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Original Article

Secular trends in anaerobic fitness test performance of physically inactive young males (2000-2006)

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Abstract
The aim of the study was to determine changes in anaerobic fitness among 1st year students attending the University of Warmia & Mazury in Olsztyn in the years 2000 – 2006. The research involved 1,642 students aged 19-21 (499, 337, 155, and 152 in the years 2000, 2002, 2004, and 2006, respectively). A diagnostic survey including measurements of the level of anaerobic fitness by means of indirect motor tests was used. Observations of the changes in the level of anaerobic fitness among 1st year students in the years 2000-2006 revealed significant differences between the analyzed years. Significant differences occurred in every applied anaerobic test. A linear trend indicating a decreasing level of power in the lower limbs was observed in the case of the standing long jump trial (r = - 0.846). In the remaining trials, i.e., skipping with clapping of hands – 8 s, sit-ups – 30 s, and 4x10 m shuttle run, no linear trends were noted. The experiment should be continued to include subsequent academic years.
Key words: Characteristics of changes, power-speed-agility abilities, male students

Introduction

Existing opinions concerning secular trends in the motor fitness of children are strongly divided in the case of both, popular and scholarly literature. Some believe that the level of motor fitness has decreased in the recent years, other have doubts as to whether or not it has changed at all. The diversity of the opinions on this aspect is not surprising, as very little scientific research regarding this subject matter has been conducted. According to Tomkinson, fewer than three studies have been devoted to secular trends in children's motor fitness in a period of two years (Tomkinson, 2007). Moreover, more of them focused mainly on secular changes in aerobic fitness rather than anaerobic fitness (Tomkinson, Hamlin, & Olds, 2006). Despite the fact that the level of endurance abilities is strongly connected with the health of the human organism (Di Pietro, Dziura, & Blair, 2004; Haskel et al., 2007), most motor movements performed by humans in fact require anaerobic effort. This stems directly from people's reluctance to perform efforts over an extended period of time, as well as a rapidly increasing level of fatigue caused by an inadequate level of cardiovascular endurance (Church, Earnest, Skinner, & Blair, 2007).

Anaerobic abilities constitute one of the main components of human *motricity* (Andrzejewski, Chmura, Strzelczyk, & Konarski, 2009). Originally, they were defined as the human organism's ability to perform motor tasks, which do not last long and do not cause fatigue which reduces the intensity of muscle work (Wachowski & Strzelczyk, 1999). One short-time effort (< 10 s), even at maximal intensity, does not cause significant changes in the human organism's metabolism in terms of energy expenditure and resynthesis of ATP. However, such a situation occurs only sporadically during sports training and concerns only those cases in which breaks between successive repetitions are quite long and sufficient for full recovery. In most sports, the human body is forced to continuously repeat short sequences of movements involving acceleration, deceleration, and changes in the direction of movement, which, in consequence, may result in significant energy expenditure, the accumulation of lactic acid, and the reduction of the human organism's level of anaerobic fitness (Draper & Lancaster, 1985; Balsom, Ekblom, & Sjodin, 1994; Fitts, 1994). The fitness requirements for athletes who take part in various sports events require them to possess adequate levels of anaerobic abilities, in order to enable them to perform short sprints at maximal speed (approx. 10 s), separated by a periods (< 30 s) often defined as RSA (repeated-sprint ability), and associated more with agility than strictly with speed abilities (Wadley & Rossignol, 1998; Dawson, Fitzsimons, & Ward, 1993; Spencer et al., 2004; Bishop & Edge, 2006).

The consequence of the conflict between theory and practice are the numerous ways of interpreting and classifying speed abilities (Hirtz, Hummel, & Rostock, 1985; Szopa, Chwała, & Ruchlewicz, 1998; Raczek, 2010), which have led to the emergence of a few basic theories. One of the current conceptions concerning the structure of speed abilities indicates that they belong to hybrid abilities (lack of a clear dominant), and their energetic potential is associated with the quality of the regulatory sensory processes (Raczek, 2010).

