# EFFECT OF VITAMIN *E* ON MUSCULAR EFFICIENCY

S. S. Srivastava, N. C. Dasgupta, K. R. Viswanathan, K. K. Sule,

K. Sain, C. M. Soni* & J. Bhati

Defence Laboratory, Jodhpur

(*Received* 7 *Feb.* 67; *Revised* 15 *Feb.* 68)

**On the basis of certain physical efficiency tests, twenty-eight healthy, clinically normal jawans in the age group of 20-25 years were divided into two equal groups, one relatively stronger than the other. Seven from each group served as test subjects while the others served as control. 210 mg of vitamin *E*, in the form of Rovigon tablets, were daily administered to each test subject for sixty days and various physiological and psychological tests were carried out periodically. From the results it was concluded that vitamin *E* had no significant role in improving muscular efficiency.**

Investigations into the methods of increasing the physical efficiency of troops, or that of acquiring a non-toxic non-habit forming substance for delaying the onset of fatigue and thereby increasing their endurance have been vigorously pursued, though not with apparent success by physiologists in various Defence laboratories. A number of anti-fatigue drugs are also available in the market, including substances such as vitamin *E* or vitamin *E* concentrates like wheat germ oil which have been claimed to improve physiological as well as psychological fatigue, stress, *etc*.

A critical survey of the literature, however, fails to indicate any conclusive data in favour of the value of any of the materials, and particularly vitamin *E* as ergogenic aid for men trying to improve their physical fitness. The first published reports of work on the effect of vitamin *E* came from Cureton and his co-workers[1-4] who produced evidence that subjects taking the wheat germ oil supplement made greater gains in a number of physical fitness measurements than subjects taking vitamin *E* or exercise alone. However, studies made on atheletic teams failed to produce any conclusive data in favour of wheat germ oil. Percival[5] has also reported the beneficial effects of vitamin *E* therapy, observing a decrease in the recovery pulses of men after completing an exhausting step test and after a 440-yard run. Ershoff & Levin[6] working with guineapigs, also confirmed the value of wheat germ oil in prolonging the time it took guineapigs to swim to exhaustion. The beneficial effect, however, could not be demonstrated with rats. Most recently, Consolazio *et al*[7] working with rats failed to establish that the administration of wheat germ oil or vitamin *E* improves performance as measured by swim time to exhaustion.

Specific role of vitamin *E* in metabolism has not yet been elucidated completely. However, there is evidence that it functions as a co-factor in the electron transfer system operating between cytochromes band *C*[8], reduces oxygen requirement of tissues and thereby enabling experimental animals to survive hypoxia. It has also been claimed that animals fed on vitamin *E* rations survived better exposure to a high oxygen tension (98 per cent oxygen at 5 atmospheric pressure) than the unsupplemented group.

*Biochemist, Govt. Ayurvedic Institute, Jaipur.

Although most of the data available demonstrate favourable effect of vitamin *E* concentrates in increasing physical performance, the failure of wheat germ oil to produce significant favourable results with athletic teams in competition or with rats in swimming tests created some doubt as to its usefulness. The present study was therefore undertaken to clarify further the role of vitamin *E* in increasing muscular efficiency in normal human subjects.

## METHODS AND MATERIALS

Fourteen strong and fourteen relatively weak subjects drawn from the Indian Armed Forces whose physical measurements are given in Table 1, were selected for the trial on the basis of physical efficiency tests (vital capacity and Harvard step test). All subjects were clinically normal. Seven subjects of each group were used as test subjects and the other seven served as control. The whole trial was carried out in four series. In series I, only the basal readings, consisting of determination of pulmonary ventilation, pulse count, steadiness test and blood lactic acid of both the groups were recorded before the administration of vitamin *E*. For the administration of vitamin *E*, Rovigon tablets (each tablet contains vitamin *A* 30,000 i.u. and tocopherol acetate 70 mg) were given. In series II, III and IV the same tests were repeated after administration of Rovigon tablets (3 tablets a day) to the test subjects in such a way that each subject reported daily for the test on 19th, 40th and 61st days along with the corresponding control subjects. Nude body weights of the subjects were also recorded on each day of the test. Although Rovigon tablets contain vitamins *A* and *E* for all practical purposes so far as muscular efficiency is concerned, it is taken for granted that the effects of vitamin *E* are only being observed. This is because deficiency of vitamin *E* is known to produce muscular dystrophy in animals, but deficiency of vitamin *A* is not known to produce any muscular dystrophy.

