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PHYSICAL FITNESS TESTS FOR THE WOMENS ROYAL ARMY CORPS,(U)
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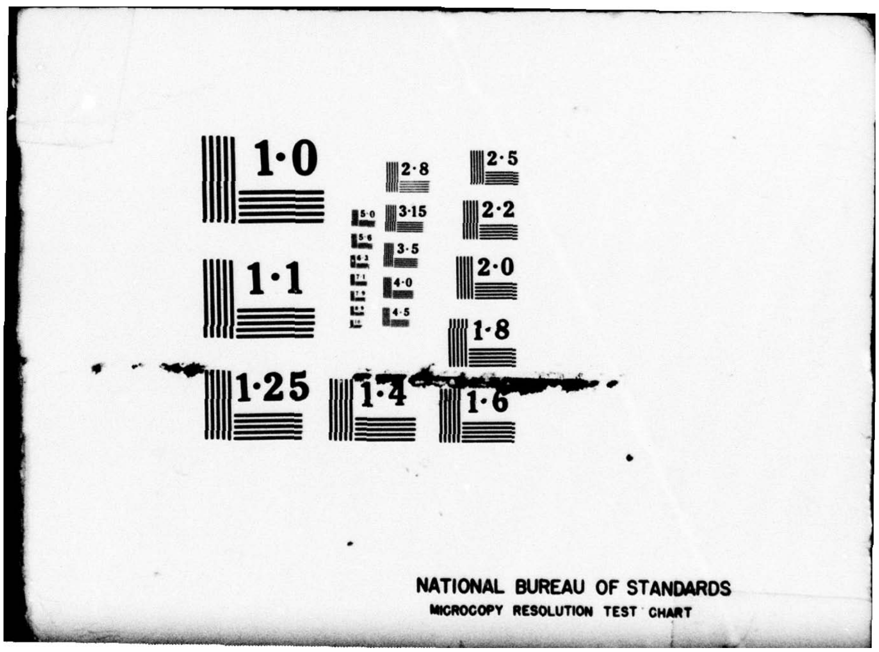
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REPORT APRE No. 26/77

PHYSICAL FITNESS TESTS FOR THE WOMENS ROYAL ARMY CORPS

by

A. F. Amor

Major. S. Taylor

JANUARY 1978

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RESEARCH ESTABLISHMENT
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c/o Royal Aircraft Establishment Farnborough Hants

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(6) PHYSICAL FITNESS TESTS FOR THE WOMENS ROYAL ARMY CORPS,

PART 1. Development of the Basic Fitness Test

PART 2. Obesity and Body Weight standards

PART 3. Physical fitness of recruits and trained servicewomen, 1977

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EXECUTIVE SUMMARY

1. Servicewomen of the Womens Royal Army Corps have not hitherto been subject to a standard physical fitness test. The introduction in 1978 of a "Fit-to-Fight" scheme with the aim of obtaining a permanent and significant improvement in physical fitness, was considered an appropriate moment for women to be included in regular fitness tests.

Basic Fitness Test

2. The test was to be based on physical performance, mainly to assess aerobic work capacity, but also present a challenge so that the candidate could display appropriate character attributes. It was desirable that the test should be similar to that used for male soldiers.

3. The test chosen was similar to the Army Physical Fitness Assessment step-test, but with a reduced workload to account for the physiological difference between the sexes. It consisted of stepping up onto a 17 inch (432 mm) stool 25 times per minute for 5 min, after which the candidate sat down on a chair. Her pulse was counted by hand for 3 half minute periods starting 1, 2 and 3 min after completing the exercise. A Step Test Score (STS) was calculated in the same way as for the APFA Test, using the formula

$$STS = \frac{15000}{\text{sum of 3 pulse counts}} - 40$$

4. The test required the same apparatus as for the male test and could be completed by 92% of a sample of 312 trained servicewomen, and also by 92% of 639 recruits who were tested at the end of their initial 5 weeks training. It was therefore considered practical and acceptable.

5. Repeatability of the test was studied in 311 trained servicewomen who completed the test twice with an interval of about 1 week between tests. On the second attempt the mean score was 4 points higher (a learning effect), and the standard deviation of differences between repeat tests was 9.1 points (mean score being 44 points).

6. Part of this error was attributable to pulse counting which was evaluated in a separate experiment on 73 women whose pulse was taken by hand and electronically. Difference between the 2 methods of pulse counting gave a standard deviation of differences between scores of 5.5 points. This result was similar to that found previously in male soldiers. Thus the test was considered suitable for evaluating the fitness of groups of women, but if individual results were required special precautions to avoid error from this source would have to be taken, and it was recommended that at least 2 tests should be taken before considering individual administrative action such as medical referral.

7. The change in the score of recruits tested on entry and after 5 weeks was 4.8 points, not much more than the learning effect found in serving servicewomen, but the proportion failing to complete the test fell from 26% to 8%. This improvement could be a result of the recruits accepting the challenge imposed by the test on the second occasion.

8. The efficiency of the test as an estimator of aerobic work capacity was assessed by comparing scores from 114 women who completed the step test and the Åstrand cycle ergometer test for estimated maximal oxygen uptake. A fair correlation (0.645) was found, and the relation between the scores was

$$y = 17.753 + 0.502x$$

where x is step test score and y is est max $\dot{V}O_2$. A reasonable proportion (42%) of the step test score was therefore accounted for by aerobic work capacity.

9. Individual pulse counts were similar to those previously found in male soldiers. The test was therefore considered to give a similar stress.

10. No data is yet available on age effects or the response of WRAC servicewomen, in terms of Step Test Score, to physical training. However on the basis of present results from a total of 951 women, and assuming a probable improvement in mean score of 20%, due to improved fitness and familiarity with the test, the following pass marks were proposed to the Fit-to-Fight Working Party:

Age	Minimum Step Test Score
Up to 29 yr	40 points
30 - 39 "	36 "
40 - 49 "	32 "

It was calculated 90% of women would pass the test provided the required improvement in physical fitness was achieved.

Obesity and Body Weight

11. Skinfold thickness measurement for determination of body fat content was made on 489 recruits at the end of initial training. Average body fat was 31%, about 5% above that considered desirable for the group.

12. Mean body weight for all heights was above the maximum desirable body weight suggested from Insurance statistics, and moreover by comparing weight and body fat data with that from other UK and US workers it was estimated the published weight standards were probably too high by 3 kg.

13. No data is yet available comparing skinfold thicknesses of WRAC with direct determination of body fat by densitometry, and this would be required to confirm the estimate of too high a weight standard. In the interim, this standard, published by the Metropolitan Life Assurance Company, is recommended for use by the WRAC whenever a skinfold estimate of body fat is not available. A margin of 20% over the maximum desirable body weight is recommended. This level should be called the maximum permitted weight.

Present levels of Fitness

14. An interaction between step test score and body weight was found. Both recruits and trained servicewomen who failed to complete the test averaged 6 kg heavier than those who stepped for 5 min. The pass-fail ratio was similar for those who were under the desirable minimum, under the desirable maximum or under the maximum permitted weight. The 11% of women over the maximum permitted weight-for-height, however, had a greater proportion of test failures.

15. Servicewomen and recruits were about 5% by weight fatter than that considered desirable, but their aerobic work capacity was about the same as other groups of women, and therefore amenable to the improvement looked for in the Fit-to-Fight aims.

16. Recruit training successfully reduced the number of women failing to complete the test, but after allowance for a learning effect, results suggest aerobic work capacity was not improved. It was considered sufficient time was available for physical training, but improvement was limited by the intensity of training achieved, and it was recommended that monitoring of heart rate could be used to confirm this.

17. **Body weight increased during recruit training but body fat did not. The use of skinfold calipers is therefore recommended as an aid in assessing obesity reduction in those women found to be either step test failures or over the maximum permitted weight.**

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PART 2. Obesity and Body Weight standards

PART 3. Physical fitness of recruits and trained servicewomen, 1977

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SUMMARY

A step test consisting of 25 steps per minute on a 17 inch bench for 5 min, with pulse counts at 1, 2 and 3 min into recovery was found to be a practical and suitable method of assessing physical fitness in WRAC personnel. Step test score correlated well with estimated max $\dot{V}O_2$ and also presented a challenge to the participants. A pass-mark of 40 points is proposed. The mean estimated max $\dot{V}O_2$ for a group of 834 WRAC women was 39 ml/(kg min), similar to other groups, but body fat was about 5% higher. About ½ the women were heavier than the Metropolitan Life recommended maximum and 11% were more than 20% above this maximum. Body weight except in the grossly overweight did not affect step test score, although it did affect the numbers completing the test.

Recruit training produced a large increase in the proportion of women completing the test, but did not improve aerobic capacity. Body fat did not increase but body weight did.

Studies of the intensity of recruit PT would assist in setting a level at which aerobic capacity is increased. Studies of body fat are required before the use of Metropolitan Life weight tables is adopted for WRAC.

Monitoring of physical training and its effects is required in order to confirm the proposed physical fitness standard.

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FOREWORD

1. Servicewomen of the Womens Royal Army Corps (WRAC) have not hitherto been subject to a standard physical fitness test, apart from the medical assessment of general physical capacity which is part of the PULHEEMS system. The introduction in 1978 into the British Army of a "Fit-to-Fight" scheme, with the aim of obtaining a permanent and significant improvement in physical fitness, was considered an appropriate moment for women to be included in regular fitness tests.

2. Women constitute some 2-3% of the Regular Army, and a large proportion are dispersed throughout the Army in sub-units. Although women PT instructors are on the establishment of some units, many women in the smaller sub-units are under the care of the male PT instructors of their

host unit, and share common sports facilities. It was therefore desirable that physical fitness tests for women should be similar to those for male soldiers, not require special apparatus and be convenient for application to small groups of women as time permits on the duty roster.

3. The primary aim of physical training in the Army is to maintain the ability to perform successfully under conditions where extra physical effort may be required. A secondary aim is to conserve long term health, (Physical Fitness in the Army, 1977, Pamphlet No 1 "Fit-to-Fight"). Following this emphasis on performance of military tasks, the ideal physical fitness test would assess aerobic work capacity, and also present a challenge so that the candidate could display appropriate character attributes. From the point of view of both long term health and physical performance, obesity was also considered to be important.

4. It was against this background that the WRAC Wing, Army School of Physical Training, assisted by APRE, studied physical fitness in both recruits and trained servicewomen during the period November 1976 - August 1977. This report presents the results of these studies and recommends methods and standards for physical fitness tests to be applied from the commencement of the Fit-to-Fight scheme.

PART 1

Development of the Basic Fitness Test *

* The test recommended as a result of these studies is called Basic Fitness Test No.5 (BFT5) in the Fit-to-Fight handbook.

INTRODUCTION

Background

5. Two tests of fitness for male soldiers are a timed 1½ mile run, and a step-up test with measurement of recovery pulse rate. The former is an adaptation of Cooper's (1970) modification of the Balke (1963) field test, while the latter is based on the Harvard step-test (Brouha et al, 1943). Both these tests are included in the Fit-to-Fight scheme, and both male and female Army PT instructors and assistant-instructors are trained in their use.

6. For practical application to women it was felt the step-test was more suitable, since it could be applied indoors in a limited space, and took less time. The advantage of the running test, in that large numbers could be processed rapidly, was not relevant in the context of women's employment in the Army.

7. The original 20 inch Harvard Step Test had been designed so that about 30% of the candidates would fail to complete the 5 min stepping exercise. Score was based on a formula containing the duration of exercise and the recovery pulse rate. This had been found, when compared with maximal oxygen uptake to be unduly influenced by the correction for test duration, (Patterson et al 1964). For this reason a 17 inch bench height was chosen for the Army Physical Fitness Assessment (APFA) test, so that only the most unfit would fail to complete the test.

