EFFECT OF A TWELVE WEEK EXERCISE PROGRAMME ON CARDIORESPIRATORY AND BODY COMPOSITION VARIABLES IN NONOBESE YOUNG AND MIDDLE-AGED FEMALES

GAIL M. WHITE* and R. J. YOUNG,† Ph.D.

**Smith College, Northampton, Massachusetts 01063*

†*Washington University, St. Louis, Missouri 63130*

Address correspondence to:

Dr. R. John Young,

Physical Education Department, Box 1067,

Washington University,

St. Louis, Missouri 63130

ABSTRACT

This study investigated the effect of a 12-week exercise programme consisting of jogging, calisthenics, and recreational activities on the cardiorespiratory function and body composition of 15 young and 15 middle-aged nonobese women 21-32 and 34-57 years, respectively. The exercise programme was 3 days per week for an average of 45 minutes each session. Pre- and post-programme data were obtained on: age, height, total body weight, resting heart rate, systolic and diastolic blood pressure, vital capacity, submaximal heart rate, supra-iliac skinfold, thigh skinfold, waist girth, cup size, body density, and percent fat. The t-test was used to test the difference between the young and middle-aged groups before and after the exercise programme and to test the pre- and post-programme mean values of each group. No differences between the groups or changes due to the exercise programme were observed on total body weight. No significant cardiorespiratory differences were found between the two groups at either test period, however, the young group decreased significantly ($p < .01$) in submaximal HR and the middle-aged group decreased significantly in resting ($p < .01$) and submaximal ($p < .001$) HR illustrating the positive effect of the programme. No significant body composition differences were found between the two groups at the pre-test. At the post-test the middle-aged group had a significantly ($p < .10$) larger thigh skinfold thickness than the young group. The young group did not change significantly on body composition measures from pre- to post-test. In contrast, the middle-aged group increased significantly in body density ($p < .01$) and decreased in percent body fat ($p < .01$) due to a significant ($p < .01$) reduction in supra-iliac skinfold thickness from 21.67 ± 2.35 to 18.13 ± 2.08 mm. The data were compared with data from other studies using similar age groups. The pre-test percent fat of the young group ($25.07 \pm .74$) was similar to values reported in other studies. The middle-aged group had a relatively lower fat percentage (27.46 ± 1.58) compared with other middle-aged groups.

INTRODUCTION

Several studies have examined the cardiorespiratory (Eiseman and Golding, 1975; Fringer, 1973; Humphrey and Falls, 1975; Katch *et al*, 1973; McArdle *et al*, 1972) and body composition (Katch and Michael, 1968; Moody, 1972; Pollock *et al*, 1975; Sloan *et al*, 1962; Wade, 1976; Wallace, 1975; Wilmore and Behnke, 1971; Young *et al*, 1962) changes due to regular exercise in young untrained women. Few studies deal with the effect of exercise on physiological (Getchell and Moore, 1974) or body composition (Pollock *et al*, 1975; Young *et al*, 1963; Young, 1974) variables in nonobese middle-aged women. This study, therefore, investigated the effect of a 12-week physical fitness programme on selected cardiorespiratory and body composition measures in nonobese young and middle-aged women.

METHODS

Subjects

Subjects were 30 women, 21 to 57 years, who partici-

pated voluntarily in the Washington University Adult Physical Fitness Programme. Two discrete groups, consisting of 15 subjects each, were established and designated "young" (21 to 32 years) "and middle-aged" (34 to 57 years). All subjects had completed successfully a physical examination by their family physician before being admitted into the programme. Attendance was recorded at each meeting and each subject had at least 60 percent attendance.

Exercise Programme

The physical fitness programme consisted of three one hour sessions weekly for 12 weeks. It was designed to improve cardiovascular efficiency, muscular strength, muscular endurance, and flexibility. At each session subjects took part in: jogging for warm-up (5 min. maxi-

The experiments described in this paper were approved by the Committee on the Use of Human Subjects in Research at Washington University. The authors appreciate the assistance of Jody Rodewald and Rand L. Rosenthal in the collection of data.

mum); calisthenics (20 min. maximum); jogging (20 min. maximum), and self-selected recreational activities (15 min. maximum). The programme was intensified progressively and consisted of individually prescribed exercise designed to elicit approximately 70 percent of maximal working capacity. The calisthenic exercises focused on flexibility, muscular strength, and muscular endurance and involved selected exercises performed in the standing, kneeling, sitting and lying positions. Following calisthenics each individual ran for a gradually increasing distance. The distance varied according to the ability of the individual but, at the conclusion of the programme, the distance range observed was between one and five miles. The recreational activities provided were swimming, weight-training, gymnastics, basketball, and soccer.

