LOAD CARRIAGE BY THE SOLDIER

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A brief review on load carriage by infantry soldier in India, U. K. and U.S.A., in respect of the energy cost of carrying graded amounts of load and different types of load carrying equipments, has been presented. Four types of load carrying equipment, including the one in current use in the Indian Army, have been briefly described. The need for further improvement in the design of equipment has been discussed and the physiological principles which should guide the design, are indicated.

The principal factors deciding the condition of load carriage are physiological. From physiological and psychological points of view the optimum load any person may be required to carry would be zero load, but the load the soldier has to carry is dictated by tactical needs of an operation and the terrain and climate in which it has to be carried. Two things are essential for a success in war: firstly, the power to carry load and rapid march without loss of numbers and energy[1] and secondly, the infantry should reach their goal in the best possible condition for engaging in combat.

An army is normally recruited from healthy men of good physique and these men are subsequently kept fit and well fed. Although physiologically the human body is not capable of enduring a limitless strain, it is to be kept in mind that the infantry soldier has to transport a reasonable amount of equipment and personal belongings during operation, without affecting his operational efficiency. With new modes of warfare and various types of terrain, the weights of loads to be carried may increase and so it is to be ensured that after marching across a long route with such heavy loads he remains effective as a fighting unit[2], his marching power and endurance do not lessen by heavy weights or by defective modes of carrying the weight. Any load, large or small, undoubtedly increases fatigue and thereby reduces the efficiency and comfort of the soldier [3,4] Efforts should, therefore, be primarily directed to reduce the load to the permissible minimum.

The main aim of this paper is to discuss various types of web equipment taking into consideration physical, physiological and psychological factors.

PHYSIOLOGICAL PRINCIPLES

From the physiological point of view, there exists no optimum load as the energy expenditure goes on increasing proportionately with increasing load. Studies at Defence Science Laboratory, Delhi support this view [5]. But it is feasible that there may be a certain critical load, after which the energy expenditure is not proportional to the increasing load. It has been shown by Cathcart[1] that the maximum load carried by a soldier should not exceed 35% of his body weight, as a load greater than this involves disproportionately large expenditure of energy[1,3]. It is important to consider the limit of weight a foot soldier is expected to carry and at the same time remain efficient.

*2 sec, 153 GH, 121 Inf. Bde., c/o 56 APO.

It is felt that the best that can be done is to adjust the speed of march (with a given load in a terrain) with the best mode of carrying that will result in the efficient distribution of load on the body. Ramaswamy *et al*[6]. have shown that with a given load, optimum speed of march comes down with the increase of gradient. It is further reported by them that in the same gradient the optimum speed comes down with increase in load.

Parkes and the British committee of 1865-68 and Turl[7] laid down the following principles for the development of personal load carrying equipment in the British Army :

(1) The total burden (Physical load, clothing and environmental stress) should be minimal (about 45 lb.).

(2) Weight to be distributed over a wide area.

(3) Weight of the knapsack behind to be balanced by pouches in front.

(4) All loads to be as close to the body as possible and as near the centre of gravity as possible.

(5) Physical stress should be minimised by adaptation of the load to the capacity of muscle and bone structure.

(6) No compression of the armpit or chest.

(7) The load should result in minimal interference with essential physiological functions.

EXISTING PATTERNS OF LOAD CARRYING EQUIPMENTS

When the military requirements of fighting order came under considertion it was soon realised that the investigation will have to be extended to include not only fighting order but also clothing. The necessity for the design of marching order and equipment for porterage was also realised. Furthermore, unless clothing, fighting order, marching order and equipment for porterage are all developed together, some particular principle which has been developed in one may not be of utility when used in conjunction with another. The problem is made even more difficult at the moment by the state of flux which exists in the field of clothing and by the change which will probably take place in the type and design of weapons and mode of transport of men.