### *Energy metabolic studies*

The expired air was collected for 10 minutes and readings for pulmonary ventilation were recorded while the soldier was standing at rest on the treadmill. During these 10 minutes, pulse count and steadiness test were performed. At the end of 10 minutes the subject was given the exercise of marching for 30 minutes at a speed of 3 mph on the treadmill set at 15% gradient. Expired air was collected and pulmonary ventilation was recorded for 2 minutes, *i.e.* from 14th to 16th minutes and from 28th to 30th minutes. During

TABLE 1

MEAN VALUES OF PHYSICAL MEASUREMENTS

| | Strong group | | Relatively week group | | Range |
|---|---|---|---|---|---|
| | Control | Test | Control | Test | |
| Age (Years) | 23 | 24 | 23 | 23 | 20—26 |
| Height | 5′ 9″ | 5′ 10″ | 5′ 7″ | 5′ 8″ | 5′ 6″ to 5′ 11″ |
| Weight (Kg) | 63·7 | 63·6 | 60·6 | 59·0 | 58·5 to 64·2 |

marching period the total pulmonary ventilation was also recorded. After the cessation of the exercise, the expired air was collected from 0 to 10 min. for finding out the oxygen debt. Volume of expired air was measured by Kofranyi-Michaelis apparatus and the sample was analysed in Haldane gas analyser for oxygen and carbon dioxide. The volume of oxygen consumed, respiratory quotient and the oxygen debt were also calculated.

*Lactic acid determination*

A sample of venous blood was collected prior to the exercise and after the cessation of the exercise between 1–1½ min. for determining lactic acid by the method of Barker and Summerson[9], using Bausch and Lomb spectronic 20 photoelectric calorimeter.

*Pulse recovery*

The recovery pulse was counted at intervals, from, ½–1 min. 2–2½ min. and 4–4½ min. after cessation of treadmill exercise while the subject was standing at rest on the treadmill.

*Steadiness test*

This psychological test which measures the steadiness of the hand, was performed by the method of Stevens[10] using the steadiness tester. This test was administered for 15 seconds, before the exercise when the subject stood at rest on the treadmill, and then immediately after the exercise between 5th and 20th seconds.

*Environmental data*

Mean values of Dry and Wet bulb temperatures (in centigrade) in series I, II, III and IV are as follows: D.B.–34·3, 34·5, 32·9 and 32·2 and W.B.—24·4, 24·5, 26·3 and 26·2 respectively.

## RESULTS AND DISCUSSION

Results of pulmonary ventilation, oxygen consumption, respiratory quotient and oxygen debt are given in Table 2 (a, b, c and d). Pulmonary ventilation during marching in the control as well as test subjects of both strong and the relatively weak groups practically remained the same in series II, III and IV. The same trend is also observed in the case of oxygen consumption during marching. Increase in ventilation is proportional to the increase in oxygen consumption[11]. Oxygen consumption for a given task is less in a person where muscular efficiency is more as compared to another subject who consumes more oxygen for the same task. As there is no fall in oxygen consumption in series II, III and IV, there is no improvement in the muscular efficiency in performing work.

During exercises the respiratory quotient increases because of hyperventilation and blowing off of carbon dioxide while contracting an oxygen debt. In the present series of experiments the above findings are confirmed in all the series.

