MORPHOLOGICAL AND FUNCTIONAL CHARACTERISTICS OF THE STUDENT POPULATION AT THE UNIVERSITY OF ZAGREB

Marjeta Mišigoj-Duraković, Stjepan Heimer and Branka Matković

Faculty of Physical Education, University of Zagreb, Croatia

Original scientific paper
UDC: 572.5:796.071.5(497.5)
Received: March 13, 1996
Accepted: October 20, 1998

Abstract:

Anthropometric and functional characteristics in the first-year student population were assessed in the sample of 96 female and 204 male students from the Faculty of Physical Education (FFK) and 260 female and 291 male students from other faculties, members of the University of Zagreb. Results significantly differ between the physical education students, both female and male, and other students on the basis of better results the former achieved in both the body structure and functional abilities.

Keywords: students, anthropometry, functional abilities

Zusammenfassung:

Auf der Stichprobe von 96 Studentinnen und 204 Studenten der Fakultät für Körperkultur sowie 260 Studentinnen und 291 Studenten anderer Fakultäten der Zagreber Universität wurden anthropometrische und funktionelle Kennzeichnungen gemessen. Es wurde festgestellt, dass sich schon am Anfang der Hochausbildung Kinesiologiestudenten/innen von ihren Kollegen/innen an den anderen Fakultäten bedeutend unterscheiden, indem sie wesentlich bessere Ergebnisse beim Messen der körperlichen Struktur und funktionellen Fähigkeiten erzielt haben.

Schlüsselwörter: anthropometrische Messung, funktionelle Fähigkeiten, Studentinnen, Studenten, Zagreber Universität

Introduction

The morphological status, body composition and functional characteristics of the student population have often been the subject of scientific scrutiny. In most cases, however, such research was carried out on the selected samples of this population, i.e. students involved in particular athletic activities (Walsh et al. 1984; Johnson et al. 1989; Bale and McNaught-Davies 1983). Studies of morphological and functional characteristics of unselected student populations are more rarely encountered (e.g. Katch and McArdle 1973; Bale et al. 1985), and there is a total lack of longitudinal studies of the final stages of morphological and functional development at this stage of young adulthood.

The present report forms a part of an extensive longitudinal study of morphological and functional-physiological characteristics of the male and female students of Zagreb University. Its aim is to determine the main morphological parameters, especially the amount of body fat and the share of fatty components in the body composition, and to establish some relevant parameters of the functional characteristics among the first-year students of both sexes at different faculties. The author's particular objective was to find out whether the differences in the amount of subcutaneous fat and the percentage of "extra" fat in the body composition, or in the indicators of functional abilities of organic systems and mechanisms, existed previously from the outset between students at the Faculty of Physical Education and those enrolled at other faculties.

Sample and methods

The sample used in the present study was drawn at random from the first-year student population at various faculties of Zagreb University in the 1991/92 academic year and consisted of 761 subjects (405 men and 356 women) aged between 18 and 19 years. Among them, 300 students were from the Faculty of Physical Education (204 men and 96 women) and 401 students (201 men and 260 women) came from other faculties of Zagreb University.

From among a total of 21 anthropometric

measurements covered in our study of the progress of the morphological status of students during a period of four years, the following anthropometric variables were used in the investigation under review:

1. body height (cm)
2. body mass (kg)
3. scapular skinfold (mm)
4. upper arm skinfold (mm)
5. calf skinfold (mm)
6. lower arm skinfold (mm)
7. pectoral skinfold (mm)
8. abdominal skinfold (mm)
9. suprailiacal skinfold (mm)

The assessment of the functional status was based on the following measurements:

1. forced vital capacity FVC (1)
2. forced expiratory volume per second FEV_1 (l)
3. absolute maximal oxygen uptake VO_2max (l/min)
4. relative maximal oxygen uptake VO_2rel (ml/kg/min)
5. speed of movement (m/s)
6. grip strength (N)
7. endurance area (Ns)
8. end force (N)
9. drop in strength (%)
10. flexibility (cm)

The skinfolds were measured in accordance with the recommendations of Jackson and Pollock (1985), so as to be used for the calculations of the body composition in the way suggested by these authors. Each skinfold was measured three times, and the measurements were carried out by two experienced persons.

