STUDIES IN PHYSICAL CULTURE AND TOURISM
Vol. 17, No. 1, 2010

BARBARA POSPIESZNA, TADEUSZ RYCHLEWSKI, EDYTA MICHALAK
Chair of Physiology, University of Physical Education in Poznań

THE INFLUENCE OF AN 8-WEEK ERGOMETER TRAINING ON POSTMENOPAUSAL WOMEN IN VIEW OF THEIR BIOLOGICAL AGE

Key words: physical tolerance, elderly women.

ABSTRACT

The aim of the study was to assess the influence of an 8-week training on physical tolerance, body mass and body composition of older women. The study was carried out in two groups of women: younger (n = 10, 57-64 years of age) and older (n = 10, 65-75 years of age). The subjects participated in a cycle ergometer workout (24 sessions, 40 min). Before and after the training the ventilatory threshold and VO_2max were estimated. Blood pressure and anthropometric measurements were also taken. In the younger group, training resulted in a significant increase of the main variables of physical tolerance and a decrease in body mass, BMI and WHR. In the older group statistical significance was achieved only for the increase in work and breathing frequency and the decrease in WHR. Increased VO_2max, test time, work and power indicate enhanced physical tolerance in women under study. The scale of changes in most parameters was more explicit in the younger group.

INTRODUCTION

The recent decades have brought significant changes of the demographic structure – lifespan extension and reduction in the number of births. Progressive aging can be, in particular, noted in highly developed countries. According to the Polish Main Statistical Office, by 2030 23.8% of people in Poland will have retired as opposed to only 10% in 2005 [10]. This projection is similar to the ones made for other EU member states [33].

Aging-related changes in body dimensions and body composition have been well documented [18, 27, 29]. Also well known are the health consequences of increasing fat body mass and at the same time decreasing lean body mass. Obesity, which is directly associated with metabolic syndrome, and increased mortality along with incidental falls and fall-related injuries are the most strenuous conditions [18, 31, 35]. Cardio-respiratory disorders and type II diabetes are also connected with aging and are usually related to a sedentary life style [6, 12, 28, 37].

Several studies have shown the positive influence of physical activity on aging-related changes in human body composition and functioning [6, 11, 19, 24, 25, 30, 37]. The research hypothesis was that an 8-week programmed aerobic training would cause an increase in the level of physical capacity of retired women and that by affecting their body composition it would entail specific economization of the cardio-respiratory system. Yet, it is still unclear whether the body response to training is related to training women's age.

Correspondence should be addressed to: Barbara Pospieszna, University of Physical Education in Poznań (Chair of Physiology), ul. Królowej Jadwigi 27/39, 61-871 Poznań, tel.: 061-8355-193, e-mail: baramich@wp.pl

The aim of this study was to evaluate the influence of an 8-week ergometer training on physical tolerance, body mass and body composition of older women in relation to their biological age.

METHODS

The study was carried out in a group of 20 women, aged 57 to 75 years, students of the University of the Third Age in Poznań (Poland). The participants were divided into two groups: the younger (n = 10, 57-64 years) and the older (n = 10, 65-75 years). The age (60.80 vs. 70.10 years), body height (162.35 vs. 156.85 cm) and body mass (74.61 vs. 66.59 kg) were the only values which were statistically different between both groups. Only healthy, non-smoking women were included into the study. The health state of all subjects was confirmed by physicians in writing. Additionally, data on dietary habits, alcohol consumption, smoking and medication history were obtained with the aid of a questionnaire. All participants gave their written, informed consent to participate in the training program. The study was approved by the local Ethics Committee.

The subjects participated in an 8-week cycle ergometer physical workout. The training included 40-min sessions three times per week. Each session consisted of a 5-min introduction, 30-min workout with a workload at 80% of ventilatory threshold intensity (VT), and 5-min cool down.

