# The effects of vitamin E and training on physiological function and athletic performance in adolescent swimmers

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1. Two experimental groups, each of thirteen boarding schoolboys, were given either 400 mg $\alpha$-tocopheryl acetate or placeboes daily in addition to their normal diet during training in swimming and various athletic activities over a period of 6 weeks. Evaluation of the experimental treatments was made from tests of anthropometric status, cardiorespiratory efficiency and motor fitness and performance, which were administered at the beginning and end of the experimental period.

2. Whereas training significantly improved physiological function and performance in both groups ($P < 0.05$), vitamin E did not.

Relationships between diet and athletic performance were studied, or accepted without study, long before nutrition became a science. Often, these relationships have been based on practical considerations and were merely the outcome of common sense. Some of the relationships proposed, however, have been largely imaginary and rooted in the particular fads of athletes or their trainers. Such rituals have led sportsmen to contemplate the possibility of supercharging the body by the provision of a diet containing an unusual abundance of those nutrients which have either a direct or an indirect effect on muscular performance. It has been hoped thereby to raise the athletic performance above that possible on a standard diet.

Vitamin E has for long attracted especial interest in this direction for three main reasons.

First, in many species of animal its deficiency causes the muscles to become dystrophic. It is tempting, therefore, to assume that when the muscles are under severe stress their demand for vitamin E may be increased and may not be satisfied by the amounts supplied in a normal diet. Not that a deficiency of the vitamin would cause dystrophy, but it could result in lower muscular performance than would be possible if the intake of vitamin E were greater.

Secondly, there is convincing evidence that in experimental animals the resistance to hypoxia and hyperoxia can be affected by the vitamin E status (Hove, Hickman & Harris, 1945; Taylor, 1953). This finding may be correlated with the ability of the

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vitamin to act as an antioxidant, as established in several investigations both in vivo and in vitro. Again, there is a temptation to suggest that, since deficiency of vitamin E can cause increased susceptibility to hypoxia, an increased intake of the vitamin might act as a shield against stresses imposed during all-out muscular performance.

The third reason for expecting vitamin E to benefit athletic performance emanates from the alleged value of the vitamin in the treatment of certain human diseases which involve defects of the heart and circulation (Shute & Shute, 1950; Shute, 1951). Although it is not claimed that the vitamin, even in large doses can effect a permanent cure, it might be presumed that if it can ameliorate conditions of circulatory strain, it would act similarly under the stress of extreme exertion.

Several claims have been made that vitamin E can improve athletic performance, of which Percival's (1951) appears to be the earliest. Vitamin E too has been used to improve the performance of racehorses (Darlington & Chassels, 1956, 1957, 1958).

The relationship between athletic performance and the energy-yielding quality of wheat-germ oil, containing vitamin E, has been investigated by Cureton (1954, 1959–60, 1970), who found significant improvement in endurance and various cardiorespiratory measurements.

Prokop (1960) carried out a study into the short-term effects of dosing subjects with vitamin E on their performance of a standard exercise task. He found that these subjects recovered more quickly after exercise, but the small dose given, the apparently considerable benefit gained merely from ingestion of a placebo and the failure to make any due allowance for a possible training effect during the course of the study make his findings equivocal.

Moreover, the findings of Thomas (1957) contradict those of Cureton (1954, 1959–60) and Prokop (1960); he could find no significant differences between dosed and undosed subjects in a series of cardiorespiratory and motor fitness tests.

The study now described was, therefore, undertaken in an attempt to establish exactly what beneficial effects on athletic performance, if any, might be attributed to vitamin E. Since Cureton (1954, 1959–60) concluded from his long series of studies that the effects of the vitamin were pronounced only during strenuous training, we decided to conduct our investigation into the long-term effects of a training programme and with a much greater dosage than had hitherto been prescribed, as there is no evidence to indicate that this would be harmful. Our preliminary findings have already been published (Sharman, Down & Sen, 1970).

## EXPERIMENTAL

### *Design of study*

An experimental, related-group design was employed to observe the effect of dietary supplementation with vitamin E on the training and performance of a group of adolescent swimmers. Two experimental groups of fifteen boys, one taking vitamin E and the other a placebo, were subjected to a battery of tests including anthropometric status, cardiorespiratory efficiency, and motor fitness and performance, at the beginning of a 6-week schedule of training for competitive swimming. Thirteen subjects in each group completed the training period and were then retested to evaluate the experimental treatments.

