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ARMY RESEARCH INST OF ENVIRONMENTAL MEDICINE NATICK MASS F/G 5/9
PHYSIOLOGICAL EFFECTS OF A MILITARY TRAINING PROGRAM ON MALES A--ETC(U)
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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER M 40/78		2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Physiological Effects of a Military Training Program on Males and Females		5. TYPE OF REPORT & PERIOD COVERED	
7. AUTHOR(s) W.L. Daniels, D.M. Kowal, J.A. Vogel, R. M. Stauffer		6. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS USA Rsch Inst of End Med, Natick, MA 01760		8. CONTRACT OR GRANT NUMBER(s)	
11. CONTROLLING OFFICE NAME AND ADDRESS USA Med Rsch and Dev Cnd, Ft. Detrick Frederick, MD 21701		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE 28 June 78	
16. DISTRIBUTION STATEMENT (of this Report) DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED.		13. NUMBER OF PAGES 15	
		15. SECURITY CLASS. (of this report)	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) NA		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
18. SUPPLEMENTARY NOTES To be published in Medicine & Science in Sports			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) TREADMILL TESTING, LACTATE, VO ₂ MAX, OXYGEN UPTAKE, MALES AND FEMALES			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The purpose of this study was to determine the effect of a military training program on the aerobic power of young, active males and females. Twenty-nine males and twenty-six females (17-21 yrs old) were evaluated at the beginning and the end of the six week training which all incoming freshmen (plebes) undergo upon entering the U.S. Military Academy. The aerobic portion of the training consisted of running for 30 minutes, 5-6 days/week.			

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Subjects ran at varied speeds depending upon their performance in an initial 1.5 mile run test. Subjects represented active populations as indicated by their initial maximal oxygen uptakes ($\dot{V}O_2$ max), 59.4 ± 1.1 and 46.0 ± 1.0 ml/kg.min, males and females respectively. Females responded to training with a significant increase ($p < 0.001$) in $\dot{V}O_2$ max to 49.7 ± 0.8 ml/kg.min (7.9%). They also had significant decreases ($p < 0.001$) in HR_{max} and % body fat. Males had significant decreases in HR_{max} ($p < 0.01$) and % body fat ($p < 0.001$) but their $\dot{V}O_2$ max did not increase significantly (60.6 ± 4.7 ml/kg.min). When the males were subdivided into three groups based upon their response to training, it became apparent that their initial $\dot{V}O_2$ max values and activity history accounted for the lack of significant increase in this population of males. Blood lactates were significantly decreased ($p < 0.05$) at the same two submaximal work loads after training. The initial difference in aerobic power between males and females was reduced from 22 to 18 %.

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6 PHYSIOLOGICAL EFFECTS OF A MILITARY TRAINING PROGRAM ON MALES AND FEMALES

by

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11 28 Jun 78

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12 28p.

14 USARIEM-M-40/78

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Running Head: Effects of Military Training on Males and Females.

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The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official department of the Army position, policy, or decision, unless so designated by other official documentation.

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

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ABSTRACT: The purpose of this study was to determine the effect of a military training program on the aerobic power of young, active males and females. Twenty-nine males and twenty-six females (17-21 yrs old) were evaluated at the beginning and the end of the six week training which all incoming freshmen (plebes) undergo upon entering the U.S. Military Academy. The aerobic portion of the training consisted of running for 30 minutes, 5-6 days/week. Subjects ran at varied speeds depending upon their performance in an initial 1.5 mile run test. Subjects represented active populations as indicated by their initial maximal oxygen uptakes ($\dot{V}O_2$ max), 59.4 ± 1.1 and 46.0 ± 1.0 ml/kg \cdot min, males and females, respectively. Females responded to training with a significant increase ($p < 0.001$) in $\dot{V}O_2$ max to 49.7 ± 0.8 ml/kg \cdot min (7.9%). They also had significant decreases ($p < 0.001$) in HR_{max} and % body fat. Males had significant decreases in HR_{max} ($p < 0.01$) and % body fat ($p < 0.001$) but their $\dot{V}O_2$ max did not increase significantly (60.6 ± 4.7 ml/kg \cdot min). When the males were subdivided into three groups based upon their response to training, it became apparent that their initial $\dot{V}O_2$ max values and activity history accounted for the lack of significant increase in this population of males. Blood lactates were significantly decreased ($p < 0.05$) at the same two submaximal work loads after training. The initial difference in aerobic power between males and females was reduced from 22 to 18%.