Before and at the end of the program, the subjects underwent ventilatory threshold estimation during an incremental cycle ergometer test (Ergo-line, Ergo Metrics 900, Germany). During the test, cardio-respiratory parameters were continuously assessed. Respiratory parameters were evaluated with CardiO$_2$ computer program (Medical Graphics Corporation, USA) to determine the ventilatory threshold [2]. Heart rate was monitored with a Polar sport-tester (Finland). The workload from initial 25 W was increased every 3 min by 25 W up to the ventilatory threshold, when the test was stopped. Maximal oxygen uptake (VO_2max) was estimated by indirect method with the use of Åstrand-Ryhming Nomogram [1].

Before the physical tests (before the training program and after its completion) blood pressure was measured and anthropometric data (body mass, body height, waist and hip circumference) were collected. Body composition was assessed by way of bioelectrical impedance analysis (101/S Analyzer, Akern, Italy). Body Mass Index (BMI) and Waist-to-Hip Ratio (WHR) were later calculated.

All data were expressed as means ± SD. The statistical analysis of the results obtained before (Term I) and after completing the training period (Term II) used non-parametric tests (Wilcoxon and U Mann-Whitney). The Statistica software package was used for all statistical calculations. The level of statistical significance was set at $p \leq 0.05$ or $p \leq 0.001$ and was marked as (*) and (**), respectively.

RESULTS

Differences in subjects' anthropometric measurements and body composition, noted after the study period are shown in Table 1. After the training program a significant decrease in body mass and BMI was observed only in the younger group. In both age groups, however, the 8-week aerobic training resulted in a significant WHR decrease. No body composition changes were observed during the training period.

Table 1. Post-training changes in subjects' anthropometric parameters and body composition

Variable	Unit	Younger group		Older group	
		Term I	Term II	Term I	Term II
Body mass	kg	74.61 ± 5.245	73.95* ± 5.194	66.59 ± 6.144	65.93 ± 6.231
BMI	kg/m^2	28.34 ± 1.825	28.08* ± 1.774	27.12 ± 2.847	26.84 ± 2.935
WHR		0.84 ± 0.050	0.80* ± 0.046	0.83 ± 0.059	0.78** ± 0.067
FBM	%	39.16 ± 3.304	38.55 ± 2.741	38.63 ± 4.778	37.56 ± 3.846
LBM	%	60.84 ± 3.304	61.45 ± 2.741	61.37 ± 4.778	62.44 ± 3.846

* $p < 0.05$, ** $p < 0.01$

Changes in the resting blood pressure values and the ventilatory parameters achieved at the ventilatory threshold are presented in Table 2. The post-training decrease in blood pressure values was statistically non-significant in both groups. An increment in minute lung ventilation was observed only in the younger women. In the older subjects the training program resulted in a significant increase in breathing frequency at VT.

Table 2. Resting blood pressure and respiratory parameters at ventilatory threshold in both studied terms

Variable	Unit	Younger group		Older group	
		Term I	Term II	Term I	Term II
BPsys	mmHg	137.20 14.219	132.30 10.404	136.40 15.869	133.00 22.341
BPdia	mmHg	85.00 6.683	83.40 8.127	81.50 10.058	81.40 6.883
V_E	$L \cdot min^{-1}$	31.30 7.364	38.00* 8.994	28.10 8.812	34.40 7.367
TV	L	1.39 0.461	1.56 0.463	1.11 0.316	1.28 0.322
Bf	$1 \cdot min^{-1}$	23.30 4.523	25.00 3.887	25.30 4.877	27.40* 4.351

* p < 0.05

The results of physical tests at the end of the training program significantly increased as compared to the basal values mainly in the younger age group (Table 3). There was a very strong significance ($p \leq 0.001$) for the increment in work, power, test time and VO_2max obtained at the end of the study period by the younger women. In this age group oxygen consumption at VT increased significantly as well ($p \leq 0.05$). In both groups there were no heart rate changes at VT level during the study period. In the older women, apart from the increased work level, parameters of physical capacity and physical tolerance did not change after 8 weeks of programmed physical activity.