The body mass index (body mass/body height^2) was determined by means of body

*Table 1: Height, body mass, subcutaneous fat measurements, percentage indices of mass and body fat in students of both sexes (F-female, M-male) at the Faculty of Physical Education (Group 1) and other faculties (Group 2) at Zagreb University. The level of significance of the differences is shown in terms of t-test values (*** 0.001, ** 0.01, * 0.05)*

VARIABLE		GROUP 1 F (N= 96) M (N=204)		GROUP 2 F (N= 260) M (N=201)		t - test
		X	SD	X	SD	
Body height	F	166.6	6.9	166.9	5.9	-0.40
	M	180.0	6.5	180.7	6.6	-1.14
Body mass	F	59.4	7.6	59.4	8.5	0.04
	M	74.8	8.4	72.5	9.3	2.57*
Scapular skinfold	F	10.7	2.9	11.7	5.5	-2.40**
	M	9.0	2.6	10.3	3.0	-2.66**
Upper arm skinfold	F	14.7	3.7	16.4	5.1	-3.57***
	M	8.7	3.3	10.4	3.6	-4.02***
Lower arm skinfold	F	6.9	1.9	7.1	2.2	-0.77
	M	5.5	1.5	5.6	2.6	-0.47
Pectoral skinfold	F	7.1	2.4	7.0	3.7	0.01
	M	5.5	2.1	6.3	2.5	-2.16*
Abdominal skinfold	F	12.0	4.1	16.5	6.6	-8.94***
	M	10.2	4.3	13.9	5.5	-6.58***
Suprailiacal skinfold	F	10.3	3.3	11.4	4.7	-2.70**
	M	6.1	2.4	7.0	3.8	-3.72***
Calf skinfold	F	14.0	4.9	16.2	6.1	-3.42***
	M	6.8	3.0	9.3	4.8	-6.69***
Body mass index	F	21.4	2.0	21.3	2.7	0.25
	M	23.1	2.3	22.2	2.5	3.82***
% of body fat	F	19.1	3.2	22.2	4.4	
	M	15.4	3.2	17.7	5.1	

height and weight. The skinfold measurements (scapular, upper arm, abdominal in men; upper arm, abdominal and suprailiacal in women) were first used to determine the body density according to the Jackson-Pollock method (1985), adjusted for "John Bull" calipers; subsequently, the body fat percentages were calculated with the aid of the Siri equation (Siri, 1956).

The spirometric measurements were carried out by means of a Vitalograph spirometer. The best of three measurements was taken as the result.

Both the absolute and the relative values of the maximal oxygen uptake were estimated indirectly by means of the one-step Astrand test on a bycicle ergometer.

The speed of movement was measured by the standardized method used in the Laboratory of kinesiological physiology of the Faculty of Physical Education, for the testing of athletes. The subject, who is in a sitting position, is asked to raise his or her dominant arm to chest height, palm downwards, to the controlateral side in front of the photocell on the celerimetric apparatus. Starting at will, he or she moves the arm in a horizontal lateral motion at maximum speed in the direction of another photocell placed at a distance of 0.5 meters from the first one. A calculator, which acts as a stopwatch with an accuracy of 10^{-3} s, computes and shows the speed of the arm movement in terms of meters per second. The end result is a factorial score based on six consecutive measurements.

The grip strength of the dominant arm was determined by means of kinesiological dynamography by an "on-line" electronic device (Heimer et al. 1991). Besides the

*Table 2: Functional characteristics of female (F) and male (M) physical education students (Group 1) and students of other faculties (Group 2) at Zagreb University (*** 0.001, ** 0.01, * 0.5)*

VARIABLE		GROUP 1 F (N= 96) M (N=204)		GROUP 2 F (N= 260) M (N=201)		t - test
		X	SD	X	SD	
FVC (1)	F	4.36	0.54	4.08	0.52	4.26***
	M	6.21	0.75	5.82	0.77	5.18***
FEV_1 (1)	F	3.98	0.48	3.74	0.47	4.20***
	M	5.41	0.62	5.20	0.68	3.27***
VO_2 max (l/min)	F	2.34	0.44	1.98	0.33	7.28***
	M	3.27	0.58	2.56	0.47	13.42***
VO_2 rel (l/kg/min)	F	39.68	7.56	33.67	5.73	7.04***
	M	44.08	8.20	35.66	6.58	11.37***
VO_2/LBM (ml/kg/min)	F	52.80	9.82	44.74	7.15	7.33***
	M	51.53	9.30	41.41	7.11	12.25***
Speed of movement (m/s)	F	4.69	0.57	3.90	0.59	11.63***
	M	5.85	1.80	4.88	1.70	11.57***
Grip strength (N)	F	406.42	58.13	378.73	56.62	3.99***
	M	639.95	85.56	579.71	85.40	6.97***
Endurance area (Ns)	F	1943	271.40	1766.38	281.01	5.38***
	M	3039.17	411.21	2725.98	426.63	7.43***
End force	F	361.31	57.29	322.65	59.48	5.55***
	M	575.99	89.16	503.94	87.62	8.10***
Strength drop (%)	F	9.87		8.52		
	M	9.00		8.70		
Flexibility (cm)	F	15.63	4.90	10.62	7.13	7.50***
	M	13.99	6.01	5.64	8.93	11.02***

maximum force, the additional analyses of the dynamogenic abilities of the agonist (force at the end of a specified period, area below the curve or endurance area) are also possible. Each subject was asked to perform the test three times.