TREADMILL TESTING, LACTATE, $\dot{V}O_2$ MAX, OXYGEN UPTAKE, MALES AND FEMALES

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Physiological Effects of a Military Training Program on Males and Females

The U.S. Military Academy at West Point recently began accepting women and placing them in traditionally all male training programs. The physiological responses of males and females to various training programs have been previously reported (1,6,9,11,13,15). They suggest that women respond to training in a quantitative and qualitative manner that is similar to males. However, absolute values for maximal aerobic power ($\dot{V}O_2$ max) of females average 10-25% lower than those reported in males. Differences in $\dot{V}O_2$ max vary depending upon the groups compared and their level of training, with considerable overlap between well-trained females and average males.

Few reports have compared males to females within the same training program. Recently, Burke (2) compared sedentary male and female college students before and after an eight week training program. He reported a reduction in the difference in aerobic power from 22% to 8% when he compared the female training group to the male control group before and after training.

During summer training at West Point, both male and female cadets now participate in a single physical training program on a daily basis. This study was undertaken to compare the effects of an intense training program on a young, active male and female population and to determine the effect on aerobic power in such a situation.

METHODS

Subjects for this study consisted of thirty male and thirty female cadets (plebes) just entering the U.S. Military Academy. They were evaluated during their

initial six week, physical and military training program prior to the beginning of the academic year. The subjects were volunteers randomly nominated from the entire freshman class. All cadets were between 17 and 21 years of age and had satisfactorily completed a vigorous physical fitness entrance qualification exam (16). Mean physical parameters are presented in Table 1.

Test subjects took part in the training with all other cadets and were dispersed throughout the corps of cadets. The aerobic training consisted of a 30 minute run, 5-6 times per week. For running, all cadets were divided into three groups based on their performance in 1½ mile test runs during the first week of training. The groups trained at different running speeds and averaged 6½, 7½, and 8½ minutes per mile by the end of training. All male subjects were in the two faster groups and all female subjects in the two slower groups.

Training was evaluated by a pre- and post-maximal oxygen uptake treadmill test. A modification of the test described by Mitchell *et al.* (14) was used. After an initial warm-up run of 6 minutes, the subjects rested for 5-10 minutes and then performed 2-4 additional runs, each interrupted by a rest period. Work loads were increased by adjusting speed and/or grade elevation. Running speeds ranged from 5-8 mph, based upon the capabilities of the subjects.

During the last minute of each run, expired air was collected through a mouthpiece attached to a Triple-J valve into vinyl Douglas bags. A plateau in $\dot{V}O_2$ (less than 2 ml/kg·min increase with 2.5% increase in elevation) was considered as $\dot{V}O_2$ max. If no plateau was reached, the point of exhaustion was considered $\dot{V}O_2$ max. Expired air was analyzed with a Beckman E-2 oxygen analyzer and Beckman LB-2 carbon dioxide analyzer. Expired air volumes were measured with a Tissot spirometer. Heart rate was recorded electrocardiographically using chest

electrodes in a modified V_5 position.

Prior to running on the treadmill, all subjects had height, weight and skin fold thicknesses measured. Skin folds were used to estimate per cent body fat using the equation of Durnin and Wormesley (8). In addition, blood lactate levels were determined at the same two submaximal absolute workloads before and after training. Blood samples were drawn four minutes after the end of exercise from the antecubital vein and lactates were determined spectrophotometrically.

An analysis of variance for repeated measures and paired t-test were used to determine significant responses to the training program.

RESULTS

Four subjects were unable to complete the post-training phase of the study due to injuries. One additional subject resigned from the Academy and could not be retested. The data reported includes only those subjects who completed both phases of testing.

The anthropometric data and average running times for males and females are summarized in Table 1. Both males and females showed a significant decrease in % body fat and running time in response to the training program. There was no change in total body weight for either group, however, both groups had significant increases in lean body mass.

Physiological data collected at maximal oxygen uptake is summarized in Table 2. There was no significant change in the maximum oxygen uptake in the males with training. However, there was a significant decrease in maximal heart rate and significant increase in maximal ventilation, ventilatory equivalent (VEQ) and the respiratory quotient (R).