DISCUSSION

The study described differences in physiological reactions induced by an 8-week ergometer training between postmenopausal women depending on their biological age.

At baseline the level of physical capacity was higher in the older group. It is probably due to natural selection of U3W students. The older students usually after years of integrated intellectual, psychic and physical elicitation offered by those institutions are generally in better health condition then those who just finished their professional carriers [32].

After the study period the physical capacity levels and physical tolerance parameters increased in both groups, however, the statistical significance was achieved mainly in the younger women. An increase in those parameters after a few weeks of aerobic training was confirmed by other researchers [31, 34, 36]. After the training period VO_2max – the primary cardiovascular fitness parameter – increased in the younger women by 25% and in the older ones only by 10%. Stewart at al. [31] analyzed the influence of aerobic training on subjects aged 55-75 years and observed a 16%

Table 3. Physical tolerance and physical capacity parameter changes after 8-week training

Variable	Unit	Younger group		Older group	
		Term I	Term II	Term I	Term II
Work	kJ	22.35 ± 9.886	39.3 ** ± 16.719	23.40 ± 11.045	29.40 (*) ± 9.720
Power	W	70.00 ± 15.811	100.00 ** ± 23.570	72.50 ± 21.89	82.50 ± 12.076
Time	min	7.85 ± 1.973	10.80 ** ± 2.710	7.95 ± 2.420	9.00 ± 1.225
HR	$1 \cdot min^{-1}$	134.80 ± 15.433	140.10 ± 11.170	124.90 ± 15.228	128.60 ± 12.456
VO_2	$ml \cdot min^{-1} \cdot kg^{-1}$	14.58 ± 3.386	17.66 * ± 3.489	14.84 ± 4.361	17.54 ± 3.912
VO_2max	$ml \cdot min^{-1} \cdot kg^{-1}$	22.27 ± 4.720	27.79 ** ± 4.650	26.25 ± 4.718	28.85 ± 5.684

* p < 0.05, ** p < 0.01

increment of maximal oxygen consumption. After merging both groups similar results would have been achieved in this study. When analyzing the results of the study conducted on participants over 65 years old the increment in VO_2max is not that spectacular. Woo at al. [34] noted a 12% increment of this parameter in subjects of both sexes, over 65 of age, after aerobic exercise training. Yet Deley et al. [5] provided evidence that physical training improved aerobic capacity by 14.8% in healthy subjects over 70 years old. These enlarged results are probably due to men's enrolment and the prolonged time (one year) of training.

In comparison with the younger women, in their older counterparts both physical capacity (VO_2max) and physical tolerance parameters (power, test time, oxygen consumption at VT) seem to be less susceptible to the identical training intensities. A lesser degree of changes in older women is possibly caused by the smaller reactivity of older organisms as compared to the younger ones. Other authors [7, 8, 14] also observed that the training influence was reduced with age. Kallinen at al. [14] even suggested that training-induced VO_2max increases only till the age of 80 years. They proved that strength or endurance training in women aged ≥ 75 years had a relatively small influence on cardiovascular fitness. In total opposition to this argumentation stands the report of Kohrt et al. from 1991 [17]. They found out that subjects of both sexes (aged 60-71 years) improved their physical capacity after 9-12 months of aerobic training, independently of age, sex and the initial level of fitness. Puugard et al. [25] also confirmed that after regular training (walking once a week over 8 months) previously sedentary 85-year old women can improve their VO_2max, even by 18%.

