SOME ASPECTS OF OPEN-AIR EDUCATION[1]

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(With 2 Charts)

It was Heraclitus who said of his predecessors that they had much knowledge but no sense, and this criticism often comes to mind when workers pause in retrospect and wonder that the application of the quite adequate knowledge of a generation ago was not applied in a practical and wise manner. Perhaps it may seem that a long time elapsed after compulsory education was adopted before it was realized that a vast number of children were physically quite unfitted to benefit from the learning presented to them; and it was a still longer time before it was hesitatingly acknowledged that the art of living, the teaching of an hygienic way of life, was the most important aspect of education. For without this the benefits of the whole system are of little lasting worth or real utility. Thus it is that open-air education, born late in time, is of such paramount importance; because although ordinarily and primarily conceived for restoring delicate children to health, the main great permanent value of this work is that it teaches in a practical and pleasant manner the greatest of all arts—the art of living.

From the beginning it was emphasized that the open-air school was not merely a school in the open air; it is, as Sir George Newman wrote, of the nature of a process and comprises a way of life and a system both of education and of medical treatment. And in this comprehensive system there are seven characteristic features: (*a*) fresh air and sunlight; (*b*) a proper and sufficient diet; (*c*) rest; (*d*) the hygienic way of life; (*e*) individual attention; (*f*) medical treatment; (*g*) special educational methods.

The combined effect of all these factors doubtless brings about the unique success of open-air education; but certain of the factors stand out, either alone or interrelated, as pre-eminently important and deserve a brief consideration before the results of their practical application can be fully apprehended. Although the sun has been worshipped by primitive races as the source of life and light, and although the function of the sun has been recognized in providing vegetable food necessary for animal life, yet it is only within the last two decades that the influence of sunlight has been found to have a direct and specific effect on animal nutrition. The benefit of sunshine, except in those institutions where systematic sun-bathing has been practised, is limited to the

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psychological effect and to the effects of the ultra-violet rays acting on the exposed surfaces of the skin; the amount of bare skin varies, but for much of the year the skin of arms, legs and face (in children nearly half the total surface area) is available for the bactericidal effect and for the irradiation of ergosterol by the ultra-violet rays.

In Torquay (Simpson, 1927) these atmospheric rays have been measured by the acetone-methylene-blue gauge for some 9 years and the daily averages recorded vary from a maximum of 13 or 14 units in summer to 1·9 units for the winter months (November to March). Moreover, in seaside resorts there is the additional amount of rays available due to reflexion by the sea; the fact that the rays are reflected was proved by the writer at Torquay. As a unit is two to four times the minimum amount required to produce an erythema on a sensitive skin, there is an adequate quantity of rays during a large proportion of the year.

But even more important than this are the cooling power and stimulating effect on metabolism of the moving air. Leonard Hill has shown by his kata-thermometer how easy it is to measure the cooling power of the atmosphere; and using his technique and after many hundreds of experiments (Simpson, 1924–8) in Torquay and elsewhere it was seen that whereas in many schools the conditions of ventilation barely reached the empirical minima postulated by Leonard Hill (1920) (viz. 6 for the dry kata reading and 18 for the wet), the readings at the open-air school were very high, denoting stimulating, healthy conditions.

The accompanying Charts, 1 and 2, show the differences very clearly. The readings at the open-air school (Chart 1) can be easily compared with those at Homelands School (a one-storey building of modern design with adequate floor space and through cross-ventilation), the Secondary School (a modern two-storey building with good floor space and cross-ventilation), and with Upton School (Chart 1), an old building on ecclesiastical lines with lofty rooms, adequate floor space, but with inadequate window space, resulting in much stagnating air.

The effect of moving air is also shown in Chart 2 on library ventilation with fans, which illustrates effectively how the kata-thermometer readings rise with increased air movement, in this case artificially produced by the various speeds of the fans.