Women did show a significant increase in $\dot{V}O_2$ max, as well as maximal ventilation and respiratory quotient. Women also showed a significant decrease in maximal heart rate.

In an effort to determine why the males showed no average improvement in $\dot{V}O_2$ max with training, they were broken down into three groups based on their individual response to training. Group I consisted of those showing no change (< 2.1 ml/kg \cdot min) in $\dot{V}O_2$ max; Group II increased (≥ 2.1 ml/kg \cdot min); and Group III decreased (≥ 2.1 ml/kg \cdot min) in $\dot{V}O_2$ max with training. A one-way analysis of variance and unpaired t-test was applied to the data and the results are shown in Table 3. There were no significant differences between groups in body weight or body fat. However, Group III had a significantly higher aerobic capacity at the beginning of the study than either Group I or II. There was no significant difference in the 1½ mile run time between these three groups initially, although Group III did have the fastest average time.

Blood lactate levels were significantly reduced at both submaximal workloads after training in both men and women. The per cent of $\dot{V}O_2$ max at which the groups were working at each workload was slightly reduced after training (Table 4).

DISCUSSION

Both males and females in this study were at an elevated level of fitness at the beginning of training. According to the American Heart Association's cardiorespiratory fitness classification (3), the women were at the upper level of the good category at the beginning of training and in the high category at the end of training. The men far exceeded the requirements for being placed in the high category.

The $\dot{V}O_2$ max values of the females at the beginning of the training program are similar to those of sedentary college females who have completed a training program (11). Their values at the end of training were comparable to those of female college athletes (7) and almost identical to values, corrected for altitude, measured in Air Force women cadets (5). The $\dot{V}O_2$ max values for males are similar to values reported in well-trained or highly active college students (1,10). These subjects were at fitness levels well above sedentary counterparts of the same age (2). This is to be expected since the selection process for the academy is geared toward acceptance of individuals who are highly active.

The women responded to the training program in a typical manner. They showed a 7.9% increase in their $\dot{V}O_2$ max with a significant reduction in HR_{max} and a significant increase in maximal ventilation. This was accompanied by a significant decrease in body fat and increase in lean body mass. Based upon the changes in $\dot{V}O_2$ max and performances in the 1½ mile run, it can be concluded that the training program resulted in significant aerobic and functional improvement in the females.

As a group, males did not show any significant aerobic improvement as a result of training. The reasons that a training program of this duration (30 min/day), frequency (5-6 days/wk) and intensity (8-9 mph) did not cause a significant aerobic improvement were puzzling until the males were subdivided into groups based upon their response to training (Table 3). Group III, which decreased in aerobic capacity as a result of training, had an initial average $\dot{V}O_2$ max of 65.1 ml/kg·min, which is similar to the value of 66.6 ml/kg·min reported by Costill *et al.* (4) in trained runners. In addition to showing a decrease in $\dot{V}O_2$ max, this group was the only one to show an average weight increase. They also had the smallest

decrease in per cent body fat. It appears that this training program represented a decrease in activity for this group as far as aerobic training. Indeed, a review of the activity history questionnaire that we gave to each subject at their entrance into the program showed that this group was most active and Group II the least active prior to their arrival at the Academy. The training program also included activities, in addition to running, which are designed to improve muscle strength. These exercises may be contributing factors to the average weight increase of Group III. The slight weight increase and a decrease in aerobic training could account for the decrease in $\dot{V}O_2$ max.

The results with the other two groups of males is also explicable in terms of their initial $\dot{V}O_2$ max. Group I, which showed no change in aerobic capacity, was obviously at a level of fitness which was maintained by the training program, i.e. the training program did not provide them with an adequate training stimulus for improving their $\dot{V}O_2$ max. Whether they would improve with a more strenuous training program or whether they have achieved their genetic maximum in aerobic capacity cannot be determined from our data. Group II had the lowest initial $\dot{V}O_2$ max and responded to training with a characteristic 9% increase in $\dot{V}O_2$ max. Obviously the training program provided them with an adequate training stimulus. Regardless of the effect of training on $\dot{V}O_2$ max, the mean time in the 1½ mile run decreased in all groups.