At baseline, there was a difference between the two study groups in their anthropometric parameters (body mass, BMI and WHR), all of which were lower in the older group. The statistical significance of the difference between the groups, however, was reached only for body mass. Due to the undertaken training, body mass and BMI were significantly reduced only in the younger age group. In the older group only a decremental tendency in both mentioned parameters was foreseeable. This difference in statistical significance is probably caused by the variable starting level, because in both groups the reduction value between the terms was almost the same. Other authors e.g. Stewart et al. [31] also noted the reduction of these parameters after endurance training. Additionally Kyle et al. [18] proved that physically active women had lower body mass, BMI and body fat percent at all ages as compared with their sedentary counterparts. The reduction of WHR was noted in this study in both age groups. This effect, on the one hand, confirms the tendency to decrease body mass in the older group, and on the other hand suggests positive visceral fat redistribution as a consequence of aerobic training. Theoretically, the training program should bring about body composition changes such as an increase in LBM and decrease in FBM [31]. In this study however, there was no significant changes of body composition in neither of the analyzed groups. Morio et al. [21] after 7 and 14 weeks of aerobic training achieved similar results. No body composition changes were also found after 12-week endurance training in healthy postmenopausal women [36]. In all three studies no change in body composition was followed by even a slight change in body mass. Thus it is probable that body composition changes are related mainly to body weight alteration, with a lesser influence of physical activity. A three-year longitudinal study on body composition changes in the elderly described by Raguso et al. [27] seems to confirm this observation.

Aging-related deterioration in cardio-pulmonary function is mainly linked to the development of hypertension, cardiovascular or coronary disease and breathing muscles weakening, usually connected with breathing insufficiency. Yet, it is proven that there is an inverse relation between increased physical activity and the risk of developing typical aging-related disorders. There is no ultimate agreement among researchers whether a few weeks of aerobic training could reduce blood pressure values. A decrement in the mean values for both systolic and diastolic blood pressure after the training period was reported by many authors [3, 9, 22, 35]. However, there are also studies revealing no change in this parameter [36]. The results of meta-analysis made by Kelley G.A. [15], representing ten studies, suggest that aerobic exercise causes a small reduction of resting systolic and diastolic blood pressure. A broader analysis (21 studies) however, showed the influence of exercise only on systolic blood pressure [16]. The conviction about the reducing influence of physical exercise on resting blood pressure is discredited by some authors who try to prove that it exists only for hypertensive subjects [13, 23, 26]. The American College of Sports Medicine Position Stand over the influence of exercise on hypertension suggests that the range of blood pressure decrement depends mainly on the initial level of this parameter [22]. In this study the post-training reduction in blood pressure values was statistically non-significant in both study groups. At baseline the level of analyzed values was normative, so even an insignificant decrease can suggest a positive exercise influence.

Age-related changes in the respiratory system are manifested through inspiratory muscle weakening which directly leads to the reduction in spirometric function. At rest this decline includes mainly forced vital capacity (FVC), forced expiratory volume in first second (FEV1), FEV1/FVC ratio, tidal volume (TV) and breathing frequency (Bf) [4]. In physical exercise conditions at the equal intensity (as proven in this study) the level of minute lung ventilation and tidal volume are decreasing with age, while the breathing rate is accelerating. As the result of aerobic training most of the spirometric parameters increase while the frequency of breathing decreases [20]. In this study an increment in minute lung ventilation at the ventilatory threshold was observed only in the younger women. It was properly caused by a proportional increase in TV and Bf. In the older subjects however, the training program resulted only in a slight increase in V_E, which was mainly caused by a significant increase in breathing frequency at VT and to a lesser extent by a change of tidal volume. This reaction confirms earlier suggestions that the reactivity of the older body to physical training is reduced as compared to the younger body.

Our findings suggest that undertaking additional aerobic training by postmenopausal women is an effective method of slowing down the consequences of age-related changes in the human body. Its desirable influence is related to enhancement of physical capacity, which clearly corresponds with seniors' ability of independent living. The scale of discussed changes is, however, much more explicit in the younger age group. Hence, the results of this study verify the range of the physical training influence on aging women.

REFERENCES

[1] Åstrand P., Ryhming I., A nomogram for calculation of aerobic capacity (physical fitness) from pulse rate during submaximal work, *Journal of Applied Physiology*, 1954, 9: 2-8.

[2] Beaver W., Wasserman K., Whipp B.J., A new method for detecting anaerobic threshold by gas exchange, *Journal of Applied Physiology*, 1986, 60: 2020-2027.

