3)

The object of the study determined the choice of the motor tests as a research tool. These tests can be regarded as appropriate tools for studies on the general population [9]. The choice of the tests was determined by minimal influence of abilities on the motor effect. Therefore, tests of the simplest possible structure of activities were chosen:

For the evaluation of upper limbs muscular power a test to throw a 5-kg ball from the front of their chest using both hands as far as possible was used. It was performed in a standing posture with the subject's legs apart and knees 'blocked' by tension of the muscles of the knee joint extensors.

For the evaluation of the lower limbs long jump test introduced. Subjects started in the squatting posture and were free to choose the most comfortable way of swinging their upper limbs.

Each of these two motor tests was repeated three times. The measurements were made to an accuracy of 1 cm. The best outcome from among the three measurements was chosen for subsequent statistical analysis.

The maximal muscular power (work) was calculated using the formula MMP = m × g × h (joule); where:

MMP = maximal muscular power,
m = body mass [kg],
g = gravitational acceleration (9.81m/s^2)
h = outcome of the test (thrust or jump).

Traditional description of power in physics defines it as work performed during a unit of time. However, the tests implemented here it didn't allow to perform measurements of work (force) and time. It was possible, however, to measure a total motor effect of the performed task using the Joule (J) as a unit of measurement.

Reliability of these measurements was evaluated by means of average Pearson's coefficient (r) between the results of 3 attempts. The calculated results of r = 0.83 for the ball throw and 0.93 for the long jump proved high reliability of the tests.

STATISTICAL ANALYSIS

Statistical analyses were conducted of the variables examined, i.e..: mean and standard deviations (SD). Correlation between morphological parameters and power was calculated. Taking into account variability relating to age, the sample was arbitrarily divided into three age groups: 1) 30-39 years (n=74); 2) 40-49 years (n=68); 3) 50-60 years (n=33).

In order to examine the effect of age and physical activity on the researched motor effects, ANOVA variation analysis was performed. Next, in order to identify the variance between the groups, the post-hoc Turkey's test for uneven population was used.

RESULTS

Descriptive statistical data of morphological parameters of the subjects is presented in Table 1.

In search of the effect of the power generated during the motor tests ANOVA variation test was performed. Its results revealed significant statistical differences between the age groups of the men examined, i.e.: for the power thrust p = 0.0009 and for the long jump p = 0.0000. The subsequent analysis by means of post-hoc Turkey's test showed that the variations for ball throw related to groups were: 1-3 p=0.0047 and 2-3 p=0.0159, whereas for long jump to groups: 1-2 p=0.0337; 1-3 p=0.002.

The next step was to calculate the correlation of coefficients between the morphological parameters and the results of the power thrust tests. The analysis revealed that for the population examined morphological parameters strongly or significantly correlated only with the power of upper limbs. The coefficients of the correlation were as follows: LBM – 0.83; body mass – 0.78; height – 0.50; lower limbs length – 0.44 (p=0.0000) and had a plus sign. Regarding upper limbs power, no or weak correlation was found. The variability of the coefficients of the correlation between the morphological parameters and power taking into account age groups is presented in figure 3.

Table. 1. Descriptive statistical data of morphological parameters

Variable	Subjects – MEAN and SD		
Age group	1 (n=74)	2 (n=68)	3 (n=33)
Height [cm]	176.6 ±7.4	175.9 ±7.1	174.0 ±6.9
Body mass [kg]	81.7 ±12.7	82.5 ±14.8	81.6 ±13.9
% FAT	22.6 ±5.6	25.7 ±5.9	28.3 ±5.6
Lean Body Mass (LBM) [kg]	62.7 ±6.8	60.6 ±7.3	57.9 ±7.1
Upper limbs length (Ull) [cm]	79.7 ±4.2	79.6 ±4.2	79.5 ±4.1
Lower limbs length (Lll) [cm]	88.9 ±5.3	88.8 ±5.0	87.8 ±4.9

The power level according to age groups determined are presented in figures: 1 – for upper limbs; 2 – for lower limbs.