*Selection of subjects*

The thirty subjects who took part in the experiment were recruited from members of the swimming club of a boys' public boarding school. The use of boarding pupils afforded a certain degree of control over some of the obvious external variables that could influence the experimental conditions, such as diet, environment, daily routine and physical activity. In effect, all subjects were eating a similar diet, albeit in different houses, and were leading similar lives in a restricted community, their recreational activity being limited, in the main, to swimming.

The subjects were paired individually on the basis of age, ponderal index (height/$\sqrt[3]{}$weight) and the time for swimming 400 m. Neither knowledge nor results of these preliminary tests, nor their meaning, was supplied to the subjects in order to minimize the individual motivational stimulus that would have resulted on the final testing.

After matching was completed, the members of the fifteen pairs were assigned at random to two groups, and the groups to the experimental treatments (vitamin E or placebo). None of the administrators who were concerned with the practical side of the experiment knew which treatment was given to any individual.

Broadly speaking, all the subjects underwent a similar training programme in terms of both frequency and effort, though it naturally had to be graduated according to individual ability and progress.

*Tests*

Three types of test were used. Normally, subjects were given the quiet-state tests first, except when insufficient time and availability precluded it, and finished with the performance tests.

*Anthropometric status*

*Height.* This was measured with the subject standing without his shoes.

*Body-weight.* The subjects were weighed in the nude.

*Skinfold thickness.* A Harpenden caliper, with a spring exerting a tension of 10 g/mm$^2$ jaw surface, was used to measure skinfold thickness at the following sites on the left side of the body: over biceps brachii; over triceps; subscapula; abdominal; suprailiac.

*Cardiorespiratory efficiency*

*Measures at rest.* (1) Pulmonary function was measured by: forced vital capacity (FVC), determined by vitalograph, the highest value of three trials being taken; timed vital capacity (TVC, 1·0 s) or forced expiratory volume (FEV, 1·0 s), measured from the vitalogram at the 1 s point; the ratio FEV:FVC, calculated as a percentage.

(2) The resting electrocardiogram (ECG) was recorded for all the leads on a Philips Cardiopan Model 571 Recorder (Philips Medical Ltd, Birmingham). The amplitudes of the P, Q, R, S and T wave deflections were measured with vernier calipers. These

measurements were made in lead II and the precordial lead (CR) which displayed the greater R or T wave amplitude. The interval measurements were made in a similar way: P–QR interval – from the start of the P wave to the start of the Q/R wave; work (contraction) time – from the start of the S–T segment to the end of the T wave; rest time – from the end of the T wave to the start of the ST segment of the next cycle.

Table 1. *Modified Schneider index test rating scale*

(1) Reclining pulse rate

| Rate (beats/min) | Points |
|---|---|
| 31–40 | 4·5 |
| 41–50 | 4 |
| 51–60 | 3 |
| 61–70 | 3 |
| 71–80 | 2 |
| 81–90 | 1 |
| 91–100 | 0 |
| 101–110 | −1 |

(3) Increase of pulse rate (beats/min) on standing

| 0–10 | 11–18 | 19–26 | 27–34 | 35–42 |
|---|---|---|---|---|
| 4 | 4 | 3 | 2 | 1 |
| 3 | 3 | 2 | 1 | 0 |
| 3 | 2 | 1 | 0 | −1 |
| 3 | 2 | 0 | −1 | −2 |
| 2 | 1 | −1 | −2 | −3 |
| 1 | 0 | −2 | −3 | −3 |
| 0 | −1 | −3 | −3 | −3 |
| 0 | −1 | −3 | −3 | −4 |

(2) Standing pulse rate

| Rate (beats/min) | Points |
|---|---|
| 41–50 | 4·5 |
| 51–60 | 4 |
| 61–70 | 3 |
| 71–80 | 3 |
| 81–90 | 2 |
| 91–100 | 1 |
| 101–110 | 1 |
| 111–120 | 0 |
| 121–130 | 0 |
| 131–140 | −1 |