[3] Braith R.W., Pollock M.L., Lowenthal D.T., Graves J.E., Limacher M.C., Moderate- and high-intensity exercise lowers blood pressure in normotensive subjects 60 to 79 years of age, *American Journal of Cardiology*, 1994, 73 (15): 1124-1128.

[4] Chen H.I., Kuo C.S., Relationship between respiratory muscle function and age, sex, and other factors, *Journal of Applied Physiology*, 1989, 66 (2): 943-948.

[5] Deley G., Kervio G., Van Hoecke J., Verges B., Grassi B., Casillas J.M., Effects of a one-year exercise training program in adults over 70 years old: a study with a control group, *Aging Clinical and Experimental Research*, 2007, 19 (4): 310-315.

[6] Dionne I.J., Ades P.A., Poehlman E.T., Impact of cardiovascular fitness and physical activity level on health outcomes in older persons, *Mechanisms of Ageing and Development*, 2003, 124: 259-267.

[7] Ehsani A.A., Spina R.J., Peterson L.R., Rinder M.R., Glover K.L., Villareal D.T., Binder E.F., Holloszy J.O., Attenuation of cardiovascular adaptations to exercise in frail octogenarians, *Journal of Applied Physiology*, 2003, 95 (5): 1781-1788.

[8] Evans E.M., Racette S.B., Peterson L.R., Villareal D.T., Greiwe J.S., Holloszy J.O., Aerobic power and insulin action improve in response to endurance exercise training in healthy 77-87 yr olds, *Journal of Applied Physiology*, 2005, 98: 40-45.

[9] Forjaz C.L., Cardoso C.G. Jr, Rezk C.C., Santaella D.F., Tinucci T., Postexercise hypotension and hemodynamics: the role of exercise intensity, *Journal of Sports Medicine and Physical Fitness*, 2004, 44 (1): 54-62.

[10] Główny Urząd Statystyczny (Polish Main Statistical Office); http://www.gus.pl

[11] Hautier C., Bonnefoy M., Training for older adults, *Annales de readaptation et de medecine physique (Annals of Physical and Rehabilitation Medicine),* 2007, 50: 475-479.

[12] Hollenberg M., Yang J., Haight T.J., Tager I.B., Longitudinal changes in aerobic capacity: implications for concepts of aging, *The Journals of*

Gerontology. Series A, Biological sciences and medical sciences, 2006, 61 (8): 851-858.

[13] Ishikawa-Takata K., Ohta T., Tanaka H., How much exercise is required to reduce blood pressure in essential hypertensives: a dose-response study, *American Journal of Hypertension*, 2003, 16 (8): 629-633.

[14] Kallinen M., Sipilä S., Alen M., Suominen H., Improving cardiovascular fitness by strength or endurance training in women aged 76-78 years. A population-based, randomized controlled trial, *Age and Aging*, 2002, 31: 247-254.

[15] Kelley G.A., Aerobic exercise and resting blood pressure among women: a meta-analysis, *Preventive Medicine*, 1999, 28 (3): 264-275.

[16] Kelley G.A., Kelley K.S., Aerobic exercise and resting blood pressure in women: a meta-analytic review of controlled clinical trials. *Journal of Women's Health and Gender-Based Medicine*, 1999, 8 (6): 787-803.

[17] Kohrt W.M., Malley M.T., Coggan A.R., Spina R.J., Ogawa T., Ehsani A.A., Bourey R.E., Martin 3rd W.H., Holloszy J.O., Effects of gender, age, and fitness level on response of VO_2max to training in 60-71 yr olds, *Journal of Applied Physiology*, 1991, 71 (5): 2004-2011.

[18] Kyle U.G., Genton L., Gremion G., Slosman D.O., Pichard C., Aging, physical activity and height-normalized body composition parameters, *Clinical Nutrition*, 2004, 23: 79-88.