The decrease in blood lactate at two submaximal workloads does not appear to be solely due to the small decrease in the per cent of $\dot{V}O_2$ max at which the subjects were working (Table 4). The decrease in per cent $\dot{V}O_2$ max for males is accounted for by the decrease in $\dot{V}O_2$ for workload #1 and the slight increase in $\dot{V}O_2$ max. In females, the increase in $\dot{V}O_2$ max accounts for most of the decrease

in the per cent of $\dot{V}O_2$ max at which they are working. However, females also showed a decrease in their oxygen consumption at workload #1. There was no change in oxygen consumption at workload #2 for either males or females. The higher $\dot{V}O_2$ during the pre-test could be accounted for by anxiety associated with running on the treadmill for the first time or by improved efficiency that develops with training which caused a decrease in $\dot{V}O_2$ during the post-test. It is interesting to note that neither the anxiety nor the improved efficiency affected $\dot{V}O_2$ at the higher workload.

It has been demonstrated that training will decrease lactate formation during submaximal work (12). Trained athletes also have lower lactate levels during submaximal work than untrained individuals (12). Our data appears to support these findings. However, it has been reported that blood lactate levels are elevated before competition and that this is due to catecholamine release (12). It is conceivable that the stress of arrival at the Academy may be partially responsible for the higher lactate levels in the pre-training phase. Whether the decrease in lactates at submaximal work in this study is due solely to a training effect on anaerobic metabolism can only be determined by further study.

As a result of training, the difference in aerobic power between males and females was reduced from 22% to 18%. This decrease in the difference is similar to that reported by Burke (2) between his experimental groups. In his study on sedentary college students the initial difference in aerobic power was 22% (31.69 ml/kg·min, females; 41.81 ml/kg·min, males). After eight weeks of training this difference was reduced to 19% (39.29 ml/kg·min, females; 48.71 ml/kg·min, males). Both studies demonstrate that the difference in aerobic power between similar groups of males and females can be slightly reduced with training. Whether or not this difference can be reduced even further with extended training can only be determined by further study.

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TABLE 1. ANTHROPOMETRIC MEASUREMENTS AND 1.5 MILE RUN TIMES BEFORE AND AFTER TRAINING

		BODY WEIGHT (KG)	% BODY FAT	LEAN BODY MASS (KG)	HEIGHT (CM)	RUN TIME (SEC)	
MEN (N = 29)	PRE	\bar{X}	70.6	13.1	61.2	177.4	565.6
		\pm S.D.	\pm 7.6	\pm 3.2	\pm 5.6	\pm 5.4	\pm 65.7
POST		\bar{X}	70.5	11.1 ^A	62.5 ^A	177.6	533.4 ^B
		\pm S.D.	\pm 6.6	\pm 2.8	\pm 5.4	\pm 5.4	\pm 34.4
WOMEN (N = 26)	PRE	\bar{X}	57.7	23.8	43.7	164.1	711.9
		\pm S.D.	\pm 6.0	\pm 4.0	\pm 3.5	\pm 6.3	\pm 76.5
POST		\bar{X}	57.7	20.8 ^A	45.6 ^A	164.4	651.9 ^A
		\pm S.D.	\pm 5.0	\pm 3.5	\pm 3.2	\pm 6.3	\pm 53.8

A $p < 0.001$

B $p < 0.05$

TABLE 2. PHYSIOLOGICAL DATA COLLECTED AT MAXIMAL OXYGEN UPTAKE.

		\dot{V}_{O_2} MAX (ML/KG MIN)	\dot{V}_{O_2} MAX (L/MIN)	HR MAX (BTS/MIN)	\dot{V}_E (BTPS) (L/MIN)	VEQ	R
PRE MEN (N = 29)	\bar{X}	59.4	4.19	191.6	148.6	29.0	1.03
	\pm S.D.	\pm 5.9	\pm .54	\pm 7.8	\pm 20.6	\pm 3.1	\pm .06
POST	\bar{X}	60.6	4.27	184.6 ^B	157.6 ^B	30.2 ^A	1.09 ^C
	\pm S.D.	\pm 4.7	\pm .40	\pm 5.2	\pm 17.7	\pm 3.3	\pm .07
PRE WOMEN (N = 26)	\bar{X}	46.0	2.64	190.2	101.1	31.4	0.96
	\pm S.D.	\pm 5.1	\pm .31	\pm 8.5	\pm 15.4	\pm 4.7	\pm .08
POST	\bar{X}	49.7 ^C	2.86 ^C	183.2 ^C	111.0 ^B	31.8	1.06 ^C
	\pm S.D.	\pm 4.2	\pm .29	\pm 7.4	\pm 12.1	\pm 3.3	\pm .07