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Szopa presents a slightly different view on this issue (Szopa, 1998) and includes anaerobic efforts in a group of energetic abilities, simultaneously labeling them strictly as speed abilities and indicating two basic mutual elements of these abilities, i.e., an energetic base (in the form of anaerobic sources) and the velocity of muscle contractions (characterized by the time needed to achieve maximal power) (Szopa et al., 1998). Under such assumptions, power, speed, and agility trials are included in a group of tests applied in measuring anaerobic fitness (Szopa et al., 1998; Szopa, 1998; Tomkinson, 2007).

Among the most important predispositions determining the level of speed abilities are:

- the structure of muscles - proportion of FT and ST muscle fibers (Holoszy & Coyle, 1984),
- the effectiveness of enzymatic systems responsible for the breakdown of fosfocreatine and glycogen (Paganini, Foley, & Meyer, 1997; Wadley & Rossignol, 1998; Hirvonen, Nummela, Rusko, Rehunen, & Harkonen, 1999),
- reaction time and activation of as many motor units as possible (Meishan & Larson, 2010),
- the frequency of movements and moments of inertia of moved body parts in a specified or variable direction (Docherty, Wenger, & Neary, 1988; Scheppard & Young, 2006).

Current outlooks on the assessment of the level of speed abilities are clearly heading in the direction of identifying its manifestation in energetic and coordinative aspects determined by the cognitive factors involved (Cox, 2002; Young, James, Monthgomery, 2002; Scheppard & Young, 2006; Raczek, 2010). This stems directly from sports training, which shows that a player's movements are largely a response to stimuli in the form of the direction and velocity of a moving ball, or the opponent's plays. In consequence, cognitive components are an inseparable aspect of sport, since players display different abilities of reading and reacting to a given impulse and present different levels of motor fitness (sports performance) (Abernethy & Russel, 1987; Farrow, Young, & Bruce, 2005). In the case of energetic factors, the quick breakdown of fosfocreatine and production of lactic acid, which restricts muscle efficiency, should be noted (Izumi et al., 1997).

Beginning in the year 2000, research concerning the level of motor fitness among students enrolling at the University of Warmia & Mazury in Olsztyn are conducted biannually. The results of motor tests constitute a basis for assessing the level of the students' motor fitness. The scope of the studies presented within this article comes from extensive observations of changes occurring in the level of anaerobic fitness among physically inactive males. Much fewer works concern changes in anaerobic fitness of physically inactive people, which most certainly pertains to academic youth, than professional athletes. Therefore, the aim of the study was to determine the changes in the level of anaerobic fitness (operationalized as performance in power, speed, and agility tests) of 1st year students enrolled at the University of Warmia & Mazury in Olsztyn during the years 2000-2006. The research was also aimed at establishing whether the average values could be characterized by a significant increasing or decreasing trend over the course of the analyzed years.

Materials and methodology

Research concerning the level of anaerobic fitness of 1st year students was conducted biannually during the summer semester between the years 2000-2006. A group of 1,143 full-time 1st year students aged 19-21 (499, 337, 255 and 152 in the years 2000, 2002, 2004, and 2006 respectively) took part in the studies. The students participated in obligatory physical education classes. All male subjects within randomly selected groups were tested. The percentage of students who participated in the anaerobic tests in relation to the total number of full time 1st year students is presented in table 1.

Table I. Number of male students participating in the anaerobic tests compared to the total number of 1st year male students

Year of conducted research	Total number of 1st year students	Number and percentage of students participating in anaerobic trials	
		N	%
2000	1476	499	33.80
2002	1987	337	16.96
2004	2298	155	6.74
2006	2248	152	6.76

When justifying the selection of the group it should be noted that university students are anatomically and physiologically mature, therefore, subjects' age completely eliminates the impact of developmental factors on the results of measurements. Students participating in the study attended only the mandatory P.E. classes (90 minutes per week) and did not take part in any other forms of exercise. All students subjected to analysis resided in the Warmia & Mazury region, mainly in small towns not exceeding 40 thousand residents. Such a group can, therefore, be considered homogenous and representative for this type of research.