(4) Increase in pulse rate (beats/min) after exercise

| 0–10 | 11–20 | 21–30 | 31–40 | 41–50 |
|---|---|---|---|---|
| 4 | 4 | 3 | 2 | 1 |
| 4 | 4 | 3 | 2 | 1 |
| 3 | 3 | 2 | 1 | 0 |
| 3 | 2 | 1 | 0 | 0 |
| 3 | 2 | 1 | 0 | −1 |
| 2 | 1 | 0 | −1 | −2 |
| 1 | 0 | −1 | −2 | −3 |
| 1 | −1 | −2 | −3 | −3 |
| 0 | −2 | −3 | −3 | −3 |
| 0 | −3 | −3 | −3 | −3 |

(5) Return of pulse to standing normal after exercise

| Time(s) | Points |
|---|---|
| 0–30 | 3 |
| 31–60 | 2 |
| 61–90 | 1 |
| 91–120 | 0 |
| 120 (2–10 beats above normal) | −1 |
| (11–30 beats above normal) | −2 |

*Measures at submaximal effort.* (1) Modified Schneider index. A continuous resting ECG was recorded after amplification on a frequency modulated tape recorder, using a modified Depex electrode (Boter, den Hartog & Kniper, 1966) consisting of domed silver discs, mounted on plastic adhesive tape and the dome filled with standard saline electrode jelly (supplied by Philips Medical Ltd, Birmingham and Cambridge Instruments Ltd, London). The process was repeated with the subject in the standing position, sufficient time elapsing for the pulse to reach a normal frequency. The subject then stepped up and down on a bench 47 cm high five times in 15 s, the prescribed rhythm being dictated by a metronome. The terminal pulse was recorded, together with the time taken for the pulse rate to return to the standing normal after the stepping exercise. If the pulse did not return to normal after 2 min the number of beats above normal was recorded. The Schneider index, as modified here, was assessed with direct reference to the rating scale (Table 1). This was calculated by summating the points score for each of the five measurements. The maximum score attainable was fixed at twenty.

(2) Modified step test (Down, 1970 unpublished). The subject after resting for 5–10 min in the sitting position, stepped up and down on a bench 45 cm high at a rate of twenty steps/min, indicated by a metronome, for 5 min. Upon completion, the subject sat down immediately and, after 5 s recovery, pulse rates ($P_R$) were taken manually over periods of 10 s at prescribed intervals as follows: 5–15 s ($P_{10}$); 25–35 s ($P_{30}$); 55–65 s ($P_{60}$); 85–95 s ($P_{90}$); 115–125 s ($P_{120}$); 175–185 s ($P_{180}$). The individual's work tolerance was evaluated on the basis of these 10 s post-exercise pulse counts according to the following formula:

$$\frac{\text{Duration of pulse count times } (T_{PR}) \times 100}{P_{10}+P_{30}+P_{60}+P_{90}+P_{120}+P_{180}},$$

$$\text{i.e. Recovery index } = \frac{\Sigma T_{PR}}{\Sigma P_R} \times 100.$$

*Measures at maximal effort.* (1) Breath-holding time. The time in s for which the breath was held after maximum inspiration was recorded.

(2) 1 mile (1609 m) run. A standard running track (of four laps to the mile) was used and the subjects were told that the best procedure was to run at even pace with an 'all-out' sprint at the end. Times for the distance were taken to the nearest second.

(3) 400 m swim. The subjects were encouraged to swim at even pace; times were taken to the nearest second.

*Motor fitness*

*Pull-ups.* The subject assumed an overgrasp hanging position with the arms fully extended. He then pulled himself up with an even, forceful motion until his chin cleared the top of the bar before lowering himself to the point where his arms were once again fully extended. The maximum number of completed pull-ups performed in the prescribed manner was recorded. For any incomplete or 'cheat' movements, a maximum number of up to two half-counts was permitted.

*Push-ups.* The subject assumed a straight-arm support position on a set of parallel bars. He then lowered his body by flexing the elbows until the angle between the fore-arm and upper arm was 90° or less. Every full push-up back to the straight-arm support position constituted one repetition. The total number of push-ups that the subject could perform in succession was recorded. A maximum of two half-counts was permitted for incomplete or 'cheat' movements.