1: 30-39 years (n=74);
2: 40-49 years (n=68);
3: 50-60 years (n=33)

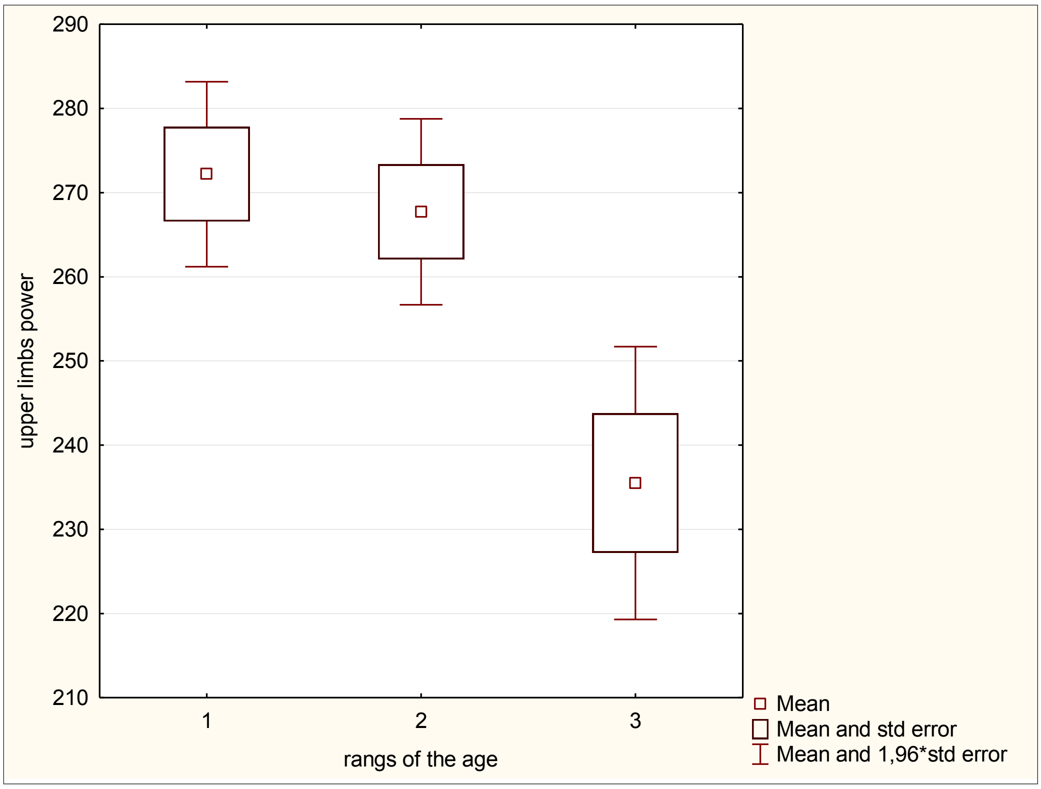


Figure 1. Upper limbs power according to age group

