

# RATES AND EFFECTS OF FOOT MARCHES

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## SYNOPSIS

**Two studies were carried out to determine the rates and effects of foot marches, one a controlled study using the steady state heart rate (SSHR) as a measure of response to anaerobic work done and fatigue, the other a field trial with troops. Both studies showed that the optimum rate of forced march is about 4 KPH. The physical effects of a prolonged forced march on soldiers were also evaluated.**

## INTRODUCTION

A successful footmarch is one in which troops arrive at their destination at the prescribed time and in a condition to carry out their tactical mission. These studies arose out of a desire to ascertain a rate of march which can be imposed on soldiers without undue physiological or physical strain as to affect their ability to execute a tactical mission.

Initially, a pilot study (Study A) was conducted to determine and compare the degrees of physiological fatigue experienced by 38 soldiers when moving at the rates of 4 KPH, 5 KPH and 6 KPH using the heart rate as an indicator of anaerobic work done.

At a later stage (Study B), 3 groups of foot soldiers marched at speeds varying from 3 KPH to 5 KPH, and the attrition resulting was evaluated.

## MATERIALS AND METHODS

### STUDY 'A'

The subjects for this study were 40 physically fit soldiers chosen randomly from a group at an advanced stage of military training. Those with any of the following were excluded from the study:

- a. Any form of Upper Respiratory tract infection during the two weeks prior to the tests.
- b. Any form of injuries to the lower limbs that had not fully recovered.
- c. Any important medical or surgical condition that would affect cardiovascular condition adversely.
- d. Any significant abnormalities in the 12-lead ECGs.

The subjects were called up to perform the tests at the Runme Shaw Sports Medicine & Research Centre. For 24 hours prior to the tests they were given light duties. On the morning of the day of the

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tests they were examined for any of the above-mentioned clinical conditions that would have excluded them from the test. They were given lunch between 1100 and 1200 hours. The tests commenced at least two hours later, between 1300 hours and 1400 hours. During the period between lunch and the tests, the subjects were not allowed to smoke or consume any alcoholic drinks or drugs that could affect the assessment of physical fitness.

The subjects were first put through the Astrand sub-maximal bicycle ergometry protocol to ascertain their maximum heart rates<sup>1,2,3</sup>. After having at least one hour of rest, each subject put on a standard weight pack of 17.2 Kg and the subjects were then taught to walk on the treadmill. When the subjects had adapted to the treadmill, they each marched on the machine at speeds of 4 KPH, 5 KPH and 6 KPH consecutively without any interval in between. The duration of each of the three speeds was 6 minutes or until such time when the subject's heart rate had reached a steady state, whichever was the later. The steady state heart rates (SSHR) at the three speeds of footmarch were recorded and was later expressed in percentages of the maximal heart rates.

**STUDY 'B'**

Three groups of soldiers each group numbering 120 were chosen to march over a distance of 30 Km during the hours of darkness. These three groups, viz Group 1, Group 2 and Group 3, were required to march initially at a rate of 4 KPH. The week after they attempted a rate of 5 KPH and one week later, a rate of 3 KPH. Those with any of

the clinical conditions mentioned earlier were excluded from the study. The load carried by each soldier varied from 37.2 Kg to 52.2 Kg depending on the weapons carried by the soldiers.

The footmarches were continuous, except for a 15 min rest during the first hour and 10 min per hour for the rest of the march. At each rest the soldiers drank water and ate biscuits and other rations supplied to them. At each rest, the timing of the groups was taken as that of the last man who came en-bloc with the rest of the group. Stragglers were considered to be dropouts. At the end of 30 Km, the soldiers were required to run up a slope to simulate an assault. For each casualty or straggler, the distance covered prior to dropping out and the reasons for dropping-out were recorded. For all casualties, immediate medical attention was provided by ambulances situated at various intervals during the march.

**RESULTS**

**STUDY 'A'**

In this study, two of the 40 subjects who passed the physical examination could not complete the tests. One soldier could not perform the Astrand bicycle test satisfactorily while the other developed significant ventricular extra-systoles while performing the test and was therefore not allowed to continue further. Thirty-eight subjects therefore completed the test.

The cumulative frequency of the SSHR at the various speeds in terms of the percentage of the maximal heart rates is shown below.

