

COMPARATIVE EVALUATION OF DIFFERENT TRAINING PROGRAMMES ON PHYSICAL FITNESS

M. S. MALHOTRA, J. SEN GUPTA AND N. T. JOSEPH

Defence Institute of Physiology and Allied Sciences, Delhi Cantt.

Summary: The Indian Army follows a physical training programme based mainly on isotonic exercises, while the US Air Force uses aerobics exercises and the Royal Canadian Air Force uses its own programme called 5BX-11, which is done only for 11 minutes a day. A comparative evaluation of these three programmes was made on 64 subjects by observing their improvements after 12 weeks of training and in laboratory tests. The physical training programme followed by the Indian Army was found to be the best of the three as it allowed maximum improvement in both the muscle strength and the endurance work capacity. The US programme only helped to increase the oxygen uptake capacity and did not much affect the muscle power. The 5BX-11 minute programme came in between the two.

Key words: physical fitness training programme comparative evaluation

It is well established that systematic physical training improves physical fitness. Various training methods like aerobics, isometric and isotonic exercises are being practiced for improving the work performance. The isometric exercises increase the static strength of the muscles without affecting the endurance significantly, (13, 8 & 6), whereas dynamic exercises primarily increase the endurance power without affecting the static strength (16, 4 & 5). As a result of various studies on training methods, it has been concluded that the improvement in performance is mainly tied to the function, which is being trained (12 & 7). The methods to be adopted for physical training are of special interest to the Armed Forces and therefore extensive studies are being made by various countries on this aspect. The training methods adopted by Indian Army, U.S. Air Force and Canadian Air Force are quite different. Attempts have therefore been made to evaluate the efficacy of some of the popular training methods with the existing physical training programme followed by the Indian Army.

MATERIALS AND METHODS

Sixty four young (20-30 years) clinically healthy and moderately active soldiers were selected for the study. All the subjects were given 1 mile running test to assess their initial state of fitness. On the basis of their performance in this test, subjects were divided into three homogeneous groups A, B and C. The mean physical characteristics and mean time in 1 mile running for the three groups are given in Table. I. Each group was put on a different training routine.

Group 'A' was imparted physical training as per 5BX-11 minutes a day plan for men (15). As the name suggests, in this plan five exercises are given daily for a total period of 11 minutes

day. Four exercises are meant to build up strength of various muscle groups and are done for 5 minutes, and the 5th exercise consisting of a stationary run, for increasing the aerobic capacity, is done for 6 minutes. The strenuousness and frequency of each exercise is increased with the progress of the training keeping the total duration of all the exercises to 11 minutes.

Group 'B' was administered the U.S. Air Force physical conditioning programme called Aerobics (1). This programme aims to improve the aerobic capacity of an individual, primarily by improving the cardio-respiratory efficiency i.e. oxygen transport mechanism. This consists of performing any one of the following exercises and games like walking, running, cycling, swimming, playing hockey, football, tennis, handball, basketball, squash, etc. depending upon the convenience and preference of the individual. Points are awarded for the speed in the exercise and the distance covered for the time spent in playing. The points allotted to each exercise are based on the strenuousness or energy consumption of the exercise and its duration. Number of points to be scored each week is increased progressively till optimum of 30 points per week are scored by increasing the speed or frequency of exercises. During these studies the subjects were made to walk or run for 30 minutes daily, at progressively increasing speeds, so as to get a score of 30 points a week.

Group 'C' was imparted the existing physical training programme as being followed by the Indian Army (9). All the exercises selected were done free hand requiring no equipment to keep parity with other two programmes. This programme aims to train both aerobic processes as well as development of various muscle groups by isotonic exercises. This training was also given for 30 minutes a day.

The entire training programmes was conducted by qualified P.T. Instructors from the Army School of Physical Training for six days a week for 12 weeks. For messing the subjects were attached to a common Army kitchen and received similar rations supplying 3800 Kcal/day during the entire training period.

Physiological assessment was made at the beginning and again after completion of 12 weeks of the training with the help of both the field performances and the laboratory tests.