The clothed kata readings were also taken at the open-air school; these are readings in which the dry kata bulb is fitted with a finger stall of a thick knitted wool glove, and shows the protection of clothes against very high cooling powers and against the great variations of cooling power in different circumstances. The clothed kata should be approximately two-thirds of the naked kata in still air at 60° F. (15·5° C.), and one-half in moving air of 20 miles per hour. "The growing child requires his metabolism to be adequately stimulated by the cooling power of the open air" (Hill, 1919), and therein lies part of the enormous benefit of open-air education.

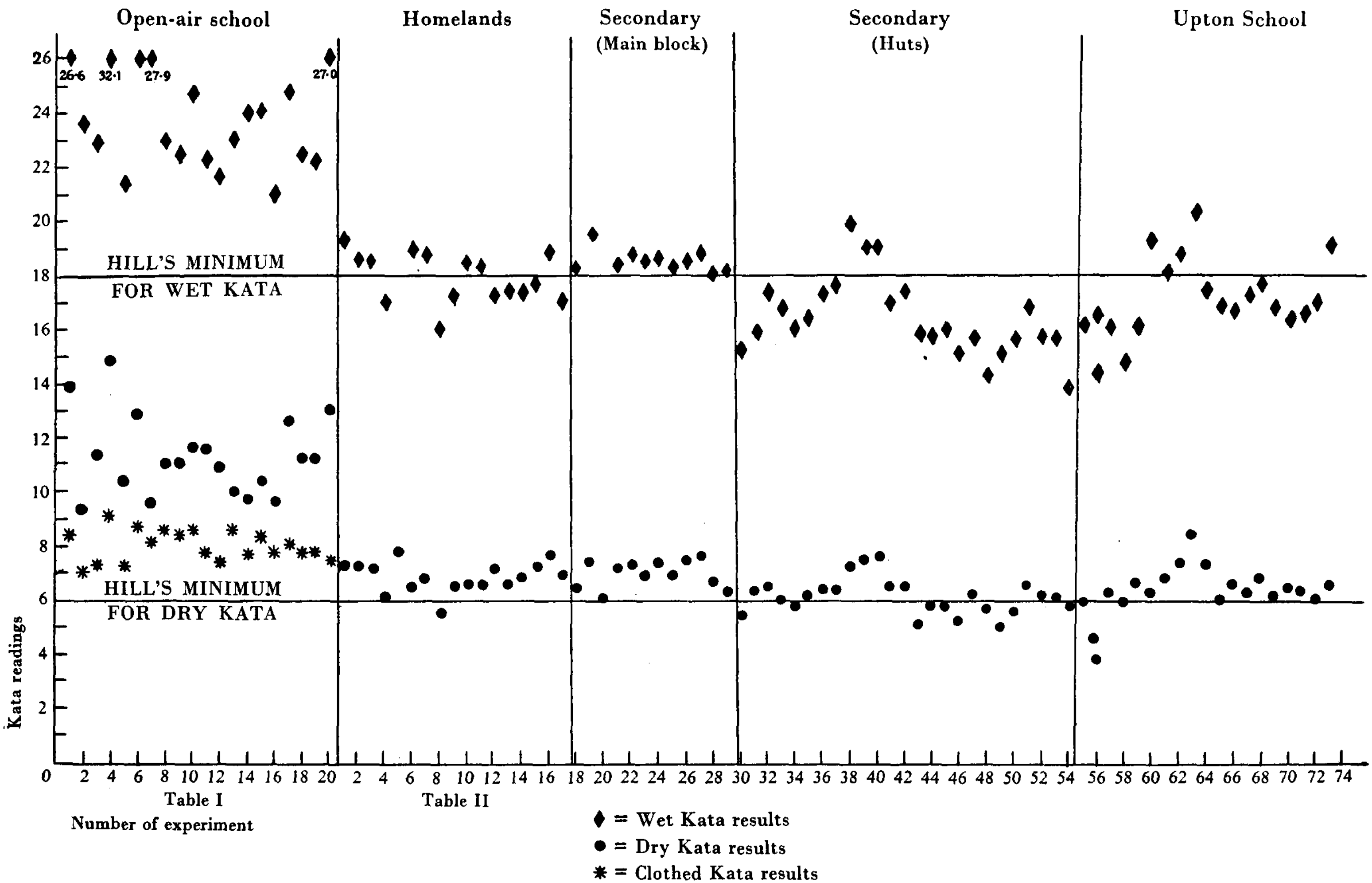

Chart 1

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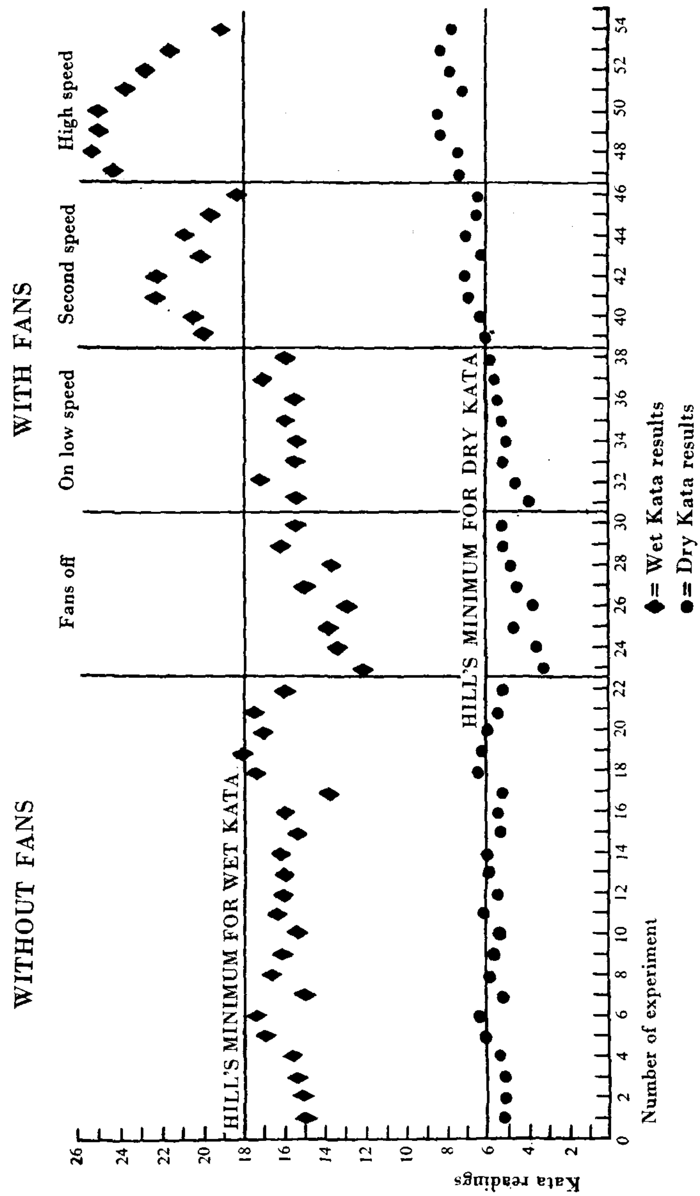

Chart 2. Fan ventilation in library

The researches of Leonard Hill (1920) into the science of ventilation and open-air treatment have demonstrated the stimulating effect of moving air. The results of the work of Hill and his collaborators (1923) show how the metabolism of children undergoing open-air treatment in England and in Switzerland is increased. "The heat production of the resting subject, stimulated by this cooling power, is put up, above that taken indoors in London, some 40–50 per cent in the case of clothed adults, and 69–225 per cent in the case of children exposed more or less nude to the sunny calm Alpine winter atmosphere. Increased appetite, better digestion and more active breathing and circulation of the blood result from this increased heat production."

