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CONTENTS.

A Simplified Method of Ventilation in Schoolrooms

by

Professor **E. Almquist.**

The public have never felt quite satisfied with the air in those schoolrooms which have been heated on the hot-air system. However perfectly the heating-chamber and furnaces have been constructed, the air in the schoolrooms has nevertheless given rise to dissatisfaction. It has been supposed to be too dry and to have an injurious effect on the teacher's throat and speech-organs. It is certain that the air, in passing through the heating-chamber, acquires a sort of flavour, which is generally believed to be due to its dryness, but which we should rather ascribe to the scorching that goes on of the dust present near the surfaces of the furnace. Even at a heat at those surfaces of 70° or 80° Centigrade, this scorching is noticeable and so its occurrence in the heating-chamber can hardly be obviated.

In order to overcome the objectionable feature in the heating-system above referred to, the windows in the schoolrooms have been regularly opened during the intervals between lessons, so that each lesson may begin at all events in thoroughly pure fresh air. This is satisfactory, so long as care is taken that the cold air from the window does not pass direct into the heating-chamber; that may be prevented by introducing a register or valve that will close the hot-air duct while the windows are open; when the windows are closed again, the register may be reopened.

A hot-air system, if combined with the opening of windows during the intervals between lessons, undoubtedly gives satisfactory ventilation in schoolrooms. We shall see from what follows that this mode of ventilation admits of being considerably simplified, if separate heating-furnaces or radiators are placed in each classroom.

But before proceeding to the simplified method we advocate, we will refer to another common device for introducing fresh air into schoolrooms. Heating is now very often effected by low-pressure steam generated in stoves that are placed adjacent to the outside walls in classrooms. Air-conduits through the walls introduce fresh air from without. In order that the air thus brought into the room may be warmed before it is diffused through the room, the orifice of the air-conduit is placed inside a coping which surrounds the stove. The inflow of air can of course be shut off by means of a regulator or iron valve. This system does not seem to be particularly popular. It is supposed to cause a draught and make the room feel chilly, besides considerably increasing the cost for fuel.

For decades past it has been accepted as an axiom, that the air of a schoolroom is impure when it contains more than 1 part of carbonic acid gas to 1,000 parts of air. This theory has been dinned into people so thoroughly, that many have literally become afraid of carbonic acid gas in the air, although its amount in schoolrooms is quite innocuous. Dr. VIRGIN found carbonic acid gas present to the extent of 7 parts per 1,000 in some of the rooms at the Stockholm City Police Court. That is the highest proportion registered in Sweden to my knowledge. In schoolrooms we have hardly anywhere probably nowadays such a high proportion as that. Carbonic acid gas is not dangerous, nor does it occasion difficulty for breathing, unless it amounts to a still higher proportion. Thus carbonic acid gas in itself is without importance as regards our schoolrooms. It is curious to notice how easily truths accepted as axiomatic may be misinterpreted, and how easily the proper limits or scope of an observation correct in itself may be lost sight of. Professor PETTENKOFER found, when he was visiting schools and hospitals fifty years ago, that the air seemed unsatisfactory to the sense of smell, when the carbonic acid gas present in it had risen to 1 part in a thousand. That is to say, by the time those present had raised the proportion af carbonic acid gas to that figure by their respiration, they had also imparted to the air a disagreeable smell, owing to their soiled linen, the impurity of the surface of their skin, their decayed teeth, etc.

The connection which was thus laid down as existing between the production of carbonic acid gas and bad-smelling substances cannot of course be assumed to be applicable at the present time just because it was established for Munich fifty years ago, though certain foolish-minded echoers of other men's views have adopted that theory. As regards Sweden, we have long known that the air of schoolrooms does not begin to be foul or offensive until a higher proportion of carbonic acid gas than 1 part per 1,000 has been reached. In the nineties I tested several rooms in different schools in Stockholm and often found satisfactory air when the proportion of carbonic acid gas was between 1 and 1·5 per 1,000. Dr. SUNDELL during the last few years has found the air in the Stockholm elementary schools tolerably free from smell even when the carbonic acid proportion has been 2 per 1,000. From what does this displacement in the relationship established between carbonic acid gas and smelly air arise? Naturally from the fact that school children have become cleaner in their habits, especially so with reference to the surface of their skins and their clothes. This is partly the result of more frequent baths and partly of their parents having more money to give them better clothing. Greater demands in respect to cleanliness have everywhere been made and have produced a corresponding result. Now that the state of things as regards cleanliness has been improved, we can restrict the ventilation in the schoolrooms, for we have no other object in ventilating than to prevent the occurrence of so-called "schoolroom atmosphere". Consequently, we do not consider here the influence which ventilation has on the temperature of the room. In this connection I would observe that infectious germs cannot be driven out of a room by ventilating it, nor can the danger of infection be lessened through ventilation. To attempt to do that would be just as futile as to seek to drive out the dust by opening the windows. We must try to dispel erroneous conceptions in this matter as soon as possible.