The fighting and marching load of the foot soldier in India is carried by means of the personal load carrying equipment (at present web equipment Pattern '37). Attempts have been made in other countries, specially in U.K., for redesigning (Pattern '37) with a view to improve the method of carriage in respect of weight distribution on body to ensure comfort and stability, simplify the design for easier manipulation, ensure physiological comforts like natural ventilation and freedom of movement of limbs, avoid skin friction and reduce the weight wherever possible. A brief description of each design is given below[2]:

Pattern '37—It is a form of brace system in which the load is carried high on the back mainly by the shoulders. It represents a lighter form of 1908 web equipment and is adaptable to suit the requirements of different Arms. A set of pattern '37 web equipment (including the haversack) weighs 4 lb. 7 oz.

Pattern '44—It is modified version of pattern '37 made from water-repellent lighter webbing, with some variation in the design of haversack, water-bottle, belt and braces for increasing the carrying capacity and comfort. A set (including haversack) weighs 4 lb. 6 oz.

Battle Jerkin—It is a streamlined jacket made of stiffened duck cotton, fitted with pockets for carrying personal load and ammunition. The weight is mainly supported on the hips. A set weighs 4 lb. 8 oz.

Z2 Equipment—It is a modified version of pattern '44 wherein the haversack and pack have been combined in one for increased capacity. A set weighs 6 lb. 8 oz.

CEFO Equipment—This design has been lately tried by the Director of Equipment Requirements, War Office, U.K. It combines the best features of current forms of personal load carrying equipment.

DISCUSSION

It is difficult to assess the merits of various methods of carrying load. The work of various investigators deals with metabolism experiments. The great majority of fitness tests, physiological or psychological, used for finding out the merits of particular equipment appear to be simple. However, the functions measured are subject to a great variety of influences and it is necessary to apply the most rigid control of environmental, physiological and psychological conditions under which a measurement is carried out. It cannot be sufficiently stressed that pre-test exercise, time relation to meals, psychological 'atmosphere' and environmental temperature and humidity must be kept as constant as possible[8]. Even though psychological factors are of importance in fitness tests, the performance of all psychomotor and maximal exertion tests depends on motivation[8]. Social and economic conditions play an important part in the performance of a soldier. The psychologist and Director of Personnel have much to contribute. The physiologist and physician can contribute by giving advice regarding a recreational programme by dealing with the hazards of monotonous life of soldier and by devoting attention to his health and nutrition. The physicians have, since the time of Hippocrates, known the importance of rest, diet and recreation in the treatment of disease. Work demands rest, good food and wholesome recreation which implies physical and mental fitness. Physical fitness is required for sustained effort and output.

The total weight of equipment is an important factor for the efficiency of a soldier, because his performance is inversely proportional to the load he carries. A British foot soldier is required to carry on his body a total load of 58½ lb. for the battle order and 78 lb. for the marching order against a total load of 52 lb. and 68 lb. respectively carried by the Indian foot soldier. The details of loads for the two countries are given in Appendices 1 and 2. The War Office of USA appears to be working on the recommendation of Continental Army Command that 45 lb. should be adopted as the optimum combat load for battle functions and 55 lb. for marching conditions. The load of 55 lb. for the marching order was divided as 20 lb. existence load, 25 lb. battle load and 10 lb. full field load. Details of these loads are shown in Appendix 3.

Pattern '37, now in use, has many undesirable features. From the military point of view, the side, front and prone silhouettes are unnecessarily large. The basic pouches suspended on the chest make crawling difficult and laying close to the ground impossible. From the physiological standpoint many faults in design are apparent. The weight of pouches and small pack is supported by the shoulder girdle which entails the continuous contraction of relatively weak muscles to keep the shoulders elevated. The result is early fatigue and discomfort. Occasionally this has been followed by a drop of clavicles with resultant compression of brachial plexus and/or subclavian artery which gives rise to numbness

and paralysis of arms[3]. The straps over the shoulders are narrow, giving rise to high pressure on the skin; this causes considerable discomfort because the clavicles are close to the surface with no cushion of fat or muscle intervening[3].