The level of anaerobic fitness was measured by means of a set of indirect anaerobic tests, i.e., standing long jump, skipping with clapping of hands – 8 s, sit-ups – 30s, and 4x10 shuttle run was applied. Szopa's classification was used during the selection of motor tests (Szopa, 1998). Prior to each trial, all male students taking part in the research observed the tests which they were to do and were informed on how to perform them. Next, participants took part in a 10-minute warm-up.

The research results were analyzed statistically with the use of a variance analysis method (test F) for univariate experiments. The means of the „time" factor (age = academic year) were compared by means of the Newman-Keuls test. Research results and statistical hypothesis verification were compiled in tables containing means, mean errors, and information regarding significant differences between the years. Statistical calculations and the assembly of results were performed with the Statistica PL software package (Stanisz, 2001).

Results

The results obtained in individual anaerobic tests are presented in table 2 and express the variability of the students' anaerobic fitness level during the analyzed time period.

Table II. Average results of anaerobic tests and regression analysis (2000-2006)

Anaerobic motor trial	Year of study				Significant differences between years
	2000	**2002**	**2004**	**2006**	
	N=499	**N=337**	**N=155**	**N=152**	
A Standing long jump [cm]	215.0 ± 26.89	212.1 ± 26.56	213.4 ± 25.38	209.3 ± 41.37	1>4*
B Sit-ups – 30 s [number of sits]	25.9 ± 4.33	26.0 ± 3.84	25.6 ± 4.67	27.3±4.10	4>1,2,3**
C 4x10 m shuttle run [s]	10.9 ± 1.70	11.0± 2.50	11.1 ± 1.50	10.2 ± 1.53	1,2,3>4**
D Skipping with clapping of hands [number of claps]	28.4 ± 4.66	28.8 ± 4.25	27.6 ± 3.76	33.8 ± 4.34	4>1,2,3** 2>3*,1>3*

Results of regression analysis

Type of test	Correlation coefficient	Percent of explained variability	F value	Regression equation
A	-0.846	71.53	2.512	**A =-1.58T+216.40**
B	0.652	42.47	0.738	**Lack**
C	-0.632	40.00	0.667	Lack
D	0.689	47.45	0.903	Lack

*- Statistically significant differences on the level $\alpha = 0.05$

**- Statistically significant differences on the level $\alpha = 0.01$

Results obtained by the 1st year students in the standing long jump trial in the year 2000 were significantly higher than those achieved in 2006. In the case of sit-ups – 30 s, the best results were achieved in 2006 (averaging 27.3 sit-ups/30 s) and were significantly higher (α = 0.01) than in other analyzed years. On the other hand, the results of the 4x10 m shuttle run in 2006 were significantly lower (α = 0.01) than those recorded in the remaining years. The highest variability of results occurred in the skipping with clapping of hands – 8 s trial. The 2006 results for this test were significantly higher (α = 0.01) than those recorded for the other time periods. Statistically significant differences (α = 0.05) were also observed between the years 2002>2004 and 2000>2004.

Statistical analysis of anaerobic test results revealed the presence of a clear linear trend between the successive years of research for the standing long jump trial. A decrease in lower limb power was observed over the course of the years. Nevertheless, a linear trend for the remaining trials (sit-ups – 30 s, 4x10 m shuttle run, and skipping with clapping of hands – 8 s) was not noted (Table 2).

Discussion

Over the course of the past two decades only nine publications pertaining to secular changes in the level of aerobic fitness among children and youth were confirmed (Przewęda & Trześniowski; 1996; Lefévre, Bouckaert, & Duget, 1997; Hamlin, Ross, & Hong, 2002; Tomkinson, Olds, & Gulbin, 2003; Tomkinson et al., 2006; Przewęda & Dobosz, 2007; Tomkinson, 2007; Albon, Hamlin, & Ross, 2010, Moliner-Urdiales et al., 2010). Research on students taking up studies at the Warsaw University of Technology (Pilicz, 2000) and University of Warmia & Mazury in Olsztyn (Podstawski, Siemianowska, & Skibniewska, 2010) constitute an additional study and the only one focused on university students. Apart from it, no other publications involving tertiary institutes were found. This fact makes the results presented in this article more valuable but, on the other hand, also makes extensive comparisons impossible.