General Testing Procedure

Data were collected on all subjects in the first and final weeks of the programme. On each occasion they reported to the Exercise Physiology Laboratory where they rested quietly in the supine position for 10 minutes. Heart rate and systolic and diastolic blood pressures were measured using standard clinical procedures at the end of the 10 minute rest. In addition, height and weight were obtained, and vital capacity was determined using a basic spirometer module unit manufactured by Collins (model P-1253).

The subject then pedalled on a Quinton-Monark cycle ergometer for 5 min. at a rate of 50 rev./min. (by a metronome) against a workload of 300 mkp/min. (50W). Submaximal heart rate was recorded at the end of the fifth minute of exercise.

Pre- and post-test anthropometric measurements were obtained by the same female investigator. Skinfold fat was measured in mm by standard methods using a Lange skinfold fat calliper at the supra-iliac and front thigh. The calliper had a constant pressure of 10 g/mm² and measures were taken on the right side. Waist girth was measured in cm using a Lufkin steel tape. Brassiere cup sizes A, B, C and D were transformed into the numerical values of 1, 2, 3 and 4, respectively. Body density was estimated using the predictive equation ($R = 0.889$, $SE = 0.0069$) of Pollock *et al*, 1975 as follows:

$$\text{Density (g/ml)} = 1.1023 - (\text{supra-iliac skinfold } 0.0005) - (\text{thigh skinfold } 0.0003) - (\text{waist girth } 0.0005) - (\text{cup size } 0.0033).$$

Percentage fat was estimated by the formula of Rathbun and Pace, 1945 as follows:

$$\text{Fat \%} = \frac{100 (5.1350 - 4.6940)}{\text{Body density}}$$

Variables

Pre- and post-programme data were collected on 15 cardiorespiratory and body composition variables. They were: age, height, total body weight (TBW), resting heart rate, systolic blood pressure, diastolic blood pressure, pulse pressure, vital capacity, submaximal heart rate, supra-iliac skinfold, thigh skinfold, waist girth, cup size, body density and percent fat.

Statistical Analysis

Student's t-test was used to compare the young and middle-aged groups before and after the exercise programme and to compare the pre- and post-test mean values of the young and middle-aged groups.

RESULTS

Personal data of the young and middle-aged groups at the pre- and post-test periods are presented in Table I. No pre- or post-test differences between the groups or changes due to the exercise programme were observed on total body weight (TBW).

TABLE I
Personal data

Variable	Pre-test		Post-test		t
	$\bar{X}$	S.E.	$\bar{X}$	S.E.	
<i>Young (n = 15)</i> <i>(21-32 years)</i>					
Age (years)	25.40	.84	25.40	.84	—
Height (cm)	162.89	1.93	162.89	1.93	—
Weight (kg)	58.04	1.97	59.54	1.58	1.29
<i>Middle-aged (n = 15)</i> <i>(34-57 years)</i>					
Age	43.47	1.67	43.47	1.67	—
Height (cm)	161.11	2.11	161.11	2.11	—
Weight (kg)	60.84	2.13	61.05	1.87	0.37

Cardiorespiratory data are presented in Table II to illustrate the effect of the exercise programme. The young group increased significantly in vital capacity ($p < .05$) and decreased ($p < .01$) in submaximal HR and the middle-aged group decreased in resting ($p < .01$) and submaximal ($p < .001$) heart rates.

Body composition data are presented in Table III. No significant differences were found between the two groups at the pre-test. At the post-test the middle-aged group had a significantly ($p < .10$) larger thigh skinfold

than the young group. The young group did not change significantly on body composition measures from pre- to post-test. In contrast, the middle-aged group significantly

reduced in supra-iliac skinfold thickness ($p < .01$), increased in body density ($p < .01$), and decreased in percent body fat ($p < .01$).