Flexibility was measured by the so-called "sit-and-reach" test (Nieman 1990). Zero value is found at the level of the footrest, so that both positive and the negative values can be achieved. The final result was in the form of a factorial score based on three consecutive measurements.

Methods of data processing

The results thus obtained were processed by means of standard statistical procedures for the determination of the basic descriptive statistical indicators. Arithmetic means and standard deviations were calculated. Differences between the groups were analyzed with the aid of the Student t-test (levels of significance denoted in the tables).

Results

Table 1 presents the basic statistical indicators of the somatometric characteristics of male and female students at Zagreb University, with special emphasis on the original and calculated measures for the estimate of the share of body fat. In accordance with the aim of the study, data for the students of the Faculty of Physical Education and those of other faculties are quoted under separate headings. The value of the t-test is shown for each measurement, together with the level of significance of the differences between the two student groups found for each characteristic.

Tables 2 and 3 show the measurements used to estimate the functional abilities. The results are shown separately for male and female students, and also for students of physical education and those from the other faculties. Similarly to the preceding table, values of the t-test are supplemented by the level of significance of the differences found between the two subsamples.

Discussion

A comparison between the basic somatometric characteristics established in the present study and the findings of a 1966 study of Croatian male and female students (Momirović et al. 1969) reveals that students of both sexes are today taller and heavier, but that they also have higher results in skinfold measurements. As the analyzed characteristics were taken in the same way in both studies it could be suggested that the described differences are attributable to the phenomenon of biological acceleration.

The male students of the Faculty of Physical Education are significantly heavier than their colleagues from other faculties, whereas their body height does not differ to any significant extent. The body mass index has been found to be considerably higher in male students of the Faculty of Physical Education. It has been established, on the other hand, that female students enrolled at the Faculty of Physical Education do not differ from other female students at Zagreb University with regard to both body height and mass. Likewise, the values of the body mass indices of these two groups do not exhibit any dissimilarities.

As for skinfolds, however, the results obtained clearly indicate that there is a difference between two groups in both sexes. As seen from the results, students of both sexes enrolled at the Faculty of Physical Education, have significantly lower average results for subcutaneous fatty tissue at all places of measurement except on the forearm and on the chest (female students).

Furthermore, the body of students of both sexes at the same faculty contains a significantly lower percentage of fatty tissue than was found in students of the other faculties. The average share of fat in the total body mass of the female students at the Faculty of Physical Education amounts to 19.1% (i.e. 11.45 kg), whereas the female students from other faculties have an average of 22.2% of fat (i.e. 13.27 kg). Among the male students of the Faculty of Physical Education the fatty tissue accounts for 15.4% (i.e. 8.55 kg) of their body composition, while students of the same sex at the other faculties have an average of 17.7% (i.e. 9.74 kg) fat. According to the commonly accepted standards for age and sex, the percentages of

body fat are near the upper limit in the case of the male physical education students and above the upper limit for the male students at other faculties. In the case of the female students, on the other hand, they are near the lower limit for both groups (according to Lohman, 1987).

The main indicators of the status of the respiratory system (volume and flow) are at the upper and standard range values (Morris et al. 1971, 1975). Both subsamples have been found to have excellent values for air flow, indicating open respiratory passages and a high capacity of expiratory musculature. Nevertheless, a highly significant difference has been found with regard to both indicators in favour of students of the Faculty of Physical Education, female as well as male.

The maximal oxygen uptake, in absolute and relative terms, proved to be unexpectedly low in both male and female students of the Faculty of Physical Education as compared with the results of the direct respiratory measurements carried out on almost identical samples (Medved et al. 1989a, 1989b). This difference becomes even more striking when these results are related to the standard results of untrained Scandiavian and North American populations of the same age. In this comparison, the aerobic capacity of the students from the Faculty of Physical Education comes out as barely average or even below average (Shaver 1975, Åstrand and Rodahl 1976, Bergh et al. 1991, Shephard 1991, Osborne et al. 1992). Nearly twenty years ago, Vračarić (1974) made similar findings on a sample of students from Zagreb University.