8. Initial feasibility trials at the Army School of Physical Training and the WRAC centre showed that although women PT instructors could complete the APFA step-test, the proportion of trained recruits failing to complete the 5 min stepping exercise was unacceptable. In seeking to reduce the severity of the exercise by about 20% to accommodate the physiological difference between the sexes, either a lower bench or a slower stepping rate could be used. Since there was some practical advantage in using the same height step as for men, a reduced stepping rate was chosen, and several studies of this test were undertaken.

9. The main aims of the investigation were:

a. To establish that women could successfully complete the test.

b. To study test-retest repeatability.

c. To compare the new test with an established test of aerobic work capacity (the Åstrand cycle test).

d. To demonstrate that the test could distinguish between women of different physical abilities.

e. To propose a fitness standard based on results from the new test.

METHODS

The Step Test

10. The subject repeatedly stepped up onto a 17 inch (432 mm) stool or bench 25 times a minute for 5 min. She then sat down on a chair and the instructor counted her pulse by palpation at the carotid artery for 30s on 3 occasions starting 1 min, 2 min and 3 min after completion of the exercise (Annex C). A test-score was calculated using the conversion chart of the APFA step-test (Annex A). This was equivalent to the formula

$$\text{Step-test score} = \frac{15000}{\text{sum of 3 pulse counts}} - 40$$

11. If the subject failed to complete the 5 min, or stepped at the wrong rate for a total of more than 15s during the 5 min, she was deemed to have produced an invalid test. Her initial pulse count was recorded to assess whether she had been making a maximal effort and her score was set to zero.

12. Tests were administered by WRAC PT instructors, and pulse counting was by either PT instructors, medical assistants, or officers and NCO's trained by the PT instructors. A mechanical or electronic metronome adjusted to 100 pulses/min was used to set the pace.

The cycle test

13. A proportion of test candidates were selected for comparative tests of estimated maximal oxygen uptake on the cycle ergometer by the Åstrand method (Åstrand and Rodahl, 1970). They rode the ergometer at 300, 450, 600 or 750 kpm/min (49, 74, 98 or 123W) for 6 min, and heartrate during the 6th min was recorded electrocardiographically, using self adhesive electrodes attached at convenient sites on the chest. Initially cycle load was usually set to 450 kpm/min, and by observing heartrate during the first minute, the load was adjusted so that a final heartrate between 120 and 170 beats/min would be obtained. No adjustment was allowed after 2 min into the test. At least 30 min rest was allowed between the tests, the cycle test being performed first in the majority of cases.

14. Selection of candidates for the cycle test was made on the basis of initial step-test results, the aim being to have results from a wide range of step-test scores. All subjects were either trained servicewomen or recruits at the end of their 6 week training course. They included a group of PT instructors and a group of recruits who had failed to complete their initial step-test, at the start of recruit training.

Electronic pulse counting

15. Some of the cycle test candidates also had electrocardiographic pulse recording for the step-test, in parallel with the normal manual pulse counts. This enabled assessment of the accuracy of the team of pulse counters.

Anthropometric details

16. Age, height and weight data were routinely recorded for recruits by the WRAC Centre, at the start and finish of the training course. Weight was measured to the nearest ½lb (227g) and height to ¼ in (0.645 cm). Age, height and weight of trained servicewomen was similarly recorded, at the gymnasium where their step-test was performed.

Test programme

17. Eleven recruit intakes, totalling 721 women, were seen at the WRAC Centre, Guildford, between November 1976 and August 1977. Tests were carried out in the first and last weeks of the recruit training course. The usual time between the 2 tests was 5 weeks. A further 348 trained servicewomen, serving at Mill Hill (London), Bicester, Donnington and Aldershot were also seen. Duplicate tests within a week were carried out at Mill Hill, Bicester and Donnington. The Aldershot group of 47 women (which included a number who took part in both the cycle and step-tests) only took the step-test once.

RESULTS

18. In the initial trial using the male APFA step-test (30 steps/min), 86 recruits attempted the test at the commencement of their training course, and 72 attepted it at the end of training. Of these only 28 women completed the test on the first occasion and 38 on the second, 33% and 53% respectively. The remainder either failed to stop for the full 5 min, or failed to maintain the correct cadence.

Ability to complete the test

19. The new test (25 steps/min) was attempted twice by 634 recruits and 311 trained servicewomen. The percentages of women completing the test are shown in Table 1. By the second test, over 90% of both groups could complete the test (ie step for 5 min at the correct cadence).

Table 1. Completion rates, %

Group	1st test		2nd test	
	No. seen	%	No. seen	%
Recruits	716	74	639	92
Trained	342	91	312	92

Recruits at the end of training had the same completion rates as trained servicewomen. There was no change in completion rate of servicewomen between 1st and 2nd test. Differences between the numbers seen on the first and second occasions were due to postings, leave, sickness, etc.

20. Table 2 compares the mean ages, heights and weights of the recruits and servicewomen who gave valid and invalid tests on the first and second occasions.

Table 2. Step-test completion rates and anthropometric data

Group	Performance	No. (%)	Age, yr	Height cm	Weight kg
Recruits Week 1	Completed	530 (74%)	18.2	163.1	58.5
	Not completed	186 (26%)	18.7	163.1	63.0
Recruits Week 5	Completed	589 (92%)	18.3	163.0	60.2
	Not completed	50 (8%)	18.8	163.3	66.6
Trained Servicewomen	Completed	290 (92%)	20.0	162.5	59.7
	Not completed	22 (8%)	20.0	161.8	65.9

There was no practical difference in age or height between those who completed the test and those who did not, but women who failed to complete the test averaged about 6kg (10%) heavier in both recruits and servicewomen.

Test-retest repeatability

21. Repeatability was studied in the cross-section sample of 311 trained servicewomen, at Mill Hill, Bicester and Donnington. A total of 273 women completed the test twice. Their mean step test score on the first attempt was 40.25 (SD = 7.95), and on the second attempt it was 44.19 (SD = 10.09). The mean difference was 3.94 points, and the standard deviation of differences was 9.12 points, a little over 20% of the group's mean score. The improvement in scores was statistically highly significant on paired t-test ($t = 7.15$).

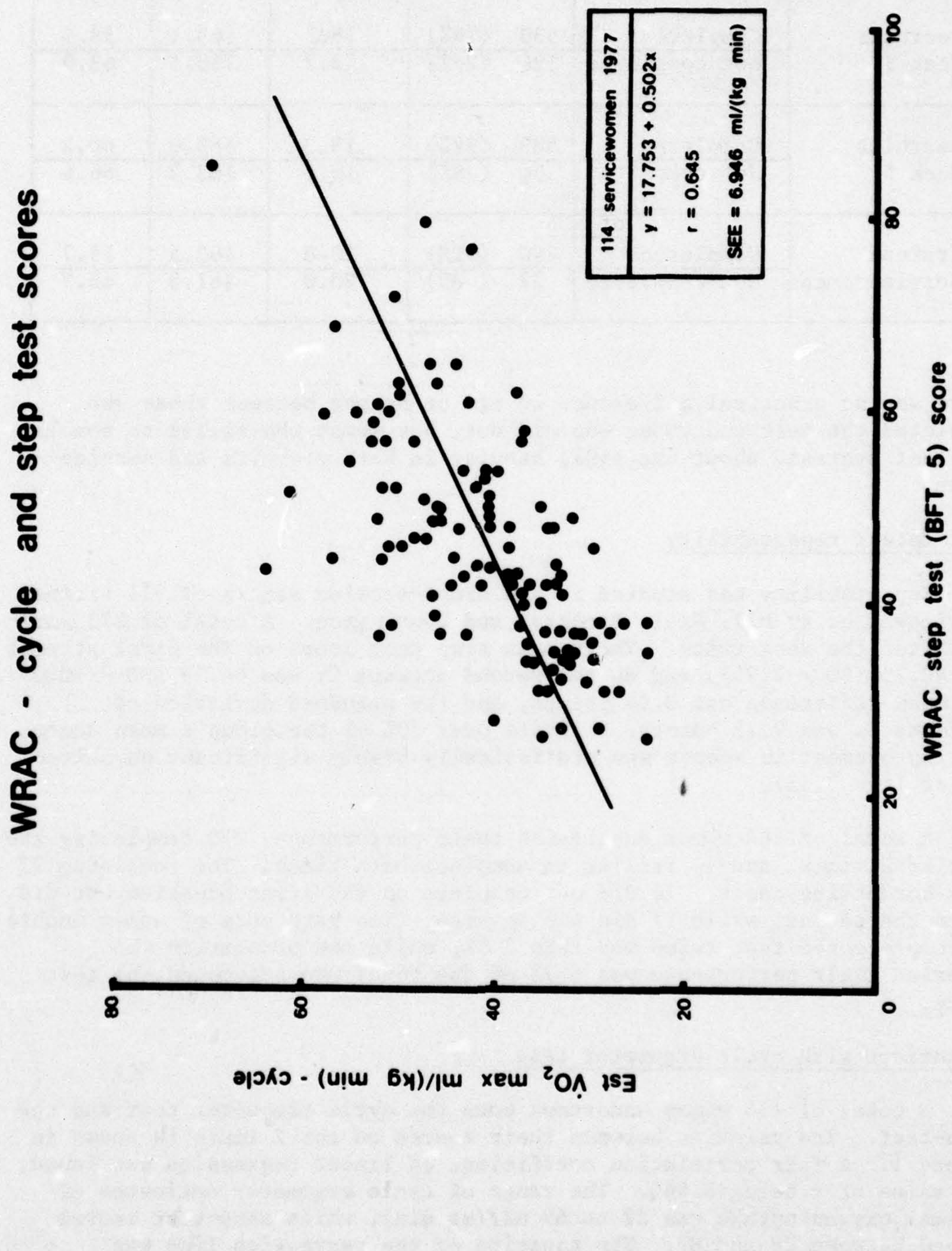
22. A total of 284 women duplicated their performance, 273 completing the test both times, and 11 failing to complete both times. The remaining 27 were borderline cases. 16 did not complete on the first occasion but did so on the second, while 11 did the reverse. The hard core of women unable to complete the test twice was thus 3.5%, while the proportion who reversed their performance was 8.7% of the total who attempted the test twice.

Comparison with cycle ergometer test

23. A total of 114 women undertook both the cycle ergometer test and the step-test. The relation between their scores on the 2 tests is shown in Figure 1. A fair correlation coefficient of linear regression was found, the value of r being 0.645. The range of cycle ergometer estimates of maximal oxygen uptake was 22 to 69 ml/(kg min), while step-test scores ranged between 28 and 87. The equation of the regression line was

$$y = 17.753 + 0.502\,x$$

where x is the step-test score and y is the estimated max $\dot{V}O_2$ from the cycle test. The sensitivity of the step-test was thus 1.99 estimated ml/(kg min) of maximal oxygen uptake per unit step-test score and the standard error of estimate of max $\dot{V}O_2$ from step-test score was 6.95 ml/(kg min).



WRAC - cycle and step test scores
114 servicewomen 1977
y = 17.753 + 0.502x
r = 0.645
SEE = 6.946 ml/(kg min)
Est $\dot{V}O_2$ max ml/(kg min) - cycle
80
60
40
20
0
20
40
60
80
100
WRAC step test (BFT 5) score

Figure 1

Test results from servicewomen of differing ability

24. Information regarding the employment of the servicewomen seen in the cross-sectional samples was available from 347 women who completed the step-test. 26 trades were represented, many by a single woman. Those trades which were represented by more than 10 women, and groups of similar trades such as clerks are listed in Table 3, together with mean heights, weights and step-test scores (STS).