A_p < 0.05

B_p < 0.01

C_p < 0.001

TABLE 3. COMPARISON OF MALES BASED UPON INDIVIDUAL RESPONSE OF $\dot{V}_{O_2 \text{ MAX}}$ TO TRAINING.

		$\dot{V}_{O_2 \text{ MAX}}$ (L/MIN)	$\dot{V}_{O_2 \text{ MAX}}$ (ML/KG MIN)	WEIGHT (KG)	% BODY FAT	RUN TIME (SEC)
GROUP I	PRE	\bar{X} 4.15 ^A	58.3 ^A	71.4	12.8	557.6
		\pm S.D. $\pm .12$	± 1.1	± 2.5	± 0.9	± 10.4
GROUP I	POST	\bar{X} 4.15	58.5	71.1	10.4	540.1
		\pm S.D. $\pm .08$	± 1.1	± 2.0	± 1.1	± 36.9
GROUP II	PRE	\bar{X} 3.93 ^A	56.5 ^A	69.8	13.8	581.8
		\pm S.D. $\pm .17$	± 1.6	± 2.6	± 1.1	± 24.9
GROUP II	POST	\bar{X} 4.29	62.2	69.2	11.3	530.6
		\pm S.D. $\pm .14$	± 1.6	± 2.1	± 0.9	± 39.9
GROUP III	PRE	\bar{X} 4.62	65.1	71.3	12.7	539.1
		\pm S.D. $\pm .14$	± 1.7	± 2.4	± 1.0	± 17.6
GROUP III	POST	\bar{X} 4.39	60.7	72.4	12.0	530.1
		\pm S.D. $\pm .14$	± 1.5	± 2.3	± 0.6	± 24.6

GROUP I (N=9) NO CHANGE IN $\dot{V}_{O_2 \text{ MAX}}$ (<2.1 ML/KG MIN)
 GROUP II (N=12) INCREASE IN $\dot{V}_{O_2 \text{ MAX}}$ (≥ 2.1 ML/KG MIN)
 GROUP III (N=8) DECREASE IN $\dot{V}_{O_2 \text{ MAX}}$ (≥ 2.1 ML/KG MIN)

^ASIGNIFICANTLY LOWER THAN
 GROUP III PRE VALUE ($p < 0.01$)

TABLE 4. BLOOD LACTATES, \dot{V}_{O_2} (OXYGEN CONSUMPTION) AND % \dot{V}_{O_2} MAX FOR THE SAME TWO SUBMAXIMAL WORKLOADS BEFORE AND AFTER TRAINING.

		WORKLOAD 1			WORKLOAD 2			
		Lactate (mM/L)	\dot{V}_{O_2} (ml/kg min)	% \dot{V}_{O_2} Max Max	Lactate (mM/L)	\dot{V}_{O_2} (ml/kg min)	% \dot{V}_{O_2} Max Max	
MEN (N = 28)	PRE	\bar{X} \pm S.D.	2.54 \pm 2.48	39.9 \pm 3.5	67.1%	5.98 \pm 3.00	52.6 \pm 4.3	88.6%
	POST	\bar{X} \pm S.D.	1.52 ^A \pm .84	37.7 ^B \pm 3.1	62.0%	3.81 ^A \pm 1.49	52.5 \pm 3.7	86.7%
WOMEN (N = 23)	PRE	\bar{X} \pm S.D.	2.11 \pm .79	33.8 \pm 4.0	73.5%	5.78 \pm 2.52	41.8 \pm 4.7	90.7%
	POST	\bar{X} \pm S.D.	1.49 ^A \pm 1.16	3.15 ^B 2.7	63.4%	3.25 ^A \pm 2.00	41.9 \pm 4.8	84.2%

A $p < 0.05$

B $p < 0.01$