It has often been asserted that human bodies generate some species of poisonous gas, which with the breath respired becomes mixed with the air of the room. This poisonous air has, it is true, received a name: "anthropotoxin", but it has never been proved to exist, nor has its occurrence even been shown to be probable. Professor Flügge of Breslau some years ago carried out some particularly instructive experiments with respect to foul air. He made the persons he was experimenting with study in a glass case of 3 cubic metres in capacity. Since there was no ventilation, studying soon became impossible, the person being experimented on began to feel tired and was unable to keep his thoughts collected. It proved that that condition of things asserted itself when the air in the little room had a certain character, viz. when it had reached a temperature of 21°—23° C. and contained a high precentage of humidity 70°— (about 75 % relative humidity). When an ordinary degree of humidity (50 %) prevailed in the air, the condition described was not experienced until the temperature had risen to 26° C. In the case above referred to 88° the temperature of the skin of the forehead had risen in the meantime to 34°—35° C. and the moisture in the air of the clothes to 55 %, that being 93°-9 normally 35 %. The proportion of carbonic acid gas in the glass case at the time did not exceed 1·5 parts in 1,000.

After the air in the glass case had undergone change in the way mentioned there was no benefit to be gained through breathing air introduced from without by means of a tube. The unpleasant symptoms remained all the same. On the other hand they disappeared immediately when an electric fan was set revolving sufficiently fast in the confined space. As long as that went on, it was possible to continue working in the warm and moist air in the room; as soon as it was set in motion no unpleasantness was noticed any longer. From these experiments, the results of which agree with experience in hot countries, we may draw the conclusion, that under the conditions mentioned the unpleasantness is caused by hot moist air becoming stagnant in immediate proximity to the surface of the body. It is without doubt that this is in general the real cause of the oppression felt in hot confined air in rooms where many people are packed close together.

An electric fan might, it is true, now and then be made use of at a school, even if not in the actual schoolrooms. In the speech-room it might undoubtedly be of value, since it is difficult to keep such a hall from getting over-heated. Other methods too may be employed for setting the air in motion. When a room has well-polished and varnished floors and panelling, the air very quickly gets to feel oppressive. This is owing to its being too stationary. If any draught can come in between cracks and joints or through porous building material, the air is kept in motion and it consequently feels pleasanter in the room. Many people on that account like to have a little ventilator or air-passage direct through the outer wall to the fresh air outside. Without letting in much fresh air this may serve to set the air of the room in motion in an agreeable manner. We now return to the schoolroom. We know that the air in it is satisfactory when it feels agreeable to the senses; it must not have a bad smell, nor must it be so warm and moist that inattention and discomfort are produced in the children. We may now ask: will the air in a classroom be likely to become seriously foul during the 45 or 50 minutes that a lesson lasts? We ought always to begin every lesson with fresh air in the room. An interval of 10 minutes is quite sufficient for completely changing the air in the room, for bringing in fresh air from outside and for driving out all the foul air from inside.

In order to establish it as certain that this can really be done in 10 minutes, Dr. Sundell carried out numerous investigations in the Stockholm elementary schools. In arriving at his conclusions he both used his sense of smell and took an analysis of the air to find out the proportion of carbonic acid gas present. His analysis showed that, at the beginning of the lesson, the carbonic acid proportion was as low as that of the outer air. Dr. Sundell in that way found that a complete change of air could be obtained in 10 minutes, not only during the winter but also during the warmer periods of the year.

Thus, the first condition for obtaining pure air in the classroom is a thorough airing of the room before each lesson. In order that this may be effective, a sufficiently large window space must be opened. In some schools the airing of the rooms has not been done completely, because too few windows and too small ones have been available for opening. Such an unsatisfactory state of things it is easy to obviate and its obviation is imperative.