In the case of students (female and male) beginning studies at the Warsaw University of Technology, slow and favorable changes in the level of anaerobic abilities were noted between the years 1966 – 1987 (females) and 1962 – 1986 (males), in the standing long jump and zig–zag run trials (Pilicz, 2000). In turn, significant differences in results achieved by 1st year female students attending UWM in Olsztyn occurred in the following trials: standing long jump, sit-ups – 30 s, 4x10 m shuttle run, and skipping with clapping of hands – 8 s (Podstawski et al., 2010).

The applied motor, i.e., standing long jump, 4x10m shuttle run and sit-ups – 30 s, are considered to be accurate and reliable indirect tests for the assessment of anaerobic abilities (Docherty, 1996; Szopa, 1998; Szopa et al., 1998; Wachowski & Strzelczyk, 1999). The accuracy and validity of the skipping with clapping of hands – 8 s trial is in the initial research stage (Podstawski, Borysławski, & Grymuza, 2010).

Conclusions

The analysis of changes occurring in the level of anaerobic fitness among 1st year students over the years 2000-2006, revealed significant differences between the individual years. These differences occurred in every applied anaerobic test, however, a linear trend indicating the deterioration of 1st year students' lower limb power was observed only in the standing long jump trial (r=-0.846). In the remaining anaerobic trials, i.e., skipping with clapping of hands – 8 s, sit-ups – 30 s, and 4x10 m shuttle run, linear trends were not noted. The research should be continued and its scope extended to include subsequent years of study.

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Conflict of interest: Nothing to declare

References

Abernethy, B., & Russel, D.G. (1987). Expert-novice difference in an applied selective attention task. *J Sport Psych*, 9, 326-45.

Albon, H.M., Hamlin, M.J., & Ross, J.J. (2010). Secular trends in distributional changes in health and fitness performance variables of 10-14-years-old children in New Zealand between 1991 and 2003. *Br J Sports Med*, 44, 263-269.

Andrzejewski, M., Chmura, J., Strzelczyk, R., & Konarski J. (2009). Individualization of Physical Loads and Speed Abilities of Young Soccer Players in Six-Month Training Macrocycle. *J Hum Kinetics*, 22, 35-42.

Balsom, P.D., Ekblom, B., & Sjodin, B. (1994). Enhanced oxygen availability during intensity intermittent exercise decreases anaerobic metabolite concentration in blood. *Acta Phys Scan,* 150, 455-56.

Bishop, D., & Edge, J. (2006). Determinants of repeated-sprint ability in female matched for single-sprint performance. *Eur J Appl Phys,* 97, 373-379.

Church, T.S., Earnest, C.P., Skinner, J.S., & Blair, S.N. (2007). Effects of Different doses of Physical Activity on Cardiorespiratory Fitness Among Sedentary, Overweight or Obese Postmenopausal Women With elevated Blood Pressure. *JAMA,* 297, 2081-91.

Cox R.H. (2002). Sport psychology: concepts and applications. 5th ed. New York: McGraw-Hill.

Dawson, B., Fitzsimons, M., & Ward, D. (1993). The relationship of repeated sprint ability to aerobic power performance measures of anaerobic work capacity and power. *Aus J Sci Medi Sport,* 25, 88-93.

Di Pietro L., Dziura, J., & Blair, S.N. (2004). Estimated change in physical activity level (PAL) and prediction of 5-year weight change in men: the Aerobic Center Longitudinal Study. *Int J Obes Relab Metab Disord*, 28: 1541-47.

Docherty, D., Wenger, H.A., & Neary, P. (1988). Time-motion analysis related to the physiological demands of rugby. *J Hum Mov Study*, 14, 269-77.

Docherty, D. (1996). Field tests and tests batteries. In: D. Docherty (Ed.), *Measurement in pediatric exercise science (pp. 285 – 334)*, Champaign, IL: Human Kinetics.

Draper J.A., & Lancaster, M.G. (1985). The 505 test: a test for agility in the horizontal plane. *Aus J Sci Med Sport,* 17, 15-18.

Farrow, D., Young, W., & Bruce, L. (2005). The development of a tests of reactive agility for netball: a new methodology. *J Sci Med Sport*. 8, 40-48.