**TABLE I**

**CUMULATIVE FREQUENCIES OF SSHR FOR SPEEDS OF 4 KPH, 5 KPH, 6 KPH**

Class interval of SSHR as % of Maximum Heart Rate	Cumulative Frequency		
	4 KPH	5 KPH	6 KPH
40-	2	0	0
45-	11	3	0
50-	20	11	0
55-	30	22	3
60-	38	32	11
65-	38	38	20
70-	38	38	31
75-	38	38	36
80-	38	38	36
85-90	38	38	38
Total		38	
Number with more than 60% (Dropouts)	8		
% dropout	21.05%	42.11%	92.11%

The means and standard deviations for the SSHR (as percentage of maximum heart rate) were calculated for all the three speeds and they are as follows:

1. **At 4 KPH** Mean SSHR = 54.25% ± 6.03
2. **At 5 KPH** Mean SSHR = 58.72% ± 5.55
3. **At 6 KPH** Mean SSHR = 69.27% ± 7.51

Paired t-test done between the SSHR values for 4 KPH and 5 KPH and between the SSHR values for 5 KPH and 6 KPH showed that the differences were highly significant.

Paired t (between 4 KPH and 5 KPH) = 13.09 (p<0.001)  
 Paired t (between 5 KPH and 6 KPH) = 13.48 (p<0.001)

**STUDY 'B'**

In this study after the medical examination the numbers found to be fit for the marches were as follows:

Attempted Rate	Number fit			
	Gp 1	Gp 2	Gp 3	Total
4 KPH	116	110	118	344
5 KPH	82	109	94	285
3 KPH	80	112	100	292

Those who were declared not fit had one or more of the medical conditions listed earlier which rendered them unsuitable for the tests.

The actual rate of move by the three groups of soldiers is as follows:

Attempted Rate	Actual Rate of Move (KPH)		
	Gp 1	Gp 2	Gp 3
4 KPH	3.60	3.79	4.04
5 KPH	4.34	4.71	4.54
3 KPH	3.89	3.75	3.67

The actual rates of move differ from the attempted rates. The differences are due to conditions on the ground and the need for troops to keep together, which results in not very successful attempts to maintain the attempted rate of move. When the first march was attempted at 4 KPH only one group, viz Gp 3 was able to maintain the required rate. When the second march was attempted at 5 KPH, all efforts to keep to the attempted rate for the whole distance of 30 km were in vain. When the third march was attempted, at 3 KPH, the troops, in spite of all efforts to slow down, managed to move easily at rates closer to 4 KPH.

The dropout rate for all the three rates of footmarch are as follows:

Attempted Rate	Number of Dropouts	% Attrition
4 KPH	74	21.5%
5 KPH	48	16.8%
3 KPH	5	1.7%
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There is an apparent lesser attrition rate for the attempted rate of 5 KPH. However, it must be remembered that the actual rate of 5 KPH was not reached, and for that march a large number (viz 75) were found medically unfit, compared to only 16 being found unfit for the first march. Many of those found not fit for the second march, were those who were casualties during the first march. For the third march attempted at 3 KPH, 68 out of 360 were found to be medically unfit for the march.

Of the 127 dropouts for all the three marches, 78 were casualties and the remainder, viz 49 were stragglers.

The reasons for occurrence of casualties are as follows:

Cause	Number
Abdominal Cramps	14
Exhaustion	13
Painful feet	13
Giddiness/headache/vomiting	10
Skeletal muscular cramps	9
Blisters	6
Ankle sprains	4
Others	9
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Total	78 <hr/>

The other causes of casualties were fever, hysteria, trance state, mild Upper Respiratory tract infection and head injury after a fall.

**DISCUSSION**

The two studies were basically two different methods of evaluating the effects of footmarches and of ascertaining an optimal rate of footmarch.

For Study A, the evaluation of the soldiers' performance at the three speeds was based on three main assumptions:

- a. Firstly, that the strain of an hour's constant anaerobic work can be aptly reflected by the SSHR attained by the subject, and this SSHR could be established as early as the 6th minute of working at the particular rate<sup>4</sup>.
- b. Secondly, that if the SSHR at a particular work rate is not more than 60% of the individual's maximum heart rate, then it can be expected that there would be efficient anaerobic work balance for one hour<sup>5</sup>. This would mean that the individual should be able to perform his work efficiently and fatigue would be minimal at the end of one hour.
- c. Thirdly, the rest period of at least one hour between the Astrand ergometry test and the treadmill test is adequate<sup>1</sup>. Therefore, the performance at the treadmill would not be affected by the ergometry test. In addition, 6 minutes is a relatively short duration and there would not be sufficient accumulation of metabolites to influence the performance and therefore the 4 KPH, 5 KPH and 6 KPH tests were done one after another without interval in between<sup>6</sup>.