Field Performance Tests:

These were given to assess the changes in agility, muscle strength of arms, shoulders, abdominal and trunk and speed in running. The details of the tests are given in our earlier paper (10).

- (a) *Agility* — was tested with the help of two tests
 - (i) Standing Broad Jump and
 - (ii) Jump and Reach
- (b) *Arm & Shoulder Muscle Strength* — was also measured by two tests
 - (i) Chin-ups and

(ii) Push-ups

(c) *Abdominal & Trunk muscle strength* — was assessed by Sit-ups and(d) *Running speed* — was measured by noting time for 1.6 km (1 mile) run.

The field tests were administered in the early morning hours between 06.00 and 07.00 hours to avoid the effects of heat and the laboratory tests were conducted during the day in an air conditioned room, as such, the changes noticed were accepted to be due to the effect of training.

Laboratory Tests:

These consisted of

- (a) Maximum oxygen uptake capacity (VO_2 max), which was determined by giving graded exercises on a bicycle ergometer according to the method of Malhotra *et al*, (11).
- (b) Maximum exercise ventilation (V_E max.) during maximal effort on the bicycle ergometer was recorded (and the values are expressed as L/BTPS/min).
- (c) Exercise heart rate (HR_{EX}) during last minute of each rate of submaximal work and during maximum effort (HR_{max}) were recorded with the help of ECG machine using MX leads.

RESULTS

The mean physical characteristics and mean timing in 1.6 km run (Table I) of the subjects selected for various training programmes show that the different groups were almost homogeneous. The mean age of the subjects was about 23 years, mean height varied between 167 and 170 cm and mean body weight between 57.8 and 59.3 kg.

TABLE I: Mean physical characteristics and mean time for running 1.6 km of the three training groups.

<i>N</i>	<i>Group</i>		<i>Age</i> (yrs.)	<i>Height</i> (cm)	<i>Weight</i> (kg)	<i>1 Km</i> <i>running time</i> (min.)
20	A Canadian	Mean	23.2	167.9	57.8	6.61
		S.D.	± 2.58	± 4.95	± 5.23	± 0.49
22	B U.S.	Mean	23.6	169.5	59.1	6.60
		S.D.	± 2.66	± 5.21	± 3.88	± 0.49
22	C India	Mean	22.8	169.7	57.2	6.52
		S.D.	± 2.17	± 7.19	± 5.49	± 0.41
64	Mean		23.2	169.1	58.0	

The improvement brought about in various field performance tests as a result of the three types of physical training programmes is compared in Table II. Of the two tests for