*Two-minute sit-ups.* The subject assumed the supine position with hands interlocked behind the head and knees bent so that the feet were flat on the floor. A full sit-up was completed when the subject had raised his trunk until the lower back was perpendicular to the floor and returned to the starting position. The subject repeated this procedure as many times as possible within the 2 min time limit, and this number was recorded.

*Presses-on-bench.* The subject lay supine on a horizontal bench, both feet being in contact with the ground. A 22·5 kg barbell was held in the palms of the hand on the chest. The width of the grip was such that the forearms were vertical at the start of the press from the chest. In time with the metronome, the subject then pressed the bar evenly up and down. The subject repeated this movement continuously, at the fixed rate of one press every 2 s, until he was exhausted, or until the required pressing rate was broken. The number of total full presses completed at the prescribed rhythm was recorded. For incomplete presses a maximum of two half-counts was permitted.

### *The training programme*

The training programme consisted, whenever possible, of a daily open-air swimming period, supplemented by bouts of free exercises or circuit training, or both, and general sports participation if conditions restricted the water training. On average the subjects had four swimming sessions per week for the 6-week period plus one of the other supplementary work-outs as indicated.

The swimming sessions were a mixture of continuous endurance swimming at constant speed, according to ability, and controlled interval training of the 'work-rest' variety geared to the individual's target racing pace. The programme had to take into account the school swimming matches which were spread throughout the experimental period.

An attempt was made to exert some degree of control over the subject's recreational activities in spare time. All were requested not to partake of any other form of vigorous physical exercise, as well as to avoid varying their regular dietary habits, during the course of the experiment. In this respect it had to be assumed that all subjects were receiving a nutritionally adequate diet according to the recommended intakes of nutrients for the United Kingdom (Department of Health and Social Security, 1969).

A record, in questionnaire form, was kept of all daily exercise undertaken.

### *Supplementary dietary treatment*

The vitamin E group received two tablets daily each containing 200 mg $\alpha$-tocopheryl acetate. The placebo group received daily two placebo tablets, identical to the vitamin E tablets in size, shape, colour and taste. To facilitate and ensure regular intake of the tablets as prescribed, they were supplied to the subjects every day after breakfast. The double blind method was employed so that neither subjects nor investigators knew what each was taking. The subjects were only told, for obvious reasons, that the tablets contained no drug of any kind.

### *Statistical procedures*

The significance of the differences among the results both within and between the two groups with respect to the tests carried out at the beginning and end of the treatment period was calculated by means of Student's two-tailed $t$ test, on the assumption that the variances of the two groups were not the same (see Ostle, 1954). These calculations were done on an ICL 1905 computer (International Computers Ltd, Putney, London).

The 5% level of confidence was accepted as denoting statistically significant differences; any difference up to the 10% level has been noted since experiments of this type inexorably involve some degree of variable motivation, training effort and dietary regimen.

## RESULTS

### *Physical characteristics*

Age, height, weight, ponderal index and the five skinfold measurements of the two groups before and after treatment and training are presented in Table 2. The fact that the original matching of the groups had been carried out satisfactorily is confirmed by the lack of any significant differences between them in respect of their physique at the initial testing. After the experimental treatment there were no significant differences between the two groups ($P < 0.1$) in respect of basic physical characteristics. Because the experiment lasted for only 6 weeks any differences that might have occurred as a result of natural growth were obviously minimal.

The only differences of any interest found between the groups after treatment were in fat over biceps ($P < 0.2$) and suprailiac crest ($P < 0.1$). Little can be read into this level of significance, but the trend was towards a greater loss of regional fat in these areas by the placebo group. This is an interesting observation, none the less, as the mean weight loss of approximately 0·5 kg was similar in both the groups. However, this finding agrees with the other results which suggested that the placebo group may have been in worse physical condition at the start.