Table 3. Mean heights, weights and step-test scores (STS) of WRAC tradeswomen

Trade	No. tested	Height cm		Weight kg		STS	
		mean	SD	mean	SD	mean	SD
PT instructor Asst PT instructor	23	160.9	4.82	57.5	5.16	61.7	12.16
Officer (recruit training) NCO " "	12	163.4	5.30	58.2	9.03	44.5	6.12
Shorthand writer	13	161.1	6.09	56.5	8.50	42.7	7.06
Postal courier	110	162.2	5.62	60.6	7.97	41.5	8.49
Clerk Pay Clerk Technical Clerk	58	162.3	6.26	58.5	7.54	40.5	6.35
Clerk/Typist	13	164.4	5.72	64.5	11.95	38.7	7.06
Storewoman RAOC Storewoman technical	80	162.2	7.47	60.6	9.99	36.2	7.22

25. As expected the PT staff scored better on the step-test than any other group. On account of the small numbers in some groups, and the large standard deviations of step-test scores, it was not possible (except for PT instructors) to distinguish statistically between adjacent groups, but the progression of scores followed the same trend as that of activity associated with the trade, the PT instructors and recruit-training staff being the more

active while the typists and storewomen had the more sedentary employment. The fittest group scored almost twice that of the least fit, whereas the heights and weights of the groups did not differ markedly, except for typists, a small group who were taller and heavier than the remainder.

Distribution of step-test scores

26. Table 4 gives the distribution of step-test scores after recruit training, of the 455 recruits who completed the test twice. A similar distribution was obtained with trained servicewomen.

Table 4. Distribution of step-test scores of 455 recruits, at end of training

Score	No. of women	%
20 - 24	2	0.4
25 - 29	18	4.0
30 - 34	55	12.1
35 - 39	106	23.3
40 - 44	106	23.3
45 - 49	95	20.9
50 - 54	44	9.7
55 - 59	14	3.1
60 - 64	4	0.9
65 - 69	7	1.5
70 and over	4	0.9
TOTAL	445	100

The distribution was mildly skewed in the positive direction, the mode and median being at about 40 points, whereas the mean was at 42. Less than 1% of scores were found below 25, except for the 8% of candidates who did not complete the test, and therefore scored nil.

Accuracy of pulse counting

27. The pulse counts on 73 of the recruits tested at WRAC Centre Guildford were recorded electrocardiographically, as well as manually by the regular team of testers. A small number of other ecg counts were done on women who took both cycle test and step-test at Aldershot, but in some cases manual counting was not done, and in others ASPT staff took the pulses. Data comparing the 2 methods has therefore been extracted only for those 73 subjects seen by the recruit training staff. Mean pulse counts by either method are listed in Table 5 together with computed step-test scores, and statistical parameters.

Table 5. Mean and SD of pulse counts and step-test scores of 73 WRAC recruits, taken manually and by ecg

	Manual		ecg		Difference		paired t	Significance
	mean	SD	mean	SD	mean	SD		
1st recovery pulse count	66.89	8.17	67.71	7.49	-0.82	5.45	1.29	NS
2nd recovery pulse count	60.04	7.89	60.23	6.98	-0.19	4.48	0.37	NS
3rd recovery pulse count	55.89	7.87	56.95	6.69	-1.06	3.82	2.36	$p<0.05$
Sum 3 pulse counts	182.82	22.63	184.89	20.70	-2.07	11.89	1.49	NS
Step-test score	42.89	11.38	41.73	9.79	1.16	5.52	1.80	NS

28. The pulse counts were not significantly different from the mean counts obtained from the entire recruit group of 589 women (P_1, P_2 and P_3 being 68.0, 60.5 and 55.8 respectively), and this sub-group can therefore be regarded as a representative sample.

29. Although mean pulse count error was -2.07 beats, which caused a mean error of only 1.16 points in step-test score, the SD of differences was 5.5 points, about 13% of the mean score, and individual errors ranged from -10 to +23 points. In only the 3rd pulse count was the mean manual count significantly different from the ecg count but with a difference of 1 pulse beat cannot be of any physiological importance.

DISCUSSION

Procedural Errors

30. The step-test result is determined from the sum of the three recovery pulse counts and therefore its accuracy is influenced by error in this observation. The mean pulse count error in a group of 73 women was sufficient to cause a mean error in score of only 2 points. Thus pulse counting error is of negligible importance when considering the mean score of a group, or the average number of women exceeding some predetermined score. For one use of the test, as a method of assessing Unit physical fitness, this source of error is therefore of little importance.

31. However individual errors in score due to pulse counting are influenced by the standard deviation of errors, which was 5.5 points, about 13% of the mean score. Thus assuming a Normal distribution of

errors about 2/3 of the subjects' scores would be in error by up to ± 13% (ie 1 SD), and 95% of scores would have an error up to ± 26% (ie 2 SD). Where individual test results are of importance, it would be necessary to take precautions against pulse counting error. The pulse count SD of errors was almost the same as the 5.3 point SD found in the men tested by 3 male PTI's (Amor and Vogel, 1973).

Repeatability

32. Another component of accuracy is the precision of the test, one measure of which is test-retest repeatability. The data on repeatability reported here includes errors from pulse counting, since manual counting was employed. The test-retest standard deviation of differences was 9 points, about 20% of the group's mean score. The repeatability data was not obtained by the same staff from whom the pulse counting error data was recorded, but if it is assumed they are typical, then repeatability errors must contain a large pulse count error component (para 29), and repeatability could be improved by using a more reliable pulse counting system. Some possibilities might be the use of a stethoscope to reduce auditory distraction, simultaneous counts by 2 observers, or the development of a form of ecg or oximeter pulse counter suitable for gymnasium use.

Comparison with the cycle test

33. The step-test, as a measure of physical fitness in the military context, does not set out to estimate aerobic capacity, but it is intended that aerobic capacity contributes a large proportion of the score. The cycle test, on the other hand, has been shown to estimate aerobic capacity (max $\dot{V}O_2$) well in groups of both men and women. The good correlation between step-test and cycle test results confirms that max $\dot{V}O_2$ does in fact contribute a high proportion of the step-test score.

34. Another desirable component in the test of physical fitness is an element of challenge. The change in recruit score, (4.76 points) was not much more than that found in servicewomen, (3.94 points), but the proportion of recruits failing to complete the test fell dramatically from 26% initially to 8% at the end of training, and this final proportion was the same as that found in servicewomen on both occasions. It could be held that this improvement was a result of the recruits accepting the challenge imposed by the test on the second occasion.

Unlike the cycle test (Amor et al, 1977) there was an improvement in mean step-test score on retesting, (the servicewomen sample). This could be attributed to a learning effect.

35. A group of 74 male soldiers tested on the APFA step-test (30 steps/min) and the cycle ergometer produced similar results to the women tested at 25 steps/min on the new step test (Table 6).

Table 6. Mean step-test and cycle test results-soldiers and servicewomen

	Men	Women
No. tested	74	73
Est. max. $\dot{V}O_2$ ml/(kg min) (cycle test)	43.0	38.7
1st pulse count	67.2	67.7
2nd pulse count	59.9	60.2
3rd pulse count	57.0	56.9
Step-test score	42.3	41.7

This suggests the adjustment of the work rate of the test to allow for the physiological difference between the sexes was successful, and the pulse counts confirm the level of stress produced was comparable in the 2 groups.

36. Text books (eg Åstrand and Rodahl, 1970) give typical female work capacity, $\dot{V}O_2$ max (directly determined), as 80% of that of males. Our finding of a result for women of 90% that of men could be a result of the relatively small sample size. Another possibility is a difference in the efficiency of the cycle test as an estimator of max $\dot{V}O_2$. This has been studied in British male soldiers by Amor, Worsley and Vogel (1977) but comparable data on servicewomen is not yet available.

A pass mark for the step-test

37. In attempting to recommend a physical fitness standard based on step-test score certain assumptions must be made at this stage in the development of the test. The standard is intended to be a minimum level of basic physical fitness, and must therefore be passed by a large proportion of servicewomen. If it is thought the present level of fitness is rather low, as is suggested by the cycle test results, then an assumption must be made about the amount of physical training which can in practice be introduced into the week's work programme, and the effect this is likely to have on these women.

38. Little data is available on the response of non-sportswomen to training or even of the level of physical fitness of average British women. This is an area where research is required. In general it is thought an improvement of 10 to 20% in aerobic work capacity may result from a training programme applied to initially rather unfit women, and a further improvement in step-test performance may result from increased familiarity with the test.

39. Referring to Table 4, and allowing for the 8% of women who did not complete the test, the present level of fitness leads to 45% of women scoring less than 40 points. If an improvement in score of about 20% is postulated, and the proportion of failures to complete the test is reduced to 2%, we might expect 10% of women to score less than 40 points, and this proportion is about the required level for an Army-wide minimum standard.

40. It seems then, that a pass mark of 40 points would be appropriate, but this would need to be confirmed in the light of experience with an improved physical training curriculum. A step-test score of 40 is equivalent to an estimated max $\dot{V}O_2$ of 38 ml/(kg min).

Allowance for age

41. The effect of age on the aerobic capacity of British women is another area where little data is available, and the effect of physical training is also difficult to predict. For the WRAC the practical influence of an age allowance is small, because less than 10% of the Corps is aged over 30 years. But this also makes investigation difficult on account of the limited availability of suitable subjects. A 5 to 10% reduction in max $\dot{V}O_2$ with each 10 years increase of age is usually considered normal. Other factors contributing to step-test score have an unknown age dependence.

42. In the introductory stages of the new physical fitness test a further consideration is the ability of the older age groups to respond to physical training, due to the influence of factors such as flexibility and joint loading. Medical advice has therefore been that, although a 10% reduction in test standard per 10 years of age seems reasonable, a further reduction would be desirable for women presently over 40 years of age, and stepping could well be avoided entirely by substituting a brisk walk as the maximum standard.

43. Accordingly, using the proposed pass mark extrapolated from the present results, and the age allowance discussed above, the suggested fitness standards, as adopted by the Fit-to-Fight working party are shown in Table 7.

Table 7. BFT5 fitness standards

Age, yr	Step test score	Alternative test
up to 29	40	none
30 - 39	36	none
40 - 49	32	walk 2 miles in 28 min

CONCLUSIONS

44. A step-test comprising 5 min of stepping at 25 steps/min onto a 17 inch (43cm) bench can be completed by over 90% of trained servicewomen, and recruits at the end of initial training. When score is calculated from recovery pulse sum in the same way as for the male APFA test a pass mark of 40 points would produce 45% failure rate at the present level of fitness, but this could feasibly be reduced to 10% by improved physical fitness.

45. The test is suitable for assessment of physical fitness levels of groups of women, but for individual assessment special care must be taken to ensure accuracy of pulse counting, and repeat tests may be desirable. Because of a Learning Effect the first test a subject undertakes could score about 10% low.

46. There is good evidence of a relation between step-test score and max $\dot{V}O_2$, but there is no evidence of any effect of stature.

47. The test produces a stress in women equivalent to that produced in men by the APFA step-test.

RECOMMENDATIONS

48. The test is recommended for adoption by the Fit-to-Fight programme as a physical fitness test for the WRAC, with a minimum standard of 40 points (age up to 29 years).

49. Future studies are recommended to confirm the standard and the age allowance in the light of experience with practical application of the Fit-to-Fight programme.

PART 2

Obesity and body-weight standards

INTRODUCTION

50. The Army's concern with obesity is an important secondary factor in the maintainance of physical fitness. Since the assessment of fitness is by means of a performance test, excess adipose tissue may be compensated to some extent by increased fitness expressed in lean-body terms. Therefore any body fatness standard must be sufficiently lenient to take this matter into consideration.

Skinfold measurement

51. A practical and convenient method of assessing obesity is the use of skinfold calipers, by means of which direct measurement of the thickness of subcutaneous adipose tissue is possible. A procedure appropriate to male soldiers was developed at APRE by Haisman (1968), using density determined from underwater weighing as a reference basis, and aspects of its application were examined by Amor and Murch (1977). Repeatable and reliable results were best obtained by skilled observers, but there was a tendency for consistent differences to occur between observers.

52. Durnin and Rehaman (1967) using the same 4 skinfold sites, gave relations between the skinfold thicknesses, and body fat determined by underwater weighing. It is their formula for women that has been used in the work reported here, since data from WRAC is not available at this time.