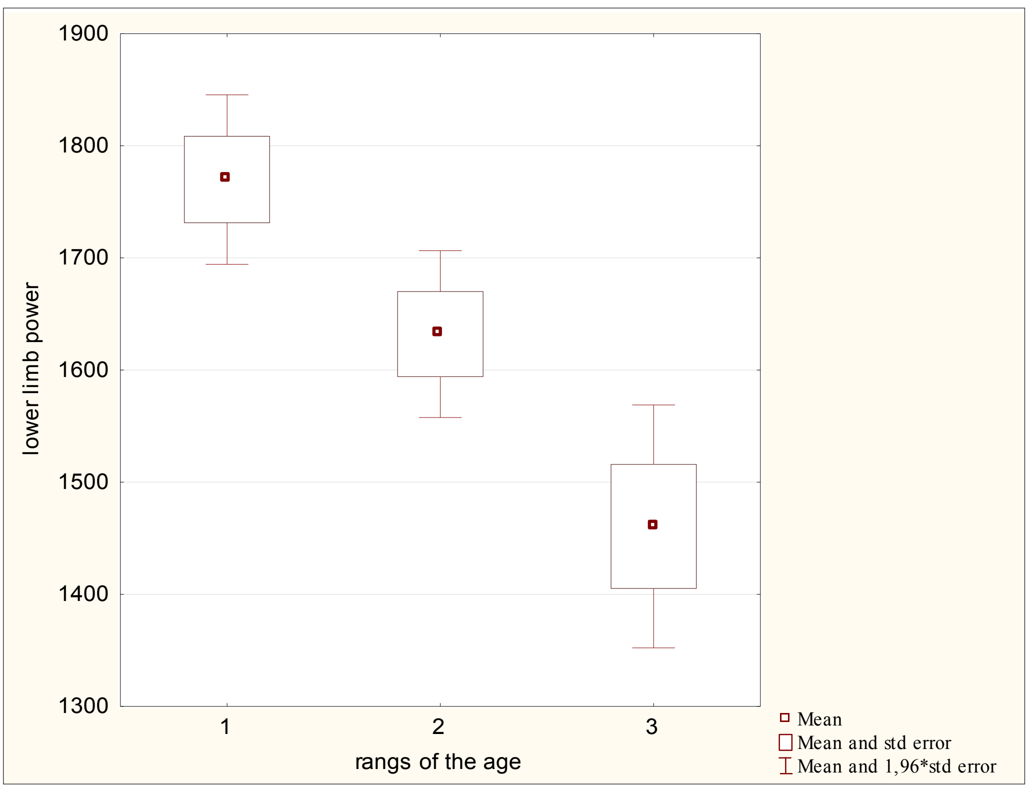


Figure 2. Lower limbs power according to age group

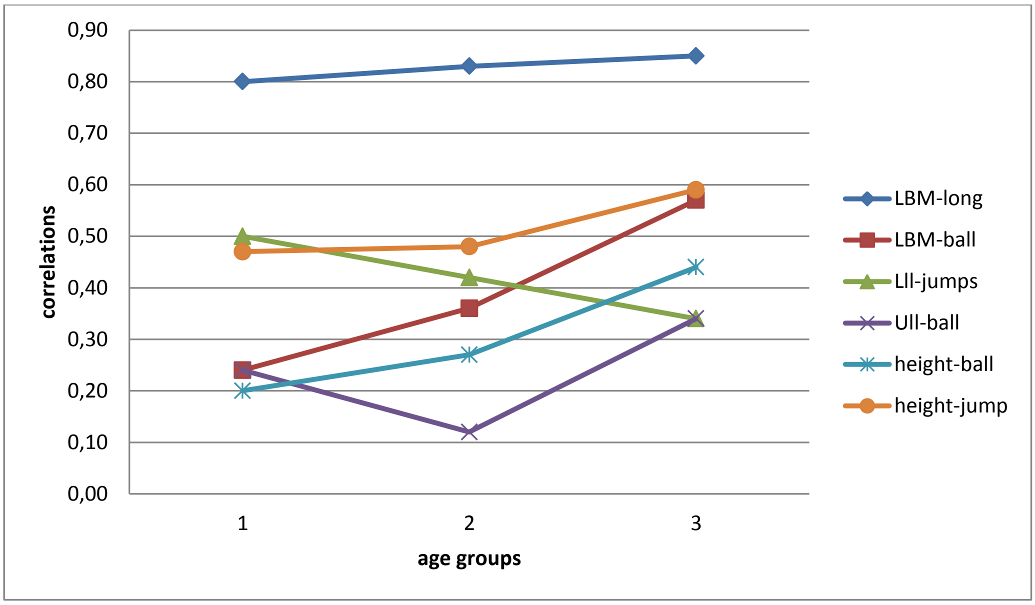
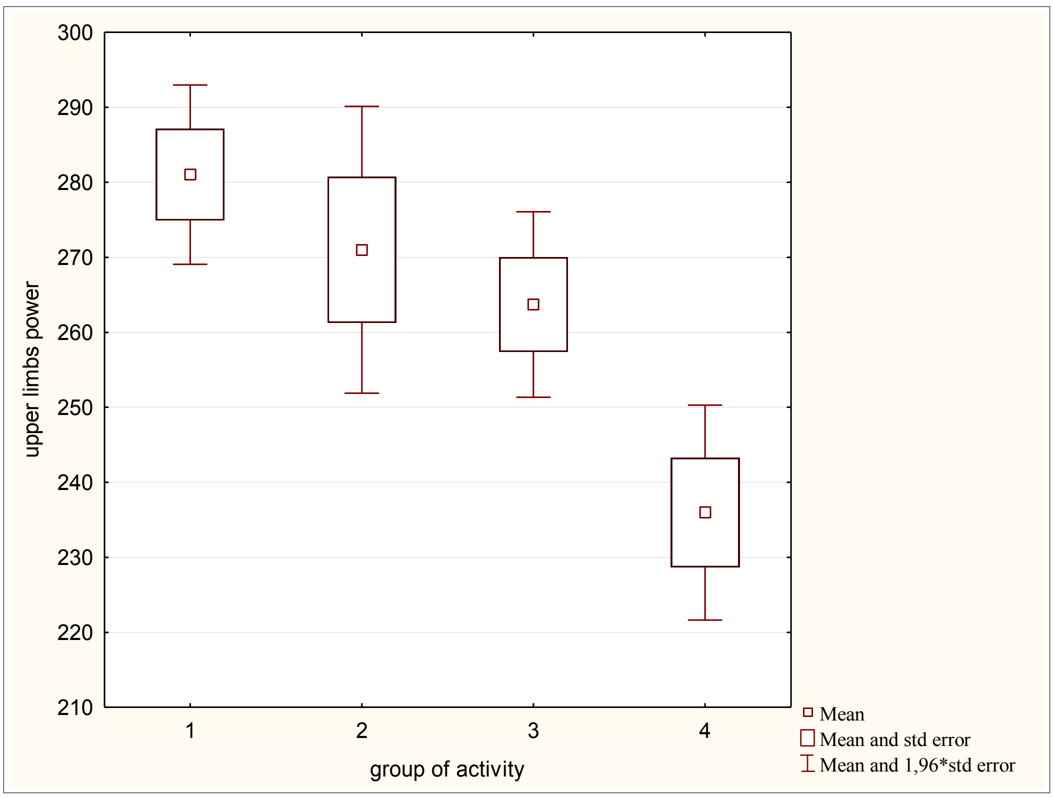