### *Cardiorespiratory functions*

*Reclining ECG.* The analysis of the reclining ECG of the groups is given in Table 3. Little or no difference was recorded in the amplitude of the various component waves of the reclining ECG either between or within groups as a result of either training or dietary treatment. Rather surprisingly, there was a tendency towards reduction, though non-significantly, in the mean amplitudes of the R wave especially, but also the T wave (highest precordial (CR) lead) at the final testing. Moreover, the values recorded at the initial testing showed that the two groups were very closely matched, albeit by chance.

The same interpretation can be applied to changes in the interval times of the various phases of the heart cycle. The tendency here, if anything, was to a slight shortening of the time intervals for the vitamin E group and a lengthening, though marginally so, for the placebo group. Neither difference, however, was significant, and it would be misleading to read further into these results.

*Modified Schneider and work recovery indices.* Neither the modified Schneider index nor any of its constituent measurements revealed significant differences between the two groups as a result of the experimental treatment (see Table 4). On the other hand, though little change occurred in the reaction of the heart rate of the vitamin E group following the training and dietary treatment, a marked improvement in

Table 2. *Physical characteristics of the two groups of schoolboys before (A) and after (B) a 6-week training period*

(Means and standard deviations)

| Group | | Age (years) | Height (cm) | Weight (kg) | Ponderal index | Skinfold thickness: Biceps (mm) | Triceps (mm) | Subscapular (mm) | Abdominal (mm) | Suprailiac (mm) | Total mean (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Given vitamin E: | A | 16·03 ± 1·28 | 176·9 ± 9·7 | 66·1 ± 11·2 | 13·29 ± 0·37 | 44·9 ± 17·5 | 98·7 ± 30·2 | 79·0 ± 13·4 | 126·5 ± 48·4 | 49·4 ± 11·9 | 79·7 ± 24·3 |
| | B | 16·16 ± 1·28 | 177·6 ± 9·3 | 65·6 ± 10·8 | 13·37 ± 0·38 | 42·7 ± 14·8 | 87·0 ± 25·8 | 77·0 ± 13·8 | 111·8 ± 40·4 | 49·5 ± 12·7 | 73·6 ± 21·5 |
| Given placebo: | A | 15·57 ± 1·17 | 173·6 ± 8·4 | 61·5 ± 9·2 | 13·33 ± 0·38 | 41·1 ± 8·6 | 99·2 ± 36·5 | 78·7 ± 19·3 | 108·4 ± 51·0 | 46·1 ± 12·7 | 74·7 ± 25·6 |
| | B | 15·71 ± 1·17 | 174·2 ± 8·3 | 61·0 ± 8·7 | 13·43 ± 0·34 | 36·7 ± 6·8 | 90·1 ± 29·6 | 76·1 ± 16·0 | 99·4 ± 52·7 | 41·9 ± 7·9 | 68·8 ± 22·6 |

Table 3. *Reclining electrocardiogram components of schoolboys before (A) and after (B) a 6-week training period*

(Means and standard deviations)

| Group | | Lead II wave amplitude (mm) | | | Precordial lead (CR): Highest wave amplitude (mm) | | | | Time (s) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | P* | R* | T* | P* | R* | S* | T* | P−QR† | Work cycle | Rest cycle |
| Given vitamin E: | A | 0·84 ± 0·31 | 14·38 ± 4·79 | 3·86 ± 1·05 | 0·90 ± 0·22 | 21·83 ± 6·99 | 4·58 ± 2·81 | 7·76 ± 2·41 | 0·18 ± 0·02 | 0·31 ± 0·02 | 0·58 ± 0·13 |
| | B | 0·96 ± 0·30 | 15·08 ± 5·16 | 3·94 ± 1·33 | 1·08 ± 0·31 | 18·04 ± 8·28 | 6·08 ± 3·68 | 7·48 ± 1·83 | 0·18 ± 0·02 | 0·30 ± 0·03 | 0·54 ± 0·12 |
| Given placebo: | A | 0·92 ± 0·46 | 13·26 ± 4·51 | 4·09 ± 0·66 | 1·02 ± 0·38 | 23·82 ± 7·67 | 7·38 ± 5·49 | 8·24 ± 1·80 | 0·18 ± 0·02 | 0·30 ± 0·03 | 0·55 ± 0·19 |
| | B | 0·98 ± 0·38 | 14·42 ± 3·72 | 4·41 ± 1·13 | 1·00 ± 0·24 | 20·16 ± 9·88 | 8·12 ± 5·25 | 7·98 ± 1·61 | 0·18 ± 0·02 | 0·31 ± 0·02 | 0·57 ± 0·10 |

* Wave deflexions.