Weight measurement

53. For the informal assessment of obesity, body weight will remain in use for some time. This of course measures bone, muscle and body water besides fat, and therefore the application of standards to individual cases must be done with caution.

54. Desirable body weights for various heights have been published by the Metropolitan Life Assurance Company (1959), using life expectancy data from several million persons insured in the United States and Canada between 1935 and 1953. Although the use of life expectancy as a criterion in recommending desirable body weights for a military population could be debated, no more appropriate standard is available, and so it is these figures, corrected to nude weight and height which will be recommended for the Fit-to-Fight programme (Annex B). The table reduces to quadratic equations relating weight and height. In imperial units (lb and in) these are:

$$\text{max desirable weight} = -16.3848 + 0.6519\,(\text{height}) + 0.0255\,(\text{height})^2$$
$$\text{and min desirable weight} = 188.6169 - 5.9414\,(\text{height}) + 0.0749\,(\text{height})^2.$$

By making an allowance of 20% over the maximum desirable weight, a level can be set for the Army at which medical advice should be sought. This is termed the "maximum permissible" weight. Although the Metropolitan Life table distinguished between "frame-sizes" no definition was given, and some authorities have stated the majority of persons can be classified as "medium". These data are given in Annex B.

Height-Weight Indices

55. Various combinations of height and weight have been proposed as an index of obesity. Two of the most popular are:

$$\text{Quetelet's Index (QI)} = \frac{\text{wt in kg x 10}}{(\text{ht in m})^2}$$

$$\text{Relative Weight (RW)} = \frac{\text{weight}}{\text{mean of Met. Life max and min desirable weights}}$$

The present study obtained skinfold thickness data from WRAC recruits during their initial and final physical fitness tests in order to evaluate changes in body weight. This data could also be used to assess height/weight data from WRAC recruits in terms of body fat. Since servicewomen were not greatly different from recruits in either age, height or weight (see Part 1), the data could also be applied to this group.

METHODS

Anthropometric data

57. Age, height and weight were obtained from administrative records. Recruits were measured within a few days of their skinfold measurements.

Skinfolds

58. Harpenden calipers were used to sample skinfold thicknesses at 4 sites on the right-hand side of the body (Annex C):

Bicep
Tricep
Suprailiac, on the mid axillary line
Subscapular

Experimental details of the method have been discussed by Amor and Murch (1977) and compared with 2 international specifications.

59. Body fat was calculated in 2 stages from the sum of the 4 skinfolds, expressed in mm, using the formulae of Durnin and Rahaman (1967), and Siri (1956):

$$\text{Density} = 1.1581 - 0.0720 \log_{10} (\text{sum 4 folds})$$

$$\text{Fat \%} = \frac{495}{\text{Density}} - 450$$

RESULTS

60. Means and standard deviations of skinfold thicknesses, calculated body fat and height/weight indices are presented in Table 8, for 489 recruits at the end of training. Changes in these parameters with training are discussed later, in Part 3.

Table 8. Skinfold thicknesses, body weight and derived parameters, in WRAC recruits at the end of initial training

(n = 489)

	MEAN	SD
Bicep skinfold, mm	9.47	3.46
Tricep skinfold, mm	19.32	5.30
Suprailiac skinfold, mm	19.47	6.53
Subscapular skinfold, mm	14.97	5.44
Body fat, % by weight	30.8	4.05
Weight kg	60.46	8.16
Height cm	162.8	5.80
Age yr	18.65	1.86
Quetelet Index	227.8	26.0
Relative weight	1.082	0.123

61. The relationships of both Quetelet Index and Relative Weight to body fat, (as estimated by skinfold thicknesses) were similar (Table 9 and Figure 2).

Body fat and Quetelet Index - WRAC

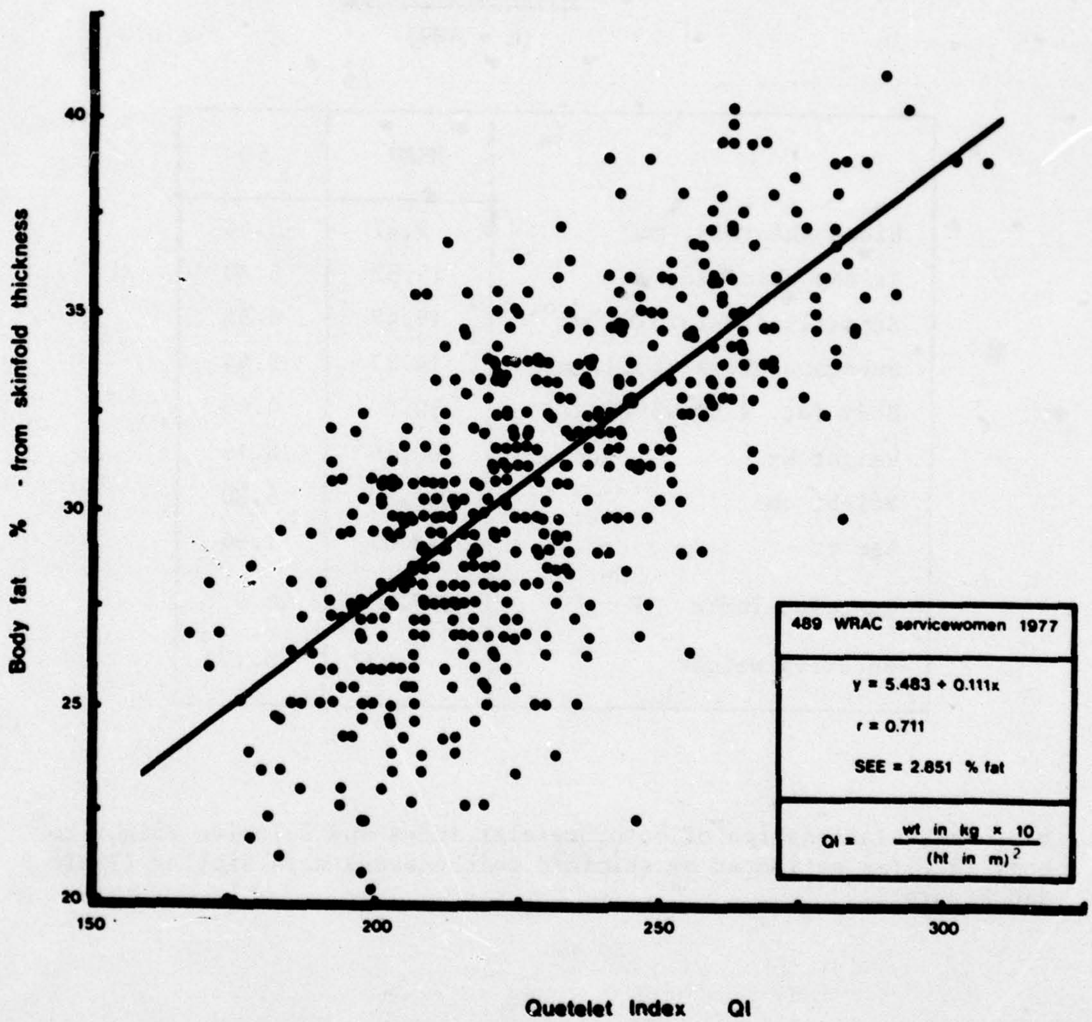


Figure 2

Table 9. Parameters of linear regression of body fat (as % of body weight) on Relative Weight and Quetelet's Index

[fat = a +b(index)], for 489 WRAC

	Constant a	Slope b	Correlation coefficient r	Standard error of estimate Fat %
Quetelet Index	5.483	0.111	0.711	2.854
Relative Weight	5.478	23.403	0.712	2.849

DISCUSSION

62. The choice of skinfold sites and of a formula for conversion to percentage body fat is very dependent on the population being studied, as evidenced by the wide variety of formulas which have been presented in the literature. Durnin and Rahaman's relation was chosen since it used the same skinfold sites that were employed by APRE on male soldiers and it had been developed on British women. However the ages and weights of their subjects were not strictly comparable with the WRAC servicewomen studied here. It will not be possible to verify the application of their formula to WRAC until a series of comparisons with skinfolds of a more accurate determination of body fat, (eg under-water weighing) becomes available. In the meantime, the Durnin and Rahaman skinfold method has been taken to be the most accurate available, and other methods are assessed against it.

63. For the group of women studied here, there was very little difference between the two height-weight indices. Correlations with body fat from skinfolds were identical to the second decimal place, and so were standard errors of estimate. Although the concepts leading to the development of QI and Relative Weight were not the same, the practical result is two indices both of which are functions of $(\text{height})^{-2}$. This follows from the close correspondence to a quadratic of the regression of Metropolitan Life desirable weight on height.

64. Applying the height/weight index to the Metropolitan Life medium-frame table of desirable body weights, it can be calculated that for WRAC the corresponding body fat levels are 27% to 30% body weight, and the 20% overweight level corresponds to 34% body fat. Lower levels of fat have been reported in British women, and in American athletes and college women, despite their average weights falling either within or slightly over the Metropolitan Life weight bracket (Table 10). Even lower values for body fat, from about 20% to as low as 10% have been reported in individual female athletes (Wilmore, 1975).

Table 10. Mean body fat and anthropometric measures of groups of women

Study	Group	No. seen	Age yr	Height cm	Weight kg	Fat % by wt	wt diff from Met. Life max (kg)
Present study	WRAC recruits week 5	489	18.7	162.8	60.5	30.8	+0.75
Vogel	US recruits week 1	92	19.9	163.2	59.0	27.9	-0.1
	US recruits week 6	95	20.9	162.2	60.6	29.0	+2.2
Durnin & Rahaman	British	45	21.7	162.5	55.9	24.2	-2.8
Cotes et al	UK factory workers	20	23.7	162	55.0	-	-3.4
Wilmore & Behnke	US students	128	21.4	164.9	58.6	25.7	-1.8
Brown & Wilmore	US athletes	5	16-23	175.4	79.0	24.7	+10.8
Katch & MacArdle	US students	69	20.3	160.4	59.0	25.6	+2.0

65. The 2 Army samples differ from other data in that they have more fat at similar body weights. As it seems reasonable to set weight standards on the basis of obesity, the Metropolitan Life tables would appear to be too high if applied to these recruits. Since other fit young women had mean body fat in the range 24-26%, it might be reasonable to reduce the Metropolitan Life standards sufficiently to reduce body fat by 5% in the WRAC sample, ie by 3 kg.

66. The validity of this discussion, as stated earlier, rests on the applicability to WRAC data of the Durnin and Rahaman formula, which was obtained from a somewhat different population. This could only be tested by further investigation.

CONCLUSIONS

67. Quetelet Index and Relative Weight gave similar relations with body fat as calculated from skinfold thicknesses. Indications are that the Metropolitan Life desirable weights are too high, by about 3 kg, when applied to WRAC, but a confirmatory experiment would be required.

RECOMMENDATIONS

68. The Metropolitan Life desirable weight table should be used as an interim guide to assessing obesity in WRAC, if skinfold data is not available. Before the use of the Metropolitan Life desirable weights are confirmed, an experiment is recommended to compare, in WRAC, skinfold and body weight measurements with a more precise method of determining body fat, such as underwater weighing.

PART 3

Physical Fitness of Recruits and Trained Servicewomen, 1977

INTRODUCTION

69. Body fat and fitness scores have been examined earlier with respect to the characteristics of the tests, and in earlier sections it was shown that recruits on their final test did not differ greatly from the servicewomen sample. This section discusses the absolute values of fat and fitness found in these samples, and examines the changes seen after recruit training. There is of necessity some repetition of results given earlier.

RESULTS

The Servicewomen Sample

70. The group of 409 women tested at Aldershot, Mill Hill, Bicester and Donnington was chosen by reason of the availability of subjects and test staff, and no attempt was made to obtain a statistically accurate cross-sectional sample. As it turned out, however, the rank structure of the sample, while being low in senior ranks, was not greatly different from that expected from Manpower Statistics data (Table 11). The sample comprised about 10% of the Corps.