Figure 3. Correlation between the morphologic variables and power



1: AES (n=51);
2: ANS (n=51);
3: NAES (n=33);
4: NANS (n=40)

Figure 4. The power of the upper limbs: activity groups

As presented in the methodology of the study, it was aimed to determine the influence of the past and present physical activity on the level of the present power of the subjects. The power of the upper limbs is presented in figure 4, whereas of the lower limbs in figure 5.

ANOVA variation analysis revealed statistically significant variation: p=0.0000. Further post-hoc test analysis showed that the differences related only to groups 4 (NANS) in relation to the other groups (1 - 4: p=0.0000; 2 - 4: p=0.0403; 3 - 4: p=0.0352).

Taking into account the sport-related past as well as present physical activity, comparison of means in particular age groups was made. It is presented in figure 6 (for long jump) and in figure 7 (for ball throw).

DISCUSSION

Motor effects studied here may be conditioned by morphological and structural predispositions. The results presented in this paper – the analysis of coefficients correlation indicate that body mass of the body, especially lean body mass, has a significant positive effect on the lower limbs power, (examined here using the long jump test). In relation to the so-called relative power, this finding would confirm the importance of muscular mass (especially in relation to total body mass) as a key power-generating factor. The significance of this factor seems to even grow, especially taking into consideration the tendency of the percentage of muscle mass decrease in the total body mass (known as sarcopenia – figure 3) [10, 11]. It suggests a certain shift of accent in the power determinants: the decrease of velocity – the increase of the importance of power. This phenomenon becomes even clearer in the case of upper limbs and the ball throw test; in the present study the correlation between lean body mass and muscular power in the oldest age group is twice as high as in the youngest age group (figure 3). Lower values of the other correlation coefficients suggest a significantly weaker effect of the remaining morphological parameters on motor effects studied. However, the analysis of how these coefficients change with increasing age (according to age groups established in this paper) indicates there is an overall growth tendency when it comes to morphological predispositions as age increases. The only exception is the opposite tendency observed, i.e. the decrease as age increases, of correlation between the length of the lower limbs and power measured with the long jump test