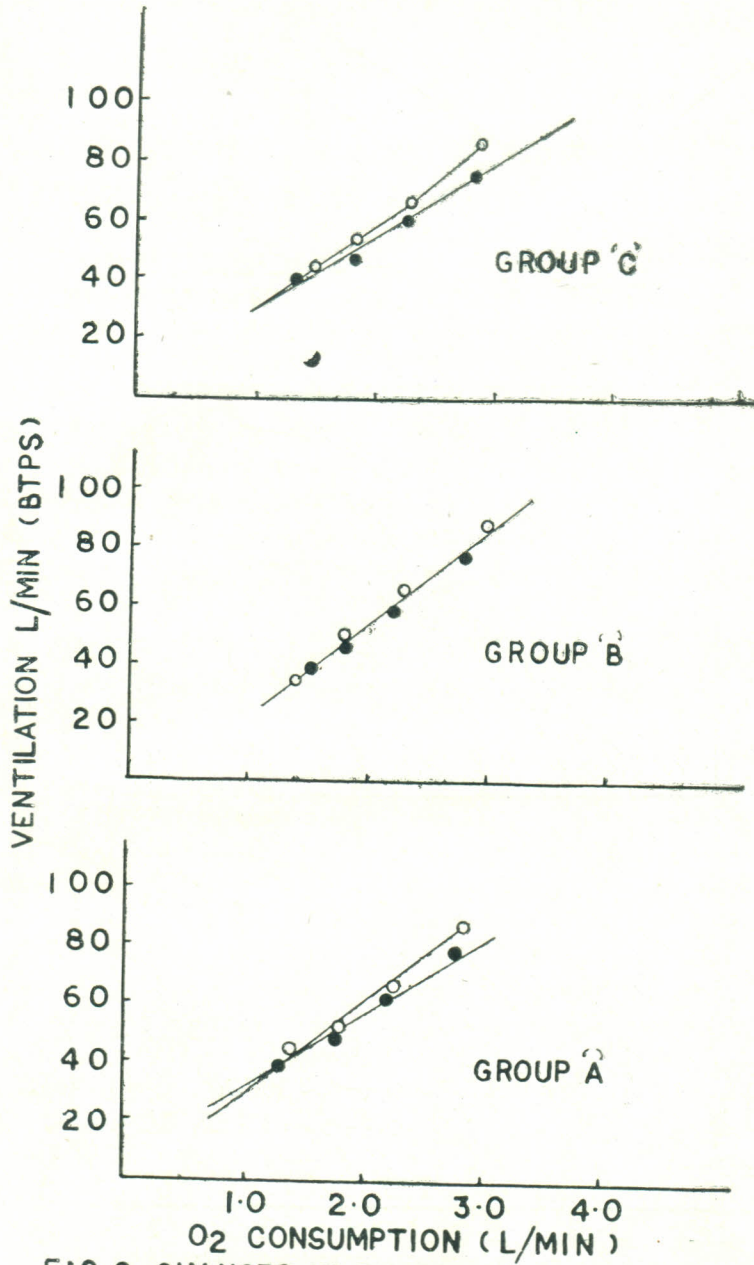


FIG. 2. CHANGES IN EXERCISE VENTILATION DUE TO DIFFERENT SYSTEM OF PHYSICAL TRAINING

● — ● = BEFORE TRAINING
○ — ○ = AFTER TRAINING

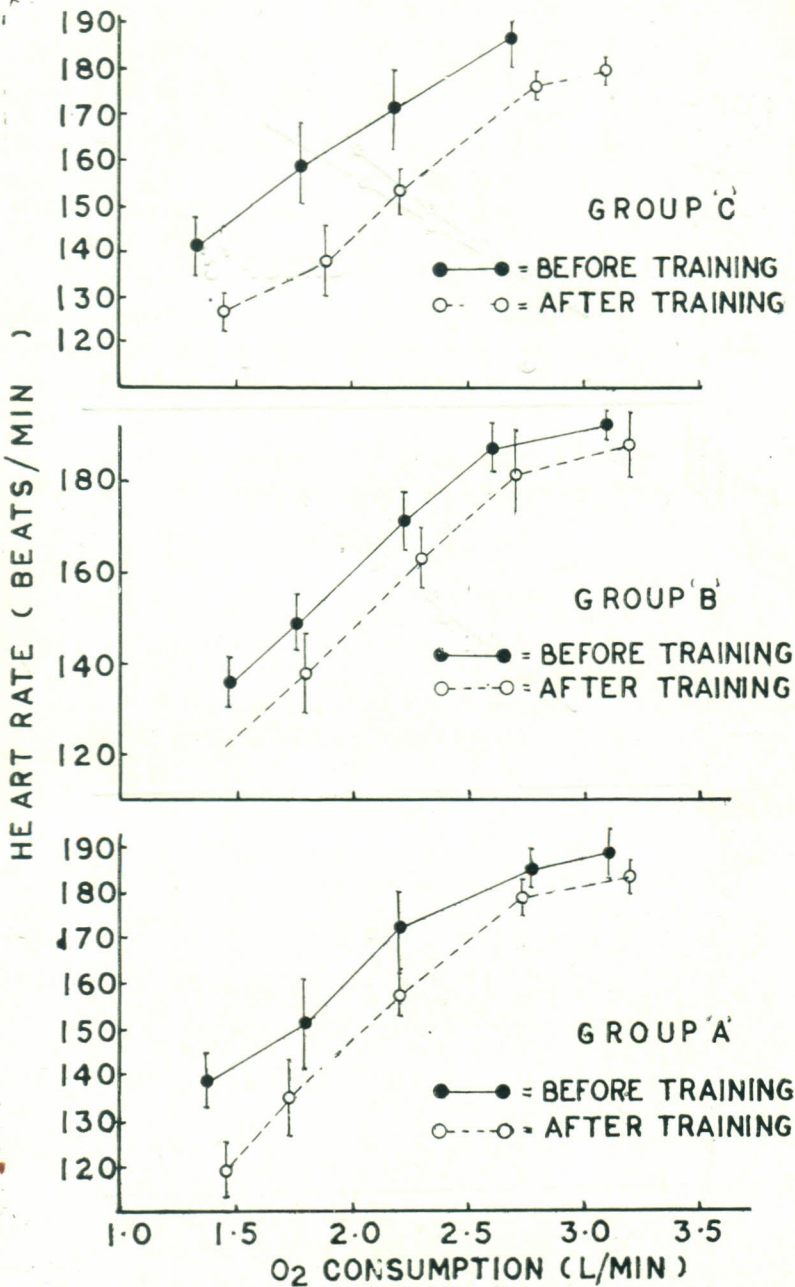


FIG. 1. CHANGES IN EXERCISE HEART RATE DUE TO DIFFERENT SYSTEM OF PHYSICAL TRAINING

measuring arm and shoulder strength, the mean improvement in A, B and C Groups in push-ups was 93.3, 60.4 and 82.4 per cent and in Chin-ups 53.9, 18.3 and 50.7 per cent respectively. In the abdominal muscle strength as evidenced from the scores in sit-ups the mean improvement was 77.64 and 142 per cent in Groups A, B and C respectively. In the two agility tests mean gain in the standing broad jump, was 12.3 and 9% and in jump and reach 18.13 and 22 per cent in the three groups. It is therefore evident that the improvement in "arm and shoulder muscle strength" was almost the same in both A and C groups and was significantly higher than in the 'B' group. In abdominal muscle strength however the highest improvement was recorded in 'C' group followed by 'A' and 'B'. In "Agility" test also A and C groups were comparable and were