[19] MacAuley D., The potential benefits of physical activity in older people, *Medicina Sportiva*, 2001, 5 (4): 229-236.

[20] McParland C., Krishnan B., Lobo J., Gallagher C.G., Effect of physical training on breathing pattern during progressive exercise, *Respiration Physiology*, 1992, 90 (3): 311-323.

[21] Morio B., Barra V., Ritz P., Fellmann N., Bonny J.M., Beaufrère B., Boire J.Y., Vermorel M., Benefit of endurance training in elderly people over a short period is reversible, *European Journal of Applied Physiology*, 2000, 81 (4): 329-336.

[22] Pescatello L., Franklin B., Fagard R., Farquhar W., Kelley G., Ray C., Exercise and Hypertension. American College of Sports Medicine Position Stand, *Medicine & Science in Sports & Exercise* (Special Communications 2004).

[23] Pescatello L.S., Kulikowich J.M., The after effects of dynamic exercise on ambulatory blood pressure, *Medicine & Science in Sports & Exercise*, 2001, 33 (11): 1855-1861.

[24] Pospieszna B., Jeszka J., Ruch – nadal niedoceniany element profilaktyki chorób cywilizacyjnych (Movement – underappreciated component of civilization disease prevention), *Medicina Sportiva*, 2006, 10 (4): 403-411.

[25] Puggaard L., Larsen J.B., Støvring H., Jeune B., Maximal oxygen uptake, muscle strength and walking speed in 85-year-old women: effects of increased physical activity, *Aging*, 2000, 12 (3): 180-189.

[26] Quinn T.J., Twenty-four hour, ambulatory blood pressure responses following acute exercise: impact of exercise intensity, *Journal of Human Hypertension*, 2000, 14 (9): 547-553.

[27] Raguso C.A., Kyle U.G., Kossovsky M.P., Roynette C., Paoloni-Giacobino A., Hans D., Genton L., Pichard C., A 3-year longitudinal study on body composition changes in the elderly: Role of physical exercise, *Clinical Nutrition*, 2006, 25: 573-580.

[28] Sato Y., Nagasaki M., Kubota M., Uno T., Nakai N., Clinical aspects of physical exercise for diabetes metabolic syndrome, *Diabetes Research and Clinical Practice*, 2007, 77: 87-91.

[29] Schuit A.J., Physical activity, body composition and healthy ageing, *Science & Sports*, 2006, 21: 209-213.

[30] Spirduso W.W., Cronin D.L., Exercise dose-response effects on quality of life and independent living in older adults, *Medicine & Science in Sports & Exercise*, 2001, 33 (6): 598-610.

[31] Stewart K., Bacher A.C., Turner K., Lim J.G., Hees P.S., Shapiro E., Tayback M., Ouyang P., Exercise and risk factors associated with metabolic syndrome in older adults, *American Journal of Preventive Medicine*, 2005, 28 (1): 9-18.

[32] Swindell R., Thompson J., An international perspective on the University of the Third Age, *Educational Gerontology*, 1995, 21 (5): 429-447.

[33] U.S. Census Bureau, International Data Base: http://www.census.gov.

[34] Woo J.S., Derleth C., Stratton J.R., Levy W.C., The Influence of Age, Gender, and Training on Exercise Efficiency, *Journal of the American College of Cardiology*, 2006, 47: 1049-1057.

[35] Yanowitz F.G., LaMonte M.J., Physical activity and health in the elderly, *Current Sports Medicine Reports*, 2002, 1: 354-361.

[36] Zarins Z.A., Fattor J.A., Brooks G.A., Effect of Endurance Training on Cardiovascular Fitness, Body Composition, and Lipoprotein Profile in Postmenopausal Women, *Medicine & Science in Sports & Exercise*, 2007, 39 (5): 349.

[37] Zdrojewski T., Aktywność ruchowa a nadciśnienie tętnicze (Physical activity and arterial hypertension), *Medicina Sportiva*, 2001, 5 (2): 151-157.