† P−QR, interval from the start of the P wave to the start of the Q/R wave.

adaptation took place in the placebo group with significant change in standing ($P < 0.1$) and light work ($P < 0.02$) heart rates and the composite, modified Schneider index ($P = 0.1$). This difference in pattern between groups probably indicates that the placebo group was not in such good condition at the commencement of the training rather than being evidence of any other effect. On the other hand, though both groups underwent virtually identical swimming programmes, the placebo group did slightly more training than the vitamin E group.

The placebo group also made strikingly significant improvement on the work recovery index. This improvement represented an increment in excess of five standard percentile scores for a normal student population, which is considerable seeing that it comes at the upper end of the scale. Certainly the placebo group demonstrated markedly the obvious benefits to the cardiorespiratory functions of the training undertaken. That improvements were not so positive in the vitamin E group may, as intimated, also be a consequence of inadequate matching of the groups with regard to functional cardiovascular efficiency. For practical reasons, no measure of this type was included when matching. This hypothesis is made more tenable by the similar results in the swimming performance test itself.

*Lung function.* Most significant was the difference ($P < 0.05$) in percentage FEV between the two groups at the beginning of the experiment. The fact that a similar level of significance ($P < 0.1$) remained after treatment indicates again, as one would expect with respect to the basic lung functions, that the treatment itself had little effect. Anyway, the initial values for both groups were well within the normal range (80–90%) so any such differences are of no consequence.

### *All-out performance tests*

Both groups improved their breath-holding ability, the vitamin E group's increase being highly significant ($P < 0.01$). In this context, it is pertinent that the initial performance of the two groups differed very significantly ($P < 0.01$), a finding not readily predictable from the hypothesis tentatively advanced that the placebo group was less fit at the beginning of the experiment. At the same time, the much higher statistical dispersion in the tests at the final trial makes any far-reaching inference from the figures here misleading, while the influence of motivation may well have skewed the results.

Both running and swimming tests fairly complement the submaximal cardiorespiratory function tests. There was virtually no difference in performance between the groups for either the mile run or the 400 m swim at the beginning of the experiment. Running performance, too, hardly changed at all among those who were able to repeat this test, though, as one would have expected, merely in consequence of the training undertaken, both groups went faster in the final swimming test. The placebo group's tendency to greater improvement ($P \simeq 0.1$) was consistent with the other findings and is further evidence that, whatever the effects of vitamin E might have been, they were probably insignificant compared to the effects of training on swimmers of this level of ability, i.e. not of highest professional standard. There is no evidence here to suggest that vitamin E has any beneficial effect on endurance performance up

Table 4. *Heart and lung function tests performed on schoolboys before (A) and after (B) a 6-week training period*

(Means and standard deviations)

| Group | | Heart rate: Lying (beats/min) | Heart rate: Standing (beats/min) | Heart rate: Light work (beats/min) | Heart rate: Light work recovery time (s) | Modified Schneider index | Work recovery index | Lung functions: Timed vital capacity (l) | Lung functions: Forced vital capacity (l) | Lung functions: Forced expiratory volume (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Given vitamin E: | A | 63·08 ± 7·66 | 79·15 ± 6·66 | 119·39 ± 8·21 | 66·46 ± 36·01 | 9·23 ± 2·01 | 67·66 ± 7·21 | 4·16 ± 0·89 | 4·70 ± 1·04 | 89·00 ± 5·98 |
| | B | 63·46 ± 8·45 | 78·69 ± 10·39 | 118·23 ± 7·67 | 63·46 ± 23·93 | 9·46 ± 2·33 | 70·97 ± 10·78 | 4·12 ± 0·98 | 4·81 ± 1·17 | 85·99 ± 6·23 |
| Given placebo: | A | 65·31 ± 9·64 | 85·62 ± 12·95 | 125·69 ± 8·63 | 59·23 ± 11·70 | 8·15 ± 2·58 | 63·75 ± 12·46 | 3·76 ± 0·84 | 4·54 ± 0·93 | 82·79 ± 7·15 |
| | B | 60·08 ± 9·54 | 76·15 ± 1·99 | 117·31 ± 7·00 | 65·00 ± 16·07 | 9·85 ± 2·61 | 74·77 ± 11·83 | 3·83 ± 0·82 | 4·65 ± 0·96 | 82·09 ± 5·12 |