better than 'B' group. On the contrary, the improvement in the 1.6 km running test as expected was highest in group 'B' followed by Group C and A as the programme 'B' primarily consisted of running and walking.

TABLE II: Comparative evaluation of improvements in field tests due to three different training programmes.

Test	Rate of improvement		Training group 'A'	Training group 'B'	Training group 'C'
	Before	Trg.			
Standing broad jump (cm)	Before	Trg.	199.80	201.90	191.10
	After	Trg.	223.70**	207.60*	208.40**
	%	Diff.	11.96	2.82	9.05
Jump & Reach (cm)	Before	Trg.	39.80	38.30	36.60
	After	Trg.	46.80**	43.40**	44.70**
	%	Diff.	17.59	13.32	22.13
Push-ups (No.)	Before	Trg.	16.30	15.40	14.00
	After	Trg.	31.50**	24.70**	25.50**
	%	Diff.	93.25	60.39	82.14
Chin-ups (No.)	Before	Trg.	7.80	8.20	7.70
	After	Trg.	12.00**	9.70*	11.60**
	%	Diff.	53.85	18.29	50.65
Sit-ups (Nos.)	Before	Trg.	15.20	12.20	10.00
	After	Trg.	26.90**	20.00**	24.20**
	%	Diff.	76.98	63.93	142.00
Time in 1.6 km run (min)	Before	Trg.	6.61	6.60	6.52
	After	Trg.	6.25**	6.18**	6.17**
	%	Diff.	-5.45	-6.36	-5.37

* Significant at 5% level. ** Significant at 0.1% level.