One occasionally hears a complaint nowadays that airing a room by opening the windows makes it strike cold. Most people like the agreeable coolness and the fresh air present in the schoolroom after 10 minutes' airing. By the help of physics it is possible to explain why the room is not thoroughly chilled when the hot foul air in it is replaced by cold fresh air from outside. If we calculate the quantity of heat that is requisite for raising the temperature of the whole room from 0° to 15° C., 200,000 thermal units per 100 cubic metres will be found 59-60° F to be required for warming the walls, ceiling and floor, while the heating of the air alone requires barely 400 thermal units. If we let in air at 0° C., it feels pleasant to us, because the walls are still as warm as before. In the process of airing only 0·2 % of the store of heat $\frac{1}{500}$ is lost.

The principal question we have now got to answer is the following: Provided we begin the lesson with perfectly fresh air in the room, will more ventilation be required during the progress of the lesson than that existing in houses generally, due to porosity of building materials, to crevices and cracks etc.? The answer to the question depends materially on the degree of cleanliness observed by the occupants of the room, on the amount of space provided per individual, and on the temperature of the walls. We exclude in the following remarks such exceptional cases as are afforded by gas burning in the room, by the sun streaming in oppressively, and by an outdoor temperature of 20° C. or upwards. In the last-named case the windows will naturally be kept open during the lesson.

We will here make a few calculations. We assume that the occupants of the room are all adults, and that each of them gives off 20 litres of carbonic acid gas in one hour; we further assume that the natural ventilation through cracks between the floor-boards etc. corresponds per hour to a volume of air equal to the capacity of half the room. Reckoning 7·5 cubic metres of air-space per person, the air should contain, under the said assumptions, the following proportion of carbonic acid gas: after $^1/_2$ hour 1·6 parts in 1,000, after 1 hour 2·5 parts in 1,000. When we have to do with people of cleanly habits, the air will be satisfactory after half an hour; after $^3/_4$ hour, when the proportion of carbonic acid gas has reached the approximate limit of 2 to 1,000, it would probably feel somewhat close to a person just entering the room, but the lesson period is now over.

If each adult in the room has an air-space allowed him of 10 cubic metres, the proportion of carbonic acid gas will have risen by the end of the first half-hour to 1·3 per 1,000; and at the end of an hour will be 2 per 1,000. The air is thus still fairly satisfactory after a lesson lasting a whole hour.

What has been said about adults, with an air-space respectively of 7·5 and 10 cubic metres per person, applies to little children for whom an air-space of 4 and 5 cubic metres respectively is provided.

Hitherto we have only considered the proportion of carbonic acid gas and the smell. We must also take the temperature into account. This rises somewhat in most cases during the lesson. Since, however, I have no exact observations on this point, I will only remark that, if the temperature of the walls at the beginning of the lesson does not exceed 17° C., the air will not probably be raised to more than 20° C. by the body-heat given off by those present in the room. Thus, if that is the case, we may exclude the probability of any disagreeable rise of temperature taking place during the lesson.

We thus come to the conclusion that, under certain suppositions, we do not need any other ventilation in the schoolroom than that from the windows. But we must then have sufficient air-space per child in the room and see carefully to the heating, so that the temperature may be kept at about 17° C.

2° Jut

The proposal does not, of course, include anything beyond what has for years past been practised in old-fashioned school buildings and in those hired temporarily. But in such premises the air is often unsatisfactory, owing to the scarcity of space and to the airing being carelessly carried out during the intervals between lessons. My proposal is, that principals of schools and teachers should endeavour to manage without any other ventilation than what can be obtained by opening the windows, and that in carrying out that plan they should carefully observe the results during the latter part of the lesson. If foul air and too high a temperature in the classroom can be avoided by the method, it must be considered a satisfactory one.

Where a school has heating-apparatus in the classrooms and also air-conduits for the introduction of fresh air and the removal of the foul air, these conduits might be stopped up, as an experiment, the temperature being kept at about 17° C. I am convinced that such an experiment will prove a success, if the air-space in proportion to the number of the pupils is not too limited. If the sun shines into the room, in the spring, the supply of artificial heat should be diminished. In order to determine the condition of the air in the room we only need our sense of smell and power of gauging the temperature, the latter being checked by the thermometer.

I am convinced that an experiment of this kind would turn out well under many of the prevailing circumstances at schools. The hygiene of the scholars would not suffer from the new arrangement and the finances of the school would benefit by a considerably decreased outlay for fuel consumed.