Furthermore, Campbell *et al.* (1921) showed that the metabolism (in terms of millicalories per sq. cm. per sec.) of subjects sitting quietly on a chair and wearing ordinary winter clothing, with a dry kata cooling power of about 7, could be calculated approximately from the formula $\frac{H_2}{4{\cdot}5}$. H_2 is obtained from the formula $H_2 = H_1 \frac{\Theta_2}{\Theta_1}$, where H_2 is the dry kata cooling power at cheek temperature, H_1 is the dry kata cooling power, Θ_1 is 36·5° C. minus the dry-bulb air temperature and Θ_2 is the mean cheek temperature minus the dry-bulb air temperature. They also showed that when the dry kata cooling power was between 15 and 20 the metabolism could be calculated approximately from the formula $\frac{H_2}{6{\cdot}5}$. Under fixed conditions, therefore, the metabolism may be determined fairly accurately from the formula $\frac{H_2}{\text{constant}}$, and the cheek temperature is of value in the approximate calculation of body metabolism.

The subjoined Tables I and II give the detailed results of a series taken under ordinary conditions in winter; Table I is a series taken in the classrooms and resting-sheds of the open-air school at Torquay, while Table II represents conditions in ordinary schools and in official buildings like the Town Hall offices. As previously stated, the method is only a rough and approximate estimation of metabolism, but it is seen that the heat loss in kg. calories per sq. m. per hour (which is 36 times the figure $\frac{H_2}{\text{constant}}$ of millicalories per sq. cm. per sec.) is from the basal figure 45–50 for children's metabolism up to 40 per cent above that level. The children were wearing ordinary winter clothing, and on most of the occasions the atmosphere was still and quiet with cooling power at its lowest for winter weather. These may be taken as mean figures; and when, as is usual for most of the year, the children are out-of-doors in an atmosphere with a high cooling power, the metabolism rates will be correspondingly very much greater. For, as Leonard Hill puts it, "while exposure to open air stimulates body metabolism, the cooling power of the atmosphere appears to be the main factor".

By contrast the readings in Table II show a definite slowing of metabolism,

Table I

No. of exp.	Air temp. °C.	Mean cheek temp. °C.	Θ_1	Θ_2	H_1	H_2	$\frac{H_2}{\text{constant}}$	Kg. cal. per sq. m. per hour
1	6·5	26·5	30·0	20·0	13·8	9·2	1·61	58
2	12·0	30·0	24·5	18·0	9·3	6·9	1·40	51
3	10·5	28·0	26·0	17·5	11·3	7·7	1·44	52
4	10·0	27·5	26·5	17·5	14·8	9·8	1·63	59
5	12·5	29·0	24·0	16·5	10·4	7·2	1·41	51
6	12·0	27·5	24·5	17·5	12·9	9·2	1·62	58
7	9·0	25·5	27·5	16·5	9·6	5·8	1·16	42
8	9·0	26·0	27·5	17·0	11·0	6·8	1·29	47
9	9·0	26·0	27·5	17·0	11·1	6·9	1·30	47
10	11·5	27·0	25·0	15·5	11·6	7·2	1·33	48
11	12·5	27·5	24·0	15·0	11·5	7·2	1·33	48
12	14·0	27·5	22·5	13·5	10·9	6·6	1·24	45
13	11·5	27·0	25·0	15·5	10·0	6·2	1·22	44
14	11·0	27·5	25·5	16·5	9·7	6·3	1·26	45
15	10·5	27·0	26·0	16·5	10·3	6·6	1·29	47
16	11·0	27·0	25·5	16·0	9·6	6·1	1·21	44
17	12·5	28·0	24·0	15·5	12·5	8·1	1·45	52
18	12·0	29·0	24·5	17·0	11·2	7·8	1·47	53
19	12·0	27·5	24·5	15·5	11·2	7·1	1·34	49
20	11·5	27·0	25·0	15·5	13·0	8·1	1·41	51
21	10·0	24·5	26·5	14·5	12·2	6·7	1·22	44
22	10·5	25·0	26·0	14·5	11·4	6·4	1·20	43
23	12·0	25·5	24·5	13·5	11·6	6·4	1·20	43
24	6·0	23·0	30·5	17·0	13·2	7·4	1·24	45
25	3·5	22·0	33·0	18·5	12·6	7·1	1·26	45