TABLE II
Cardiorespiratory data of young and middle-aged groups

Variable	$\bar{X}$	Pre-test S.E.	$\bar{X}$	Post-test S.E.	t
<i>Young</i>					
Resting HR (beats/min)	72.67	2.70	67.07	2.77	2.04
Systolic BP (mmHg)	118.00	3.68	118.67	2.81	.25
Diastolic BP (mmHg)	73.60	2.83	71.20	2.67	.90
Pulse pressure (mmHg)	44.40	2.29	47.47	1.98	1.98
Vital capacity (L)	3.35	.15	3.49	.13	2.85*
Submaximal HR (beats/min)	123.60	4.47	110.87	3.63	3.21**
<i>Middle-aged</i>					
Resting HR (beats/min)	76.40	1.89	66.60	2.02	3.86**
Systolic BP (mmHg)	119.07	2.93	114.87	3.48	1.91
Diastolic BP (mmHg)	76.07	2.38	72.53	2.79	1.84
Pulse pressure (mmHg)	43.00	1.75	42.33	2.40	.27
Vital capacity (L)	3.17	.14	3.25	.14	1.34
Submaximal HR (beats/min)	125.07	2.41	114.13	2.60	5.52**

* t-Ratio 2.15 = $p < 0.05$

** t-Ratio 2.98 = $p < 0.01$

*** t-Ratio 4.14 = $p < 0.001$

TABLE III
Body composition data of young and middle-aged groups

Variable	$\bar{X}$	Pre-test S.E.	$\bar{X}$	Post-test S.E.	Δ	t
<i>Young</i>						
Supra-iliac skinfold (mm)	19.17	1.29	17.00	1.39	-2.17	1.90
Thigh skinfold (mm)	42.93	1.88	40.70	1.72	-2.23	1.25
Waist girth (cm)	69.42	1.58	69.19	1.50	-0.23	.27
Cup size	2.00	.24	2.07	.23	+0.07	1.00
Body density (g/ml)	1.0385	.002	1.0401	.002	+0.0016	1.47
Fat (%)	25.07	.74	24.35	.78	-0.72	1.39
<i>Middle-aged</i>						
Supra-iliac skinfold (mm)	21.67	2.35	18.13	2.08	-3.54	3.87**
Thigh skinfold (mm)	46.70	2.58	46.03 ^a	2.13	-0.67	.37
Waist girth (cm)	73.10	2.30	71.93	1.86	-1.17	.91
Cup size	2.20	.24	2.20	.24	-	-
Body density (g/ml)	1.0336	.003	1.0362	.003	+0.0026	2.98**
Fat (%)	27.46	1.58	26.24	1.39	-1.22	3.07**

^a Significantly different from young group ($p < .10$)

**t-Ratio 2.98 = ($p < 0.01$)

TABLE IV
Comparison of body composition results in young and middle-aged women

Investigator	Age (yr)	N	Ht (cm)	Wt (kg)	Density (g/ml)	Fat (%)
<i>Young</i>						
Sloan <i>et al</i> , 1962	17-25	50	165.1	55.5	1.0467	22.9
Pollock <i>et al</i> , 1975	18-22	83	166.1	57.5	1.0427	24.8
Novak, 1972	18-25	89	163.2	56.3	1.0221**	33.0
Getchell <i>et al</i> , 1977	18-25	21	164.8	56.5	1.0491**	20.1
Katch & Michael, 1968	19-23	64	165.9	58.4	1.0490	21.9
Young <i>et al</i> , 1962	16-30	94	167.4	59.0	1.0342	28.7
Novak, 1972	25-36	33	162.4	58.4	1.0237**	32.2
Present study*	21-32	15	162.9	58.0	1.0385	25.1
<i>Middle-aged</i>						
Lewis <i>et al</i> , 1976 ^a	30-52	22	161.0	76.2	1.0100	40.4
Pollock <i>et al</i> , 1975	33-50	60	165.8	61.2	1.0319	29.8
Novak, 1972	35-45	44	162.1	61.5	1.0163**	35.9
Young, 1964	40-70	62	162.0	63.0	1.0138	38.2
Novak, 1972	45-55	72	162.0	67.1	1.0028**	42.7
Present study*	35-57	15	161.1	60.8	1.0336	27.5

*Pre-training values

**Estimated from data provided by authors

^a Obese subjects

Comparison of the data from this study with data reported by other investigators (Table IV) revealed that the pre-test percent fat of the young group ($25.07 \pm .74$) was similar to values reported in other studies. The middle-aged group had a relatively lower fat percentage (27.46 ± 1.58) compared with studies using subjects in the same age range.