Table 5. *Motor fitness and all-out performance tests performed on schoolboys before (A) and after (B) a 6-week training period*

(Means and standard deviations)

| Group | | Push-ups (no.*) | Pull-ups (no.*) | Press on bench (no.†) | Sit-ups (no./2 min) | Breath-holding (s) | Mile run (s) | 400 m swim (s) |
|---|---|---|---|---|---|---|---|---|
| Given vitamin E: | A | 5·0 ± 3·9 | 5·2 ± 3·1 | 22·4 ± 9·8 | 47·8 ± 9·8 | 53·4 ± 15·6 | 369·5 ± 20·3 | 442·1 ± 74·8 |
| | B | 7·2 ± 4·0 | 6·5 ± 3·4 | 24·9 ± 8·6 | 53·0 ± 9·5 | 76·8 ± 23·7 | 365·9 ± 36·3 | 418·2 ± 59·8 |
| Given placebo: | A | 5·5 ± 4·5 | 4·6 ± 2·9 | 21·6 ± 13·0 | 48·0 ± 11·3 | 69·6 ± 13·9 | 369·8 ± 26·8 | 451·5 ± 60·2 |
| | B | 6·5 ± 4·7 | 6·1 ± 3·3 | 24·0 ± 10·8 | 53·1 ± 13·4 | 78·2 ± 22·9 | 374·0 ± 27·7 | 413·1 ± 52·3 |

* Until subject was exhausted.
† Until subject was exhausted or until pressing rate of one press every 2 s was broken.

to 10 min duration. Indeed the evidence, if anything, suggests that the vitamin had an unfavourable effect.

*Motor fitness tests*

The results are given in Table 5. Not surprisingly, no significant differences were found between groups on the motor fitness tests, for vitamin E has never really been promoted as an ergogenic aid to strength or local muscular endurance. Both groups, however, slightly improved on all these tests – presumably as a result of the swimming training, the most notable improvement being in the number of sit-ups completed in 2 min. Improvement is to be expected as the tests involve circulatory efficiency to a greater degree than any of the other tests. Though not significant at a statistically acceptable level, the increases recorded present improvements of around ten percentile scores on a normal student population scale for each of the motor fitness tests.

## DISCUSSION

Under the conditions of the trial, significant differences at the 5% level were observed in both groups as the result of training, but no significant differences were found between the group given vitamin E and that given placebo tablets.

Although the experiment was planned to minimize, as far as possible, psychological influences by the use of a double blind technique, it was virtually impossible to eliminate them completely. The mere knowledge that the subjects were 'guinea-pigs' in an experiment may have had considerable effects, none of which are measurable. The trial was also limited by the fact that it was not possible to have full control over the subject's diet and activity. Some of the tests, too, being of an endurance type either muscular or cardiorespiratory in their stress, would probably demand a high-degree motivation and committal and that is never certain with volunteer subjects of the kind described here, especially as they had to carry out the final set of tests during or shortly after academic examinations.

When so many tests are used, the possibility of inconsistency in the measurements made must be recognized, although with few exceptions, all the tests were administered on both occasions by the same people. It is now recognized that the use of push-up and pull-up tests was not entirely satisfactory for subjects of the age group described here because they were unable to perform sufficient repetitions.

It is recommended that in any future trial tests should be carried out with swimmers of a high performance, since it would appear that if there are any beneficial effects of vitamin E on performance they would be manifest in assisting the subject to undergo a more strenuous training programme. Measurement of oxygen debt should be included to ascertain whether vitamin E has any beneficial effect on anaerobic capacity and performance.

It is further suggested, since in this experiment only vitamin E was investigated, that in any future trial the effects of substances associated with vitamin E (such as octocosanol (Cureton, 1970) which is present in wheat-germ oil) might be examined.

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