When aerobic resynthesis of energy stores cannot keep pace with the utilisation in skeletal muscles, energy needs are met for short periods by anaerobic glycolysis and oxygen debt is incurred. The oxygen debt mechanism makes possible even in greater muscular exertion than would be possible in its absence. In our present series of experiments oxygen debt was studied by two methods : (*a*) by determining the oxygen consumption during recovery period and (*b*) by determining the lactic acid content of the venous blood by calorimetric method. Lactic acid was determined in series II, III, and IV. Results are shown in Table 3. Normally, if the oxygen debt or lactic acid of venous blood for given task is dec-

TABLE 2

EFFECT OF VITAMIN 'E' ON VARIOUS PHYSIOLOGICAL FACTORS

(a) *Mean pulmonury ventilation (L/Kg*/hr)*

| | Series I | | | Series II | | | Series III | | | Series IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec |
| Strong Group (Control) | .. | 40·1 | 12·2 | .. | 39·8 | 11·5 | .. | 37·9 | 12·5 | .. | 37·2 | 12·[illegible] |
| (Test) | .. | 45·5 | 13·4 | .. | 41·6 | 13·8 | .. | 41·6 | 12·8 | .. | 41·6 | 13·2 |
| Relatively Weak Group (Control) | .. | 43·2 | 12·7 | .. | 45·9 | 13·7 | .. | 37·4 | 12·8 | .. | 43·0 | 14·5 |
| (Test) | .. | 46·5 | 14·7 | .. | 44·1 | 14·1 | .. | 44·6 | 13·8 | .. | 45·6 | 14·5 |

(b) *Mean oxygen consumption (L/Kg*/hr)*

| | Series I | | | Series II | | | Series III | | | Series IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec |
| Strong Group (Control) | .. | 1·87 | .. | .. | 1·89 | .. | .. | 1·85 | .. | .. | 1·72 | .. |
| (Test) | .. | 1·92 | .. | .. | 1·85 | .. | .. | 1·90 | .. | .. | 1·94 | .. |
| Relatively Weak Group (Control) | .. | 1·95 | .. | .. | 1·98 | .. | .. | 2·06 | .. | .. | 1·96 | .. |
| (Test) | .. | 2·02 | .. | .. | 2·03 | .. | .. | 2·01 | .. | .. | 1·97 | .. |

(c) *Respiratory quotient (R.Q.) (mean values)*

| | Series I | | | Series II | | | Series III | | | Series IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec |
| Strong Group (Control) | ·92 | ·94 | ·99 | ·81 | ·91 | ·92 | ·77 | ·89 | ·86 | ·86 | ·86 | ·89 |
| (Test) | ·85 | ·98 | ·96 | ·81 | ·94 | ·94 | ·74 | ·87 | ·81 | ·81 | ·88 | ·90 |
| Relatively Weak Group (Control) | ·81 | ·91 | ·91 | ·80 | ·89 | ·90 | ·84 | ·86 | ·88 | ·88 | ·91 | ·92 |
| (Test) | ·92 | ·94 | ·92 | ·84 | ·87 | ·86 | ·81 | ·85 | ·77 | ·77 | ·96 | ·92 |

(d) *Effect of vitamin 'E' on oxygen debt (in litres) (Mean values)*

| | Series I | | | Series II | | | Series III | | | Series IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec | Res | Mar | Rec |
| Strong Group (Control) | .. | 2·03 | .. | .. | 1·11 | .. | .. | 2·30 | .. | .. | 1·57 | .. |
| (Test) | .. | 1·80 | .. | .. | 1·80 | .. | .. | 2·93 | .. | .. | 2·07 | .. |
| Relatively Weak Group (Control) | .. | 1·58 | .. | .. | 1·96 | .. | .. | 2·05 | .. | .. | 2·27 | .. |
| (Test) | .. | 2·13 | .. | .. | 2·09 | .. | .. | 2·04 | .. | .. | 2·29 | .. |

Res=Resting; Mar=Marching; Rec=Recovery.

*Total body weight inclusive of boots and clothing in kilograms.