Table II

No. of exp.	Air temp. °C.	Mean cheek temp. °C.	Θ_1	Θ_2	H_1	H_2	$\frac{H_2}{\text{constant}}$	Kg. cal. per sq. m. per hour
26	17·5	28·0	19·0	10·5	5·7	3·2	0·70	25
27	14·5	27·0	22·0	12·5	7·2	4·1	0·91	33
28	15·0	28·0	21·5	13·0	6·2	3·8	0·84	30
29	18·0	28·5	18·5	10·5	6·7	3·8	0·84	30
30	17·0	28·0	19·5	11·0	5·1	2·9	0·64	23
31	14·5	26·5	22·0	12·0	6·8	3·7	0·82	30
32	16·0	28·0	20·5	12·0	6·2	3·6	0·80	29
33	14·5	26·0	22·0	11·5	6·5	3·4	0·76	27
34	13·5	26·5	23·0	13·0	6·6	3·7	0·83	30
35	16·5	27·5	20·0	11·0	6·2	3·4	0·76	27
36	17·0	27·5	19·5	12·5	6·5	4·2	0·93	33
37	14·5	27·5	22·0	13·0	8·0	4·8	1·01	36
38	15·0	26·5	21·5	11·5	10·1	6·1	1·19	43
39	17·5	29·0	19·0	11·5	5·9	3·6	0·79	29
40	17·0	30·0	19·5	13·0	5·7	3·8	0·84	30
41	16·0	28·5	20·5	12·5	6·3	3·8	0·85	31
42	16·5	29·5	20·0	13·0	6·2	4·0	0·90	32
43	16·5	29·0	20·0	12·5	5·4	3·4	0·75	27
44	18·5	30·0	18·0	11·5	4·9	3·1	0·70	25
45	17·5	30·5	19·0	13·5	5·7	4·0	0·90	32
46	15·5	29·0	21·0	13·5	6·5	4·2	0·93	33
47	15·5	28·0	21·0	12·5	6·2	3·7	0·82	30
48	13·5	27·5	23·0	14·0	7·1	4·3	0·96	35
49	13·0	25·0	23·5	12·0	6·7	3·4	0·76	27
50	14·0	26·0	22·5	12·0	7·5	3·7	0·82	29

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well below the limit of 40 for adult males, or of 35 for adult females, and far short of the high rates of 45 and 50 which children usually need.

Allied to the atmospheric cooling powers and their stimulating effect on metabolism, is the diet: this is properly controlled to meet the varying requirements of the child in his need of protein, fats, carbohydrates, mineral salts, vitamins and water, and quickly results in a progressive and steady improvement in the nutrition of the majority of the cases.

In many defective children there is a deficiency in the calcium intake or an alteration in the calcium-phosphorus ratio. Sherman and Booher in an experiment extending through several generations of rats of both sexes, found that growth may proceed at practically the same rate at different levels of calcium intake above the minimum requirement. The animals receiving the lower calcium ration had every physical appearance of being as well nourished as those reared on a calcium-rich diet, but chemical analyses showed that their bodies were calcium-poor. The same has been found with children, that a calcium-poor condition may co-exist throughout much or all the period of growth, with apparently normal increase in height and weight and with every physical appearance of health. In other words normal growth cannot always be assumed to indicate normal development, and a high calcium intake together with adequate vitamin D during the period of growth is essential. The open-air school diet, with its abundance of calcium must help to combat incorrect feeding and the accompanying predisposition to disease.

Rest is the further factor which is essential, for as John Hilton (1860) wrote: "Rest is the necessary antecedent to the healthy accomplishment of both repair and growth." And the results of all these factors are quickly apparent in the almost magical effect of open-air education on cases of malnutrition. Such results need no detailed description; they are obvious to even the casual observer.

But less apparent, although no less important, are the excellent results obtained in cases of organic disturbance like some forms of heart disease: in Torquay, although the numbers are very small, quite satisfactory progress has been recorded in children with functional or organic heart disease. In the functional type the effect of open-air education is decisive in building up the nutrition of the myocardium, in toning up an atonic myocardium and vaso-motor system, and in generally restoring a healthy circulation: while in organic disease the effect is very similar—always provided that the work of the heart is kept within the limits of its capacity.