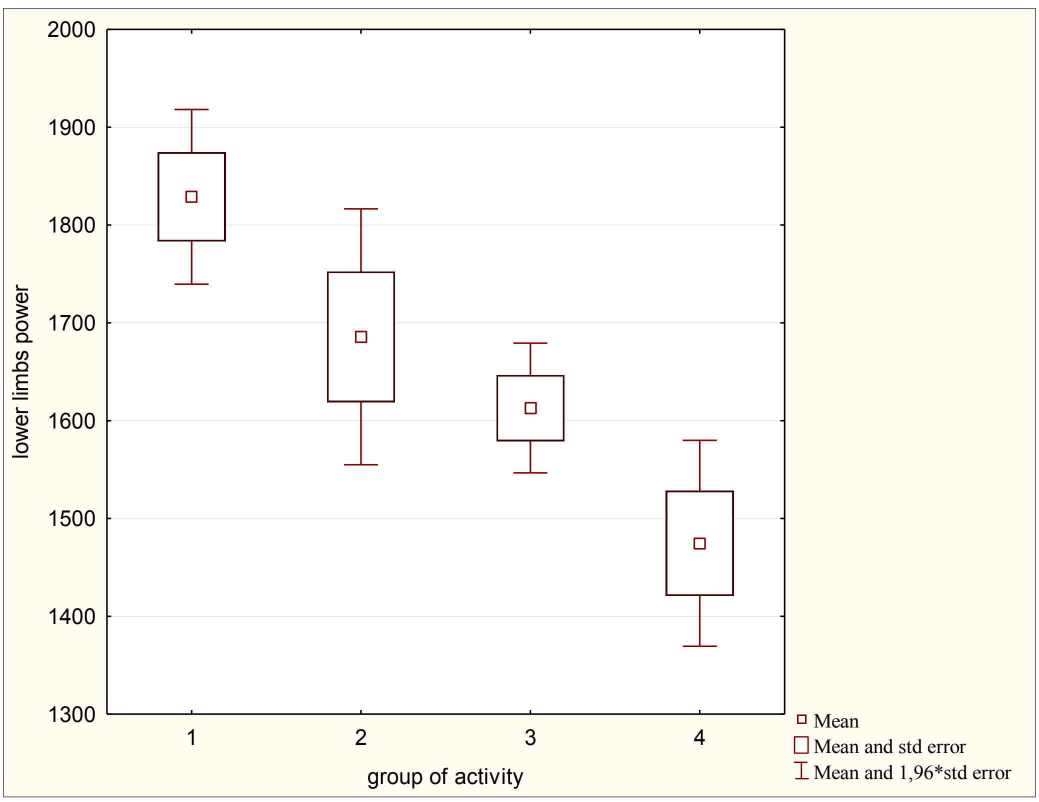


Figure 5. The power of the lower limbs: group of activity

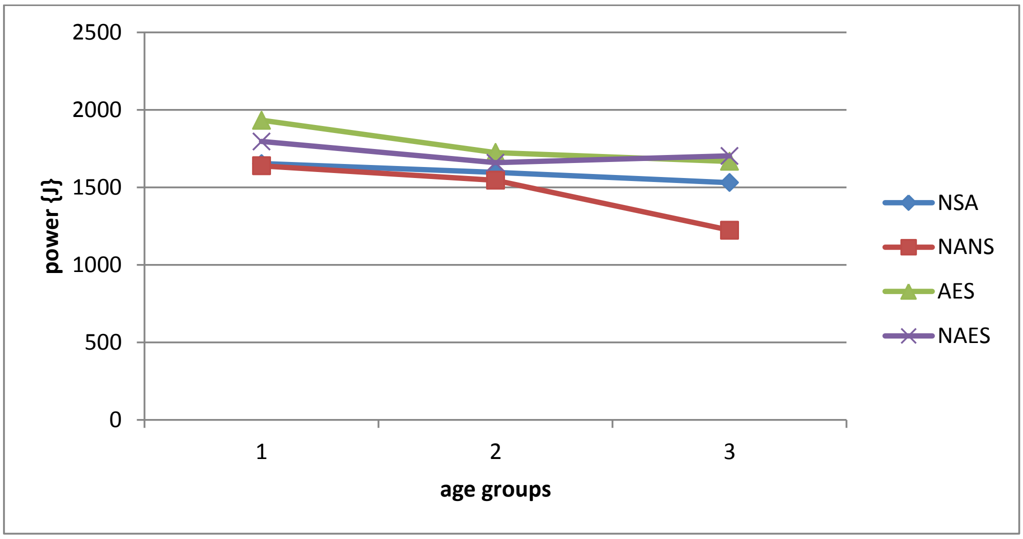


Figure 6. Lower limbs power: variability in relation to age groups with past and present sport related activity

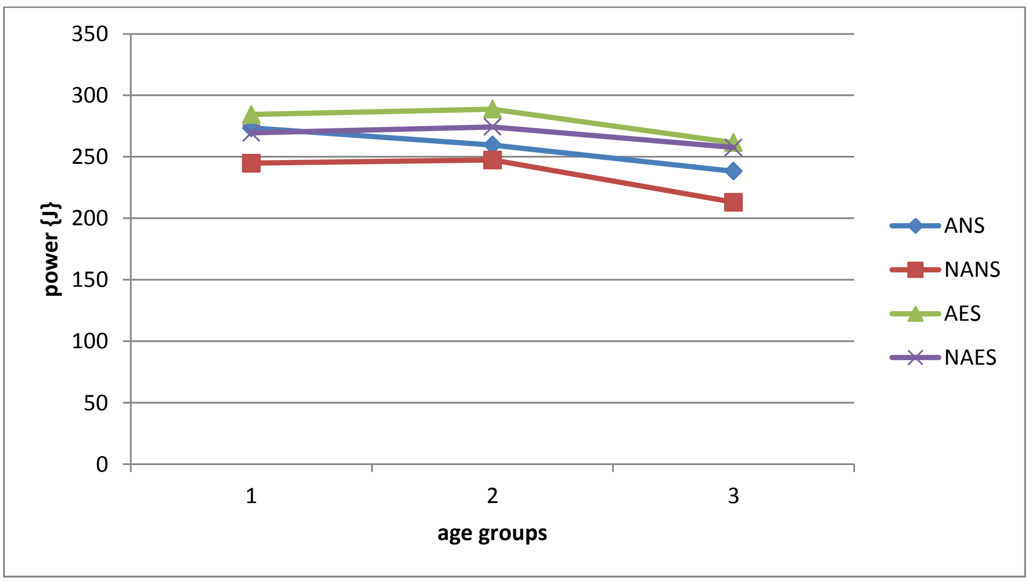


Figure 7. Upper limbs power - variability in relation to age groups with past and present sport related activity

(figure 1). It would confirm the increase of importance of muscular power presented before.

Analysis of the three age groups revealed statistically important differences in the rate of age-related power decrease for the upper and lower limbs. In the case of arms, the decrease of power of 40 year olds compared with 30 year-olds is fairly insignificant- only about 2%. A dramatic decrease takes place during the next decade, in the age group of 50-60 years-olds, in which the difference compared with the youngest subjects reaches 14% (figure 1). For lower limbs a higher rate of decrease in power was registered, i.e. 8% and 18%, respectively (figure 2). This may indicate that the processes of motor fitness involution, in this case of muscular power, don't occur uniformly. Taking into consideration the before-mentioned significance of force factor in generating power, the findings would confirm the greater decrease of the power of lower limbs compared with the decrease of power of upper limbs. This observation confirms earlier research into the matter [12, 13].