The stresses imposed by the four designs of load carrying equipment on the infantrymen when carrying full battle and marching loads have been examined and an analysis as to how they fulfilled the other military requirements, has also been made. It was found that Pattern '44, even after certain modifications, was inferior to Pattern '37 both in wearing quality and in general use. Z2 equipment was found to be more comfortable in battle order than either Patterns '37 or '44, but the belt of Z2 securing the clip has a tendency to dig into the hip bone. In the marching order, however, Pattern '37 was preferred, as the weights suspended were more evenly distributed in this design. Battle Jerkin, which is 2 lb. lighter in weight than Z2 equipment and carry more ammunition, was more suitable than other types for prolonged activities, like long route marches, but the main criticism against it was that it prevented the soldier to fight light because the haversack is not detachable and the design is too hot for tropical climates and for general use. Modified battle jerkins of different types made from woven nylon or other materials and known as skeleton jerkins were also tried and discarded as unsuitable. Lately the War Office in U.K. tried a new design of personal load carrying equipment, called the C.E.F.O. This has been preferred for marching and crawling, but the position of the water bottle has been reported as inconvenient. Both C.E.F.O. and Z2 equipments have shown some mechanical defects.

A light weight water repellant webbing material (having 20% less weight but equal in strength to Pattern '37) has been developed in India. Investigations are being made for the possibility of using light aluminium alloy in place of brass used for metal components. The tips at the ends of web straps have been hardened by chemical treatment to replace existing metal tips. Action is also being taken to prepare a modified design of Pattern '37 incorporating the final feature of other designs[2].

RECOMMENDATION

It is suggested that the small pack be designed so that it can be supported on the hips and be long, thin and narrow in shape and be balanced by the pouches to be carried at the front. It is further suggested that a comparison of various types of personal load carrying equipment, *i.e.*, 1937 Web, Modified Battle Jerkin, Berger Rucksack and experimental Z2 equipment be made as done at CEPRE by Reid. Renbourne and Drapper and other newly designed equipments should be studied in India under different environmental conditions. This should take the form of planned laboratory experiments handled by a team consisting of one experienced infantry officer, concerned with the design and construction of the equipment, and a team of physiologists and psychologists.

CONCLUSION

The production of an ideal set of load-carrying equipment universally suitable for the three Armed Services is yet to be made. The fatigue of the soldier is too subtle to yield to ordinary tests of physiologists. The test of psychologists do not provide the answer. Neither the physiologists nor the psychologists could explain the basis of chronic fatigue or of decrease and increase in illness associated with long hours of march.

The question of how best and how much the foot soldier should carry on his body under different environmental conditions and how the weight of his combat clothing and equipment can be reduced to a minimum in the interest of operational efficiency yet remains to be

solved. Perhaps a proper design of shoulder straps, say by having wider straps with proper pads, may distribute the pressure on the shoulder and breast muscles more evenly and thereby make this mode of load carriage somewhat more comfortable.

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REFERENCES

1. CATHEART, E.P., "On maximum load to be carried by the soldier" *J. Royal Army Med. Corps*, **61** (Sept 1923).
2. Tech. Dev. Est. (Lab.), Min. Def., Kanpur, "Equipment and clothing load on the foot soldier and possibilities of reduction in this load". Report No. IND.—4.
3. LIPPOLD, O.C.J. & TAYLOR, P.F.D., "Army Operational Res. Group Report No. 11/50"
4. Army Operational Res. Group Report No. 3/51.
5. RAMASWAMY, S.S. & SIVARAMAN, R., *Indian J. Physiol. & Allied Sci.*, 10 (1956), 49.
6. RAMASWAMY, S. S. *et al.*, Internat. Symp. 'High Altitude', Darjeeling (1962), 78.
7. TURL, L.H., & HUNTER J., Fourth Comm. Def. Conf. Clothing General Stores, U.K. (1953).
8. TAYLOR, L. S. & BROZEK, J., "Evaluation of fitness" (1944), 216.