Table 11. Number of women tested, by rank, compared with total numbers in WRAC

Rank	Corps %	Sample	
		No. seen	%
Pte	53	253	61.9
L/Cpl	18	73	17.8
Cpl	11	42	10.3
Sgt & S/Sgt	8	26	6.3
WOI & WOII	2	2	0.5
2nd Lt & Lt	3	11	2.7
Capt & over	5	2	0.5
Total	100%	409	100%

71. Trades on the other hand were not well represented in the sample. Table 3 lists the trades where more than 10 women were seen. Although many office workers were represented, there were relatively few women from more active trades (policewomen, dog-handlers), or from manual trades (cooks, drivers, technicians).

Recruit Sample

72. Recruit intakes Nos 389 to 399 at WRAC Centre were seen, between Nov 1976 and Aug 1977, a total of 809 women. Since intake 389 tried the step-test at the male stepping rate, there were a smaller number of step-test results, and 634 women attempted the new test twice, at beginning and end of recruit training.

73. Table 12 gives mean physical characteristics for each recruit intake, at their first test, full data being available for 779 women. Although significant differences existed between intakes, there was no trend to be found over the period from winter 1976 to summer 1977.

Table 12. Physical characteristics. WRAC intakes 389-399 (1977) on recruitment

Intake	No. Tested	Age yr Mean	Age yr SD	Height cm Mean	Height cm SD	Weight kg Mean	Weight kg SD	Step-test Score Mean	Step-test Score SD
389	78	18.4	2.04	162.9	5.69	59.2	8.66	-	-
390	57	17.9	0.82	164.0	7.26	61.2	8.38	35.9	6.01
391	74	18.3	1.32	163.3	6.70	60.9	9.85	35.5	6.00
392	70	18.3	1.45	162.4	6.20	57.7	7.51	42.0	9.66
393	72	18.3	1.70	162.6	5.75	57.5	9.10	37.4	8.80
394	71	18.0	1.49	161.9	4.96	58.1	7.74	37.3	8.46
395	75	18.4	1.41	162.7	5.49	58.9	7.63	37.1	7.66
396	76	18.4	1.23	163.1	5.63	60.6	9.14	38.7	8.19
397	90	18.5	1.29	163.3	6.72	60.8	9.33	36.8	5.49
398	64	18.6	1.39	163.9	5.47	60.7	8.18	42.7	8.54
399	52	18.8	1.22	163.8	6.34	60.9	8.52	36.8	5.73
Overall	779	18.3	1.37	163.0	6.07	59.6	8.44	38.0	7.91

The Step-test

74. Mean score of recruits on second test was 42.2, and the servicewomen scored 43.8, virtually the same. The combined mean score was 42.7 (SD = 9.15). Applying the cycle step-test regression, this was equivalent to an estimated maximal oxygen uptake of 39.2 ml/(kg min).

75. The servicewomen exhibited a learning effect, their step-test scores improving by 3.94 points on the second test. The regression of step-test improvement (y) on initial score (x) had a low correlation, r = -0.309. The regression line was:

$$y = 18.152 - 0.353\,x$$

Thus there was a tendency for low scorers to improve on the second test, while high scorers obtained a lower score on retest. The no-change point was at an initial score of 51 points, and about 10% of the sample had scores above this value.

76. This effect was similar but more pronounced in recruits, who improved by 4.76 points over the 5 weeks training period (Figure 3). In their case the regression of step-test improvement (y) on initial score (x) was:

$$y = 32.159 - 0.731\,x \qquad r = -0.569$$

The slope of their line was double that of the servicewomen, and the correlation was good. The no-change point was at a step-test score of 44, equivalent to an estimated max $\dot{V}O_2$ of 39.8 ml/(kg min) (Figure 4). About 80% of recruits scored below 44 on initial test.

Fat levels

77. No skinfold measurements were taken on servicewomen, except for a few of the Aldershot sample. However, since the mean height and weight of servicewomen was near that of recruits at the end of training, it can be inferred they had similar fat percentages. The mean body fat in 489 recruits on second test was 30.8% by weight, corresponding to a mean Quetelet Index of 229. The Quetelet Index of 378 servicewomen was 227, within 0.2% body fat of the recruits. Body weights at all heights were near the Metropolitan Life desirable maximum (Figure 5).

78. There was a small reduction in obesity in 254 recruits whose skinfolds were measured before and after recruit training (Figure 6). Body fat decreased by 0.28% bodyweight (SD = 1.5%) from 31.8% to 31.5% by weight, while weight increased by a mean of 1.2 kg (SD = 2.16 kg) from 59.6 kg to 60.8 kg.

Effect of obesity on step-test performance

79. Since step-test scores, height and weight were similar for recruits at 5 weeks and servicewomen, the combined data from 911 women was examined for this relation. This procedure enabled sufficient numbers to be found in the smaller groups (eg only 8% of women failed to complete the test) for statistical analysis. Table 14 gives a cross-tabulation of the numbers of women who either passed (score 40 or over), failed or did not complete the test, related to their body weight category.

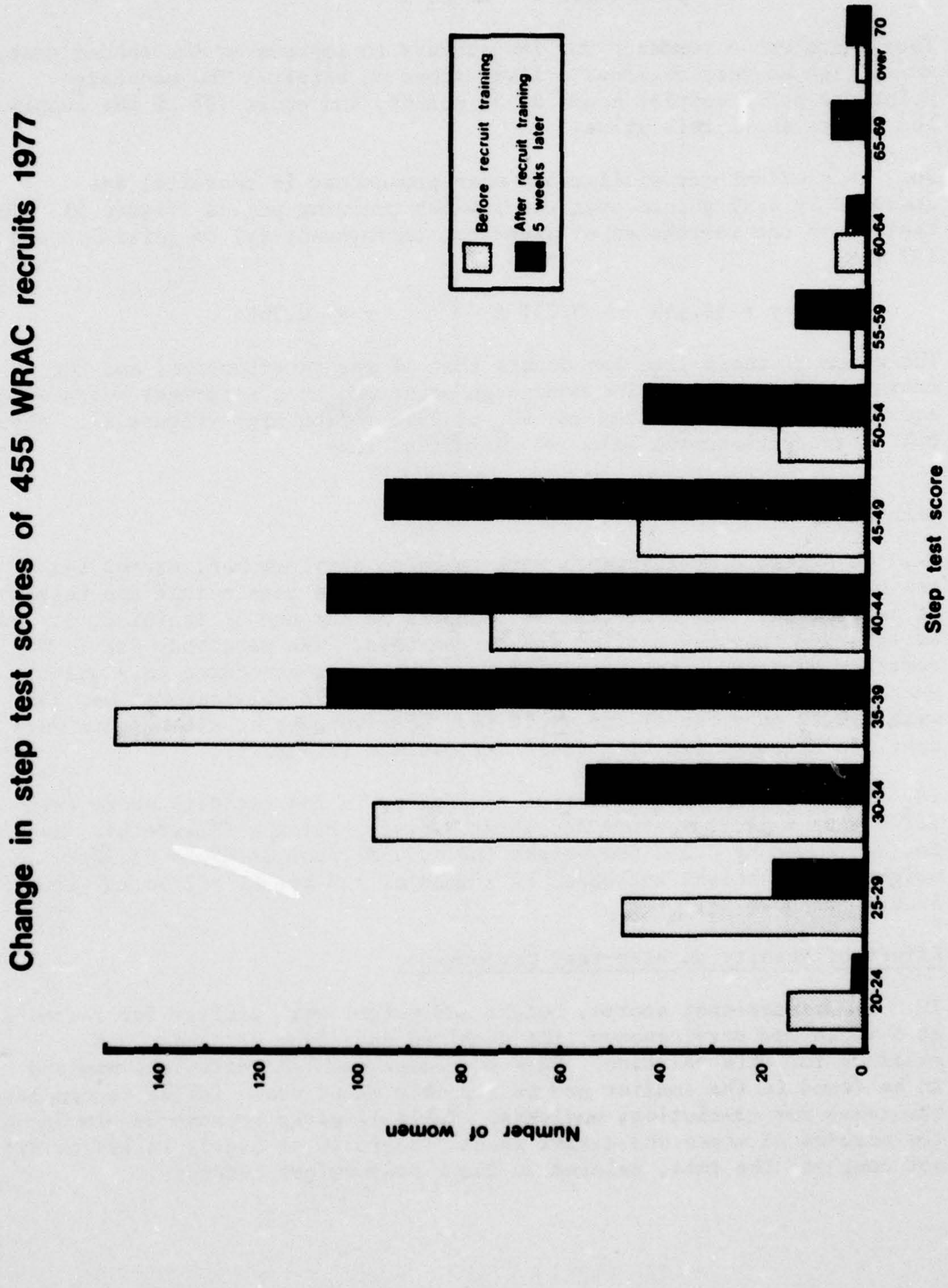

Change in step test scores of 455 WRAC recruits 1977
Before recruit training
After recruit training 5 weeks later
Number of women
0
20
40
60
80
100
120
140
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
over 70
Step test score

Figure 3

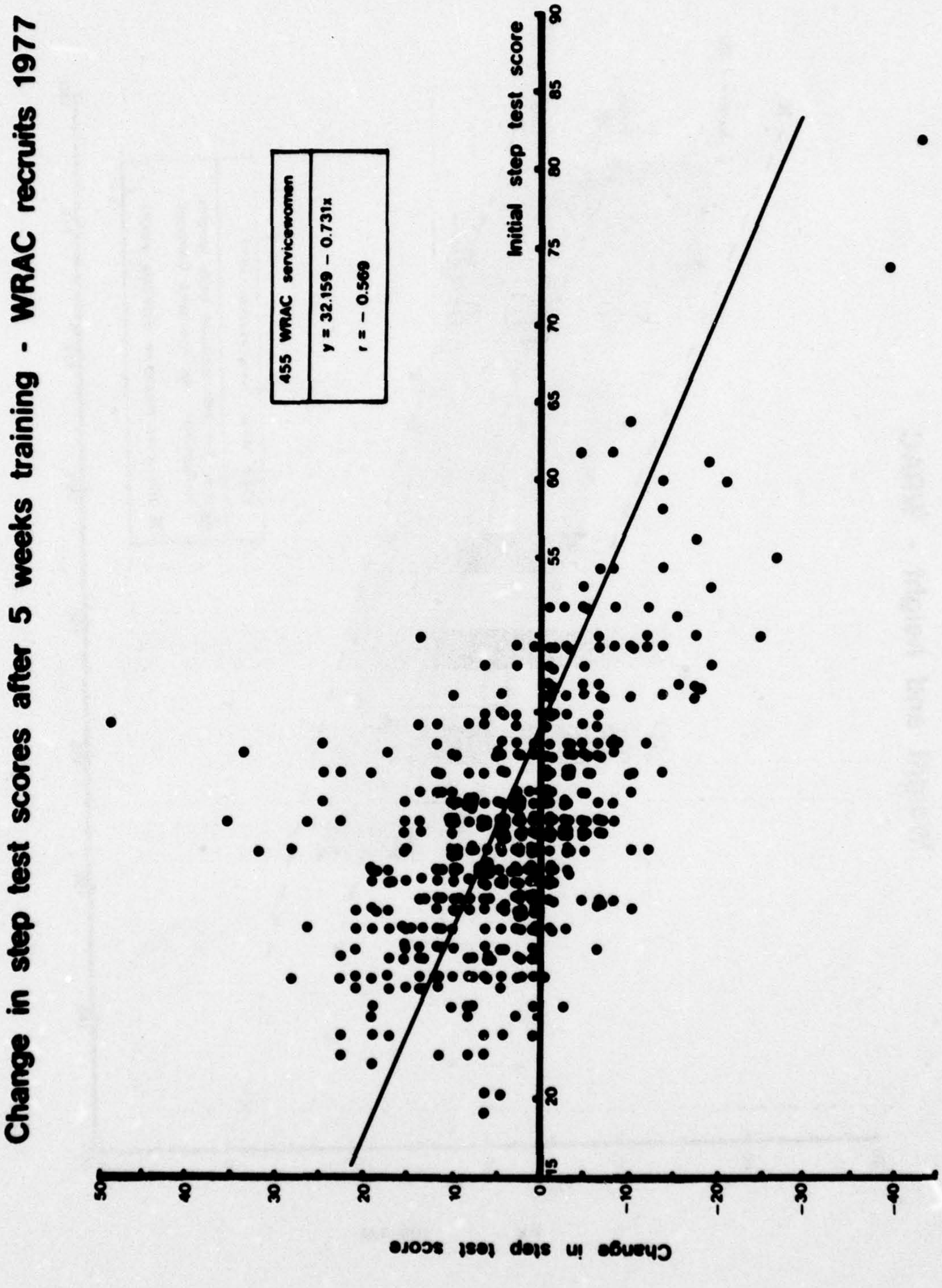

Change in step test scores after 5 weeks training - WRAC recruits 1977
455 WRAC servicewomen
y = 32.159 – 0.731x
r = – 0.569
Initial step test score
Change in step test score
15
20
55
60
65
70
75
80
85
90
50
40
30
20
10
0
-10
-20
-30
-40

