LOAD CARRIAGE, PHYSICAL EFFICIENCY AND VITAMIN E

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It is a well known fact that the fighting capacity of a soldier is inversely proportional to the load he carries, other factors like training, physical fitness and morale remaining unaffected. At the same time it is essential for a soldier to carry sufficient equipment and personal belongings wherever he goes in the fighting zone. Therefore within the limits of his physical efficiency he is expected to play the dual role of a porter as well as a fighting machine. The overloaded soldier can easily become exhausted and is unable to fight efficiently at the end of a march. Hence it is clear that a balance must be struck between the handicap of any load on physical efficiency and the weight of weapons, equipments, clothing etc., essentially required for battle order. Such a weight can be called as maximum economic load.

In 1923 Cathcart and his co-workers stated that the maximum economic load which a soldier could carry, with a relatively low consumption of oxygen on level march at sea level, was equal to approximately one-third of his body weight. Their recommendations put to subjective trials proved their merits at sea level. However, no reliable information is available regarding the maximum economic load which can be carried by the soldier at higher altitudes. The necessity arose when our troops had to face Chinese aggression at the heights of 13,000 feet and above. At that time it became obvious that the physical efficiency of a soldier altered with the altitudes and the recommendations which were made for sea-level load-carriage could not be applied at high altitudes. Thus it was necessary to determine the effect of altitude on the load-carriage efficiency of the soldier. With this view in mind, a comparative study of load-carriage by acclimatised soldiers at sea level, 13,000 and 16,500 feet above sea level was undertaken.

In this study the most economically carried load has been determined by the ordinary costing principles. On the debit side is the extra oxygen consumption required for a particular piece of "load-carrying work". On the credit side is the end product of this work. The extra oxygen consumption for the work is taken as the difference between the oxygen consumption during work and rest under the same dietary and environmental conditions. The load-carrying work is determined in kilogramme-metres, by multiplying the total weight of subject plus load carried in kilogrammes by the horizontal displacement in metres. The cost per horizontal kilogramme-metre is found by dividing the extra oxygen consumption in millilitres per minute by load work in kilogramme-metres per minute.

The experiments were conducted in a group of acclimatised soldiers. The studies were done at three altitudes viz. at Delhi which is almost at sea level, at 13,000 feet and at 16,500 feet above sea level. The average barometric pressures recorded at these altitudes were 736, 475 and 400 mm Hg. respectively. During the experiments the atmospheric temperature at the three varying altitudes varied between 29° to 33°C, 10° to 18°C and −2° to 4°C respectively.

The experiments were carried out about 3 hours after a comparatively light meal. First of all the resting respiratory minute volume and oxygen consumption were measured in each subject after resting him on a stretcher for 30 minutes. Thereafter each subject carried a certain load and marched a fixed distance of 1530 metres. The track was made for level walking with a circuit of 102 metres i.e. 15 circuits amounted to 1530 metres. Each subject marched at the rate of 120 paces a minute and the rate of marching was regulated by a drummer. The average speed of marching was calculated to be 90±2 metres per minute. Each subject was tested on any day while carrying at random one of the loads varying from 10 to 50% of his body weight. It was presumed that a steady level of oxygen consumption would have been reached during marching through the first 13 circuits. From the end of 13 to 15 rounds, the expired air was collected in Douglas bag while the subject was marching with different loads. The recovery pulse rate at the end of the march was counted. The expired air was measured by dry gas-meter and corrected to standard temperature and pressure (S.T.P.D.). Oxygen consumption was determined by Beckman oxygen analyser.

The resting ventilation and oxygen consumption per minute at the three different barometric pressures were :

Barometric Pressures	*Respiratory Minute Volume (STPD)*	*Oxygen Consumption Per Minute (STP)*
736 mm Hg.	5.4 litres (±0.19)	246 ml (±13.97)
475 mm Hg.	5.3 litres (±0.35)	252 ml (±12.3)
400 mm Hg.	6.86 litres (±0.41)	283 ml (±21.62)

The cost per horizontal kilogramme-metre, found by dividing the extra oxygen consumption in millilitres per minute by load work in kilogramme-metres per minute was as follows :—