It would be least favourable when it was rainy and muddy outside. Damp clothes and wet shoes emit a good deal of smell. As, however, presumably all school children now wear outdoor garments in rainy weather, and these are not taken into the classroom, there remains only the difficulty with regard to their boots and shoes. In order to ensure thoroughly satisfactory air in the classrooms, either galoshes should be worn out of doors in damp and muddy weather or the children's boots should be changed; this desideratum holds good also when ventilation proceeds during the whole lesson.

The Decrease of Short-Sightedness in Secondary Schools for Boys in Sweden

by

Professor **Johan Widmark.**

It is generally assumed that Germany is the country in which short-sightedness prevails most extensively in schools. COHN's investigations in 1867 — embracing more than 10,000 school-children — revealed that 44 % of the pupils were affected with short-sightedness in the highest class of the "Realschule", and 55·8 % in the highest form of the classical "Gymnasium". And yet COHN did not include in his statistics the lower degrees of short-sightedness (below 1 dioptric), nor the cases that he met with of short-sightedness in only one eye.

Moreover, many other investigators who have carried out research respecting short-sightedness in German schools have obtained even higher figures than COHN. He, again, has since collected the results of his testing of a total of 9,344 pupils in 24 German "Realschulen" and "Gymnasien", and obtained the result: 58 % of short-sighted boys in the highest class. In two of these schools short-sightedness in the highest class was even as high as 80 %. Still higher figures where obtained by O. BECKER, who tested the pupils of a school at Heidelberg in 1877. There all the pupils in the highest class where found to be short-sighted.[1]

From the investigations made in Sweden during 1870—1880 it appears that in our schools too short-sightedness at that period was particularly prevalent. A comparison made by KEY of the results of more than 15,000 tests carried out in Swedish boys' schools in the year 1883, gave, it is true, as a result only 37 % and 21 % in the highest class on the classical and modern sides respectively. The initial particulars, however, on which KEY based his statistics were not very reliable, and the figures which he obtained from his study of them cannot therefore lay claim to any great value. KEY himself observes that, in dealing with such a

[1] H. COHN: "Lehrbuch der Hygiene des Auges", 1892.

large number, the testing of each individual, even though the boys are distributed at a number of separate schools, cannot be carried out with all the necessary exactness for it strictly to comply with scientific requirements. The test with the aid of glasses was only made at a small number of the schools, while at others the reading-test alone was applied. Nor was the examination always made by medical men, details concerning the presence and degree of short-sightedness being merely furnished by the parents of the pupils after they had elicited the facts from the boys themselves, those facts, where necessary, being confirmed and amplified by the family doctor or the school-medical officer.[1] KEY is of the opinion that it must have very often been the case that a slight degree of short-sightedness was left out of account, when the pupil was not incommoded to any appreciable extent by it, or when it had not attracted the notice of those around him.[2] The percentage of short-sighted boys in KEY's voluminous statistics is therefore probably considerably lower than the actual facts would justify. But that is not all, for owing to the mode of testing adopted — often only the reading-test — it is evident that in many cases short-sightedness was confused with poor eyesight due to other causes, such as astigmatism, corneal specks, etc. ??

KEY, however, out of his voluminous statistics was able to point to 10 State secondary schools[3] in different part of the country, with a total of 3,054 pupils, at which testing for short-sightedness had been carried out by medical men and was stated in dioptrics. His figures there for the two highest forms gave a short-sightedness of 42·1 %.

In addition to this, contributions to our knowledge of the prevalence of short-sightedness in Swedish schools have been received from several other sources. Thus K. SCHULZ tested the pupils at the Uppsala Secondary School for Boys in the years 1870—1877, and out of a total of 2,605 boys tested in the two highest forms he discovered that 54·8 % were short-sighted.[4]

In the year 1883 the pupils at a large number of schools in Stockholm were tested by eye specialists. Similar tests were taken at the same time at Uppsala. They embraced 4,223 pupils altogether, 250 being in preparatory schools and 3,973 in higher schools; in the two highest forms there was a percentage of short-sightedness of 51·9.[5]

[1] A. KEY: "Läroverkskommitténs hygieniska undersökningar", Bilaga I, 1885, P. 114.

[2] A. KEY: loc. cit., P. 214—215.

[3] These schools were: Stockholm (5), Linköping, Skara, Luleå, Falun and Sundsvall.

[4] A. KEY: loc. cit., P. 226.