Figure 4

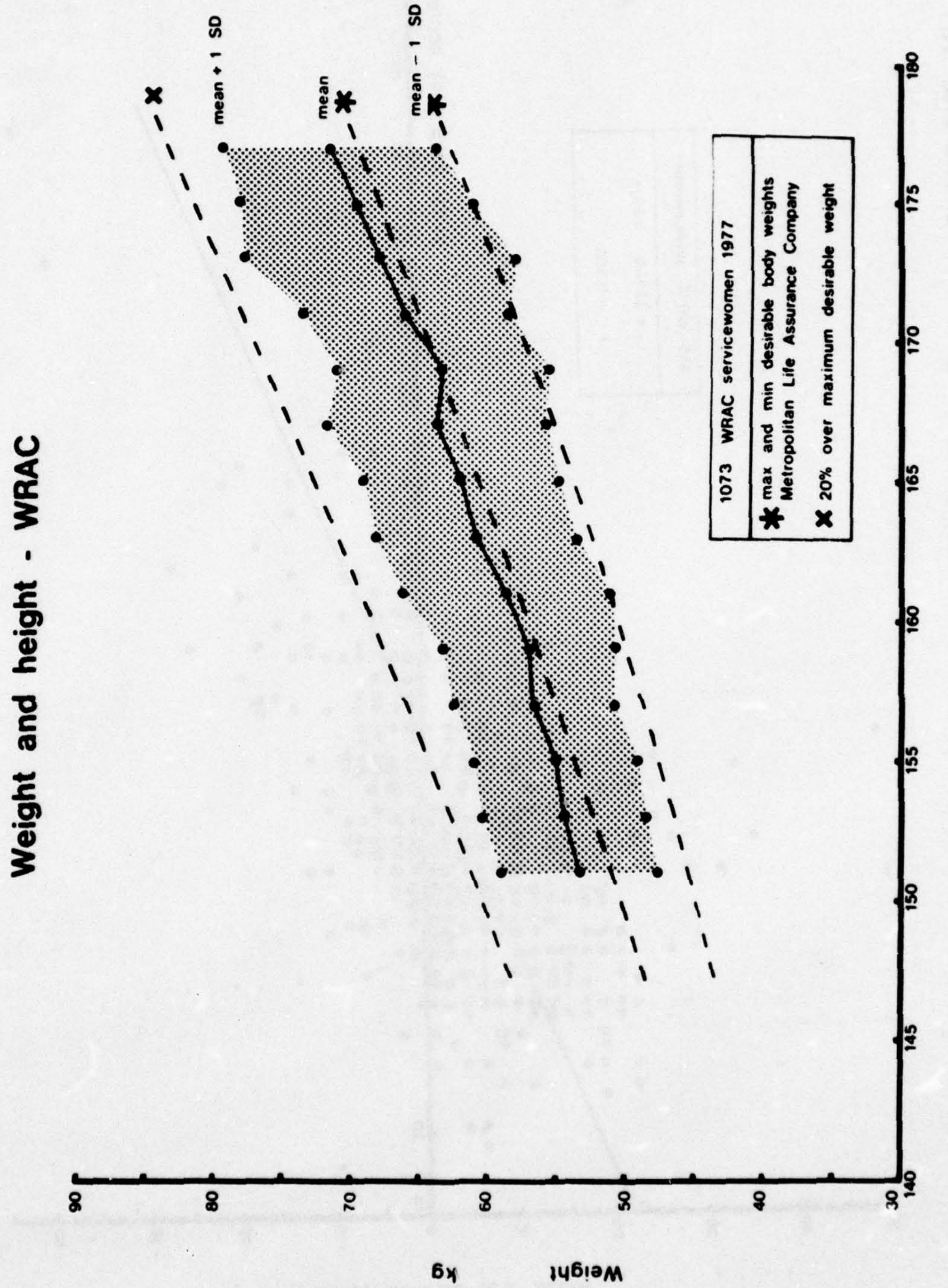
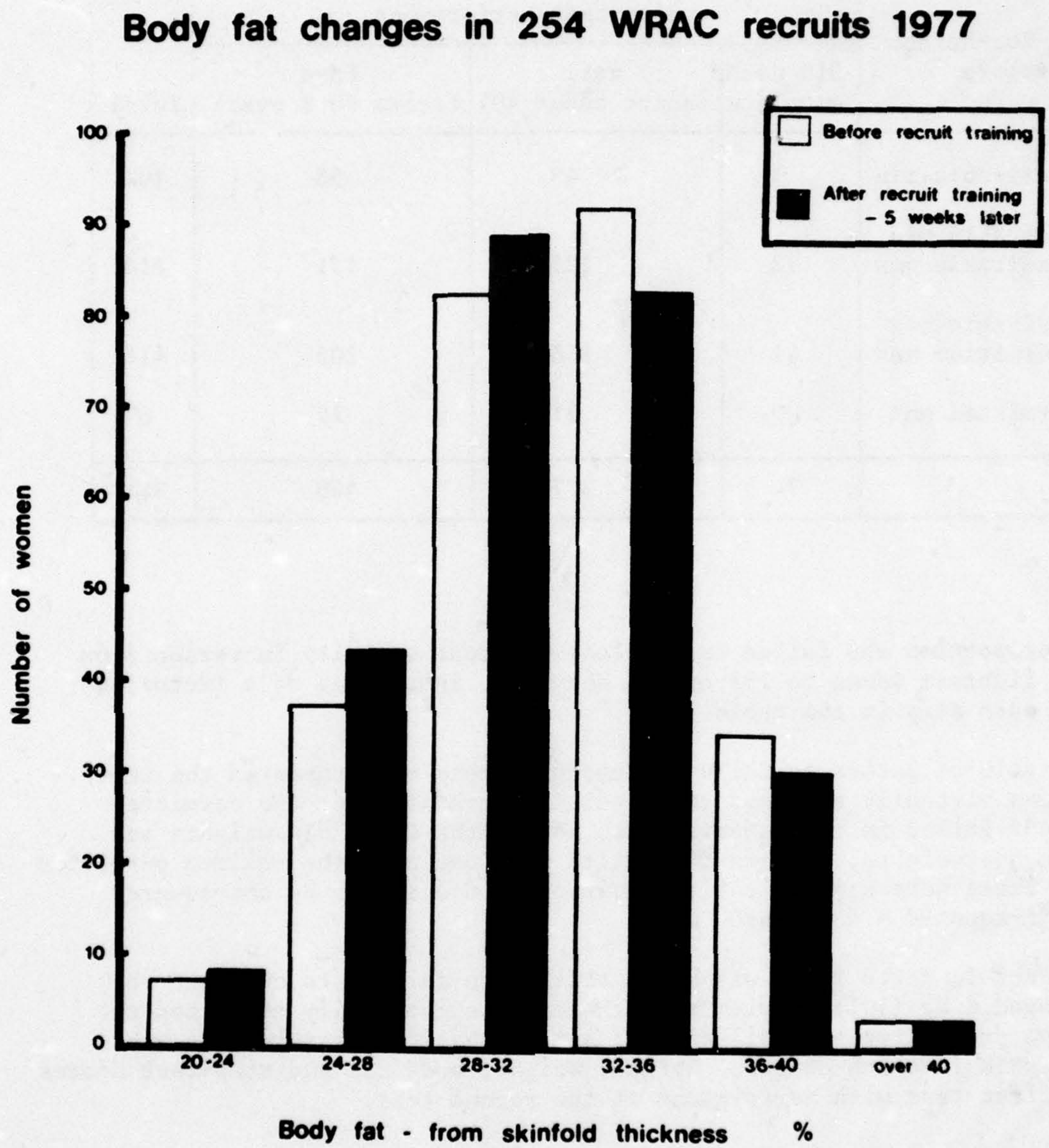

Weight and height - WRAC
Weight
kg
90
80
70
60
50
40
30
Height
cm
140
145
150
155
160
165
170
175
180
mean + 1 SD
mean
mean – 1 SD
1073 WRAC servicewomen 1977
max and min desirable body weights Metropolitan Life Assurance Company
20% over maximum desirable weight

Figure 5



Body fat changes in 254 WRAC recruits 1977
Before recruit training
After recruit training - 5 weeks later
Number of women
100
90
80
70
60
50
40
30
20
10
0
20-24
24-28
28-32
32-36
36-40
over 40
Body fat - from skinfold thickness %

Figure 6

Table 13. Numbers of women in different weight categories, by step-test performance - WRAC

Weight-for-height category	Step-test Performance			Total
	Did not complete	Fail (score under 40)	Pass (score 40 & over)	
Under desirable min	1	43	58	102
Over desirable min Under desirable max	12	135	171	318
Over desirable max Under permitted max	41	168	202	411
Over permitted max	20	31	29	80
Total	74	377	460	911

80. The proportion who failed to complete the test steadily increased from 1% of the lightest women to 25% of the heaviest, increasing by a factor of 2 to 3 at each step in the table.

81. The ratio of passes to failures, amongst those who completed the test, however, was virtually constant until weight increased over the permitted maximum (43% failed in the underweights, 44% in the desirable weights and 45% in the overweights, whereas 52% failed in those over the maximum permitted weight). These were statistically significant on analysis by chi-squared test. (Chi-squared = 48.7, $p<0.001$).

82. In Part 1, Table 2, it was shown that women failing to complete the test averaged 6 kg (10%) heavier that those who successfully completed the 5 min. The predictive possibilities of simple physical measurements are given in Table 14 which compares height, weight, body fat and step-test scores from the first test with performance at the second test.

Table 14. Initial physical measurements and final step-test performance - WRAC recruits

Step-test Performance after 5 weeks	Initial Measurements											
	Height (cm)			Weight (kg)			Fat %			Step score		
	n	mean	SD	n	mean	SD	n	mean	SD	n	mean	SD
Fail to complete	48	163.0	6.2	48	66.2	9.2	21	34.5	3.4	11	32.6	6.1
Discharged	50	164.8	6.7	50	60.5	9.6	25	32.0	5.0	40	38.4	7.3
Fail (score under 40)	254	162.7	6.1	254	59.4	8.7	103	32.0	3.9	181	35.2	7.2
Pass (score 40 or over)	335	163.1	6.0	335	58.8	7.8	127	31.2	4.2	274	39.0	8.0

Women who failed to complete on the second test averaged 7 kg heavier initially than those who completed but failed. Women who were discharged were not markedly different in body composition or initial test score from those who passed the final step-test.

DISCUSSION

Aerobic work capacity

83. Very little data is available concerning the aerobic capacity and body composition of young British women, so assessment of these WRAC women in absolute terms is not easy. In 2 reports where women of a similar age-group were examined, maximal oxygen uptakes on the cycle ergometer were both 39 ml/(kg min), the same as WRAC recruits after 5 weeks training. These groups were 20 factory workers aged 20-28 examined by Cotes and co-workers (1969) and 32 PT students aged 19-21 seen by Watson (1970).