TABLE 3

INCREASE IN BLOOD LACTIC ACID (MEAN VALUES IN MG/100 ML).

| | Series I | Series II | Series III | Series IV |
|---|---|---|---|---|
| Strong Group (Control) | .. | 7·47 | 15·41 | 7·22 |
| (Test) | .. | 5·50 | 11·06 | 10·78 |
| Relatively Weak Gp. (Control) | .. | 11·84 | 13·48 | 18·27 |
| (Test) | .. | 12·82 | 7·80 | 16·40 |

reased after administration of vitamin *E* or any other material, then it could be concluded that muscular efficiency is increased by the particular drug. In series II, III and IV there is no decrease of oxygen debt or lactic acid of venous blood in the test subjects as compared to controls. Hence, it seems that there is no increase of muscular efficiency as a result of the intake of vitamin *E*.

Mean values of resting pulse and recovery pulse from 0-½ min. are given in Table 4. Recovery pulse from 0-½ min. at the end of the exercise was obtained by the extrapolation of the three half-minute counts of pulse during ½-1 min., 2-2½ min. and 4-4½ min. The percentage difference between recovery and resting pulse are also given in Table 4. In series II there is practically no change in the pulse recovery of the test subjects belonging to strong group. But in series III and IV there is a trend towards a fall. It is interesting to note that the percentage difference between the recovery and resting pulse of test subjects belonging to relatively weak group remain the same throughout the four series, whereas the control subjects show slight variation in the values. Normally, recovery pulse represents the degree of stress of work on the body. A low value of the pulse during recovery indicates a less strain and a high value indicates more strain. Similarly, during recovery period if the pulse returns to normal quickly, it may be considered that the person is physically more efficient. In the present trial since there is no appreciable difference in the recovery pulse of the control as well as the test subjects in both strong and relatively weak groups, it may be concluded that the administraton of vitamin *E* has not produced any improvement in muscular efficiency.

Results of steadiness test from series I to IV are shown in Table 5. Examination of the individual scores shows a large degree of variation. Comparison of the mean values of the control as well as test subjects (strong and relatively weak groups) of series I, II, III and IV shows that after the administration of vitamin *E* for 19,40 and 60 days there is no decrease in mean errors before and after the exercise, rather there is an increase in mean error. The same result applies to the comparison of the mean errors of 14 subjects of the control and test subjects. Also, the mean errors of difference before and after exercise in series I, II, III and IV of the control and test subjects shows no decrease in values, rather there is an increase in errors. It indicates that vitamin *E* is not effective in series I, II, III and IV, so far as it relates to the increase of muscular efficiency in terms of the steadiness test.

TABLE 4

EFFECT OF VITAMIN *E* ON PULSE

Mean values of resting pules and recovery pulse at 0—½ min obtained byExtrapolation

| | Series I | | | Series II | | | Series III | | | Series IV | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Resting pulse 1 min. | Recovery pulse extrapolated to 0—½ min. | Percentage difference between resting & recovery pulses | Resting pulse 1 min. | Recovery pulse extrapolated to 0—½ min. | Percentage difference between resting & recovery pulses | Resting pulse 1 min. | Recovery pulse extrapolated to 0—½ min. | Percentage difference between resting & recovery pulses | Resting pulse 1 min. | Recovery pulse extrapolated to 0—½ min. | Percentage difference between resting & recovery pulses |
| Strong Group (Control) | 75 | 71 | 45·2 | 73 | 68 | 42·1 | 73 | 68 | 43 | 72 | 69 | 46·7 |
| (Test) | 84 | 77 | 41·1 | 72 | 65 | 39·9 | 82 | 70 | 36 | 78 | 70 | 38·7 |
| Relatively Weak (Control) | 80 | 75 | 43·3 | 79 | 78 | 46·7 | 79 | 73 | 42·2 | 74 | 71 | 46·2 |
| (Test) | 83 | 74 | 39·7 | 85 | 76 | 39·4 | 82 | 74 | 39·3 | 89 | 79 | 39·1 |