Provided the climate is advantageous, a reasonable case seems to have been made out for treating some, if not most, children with cardiac affections in this way; the regulated life—fresh air, diet, rest, modified exercise, controlled school lessons—teach the child how to live correctly, how to keep the load imposed on his damaged heart within the limits of its capacity.

The importance of a good tone in a well-nourished myocardium and of a stable vaso-motor system became apparent in the application of the Air Force tests designed by Martin Flack (1920) to elementary schoolboys, including some at the open-air school. In the persistence test, modified by Woolham for schoolboys (1923), the subject is asked to breathe out as far as possible, then inspire fully, blow the mercury up to half the height of the expiratory pressure test and—with the nose clipped—hold it there, without breathing, as long as possible. The time, pulse rate each 5 sec., blood pressure, have all been charted for many cases, and it is evident (Lamb & Simpson, 1928) that even in boys at the open-air school quite good or satisfactory results were found when their nutrition had been improved.

This test probably throws the maximum strain on the cardio-vascular system; and, as in the writer's opinion myocardial fatigue or exhaustion is an important factor in determining the "breaking point" of the test, it is considered that open-air education has a marked beneficial effect on the nutrition and tonicity of the myocardium. Flack & Burton (1922) suggest that in "subjects with pronounced tendency to abdominal pooling the systolic arterial pressure becomes so greatly increased together with acceleration of the heart due to increased blood supply to the right heart, that a vagal reflex initiated by the stimulation of the depressor nerve endings in the aortic arch, causes a marked slowing of the heart rate". This may be one reason, but the fall in the last few seconds prior to the breaking point did not appear to have any relationship to the length of holding period, and it occurred with different types of pulse: so that under these circumstances it is quite possible that actual myocardial fatigue or exhaustion plays a part at the finish of the test.

Then surely if the physically defective case does so well, the delicate and malnourished children, without organic disease but with a bad home environment, are equally, or even more responsive, to this treatment (Simpson, 1925). It has been found that children with unsatisfactory home conditions are often quick to realize the benefit to their health which a stay at the open-air school produces; and whether defective physically, or admitted more on sociological grounds, these children will frequently return to the school in after-life and quite voluntarily express their appreciation of what open-air education did for them.

In Torquay during the 15 years ending July 1935 some 686 children were admitted to the open-air school, and of these 378 have been certified fit to return to ordinary schools, 91 have stayed until 14 years of age or over and have obtained work on leaving, while 6 stayed until over 14 years of age but were unable to earn a living. Out of the remainder, 67 left the town, 26 left for hospital treatment, 20 were too ill to attend, 21 were unsatisfactory in attendance, and 11 children died; the others are still attending. The average length of stay of children who were certified fit to return to their own school was 1 year 8 months, while the average stay of those who remained at school until over 14 years of age was 2 years 5 months; the figures show what the writer has always contended, that the earlier the children get to the open-air school, the sooner they are well again. The object in Torquay has always been to try and

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search out the suitable cases as early as possible during the children's school career. There were 73 children readmitted (having deteriorated in physique when sent back to ordinary schools), and there were 7 admitted a third time.

The average length of stay may seem long in comparison with other open-air schools, but Torquay is fortunate in having nearly 100 places for some 3700 elementary children. Furthermore, it has been part of the policy in this area to keep the children at the open-air school not merely until they were physically fit again, but until they had realized as far as possible the mental adjustment that their health is something worth considering; and that only by living "an hygienic way of life" can they attain and retain a physique adequate enough to meet the demands of life. In other words the individual has to realize the cry of the Philippian gaoler: "What must I do to be saved?" So far as physical welfare is concerned open-air education gives the answer in a practical and in a pleasant way, and teaches the old maxim of Goethe: "Gedenke zu Leben." The psychological aspect is important too, for all the children are exceedingly happy there, and the happy aspects of childhood may be engraven in their memories.

The development of a full glow of health is not impossible of attainment; for open-air education has shown, that with reasonable care and diligent self-help, it should be within the grasp of every boy and girl to reach that much-desired aim—physical fitness and mental efficiency, with character and personality that will endure.

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