84. Vogel (1975) examined US Army recruits by the Åstrand cycle method and found a mean estimated max $\dot{V}O_2$ of 41.2 ml/(kg min) in 95 women after training for 6 weeks. Maximal oxygen uptake, directly measured on the treadmill however was 39.5 ml/(kg min), suggesting an overestimate by the cycle method in his group.

85. In other US data from students values of 35 to 40 ml/(kg min) have been found for young women aged 17 to 29 yr. Somewhat higher values, of 40 to 60 ml/(kg min), have been reported from athletes.

Response to physical training

86. The response of young women to aerobic training has generally been studied in athletes, and little data is available from the normal population. In general, opinion is that their response to training is similar to that of men, and an improvement of 10 to 20% might be expected from initially rather sedentary women. Yeager and Brynteson (1970) for example studied 18 US college entrants who trained at a heartrate of 144 beats per min for 6 weeks, 3 sessions per week. Initial estimated max $\dot{V}O_2$ by the Åstrand cycle test was 37 ml/(kg min) and improvement was 5 ml/(kg min) for 12 women who cycled for 10 to 20 min per session and 8 ml/(kg min) for 6 who cycled for 30 min.

87. The WRAC recruit training included 14 periods of physical training in the 5 week period between the 2 test sessions. Each period was scheduled for 40 min, so that, after changing, perhaps 25 to 30 min were spent in activity. Recruit training also included 26 periods of drill. The improvement in step-test score of the recruits, after allowing for a learning effect, (as found in servicewomen) was only 1 point, but there was a large decrease in the number of women who failed to complete the test. It therefore seems probable that step-test improvement was a result of a positive response by the recruits to the challenge to complete the 5 min stepping, together with an improvement in agility and co-ordination as a result of PT and drill training. Improvement in aerobic capacity however was probably only slight.

88. This argument is based on the assumptions that the recruits exhibited a step-test learning response similar to the servicewomen. If it is further assumed that their response to training would be similar to Yeager and Brynteson's US college girls, and that they have the capacity to improve by a similar amount, then it can be concluded that the activity in the PT classes, although of sufficient duration, was not sufficiently intense to keep their heartrate above 144 beats/min for the duration of the period. Some confirmation of this is shown by the tendency for the fittest women to decrease in step-test score during recruit training, but it would be necessary to monitor heartrate during physical training (and possibly other intense recruit activities such as games and drill) to confirm the hypothesis. This could conveniently be done by radio telemetry.

89. Servicewomen are allocated 2 hours per week PT. In order to achieve an adequate improvement in aerobic fitness they may need to do a proportion of training in their own time.

Obesity

90. Table 10 (Part 2) has already compared the WRAC sample by body fat and weight with British and US women. The WRAC women were about 2% by weight fatter than the US recruits, and 5% by weight fatter than other groups of a similar weight. However, the step-test performance, provided they could complete the test, was not unduly affected by weight unless they were over 20% heavier than the Metropolitan Life recommended maximum weight.

91. The effect of recruit training was to increase body weight, but skin-fold measurements were reassuring in that obesity, while undesirably high, was not increased during the 5 weeks. Women who commenced training as step-test failures with associated overweight did not improve.

CONCLUSIONS

92. WRAC servicewomen and recruits at end of training are about 5% by weight fatter tha might be recommended, but their aerobic work capacity is about the same as other groups of young women.

93. Recruit training is successful in reducing the number of women who fail to complete the step-test, but results (after allowance for a learning effect) suggest aerobic work capacity is not improved. Improvement in step-test performance could be achieved by aerobic training, and also by obesity reduction in the women who either fail to complete the initial step-test, or who weigh more than 20% over the Metropolitan Life recommended maximum for their height. The physical fitness level at the end of recruit training is similar to that of servicewomen.

94. Women who enter recruit training and are subsequently discharged do not differ in their physique or physical performance from those who complete recruit training.

RECOMMENDATIONS

95. All women who are excessively obese (over permitted weight) and those who fail to complete their initial step-test should be considered as candidates for an obesity-control programme. Since for the average woman recruit training produces an increase in weight without an increase in adipose tissue, skinfold calipers could be usefully employed to monitor the progress of the obesity-reduction candidates.

96. A general obesity reduction programme, designed to reduce fat by 5% of body weight, is desirable on health grounds, but is unlikely to greatly affect step-test performance, unless accompanied by increased exercise.

97. An increase in the amount of aerobic training is required to raise the general level of step-test performance in both recruits and servicewomen. It may be possible to achieve this within the existing time allocation by increasing the intensity of exercise during PT classes. Heartrate monitoring would be useful in setting the level of intensity of PT, and in assessing the training potential of other recruit activities.

PART 4

<u>Summary of Conclusions of Parts 1, 2 and 3</u>

PART 4

SUMMARY OF CONCLUSIONS OF PARTS 1, 2 AND 3

98. The proposed step-test is an acceptable and practical method of assessing physical fitness in WRAC. Score is mainly determined by max $\dot{V}O_2$, but the test also presents a challenge to the candidate.

99. The test is suitable for assessing the average fitness of a group of women, but special care must be taken to avoid pulse counting errors, and to allow for repeatability if an individual result is required.

100. The general level of aerobic capacity in the WRAC is similar to other groups of young women, but obesity is somewhat higher, from initial recruitment. Consequently recommended height-weight tables may require amendment.

101. Recruit training improves agility co-ordination and determination as assessed by the proportion of women completing the fitness test, but aerobic capacity is probably not improved.

102. Further studies of the intensity of recruit PT, and of body fat content, combined with monitoring of Fit to Fight test results in the first year, would assist in improving fitness training and would help to confirm the standards for step-test performance and body weight proposed here.

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ARMY PHYSICAL FITNESS ASSESSMENT

CONVERSION CHART - SUM OF PULSE COUNTS TO STEP TEST SCORE

SPC	PFA	SPC	PFA	SPC	PFA	SPC	PFA
101	109	151	59	201	35	251	20
102	107	152	59	202	34	252	20
103	106	153	58	203	34	253	19
104	104	154	57	204	34	254	19
105	103	155	57	205	33	255	19
106	102	156	56	206	33	256	19
107	100	157	56	207	32	257	18
108	99	158	55	208	32	258	18
109	98	159	54	209	32	259	18
110	96	160	54	210	31	260	18
111	95	161	53	211	31	261	17
112	94	162	53	212	31	262	17
113	93	163	52	213	30	263	17
114	92	164	52	214	30	264	17
115	90	165	51	215	30	265	17
116	89	166	50	216	29	266	16
117	88	167	50	217	29	267	16
118	87	168	49	218	29	268	16
119	86	169	49	219	28	269	16
120	85	170	48	220	28	270	16
121	84	171	48	221	28	271	15
122	83	172	47	222	28	272	15
123	82	173	47	223	27	273	15
124	81	174	46	224	27	274	15
125	80	175	46	225	27	275	15
126	79	176	45	226	26	276	14
127	78	177	45	227	26	277	14
128	77	178	44	228	26	278	14
129	76	179	44	229	26	279	14
130	75	180	43	230	25	280	14
131	74	181	43	231	25	281	13
132	74	182	42	232	25	282	13
133	73	183	42	233	24	283	13
134	72	184	42	234	24	284	13
135	71	185	41	235	24	285	13
136	70	186	41	236	24	286	12
137	70	187	40	237	23	287	12
138	69	188	40	238	23	288	12
139	68	189	39	239	23	289	12
140	67	190	39	240	22	290	12
141	66	191	38	241	22	291	11
142	66	192	38	242	22	292	11
143	65	193	38	243	22	293	11
144	64	194	37	244	21	294	11
145	63	195	37	245	21	295	11
146	63	196	37	246	21	296	11
147	62	197	36	247	21	297	10
148	61	198	36	248	20	298	10
149	61	199	35	249	20	299	10
150	60	200	35	250	20	300	10

SPC = Sum of Pulse Counts

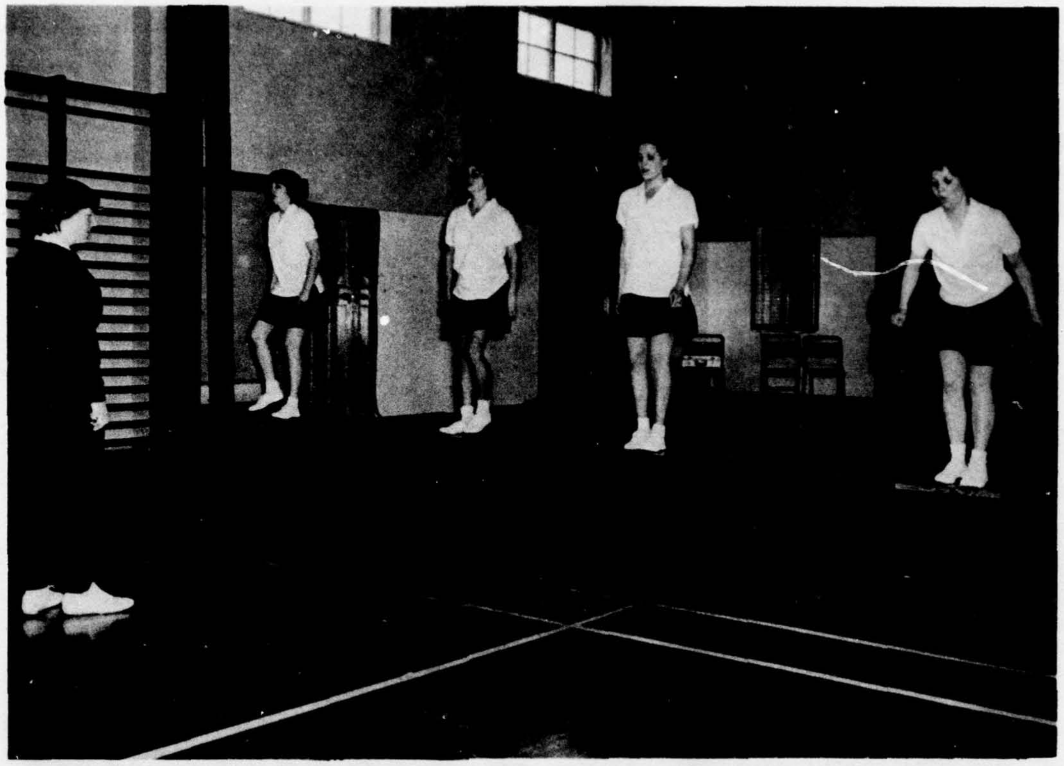
PFA = Physical Fitness Assessment Step Test Score

ANNEX B

Weight - for-height standards for women, cm and kg.

These figures are based on the Metropolitan Life Assurance Company recommendatiens, with correction to nude height and weight.