The question then arises as to whether these differences are conditioned by biological or behavioural factors [14, 15]. It seems that age-related reduction in the level of physical activity and overall change in the character of physical activity may play an important role. Differences in the type of motor stimulation may also be of significance, for example, the more precise movements characteristic of the upper limbs in contrast to more 'heavy locomotion' involved in the lower limbs, may, as a consequence, define uneven level of motor regression. However, the overall decrease in muscular power seems to have definitely biological rather than behavioural background, regardless of present and past physical activity, which can be concluded on the basis of analysis of the variability of mean results with age (figure 1, 2). It should be therefore established that the type of sport performed in the past does not have particular influence [16].

From the physiological perspective, the power tests chosen are indirectly manifestations of the alactacid anaerobic power (AAP). Crucial factors determining muscular velocity in such understanding are: trans-sectional area of the muscle, number of motor units, degree of innervation of motor units, ratio of fast twitch and slow twitch muscle fibres, as well as the efficiency of enzymatic mechanisms associated with phosphocreatine metabolism. It is reported that the proportions of different types of muscle fibres are determined genetically [17, 18] and, as Larsson and co-authors have concluded, that there is a gradual age-related decrease in the content of slow twitch fibres [19]. A decrease in the number of activated motor units, degradation of neuromuscular conduction mechanisms and lower levels of spinal moto-neurons activity have also been reported, which all result in a reduced level of muscular force and lower ability to generate anaerobic power [20]. Consequently, a decrease in the alactacid anaerobic power related to age can be observed. There is a general belief that the overall decrease of muscular power is not associated with the level of physical activity; however, the results presented in the present work indicate that this decrease in the case of active males takes place on higher levels (figure 6, 7).

Owing to the effect of training and exercise on neural mechanisms (neuromuscular facilitation, senso-motor integration, development of automatic motor habits), very high individual levels of muscular power can be achieved. Especially interesting is how long such a favourable change can persist. Significant differences in the levels of upper limbs and shoulder girdle power between non-active, non-sportsmen subjects (NANS subgroup) and active subjects (AES, ANS subgroups), irrespective of their sport history, lead to the conclusion that physical activity, regardless of the point of time at which it was started, constitutes a behavioural factor of interest which allows for a slower natural age-related decrease of muscular power and brings the power level higher. The results presented demonstrate a statistically significant difference between two non-active groups (NAEN and NANS)– the subjects who previously practised sport professionally showed a slower decrease in muscular power. It indicates a type of '**transposition effect**' in which high level of motor stimulation in the early age translates to a higher level of motor abilities (in this case, durability of speed development mechanisms) in later life. This finding would also support the hypothesis claiming that, in the case lower limbs, the presence of the transposition effect is supported by significant differences in the results of the long jump test between active sportsmen (ESA subgroup) and subjects who did not practise sport professionally in the past (irrespective of the current level of physical activity; i.e. the NANS and NAES subgroups). Also of relevance is a lack of significant difference between currently active and non-active persons who practised sport in the past. This observation also applies to the ball throw test, thereby providing additional support to the transposition effect.

From the perspective of the described methodology, the proposed explanation of the transposition effect remains speculative. Potentially, this effect may be associated with neuromuscular co-ordination which was enhanced to a high and lasting degree during the period of professional training, compared to the non-sportsmen subgroups. In the case of ex-sportsmen, motor involution that accelerates with increasing age would start from the higher initial level and would be a subject to the level and type of motor stimulation, or more generally, of life style represented. After this point, the amount and character of the motor stimulation takes the dominant role. It seems that the existence of the before-mentioned transposition effect would require confirmation using similar or more precise (laboratory) research methods.

CONCLUSIONS

Involution of muscle strength with age is biologically determined and its pace is varied depending on particular muscle group.

Higher level of physical activity, both current and past one, correlate positively with the level of muscle strength in middle-aged men.

Compared with men who didn't practise sport professionally, ex-sportsmen demonstrate higher levels of muscular power irrespective of the level of present physical activity. However, the magnitude of this difference is associated with the current level of physical activity.

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