Varying Loads Carried	*Barometric 736*	*Pressures 475*	*in mm Hg 400*
10% of Body Weight	0.12(±0.0012)	0.141(±0.0014)	—
15% ,, ,,	0.12(±0.0015)	—	0.132(±0.0104)
20% ,, ,,	0.117(±.0017)	0.135(±0.0018)	0.134(±0.0119)
25% ,, ,,	0.116(±.0017)	—	0.130(±0.0019)
30% ,, ,,	0.113(±.0018)	0.131(±0.0018)	0.157(±0.0101)
35% ,, ,,	0.111(±.0019)	—	0.165(±0.0138)
40% ,, ,,	0.109(±.0016)	0.143(±0.0021)	0.174(±0.0102)
45% ,, ,,	0.119(±.0026)	—	—
50% ,, ,,	0.126(±.0018)	0.163(±0.0029)	—
55% ,, ,,	0.128(±.0023)	—	—

It will be observed that the ratio increased markedly with loads more than 40% of body weight at sea level, 30% of body weight at 13,000 feet and 25% of body weight at 16,500 feet above sea level.

Other parameters like respiratory minute volume and recovery pulse rate increased linearly with the increase in load and thus did not give any indication of the maximum economic load to be carried at varying altitudes.

Thus under the conditions stated above the most economic load which could be carried by the soldier with an average speed of 90 metres per minute, was 40% of the body weight at sea level, 30% of body weight at 13,000 feet and 25% of body weight at 16,500 feet above sea level. This means that compared to sea level values, the load carrying efficiency decreases by 25% at the height of 13,000 feet and 37.5% at 16,500 feet above sea level. These figures compare well with those found by Pugh (1958) during his Himalayan Scientific Expedition.

Unlike the findings of Houston and Riley (1947) the Oxygen consumption for a given rate of work increased with the altitude. Their observations were made under simulated altitude conditions produced in a low pressure chamber, whereas in the present study, the observations were made under actual field conditions at 13,000 and 16,500 feet above sea level. The difference in results may thus be due to the drag while marching caused by heavy clothings worn at high altitudes and variations in meterological conditions e.g. temperature, humidity, wind velocity etc.

Having established that the load carrying efficiency decreased at high altitudes a search was undertaken to find out some drug which would increase the physical efficiency of the soldier. Out of the drugs tested so far, vitamin E gave some encouraging results (Medical Officer 1957). In a pilot project, the observations were made on 8 acclimatised soldiers at an altitude of 11,500 feet above sea level. They were tested before and after giving tablets containing 70 mgm vitamin E three times a day for 42 days.

The parameters of assessment for judging their performance were as follows:-

(a) The time for onset of fatigue as estimated by the finger ergograph.

(b) Scoring points with D.S.L. test as evolved by Mookerjee and Majumdar (1952).

(c) Oxygen cost for carrying load equal to 30% of body weight, on level march.

(d) Muscular efficiency as calculated by work done on bicycle ergometer and amount of oxygen consumed.

It was observed that vitamin E delayed the onset of fatigue as tested by hand ergograph. Also it reduced the oxygen requirement for a particular kind of work as tested by bicycle ergometer and load carriage experiments. D.S.L. test score also improved.

However, no conclusions could be drawn from this pilot project because firstly no control group was included in the experiments and secondly only one observation was made after a period of 42 days. Therefore two more projects have been undertaken to assess the value of vitamin E on muscular efficiency; one at sea level and the other at 11,500 feet above sea level. In these projects control groups have been included and the observations are made at regular intervals of 2 weeks. The sea level trials have been completed but the results are yet to be analysed. The high altitude trials are under progress. Only on conclusion of these experiments, it will be possible to say if vitamin E has got any role in increasing the muscular efficiency of the soldiers.

The possible role of vitamin E is to delay the onset of fatigue by improving the respiratory activity of the cell. It helps in checking the accumulation of linoleic acid and archidonic acid levels. The latter acids act as auto-oxidase and not only weaken the cell wall but also damage the mitochondria and microsomes. The microsomes have haemosiderin which oxidises tochopherol and converts it into its active form. Thus we have got a possibility before us that vitamin E acts at cellular level to improve its respiratory activity.

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