A comparison of the physiological assessment in the laboratory tests of the three training programmes is shown in Table 3. The mean final VO₂ (max) values in A, B and C training groups were 47.9, 51.2, 52.2 ml/kg/min the improvement being 9.5, 13.5 and 13.1 per cent

respectively. The mean final values for V_E (max) were 88.1, 91.0 and 89.1 l/min, the percentage increase as a result of training being 6.2, 17.1 and 7.0 respectively. The higher increase in the 'B' group was possibly due to their low initial values. The maximum heart rate values (Hr max) for the three training groups were 183, 186 and 183 beats/min. In respect of reduction in heart rate and increase in V_E (max.), the three groups were almost comparable, though the VO_2 (max) values were higher in groups B and C than in Group 'A'.

TABLE III: Comparative physiological responses in maximum work in three training groups.

Functions	Group A			Group B			Group C		
	Initial	Final	Improvement %	Initial	Final	Improvement %	Initial	Final	Improvement %
VO_2 max. (l/min)	2.54	2.80	10.3	2.60	2.93	12.7	2.56	2.88	12.5
VO_2 max. (ml/kg/min)	43.80	47.90	9.4	45.10	51.20	13.5	46.10	52.20	13.2
V_E max. (LBTPS/min)	83.00	88.10	6.2	77.70	91.00	17.1	83.30	89.10	7.00
HR max. (beats/min)	188	183	2.7	190	186	2.1	195	183	6.2

DISCUSSION

The training programme 'A' comprised exercises to be done at the same spot like bending of trunk, push-ups, sit-ups and stationary running for 11 min daily. The group B had a continuous prolonged exercise of moderate severity like walking and running over long distances for 30 minutes and group C had free-hand exercise involving bending of trunk, flexing of arms and legs, running, climbing etc for 30 minutes. Therefore whereas the groups B and C exercised for 30 minutes a day, group A exercised for 11 minutes daily, for 6 days in a week. The improvement has been assessed with the help of field performance as well as laboratory tests. The field tests measured the affect on the muscle strength as well as the endurance capacity for strenuous work whereas the laboratory tests assessed the physiological functions concerned with the oxygen transport mechanism. In the field performance tests overall improvement brought about in different tests has been pooled and mean percentage improvement thus obtained works out to be 50.8, 31.7 and 61.2 per cent for the group A, B and C respectively showing thereby that the maximum improvement occurred in group C i.e. with the Indian training programme and next with the 5 BX-11 programme. As regards the laboratory tests the most objective criterion for assessment of the physical fitness is taken to be the maximum oxygen uptake capacity (VO_2 max). Quite a number of studies have been done by various workers to assess the effect of physical training in improving the maximum oxygen uptake capacity (14, 2, 18, 3, 4, 5 and

7) The improvement observed by various workers has been found to vary from 10 to 16% after 4 to 16 weeks of training. The 10 to 12% improvement in Vo_2 max observed in the present studies as a result of 12 weeks of training is therefore comparable with that found by other workers. The improvement in B and C groups is slightly more (12.7% and 12.4%) than in group A (10.3%). This is expected as the main function of aerobic exercises for Group B is to increase the oxygen uptake capacity whereas the Group C had both aerobic and static exercises. The improvement in Vo_2 max in both B and C groups is almost the same.

The other important physiological change due to training is in lowering of cardiac frequency for the same work load indicating increase in the stroke vol. Changes in the cardiac frequency as a result of the three training programmes are shown in Fig. 1. It will be seen that there is fall in the HR in all the three groups as has been found by other workers from the pretraining values. On comparison between the groups it is found that at O_2 consumption of 2.5 l/min the corresponding heart rate is 170, 172 and 159 per minute for groups A, B and C respectively. This shows that improvement with Indian training programme is better than the other two.

Ventilatory responses during submaximal exercises showed minor differences with training. The ventilatory co-efficient (ventilatory volume/ O_2 uptake) during submaximal and maximal exercises did not therefore change with training (Fig. 2). Mean ventilatory volume during maximal work was however increased by 6-17 per cent with different training methods and the increase was related to the changes in maximum O_2 uptake capacity (Table III). Both these findings are in complete agreement with the observations of Saltin *et al.* (16).