Height cm	Minimum desirable weight kg	Maximum desirable weight kg	Maximum permitted weight kg
146	43.0	47.5	57.0
148	44.0	49.0	59.0
150	45.0	50.5	60.5
152	46.0	51.5	62.0
154	47.0	53.0	63.5
156	48.5	54.5	65.5
158	49.5	56.0	67.0
160	50.5	57.0	68.5
162	52.0	58.5	70.5
164	53.5	60.0	71.5
166	54.5	61.0	73.5
168	56.0	62.5	75.5
170	57.5	64.0	76.5
172	59.0	65.5	78.5
174	60.5	67.0	80.5
176	62.0	68.5	82.0
178	63.5	70.0	84.0
180	65.5	71.5	86.0
182	67.0	73.0	87.5
184	69.0	74.5	89.5



Figs 7 and 8. The Step-Test

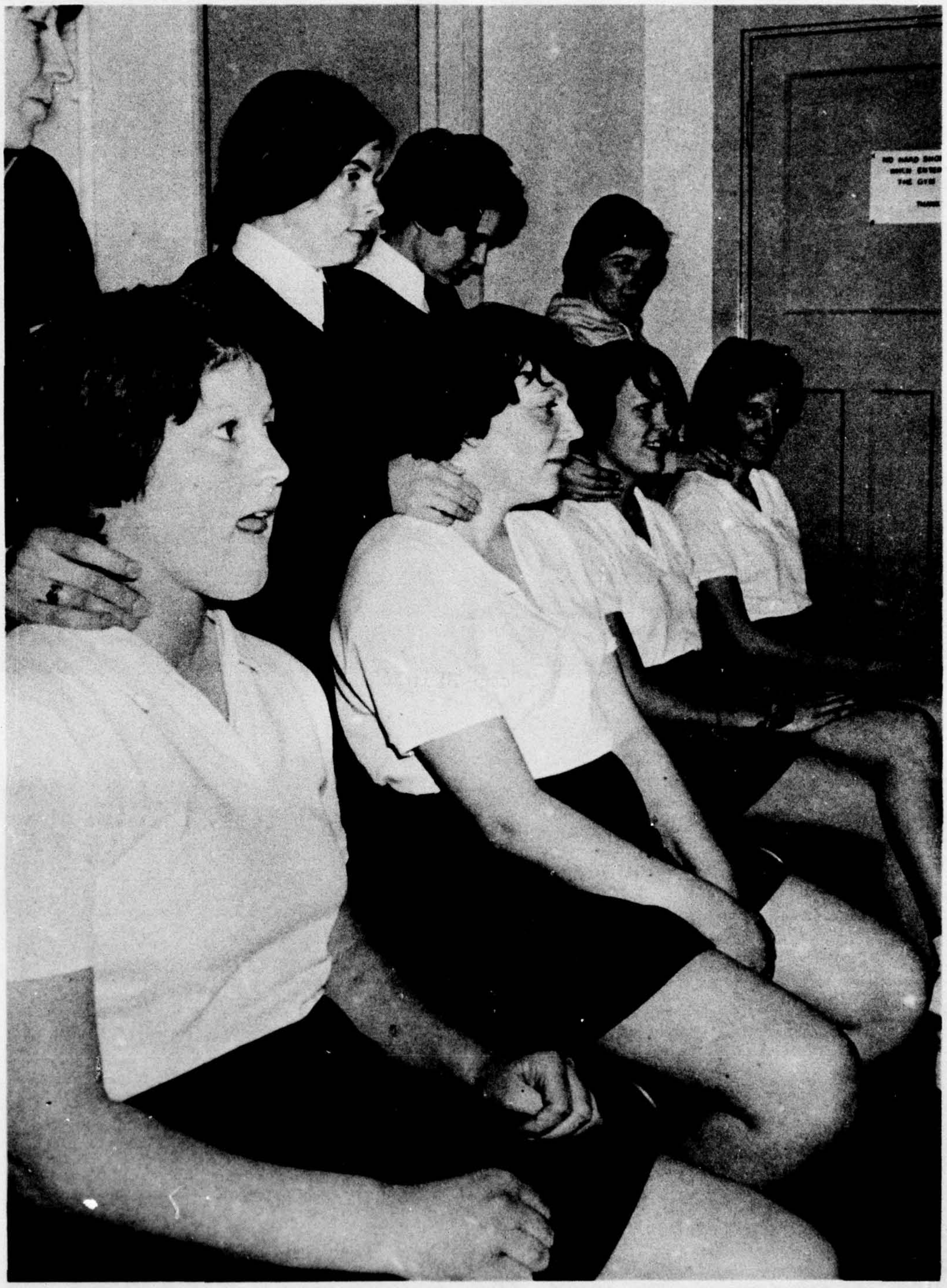


Fig 3. Pulse Counts

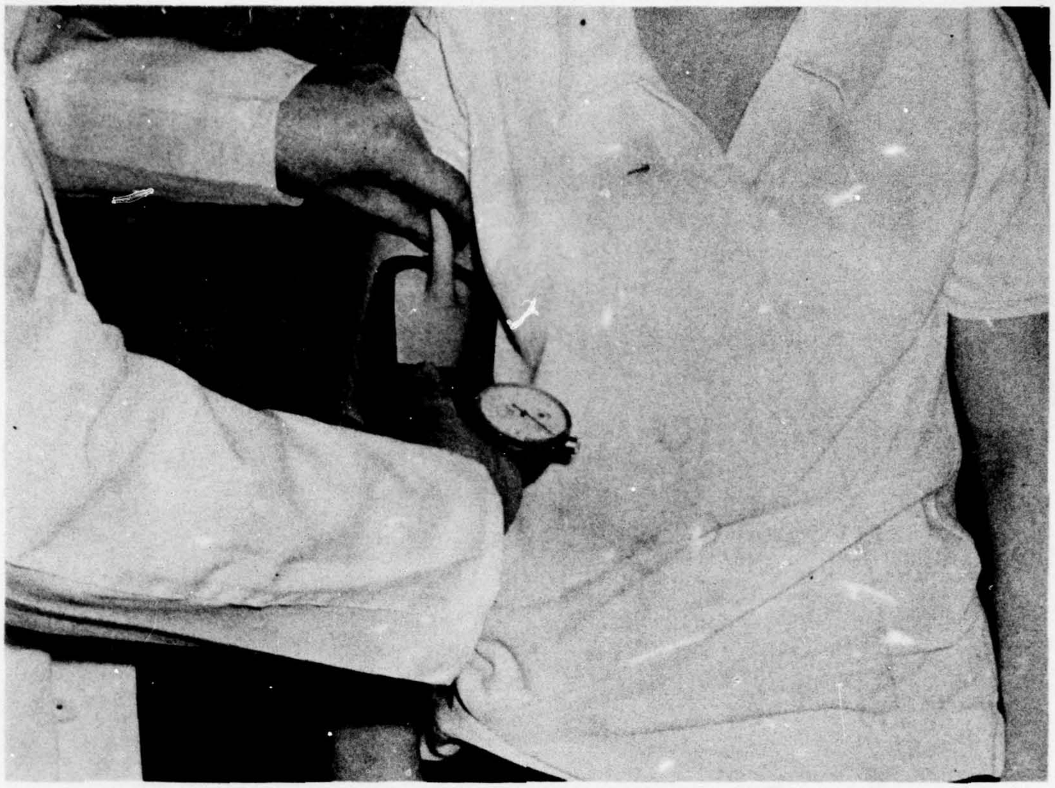


Fig 10. Bicep Skinfold

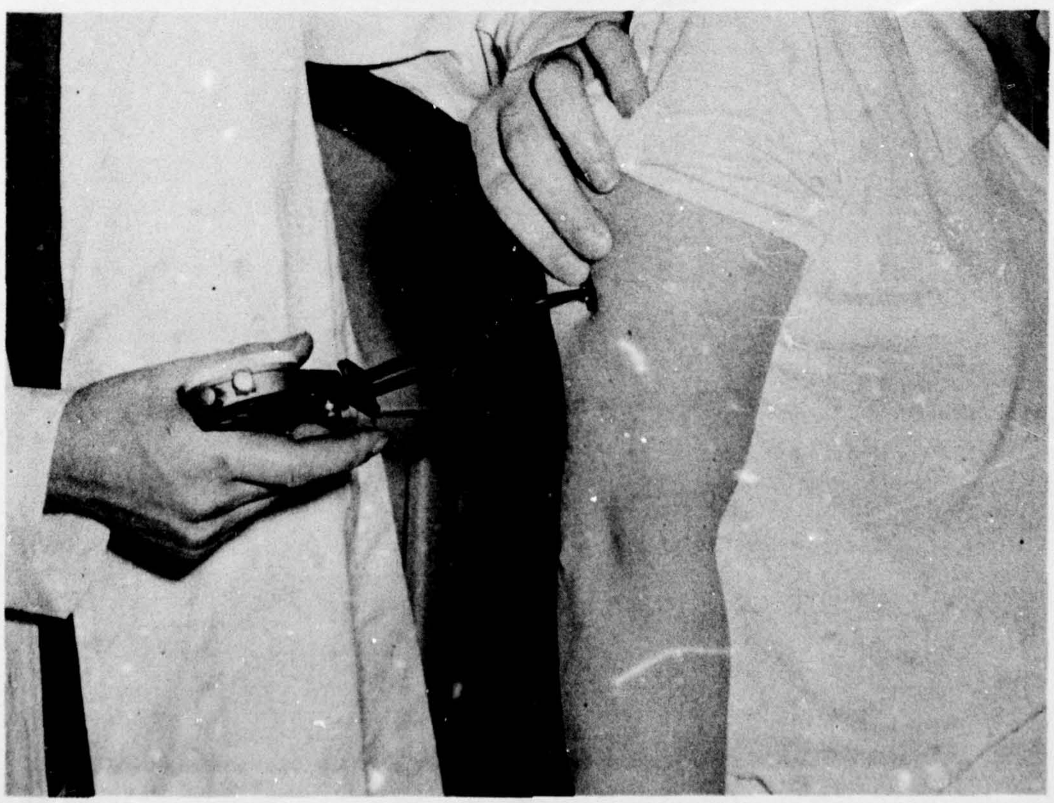


Fig 11. Tricep Skinfold

Fig 12. Suprailiac Skinfold

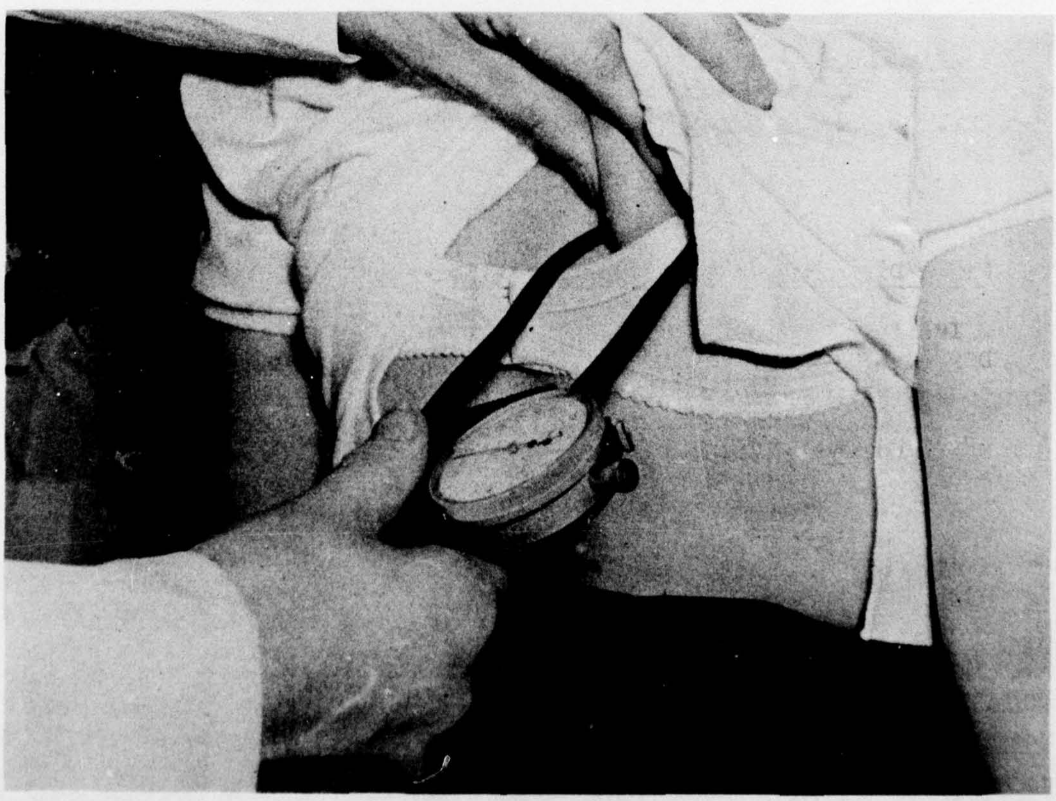


Fig 13. Subscapular Skinfold

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