Regardless of this, though, a substantial difference was found with the aid of the same methodology between the students of physical education and those from the other faculties, in favour of the former.

Comparing the aerobic capacities of our sample with the results of female athletes it becomes evident that the female students of physical education possess an aproximately 15-30% lower aerobic endurance (Jonssellin et al. 1984, Wells 1985, Bergh et al. 1991).

It must be stressed at this point, however, that the researchers have established that the results for the aerobic capacity obtained by the indirect Astrand method produced up to 15% lower values than those obtained by direct measurements (Nieman 1990), which may account to a certain extent for the relatively poor aerobic capacity found in the students of the Faculty of Physical Education.

The results for movement speed of male and female kinesiology students indicate a high segmetary speed ability of individual hand movements. The results of this particular subsample surpass on average even the results of the trained athletes from various sport events (Heimer et al. 1987, 1988, Janković et al. 1992). Furthermore, it was found that female and male students from other faculties have a statistically significantly lower hand movement speed than physical education students.

The grip strength of the dominant hand in kinesiology students reaches almost half the value of the grip strength with both hands of other students of the same faculty (Medved 1987). Also, both female and male students of the Faculty of Physical Education have been found to possess a statistically significantly stronger hand grip than the students from the other faculties. The grip strength of our female students of physical education exceeds even that of some female athletes (ice skating - Niinimaa, 1982; tennis - Vodak et al. 1980, Powers and Walker, 1982; hockey - Bale and McNaught-Davies, 1983). Similar results, although at a slightly higher level, were obtained in Bale's study (1980) of female students of physical education.

The integral endurance area is also an indicator of the dynamogenic ability capacity linked with the previous variable. In view of the results for strength, it was to be expected that higher values of this measurement would be found in students of kinesiology, both male and female. Accordingly, the difference with respect to the general population of students at Zagreb University had an extremely high degree of statistical significance.

The end force during the endurance measurements over a fixed time is a function of the starting value. The highly significant difference found in the end force is an additional confirmation of the superior dynamogenic capacity of the students at the Faculty of Physical Education. At the same time, however, the equivalent relative drop in strength indicates that both groups have a similar relative strength endurance.

According to the criteria of the Canadian standardized capacity test (Canadian Ministry of State, Fitness and Amateur Sports, Ottawa 1987 - Nieman 1990), the first-year male students of kinesiology have somewhere between above-average and excellent flexibility, whereas the results of the first-year male students from the other faculties are within the average range of values. Female students enrolled in the first year at Zagreb University were shown to have good flexibility of the lumbar part of the spine. Female students of physical education were found to have results above the level denoting excellent flexibility, while the female first-year students at other faculties range around the upper level of average values. The differences established between the samples under review were highly significant.

Conclusion

The present study has established considerable differences with regard to the skinfold thickness and percentage share of fat between the students at the Faculty of Physical Education and those from the other faculties of Zagreb University.

The results of the measurements of the functional abilities of the kinesiology students and of their colleagues from the other faculties of Zagreb University reveal a higher level of ability of female and male students of kinesiology, both with respect to respiratory capacity and with respect to aerobic capacity, strength and flexibility. The observed differences define a morphological and functional phenotypes of the first-year kinesiology students of both sexes as those with a higher readiness to meet the motor requirements expected when studying kinesiology. This could be ascribed to the fact that young people who attend the Faculty of Physical Education belong to the population group who have been more or less involved in sport over many years which makes them different from the average population of the same age. Further selection is made by the Faculty entrance exam.

References

1. Åstrand, P.O., K. Rodahl (1976). *Textbook of work physiology.* New York: McGraw-Hill.

2. Bale, P. (1980). The relationship of physique and body composition to strength in a group of physical education students. *Brit J Sports Med,* 14:193-198.

3. Bale, P., E. Colley, J.L. Mayhew (1985). Relationship among physique, strength, and performance in women students. *J Sport Med Phys Fitness,* 25:98-103.

4. Bale, P. and P. McNaught-Davies (1983). The physiques, fitness and strength of top class women hockey players. *J Sports Med,* 23:80-88.

5. Bergh, U., Sjodin, B., Forsberg, A., Svedenhag, J. (1991). The relationship between body mass and oxygen uptake during running in humans. *Med Sci Sports Exerc,* 2:205-211.

6. Heimer, S., R. Medved. and V. Medved (1991). Aparatura za kineziološku dinamografiju. *Hrvatski športskomedicinski vjesnik,* (1-2):46-47.