It can thus be concluded that the physical training programme currently being followed by the Indian Army is best of the three, as the improvement in the muscle strength, cardiovascular efficiency and aerobic capacity is the highest with this training. The US programme of Aerobics only helps to increase the O_2 uptake capacity and has not much effect on the muscle power. The 5 BX-11 minute programme of Canadian AF comes in between the two. The training in this programme has, however, been done only for 11 minutes a day as against for 30-minutes in Indian programme. If the 5BX plan is extended for a longer duration the improvement with this is likely to be as much as with the Indian programme.

ACKNOWLEDGEMENT

Authors are thankful to N. Srinivasulu, T. Sampathkumar and B. S. Arora for technical assistance and to G. P. Dimri and S. S. Verma for statistical analysis of the data.

REFERENCES

1. *Aerobics Physical Fitness Programme (Male)* U.S. Air Force, 1969.
2. Astrand P.O. *Experimental Studies of Physical Working Capacity in Relation to Sex and Age*. Munksgaard, Copenhagen, 1952.
3. Buskirk, E.R. & H.L. Taylor. Maximal Oxygen intake and its relation to body composition, with special reference to chronic physical activity and obesity. *J. Appl. Physiol*, **11** : 72-78, 1957.

4. Exblom, B., P.O. Astrand & B. Saltin. J. Stenberg & B. Wallstrom. Effects of training on circulatory response to exercise. *J. Appl. Physiol.* **24**, 518, 1968.
5. Ekblom, B. Effect of physical training on oxygen transport system in man. *Acta. Physiol. Scand. Suppl.* 328, 1969.
6. Hansen, J.W. The training effect of repeated isometric muscle contractions. *Intern. Z. Angew. Physiol.* **18** 474, 1961.
7. Hansen, J.W. Effect of dynamic training on the isometric endurance of the elbow flexors. *Intern. Z. Angew. Physiol.* **23**: 367, 1967.
8. Hettinger, Th. "Isometrisches Muskel Training" Georg Thieme Verlag. Stuttgart, 1968.
9. *Basic and Battle Physical Training Pamphlet No. 3* : Trained soldiers tables and physical proficiency and battle physical efficiency tests, 1967. Manager of Publications, Delhi.
10. Malhotra, M.S., S. S. Ramaswamy, G. L. Dua & J. Sen Gupta. Physical work capacity as influenced by age. *Ergonomics*, **9**: 305-316, 1966.
11. Malhotra, M.S., S. S. Ramaswamy, N.T. Joseph & J. Sen Gupta. Physiological assessment of Indian athletes. *Ind. J. Physiol. Pharmac.*, **16**: 55-62, 1972.
12. Petersen, F.B., H. Grandal, J.W. Hansen & H. Hvid. The effect of varying the number of muscle contractions on dynamics muscle training. *Intern. Z. Angew. Physiol.* **18**, 468, 1961.
13. Rasch, P.J. and L.E. Morehouse. Effect of static and dynamic exercise on muscular strength and hypertrophy. *J. Appl. Physiol.*, **11**: 29, 1957.
14. Robinson, S. & P.M. Harmon. The effects of training and of gelatin upon certain factors which limit muscular work. *Am. J. Physiol.*, **133**: 161, 1941.
15. Royal Canadian Air Force "Exercise plans for physical fitness". *This week Magazine*, Mount Vernon, N.Y. 1962.
16. Saltin, B., B. Bloomqvist, J. H. Mitchell, R. L. Johnson Jr., K. Wildenthal and C. B. Chapman. Response to submaximal and maximal exercise after bed rest and training. *Circulation*, **38**: (Suppl-7) 1968.
17. Sen Gupta, J., M. S. Malhotra, S. S. Ramawamy & G. L. Dua. Effect of training on the physical work capacity. Proceedings of the symposium "Human Adaptability to Environments and Physical Fitness" New Delhi, pp 120-129, 1966. Ed. MS. Malhotra.
18. Taylor, H. L., Z. Henschel. J. Brozek and A. Keys. The effect of bed rest on cardiovascular function and work performance. *J. Appl. Physiol.* , 223-239, 1949.