TABLE 5

EFFECT OF VITAMIN *E* ON STEADINESS

(*a*) *Mean errors of the cont'ol and Test subjects of the stroug and relatively weak groups before and after exercise.*

| | Series I | | Series II | | Series III | | Series IV | |
|---|---|---|---|---|---|---|---|---|
| | Before exercise | After exercise | Before exercise | After exercise | Before exercise | After exercise | Before exercise | After exercise |
| Strong Group (Control) | 32·57 | 56·28 | 25·14 | 51·58 | 22·66 | 45·40 | 28·00 | 52·85 |
| (Test) | 21·42 | 56·00 | 22·85 | 50·57 | 16·25 | 42·85 | 26·33 | 47·40 |
| Relatively Weak Group (Control) | 29·14 | 58·35 | 28·66 | 63·83 | 28·14 | 57·77 | 24·66 | 57·50 |
| (Test) | 21·42 | 48·85 | 33·57 | 59·66 | 26·42 | 50·00 | 21·33 | 44·16 |
| Both Groups Combined (Control) | 30·85 | 57·57 | 26·90 | 57·70 | 25·40 | 51·53 | 26·33 | 55·18 |
| (Test) | 21·42 | 49·42 | 28·21 | 55·11 | 21·33 | 46·42 | 24·08 | 45·78 |

(*b*) **Mean Errors of difference between the pre-and post-exercise period of the control and test subjects of strong and relatively weak groups.**

| | Series I | Series II | Series III | Series IV |
|---|---|---|---|---|
| Strong Group (Control) | 23·71 | 26·42 | 26·42 | 24·85 |
| (Test) | 22·71 | 29·14 | 29·14 | 19·20 |
| Relatively Weak Groups (Control) | 29·71 | 30·14 | 29·57 | 32·83 |
| (Test) | 26·60 | 30·00 | 23·57 | 17·60 |
| Both Groups Combined (Control) | 26·71 | 28·28 | 27·99 | 28·84 |
| (Test) | 24·35 | 29·56 | 26·35 | 18·40 |

The results of physiological and psychological tests thus obtained, confirm the results of the studies by Ershoff & Levin, and Consolazio *et al*, where performance of experimental animals receiving vitamin E has not been found to be significantly different from that of the controls. Our findings are, however, contrary to some of the data reported originally by Cureton and his co-workers[1-4] and by Percival[5] where increases in endurance and performance in humans have been observed after administration of vitamin *E* concentrates, particularly wheat germ oil.

## CONCLUSION

In the present series of trials it may be concluded that vitamin *E* has no effect in the improvement of muscular efficiency.

## ACKNOWLEDGEMENTS

The authors are indebted to Dr. H. Nath, Director of Research (Labs), R & D Organisation for his valuable guidance. Thanks are also due to Dr. J.V.S.R. Anjaneyulu, Director, Defence Laboratory, Jodhpur for his kind permission to publish this paper.

## REFERENCES

1. CURETON, T.K., *Scinece News Letter*, 66 (1954), 216.
2. CURETON, T.K., *Amer. J. Physiol.*, 179 (1954), 628.
3. CURETON, T.K., *Scholastic Coach*, 24 (1955), 36.
4. CURETON, T.K. & POHNDORF, R.H., *Research Quart*, 26 (1955), 391.
5. PERCIVAL, L., SCTURTE, *Foundation for Medical Research*, 3 (No. 2), (1951).
6. ERSHOFF, B.H. & LEVIN, E., *Federation Proc.*, 14 (1955), 431.
7. CONSOLAZIO, C.F., MATONSH, L.R.O., NELSON, R.A., ISSAC, G.J. & LAURENCE, M.H., *J. Appl. Physiol*, 16 (1964), 265.
8. BEST, C.H. & TAYLOR, N.B., *The Physiological Basis of Medical Practice*, 879, 912-913.
9. HAWK, OSER & SUMMERSON, *Practical Physiological Chemistry*, (1947), 622.
10. STEVENS, S.S., *Handbook of Experimental Psychology* (1933), 1348.
11. GANONG, WIN. F., *Rev. med. physiol.* 199 (1963), 509.