DISCUSSION

This study investigated the effect of a supervised physical fitness programme on the cardiorespiratory function and body composition of nonobese young and middle-aged women. Significant reductions were found in submaximal HR, in the case of the young group, and resting and submaximal HR, in the case of the middle-aged group reflecting improvements in cardiorespiratory function due to the exercise programme. Similar findings have been reported by Kilbom, 1971 and Drinkwater, 1973. No significant differences were found between the two groups at either test period on cardiorespiratory measures. Expected age differences were found on all measures collected. For example, lower blood pressure, lower heart rates, higher body density, and less body fat were associated with youth.

No pre- or post-test differences between the groups or changes due to exercise were observed on TBW, in fact, both groups increased slightly. This finding is not

entirely surprising. Only slight reductions in mean TBW are seen in comparable studies on men (Boileau *et al*, 1971; Carter and Phillips, 1969; Dempsey, 1964; Glick and Kaufman, 1976) and it is not uncommon for TBW to increase slightly at the outset of an exercise programme before reducing after 3 to 4 months of regular exercise if diet is held constant. Some investigators report a reduction in the TBW of women as a result of exercise (Getchell and Moore, 1974; Lewis *et al*, 1976; Wallace, 1975; Zuti and Golding, 1973) while others have found no reduction (Girandola, 1976; Katch, 1969; Moody, 1972; Shire *et al*, 1977; Wade, 1976). Lewis *et al*, 1976 found that exercise reduced TBW by as much as 4.2 kg in a group of obese women with 40 percent body fat initially. The reduction in TBW in their study was more pronounced when the exercise programme was accompanied by a dietary programme. The subjects in this study were not obese as evidenced by the pre-test percent fat values of each group (young, $25.07 \pm .74$; middle-aged, 27.46 ± 1.58). They were instructed not to alter their normal diet but no record was kept to ensure their compliance.

The average percent body fat reported for nonobese young women is 22 to 29% (Pollock *et al*, 1975) and 29 to 35% for middle-aged women (Pollock *et al*, 1975; Young *et al*, 1963). The young group in this study resembled young groups studied by other investigators (Getchell *et al*, 1977; Katch and Michael, 1962; Novak,

1972; Pollock *et al*, 1975; Sloan *et al*, 1975; Young *et al*, 1962) but the middle-aged group was relatively lower in percent fat (Table IV). Not surprisingly there was no significant alteration in the body composition of the young group in this study, however, the middle-aged group increased significantly in body density and

decreased significantly in percent fat due largely, it would appear, to a reduction in supra-iliac skinfold thickness from 21.67 ± 2.35 to 18.13 ± 2.08 mm. These results suggest that a programme such as the one described in this paper can be effective in altering body composition in non-obese middle-aged women.

REFERENCES

- Boileau, R. A., Buskirk, E. R., Horstman, D. H., Mendez, J. and Nicholas, W. C., 1971. "Body composition changes in obese and lean men during physical conditioning", *Med.Sci.Sports*, **3**: 183-189.
- Carter, J. E. L. and Phillips, W. H., 1969. "Structural changes in exercising middle-aged males during a 2-year period", *J.Appl.Physiol.*, **27**: 878-894.
- Dempsey, J. A., 1964. "Anthropometric observations in obese and nonobese young men undergoing a program of vigorous physical exercise", *Research Quart.*, **35**: 275-287.
- Drinkwater, B. L., 1973. "Physiological responses of women to exercise", In: *Exercise and Sports Sciences Reviews*, edited by J. H. Wilmore, Academic Press, p. 125: New York.
- Eiseman, P. and Golding L. A., 1975. "Comparison of effects of training on $\dot{V}O_2$ max in girls and young women", *Med.Sci.Sports*, **7**: 136-138.
- Fringer, M. N., 1973. "Relationships among selected cardiorespiratory variables in young adult females", *Research Quart.*, **44**: 448-457.
- Getchell, L. H. and Moore, J. C., 1974. "Physiological response of middle-aged women to physical training", *Med.Sci.Sports*, **5**: 75.
- Getchell, L. H., Kirkendall, D. and Robbins, G., 1977. "Prediction of maximal oxygen uptake in young adult women joggers", *Research Quart.*, **48**: 61-67.
- Girandola, R. N., 1976. "Body composition changes in women: effects of high and low exercise intensity", *Arch.Phys.Med.Rehab.*, **57**: 297-300.
- Glick, Z. and Kaufman, N. A., 1976. "Weight and skinfold thickness changes during a physical training course", *Med.Sci.Sports*, **8**: 109-112.
- Humphrey, L. D. and Falls, H. B., 1975. "Circulatory and metabolic responses of young women at HR = 180 and HR = max", *Research Quart.*, **46**: 498-504.
- Katch, F. I. and Michael E. D. Jr., 1968. "Prediction of body density from skinfold and girth measurements of college females", *J.Appl.Physiol.*, **25**: 92-94.
- Katch, F. I., Michael, E. D. Jr., and Jones, E. M., 1969. "Effects of physical training on body composition and diet of females", *Research Quart.*, **40**: 99-104.
- Katch, F. I., McArdle, W. D., Czula, R. and Pechar, G., 1973. "Maximal oxygen intake, endurance running performance, and body composition of college women", *Research Quart.*, **44**: 301-312.
- Kilbom, A., 1971. "Physical training in women", *Scand.J.Clin.Lab.Invest.*, **28**: (Suppl. 119): 1.
- Lewis, S., Haskell, W. L., Wood, P. D., Manoogian, N., Bailey, J. E. and Pereira, M., 1976. "Effects of physical activity on weight reduction in obese middle-aged women", *Am.J.Clin.Nutr.*, **29**: 151-156.