Fitts, R.H. (1994). Cellular mechanisms of muscle fatigue. *Phys Rev,* 74, 49-94.

Hamlin, M.J., Ross, J.J., & Hong, W. (2002). Health-related fitness trends and gender differences in 6-12 years old New Zealand children. *New Zeal J Sports Med,* 30, 4-17.

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., Macera, C.A., Heath, G.W., Thompson, P.D., & Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Med Sci Sport Exerc, 39, 1423-1434.

Hirtz P., Hummel, A., & Rostock, J. (1985). Aneignung individueller motorischer Handlungsfähigkeit im Sportunterricht. *Körpererziehung*, 12, 402-9. [in Doutch]

Hirvonen, J., Nummela, A., Rusko, H. Rehunen, S., & Harkonen, M. (1999). Fatigue and changes of ATP, creatine phospfate, and lactate during the 400m sprint. *Canad J Sports Sci*, 17, 141-144.

Hirvonen, J., Rehunen, S., Rusko, H., & Harkonen, M. (1987). Breakdown of high-energy phosphate compounds and lactate accumulation during short supramaximal exercise. *Eur J Appl Occup Physiol*, 56, 253-59.

Holloszy, J.O., & Coyle, E.F. (1984). Adaptation of skeletal muscle to endurance exercise and their metabolic consequences. *J App Physiol*, 56, 831-38.

Izumi, T., Kouichi, I., Motoki, K., Kouji, N., Futoshi, O., & Motohiko, M. (1997). Metabolic profile of high intensity intermittent exercises. *Med Sci Sports Exerc*, 29, 390-395.

Lefévre, J., Bouckaert, J., & Duget, W. (1998). De barometer van de fysieke fitheid van de Vlaamse jeugd 1997: De resultaten. *Sport (Bloso Brussel),* 4, 16-22.

Meishan, L., & Larson, L. (2010). Force-generating capacity of human myosin isoforms extracted from single muscle fibre segments. *J Physiol*, 588, 5105-5114.

Moliner-Urdiales, D., Riuz, J.R., Ortega, F.B., Jiménez-Pavón, D., Vincente-Rodriguez, G., Rey-López, J.P., Martinez-Gomez, D., Kacajús, J.A., Mesana, M.I., Marcos, A., Noriega-Borge, M.J., Sjöström, M., Castillo, M.J., & Moreno, L.A. (2010). Secular trends in health-related physical fitness in Spanish adolescents: The AVENA and HELENA Studies. *J Sci Med Sport*. (on line version), doi: 10.1016/j.jsams. 2010.03.004.

Paganini, A.T., Foley, J.M., & Meyer, R.A. (1997). Linear dependence of muscle phosphocreatine kinetics on oxidative capacity. *Am J Physiol*, 272, 501-510.

Pilicz, S. (2000). Kierunki zmian w rozwoju fizycznym i sprawności fizycznej studentek i studentów Politechniki Warszawskiej. In: Z. Dziubiński, B. Gorski (Ed.), *Kultura fizyczna studentów w okresie transformacji szkolnictwa wyższego w Polsce (pp. 67-72).* Warsaw: Politechnika Warszawska [In Polish].

Podstawski, R., Borysławski, K., & Grymuza, E. (2010). Ewaluation of realationships between physical development and speed abilities of children from classes I-III, for the formulation of fair Requirements in relation to students on physical education lessons (on ex ample of pupils from primary school in Szydlowo, Mazovia Voivodships). *Aktywność Ruchowa Ludzi w Różnym Wieku*, 14, 103-113.

Podstawski, R., Siemianowska, E., & Skibniewska, K.A. (2010). Characteristics of changes in speed abilities of the first year female students of Warmia and Mazury University in Olsztyn (2000-2006). *Aktywność Ruchowa Ludzi w Różnym Wieku*, 14: 159-170.

Przewęda, R., & Dobosz, J. (2007). Rozwój i kondycja fizyczna polskiej młodzieży. Warszawa: AWFiS Press [In Polish].

Przewęda, R., & Trześniowski, R. (1996). Sprawność fizyczna polskiej młodzieży w świetle badań z roku 1989. Warszawa: AWF. [in Polish].