7. Heimer, S., B.R. Matković, B. Matković, M. Mišigoj, (1987). Neke antropološke karakteristike košarkaša, *Košarkaški medicinski vijesnik,* 2:3-12.

8. Heimer, S., M. Mišigoj, V. Medved (1988). Some anthropological characteristics of top volleyball players in Yugoslavia. *J Sport Med Physic Fit,* 28:200-208.

9. Jackson, A.S. and M.L. Pollock (1985). Practical Assessment of Body Composition. *The Physician and Sportsmedicine,* 5:76-90.

10. Janković, S., S. Heimer, B.R. Matković, (1992). Physiological profile of prospective soccer players. In: Reilly T, Clarys J, Stibbe A. (Eds.). *Science and football 2*, London: E & FN Spon.

11. Johnson, G.O., L.J. Nebelsic-Gullett, W.G. Thorland, T.J. Housh, (1989). The effect of a competitive season on the body composition of university female athletes. *J Sports Med Phys Fitness*, 4:314-320.

12. Jonssellin, E., R. Handschuh, D. Barrault, M. Rien (1984). Maximal aerobic power of French top level competitors. *J Sports Med,* 24:175.

13. Katch, F.I., W.D. McArdle (1973). Prediction of body density from simple anthropometric measurements in college-age men and women. *Human Biology*, 54:445-454.

14. Lohman, T.G. (1987). The use of skinfold to estimate body fatness in children and youth. *JOPERD*, 98-102.

15. Medved, R. (1987). *Sportska medicina.* Zagreb: JUMENA.

16. Medved, R., B.R. Matković, M. Mišigoj-Duraković, L. Pavičić (1989a). Neki fiziološko funkcionalni pokazatelji djece i omladine ženskog spola od 8. do 18. godine života. *Sportskomedicinski glasnik*, 2:10-15.

17. Medved, R., B.R. Matković, M. Mišigoj-Duraković, L. Pavičić (1989b). Neki fiziološko funkcionalni pokazatelji djece i omladine muškog spola od 8. do 18. godine života. *Med Vjes*, 15:2-16.

18. Momirović, K. et al. (1969). *Faktorska struktura antropometrijskih varijabli.* Institut za kineziologiju, Zagreb.

19. Morris, J.F., Koski, A., Brease, J.F. (1975). Normal values and evaluation of forced and expiratory flow. *Amer Rev Resp Dis*, 11, 755-765.

20. Morris, J.F., Koski, A., Johnson, C. (1971). Spirometric standards for healthy nonsmoking adults. *Amer Rev Resp Dis*, 103, 57-64.

21. Nieman, D.C. (1990). *Fitness and Sports Medicine: an Introduction.* Bull Publishing Company: Palo Alto, California.

22. Niinimaa, V. (1982). Figure skating: What do we known about it? *The Physician and Sportsmedicine*, 10, 1, 51-6.

23. Osborne, G., Wolfe, L.A. Burggraf, G.W., Norman, R. (1992). Relationships between cardiac dimensions, anthropometric characteristics and maximal aerobic power (VO_2max). *Int J Sports Med,* 13, 219-224.

24. Powers, S.K., Walker, R. (1982). Physiological and anatomical characteristics of outstanding female junior tennis players. *Research Quarterly for Exercise and Sport*, 53, 172-175.

25. Shaver, L.G. (1975). Maximum aerobic power and anaerobic work capacity prediction from various running performances of untrained college men. *J. Sports Med*, 15, 147-150.

26. Shepard, R.J. (1991). Measurements of fitness. The Canadian experience. *The journal of sports medicine and physical fitness*, 3, 470-480.

27. Siri, W.E. (1956). The gross composition of the body. In: *Advances in biological and medical physics*, 4:239-280, Academic Press, N. York.

28. Vodak, P.A., Savin, W.M., Haskell, W.L., Wood, P.D. (1980). Physiological profile of middle-aged male and female tennis players. *Med Sci Sports Exercise*, 12, 159-163.

29. Vračarić, F. (1974). *Maximal oxygen uptake assessed by Astrand's method of Zagreb University students.* Graduate Final Paper. Faculty of Physical Education University of Zagreb, Zagreb.

30. Walsh, F.K., Heyward, V.H., Schau, C.G. (1984). Estimation of body composition of female intercollegiate basketball players. *The Physician and Sportsmedicine,* 11, 74-89.

31. Wells, C.L. (1985). *Women, sport and performance. A physiological perspective.* Human Kinetics Publishers: Champaign.