- McArdle, W. D., Katch, F., Pechar, G., Jacobson, L. and Ruth, S., 1972. "Reliability and interrelationships between maximal oxygen intake, physical work and step-test scores in college women", *Med.Sci.Sports*, **4**: 182-186.
- Moody, D. L., Wilmore, J. H. and Girandola, R. N., 1972. "Effects of a jogging program on body composition of normal and obese high school girls", *Med.Sci.Sports*, **4**: 210-213.
- Novak, L. P., 1972. "Aging, total body potassium, fat-free mass, and cell mass in males and females between ages 18 and 85 years", *J.Gerontol.*, **27**: 438-443.
- Pollock, M. L., Laughridge, E. E., Coleman, B., Linnerud, A. C. and Jackson, A., 1975. "Prediction of body density in young and middle-aged women", *J.Appl.Physiol.*, **38**: 745-749.
- Rathbun, E. D. and Pace, N., 1945. "Studies on body composition. I. The determination of total body fat by means of the body specific gravity", *J.Biol.Chem.*, **158**: 667-676.
- Shire, T. L., Avallone, J. P., Boileau, R. A., Lohman, T. G. and Wirth, J. C., 1977. "Effect of high resistance and low resistance bicycle ergometer training in college women on cardiorespiratory function and body composition", *Research Quart.*, **48**: 391-400.
- Sloan, A. W., Burt, J. J. and Blyth, C. S., 1962. "Estimation of body fat in young women", *J.Appl.Physiol.*, **17**: 967-970.
- Wade, C. E., 1976. "Effects of a season's training on the body composition of female college swimmers", *Research Quart.*, **47**: 292-295.
- Wallace, J. P., 1975. "Responses of the composition of body fat to cardiovascular training in college women", *Research Quart.*, **46**: 317-322.
- Wilmore, J. H. and Behnke, A. R., 1971. "An anthropometric estimation of body density and lean body weight in young women", *Am.J.Clin.Nutr.*, **24**: 1186-1192.
- Young, C. M., Martin, M., Tensuan, R. and Blondin, J., 1962. "Predicting specific gravity and body fatness in young women", *J.Am.Dietet.Assoc.*, **40**: 102-107.
- Young, C. M., Blondin, J., Tensuan, R. and Fryer, J. H., 1963. "Body composition of 'older' women", *J.Am.Dietet.Assoc.*, **43**: 344.
- Young, C. M., Blondin, J., Tensuan, R. and Fryer, J., 1963. "Body composition studies of 'older' women, thirty to seventy years of age", *Ann.N.Y.Acad.Sci.*, **110**: 587-607.
- Young, C. M., 1964. "Prediction of specific gravity and body fatness in older women", *J.Am.Dietet.Assoc.*, **45**: 333-338.
- Zuti, W. B. and Golding, L. A., 1973. "Effects of diet and exercise on body composition of adult women during weight reduction", *Med.Sci.Sports*, **5**: 62.