In this study, a 21.05% attrition rate was observed for a rate of 4 KPH (Table I). The rate of footmarch for sustained periods should not therefore exceed 4 KPH. The difference in attrition for higher rates of footmarch has been shown to be significant, and these higher rates of march should not therefore be carried out except under exceptional circumstances.

This study moreover had the following limitations:

- a. It was conducted in an airconditioned environment with a range of air-temperature from 23°C to 25°C and relative humidity from 78% to 80%.
- b. The conclusions reached were only applicable to one hour's footmarch. The effect of marching for more than one hour either continuously or with short periods of rest cannot be extrapolated with present findings.
- c. The study could not take the following factors, which influence the performance of the soldier in the field, into consideration:
  - (1) the terrain
  - (2) the load carried by the soldier
  - (3) subject factors e.g. morale of the soldiers, command and control, individual response to fatigue.

Study 'B', though impossible to be tightly controlled, had the following advantages:

- a. It was conducted in terrain similar to that usually used by soldiers on a footmarch.
- b. It was conducted in environmental conditions that closely resemble the soldiers working environment in Singapore, viz air-temperature from 27°C to 29°C and relative humidity from 92% to 100%.
- c. The soldiers carried the full weight that they would normally use. They were commanded by their own officers and marched in the same formation as they would for an operation. The subjective factors mentioned earlier were thus greatly minimised.

Both studies are, however, comparable as the soldiers involved in both studies were in a similar state of military training and physical fitness.

For Study B, the soldiers were carrying the loads of between 37.2 kg and 52.2 kg for the first time, and the initial heavy drop-out rate of 21.5% for the first march of 4 KPH was thus partly due to the relative inexperience of soldiers carrying these weights. An improved performance in subsequent footmarches can be partially attributed to the soldiers getting used to carrying heavy loads.

The lower attrition of 16.8% for an attempted rate of 5 KPH cannot be taken to mean that performance was improved. It must not be forgotten that there were 75 soldiers who did not participate in this second march — a non-participation rate of 20.83%. The net proportion of soldiers from the three groups participating in the operation would then amount to more than 35%, which is clearly not acceptable.

It is our impression that the experience gained by the soldiers stood them in good stead for the final march attempted at 3 KPH, so that in spite of efforts to keep close to a rate of 3 KPH, rates varying between 3.67 KPH and

3.89 KPH were achieved with an extremely low dropout rate of 1.7% and a non-participation rate of 18.89%.

Study B therefore shows that the optimum rate of footmarch is about 4 KPH, and this rate can be maintained with minimal dropouts.

Of the 78 casualties sustained during the footmarch, 14 had abdominal cramps. This condition is one manifestation of early exhaustion and can occur even among the physically fit. It usually occurs after much sweating. Adequate regular intake of water and salt may therefore be helpful. A number of cases of abdominal colic or gastritis were initially reported as abdominal cramps, but responded to proper treatment and were allowed to continue the march.

Exhaustion can be the result of excess sweating and also reflects a physical condition that needs improvement. Graduated training before forced marches will help to decrease the incidence of cases of exhaustion.

Painful feet and blisters may occur because of some bony deformity in the feet which should be unlikely as our soldiers had gone through adequate medical examinations prior to enlistment and even before the forced marches. Another common cause, especially among footsoldiers is slight non-fitting of boots or of boots laced too loosely, resulting in sliding friction between the feet and shoes and culminating in blisters and abrasions which cause the pain.

Giddiness, headache and vomiting usually occur because the soldiers may not be very well on the day of the march or have not adequately recovered from illness. These cases are not preventable and such soldiers need proper rest.

Skeletal muscular cramps usually occurred in the calf and thigh muscles. Their incidence may be minimised with adequate salt and water intake. However, their immediate and proper treatment will lead to the soldier being able to carry on with the march.

The number of casualties can therefore be minimised by proper water and salt intake, adequate care of the feet, and immediate and proper treatment of muscular cramps.

There were a total of 49 stragglers for all the three rates of march. The reasons given by them were painful feet with blisters, too heavy a load and inadequate rest. Closer interviewing suggested that the main problem was one of inadequate motivation and low morale. Fortunately, the incidence of stragglers was low (4.54%).

## CONCLUSION

Regular training will improve the performance of troops in footmarches. Even then, the rate of footmarch should not exceed 4 KPH if we are to be sure that they are fit to tackle any mission at the end of the footmarch. Steady-state heart rates are an adequate measure of the fitness of persons to perform strenuous activities—such as prolonged footmarches. The effects of such footmarches can be minimised, and simple measures to combat some of these effects will have to be carefully studied.

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