[5] I. W. VON DÖBELN: "Bidrag till statistiken öfver refraktionsförhållanden i skolorna". Hygiea 1891: 1, P. 1. VON DÖBELN does not state in his report which schools these were. I believe I am right in assuming that they included a number of private schools besides the State ones. The numbers tested amounted to as many as 4,223, including 250 pupils at preparatory schools. For purposes of comparison it may be mentioned that in 1904 (Spring term), in spite of a considerable increase in numbers, especially in Stockholm, there were only 3,587 pupils in all at the State Secondary Schools for boys in Stockholm and Uppsala.

Thus, according to all these investigations, the number of short-sighted pupils was quite high, though it did not attain, as Ask had already stated, to the same proportions as in German schools. If we take into account, however, the fact that Swedish schools are generally combined schools, i. e. with both a classical and a modern side (e. g. in 1880 with 70 % of the boys on the former and 30 % on the latter), and that hitherto all the investigations carried out have shown that short-sightedness is more general in classical schools than in modern ones, we may draw the conclusion that short-sightedness among boys on the classical side in the period 1870—80 attained a percentage of 50, in some schools even exceeding that figure. Short-sightedness among pupils on the classical side in Swedish State schools thus amounted to a percentage not much below that among pupils in the German classical "Gymnasien".

The crusade against short-sightedness has been carried on with great zeal, and fortunately it has been crowned with great success. A comparison between the results of the investigations already referred to and those of tests more recently carried out in Swedish schools, shows that short-sightedness has decreased during the last 20 or 25 years by about 50 % or even more, undeniably an excellent and very gratifying result. I show in a Table below a number of figures to illustrate these facts.

In reference to the particulars comprised in the Table, I think I had better point out that the figures for 1883 regarding two Secondary Schools for Boys (the Norra Latinläroverk and the Norra Realläroverk) in Stockholm and the Secondary Schools for Boys at Uppsala, Linköping, Skara, Falun, Luleå and Sundsvall are taken from Key's work, to which I have already referred; the particulars regarding one Secondary School for Boys (Nya Elementarskola) in Stockholm (1884) are taken from my own work, "Researches on Refraction in some Stockholm Schools" 1886; those again regarding the Secondary Schools in Stockholm and Uppsala from von Döbeln's work, "Contributions to the Statistics of the Conditions respecting Refraction in Schools" ("Hygiea", 1891), and the figures for 10 Secondary Schools for Boys in different parts of Sweden from Key's work. The figures for 1905 have been collected and grouped together partly from the Swedish Official Statistics, partly from first-hand information to be found in the Annual Reports of the several schools. I have obtained some further information from the Statistical Department of the Board of Education, through the kind assistance of Herr Gustafsson, Assistant Secretary. For the purposes of convenient comparison I have combined the figures for the two highest forms.

Table I.

Prevalence of Short-sightedness in a Number of Secondary Schools in Sweden, 1882—4 and 1905.

School.	1882—4			1905		
	Number of Pupils	% Short-sighted Pupils in two Highest Forms	% Short-sightedness in Whole School	Number of Pupils	% Short-sighted Pupils in two Highest Forms	% Short-sightedness in Whole School
Stockholm Norra Latinläroverk	569	52	23.9	713	31	15.4
» Norra Realläroverk	300	43.2	31	622	12.3	7.7
» Nya Elementarskola	286	50	24	375	11.8	10.7
Uppsala Secondary School . . .	565	40.1	20.8	546	15.0	14.4
Linköping » » . . .	488	50.5	26.0	588	28.3	11.4
Skara » » . . .	389	25.3	10.8	434	7.1	5.5
Falun » » . . .	223	65.4	19.73	352	14.7	6.2
Luleå » » . . .	91	46.6	20	248	12.1	6.9
Sundsvall » » . . .	178	30	17	363	27.2	7.7
Secondary Schools in Stockholm and Uppsala	3,973	51.9	28.29	3,587	19.3	12.6
Ten schools in different parts of Sweden	3,054	42.1	23.2	4,501	18.8	9.8

The decrease in short-sightedness, according to the above Table, is surprisingly great, and I do not think that such a favourable result has been shown to exist in any other country but Sweden. I have indeed from several quarters heard doubts expressed as to the reliability of the above figures. A number of researches, however, which I have myself made regarding the prevalence of short-sightedness among the scholars at the schools of this country agree so closely with the figures shown above, that for my own part I cannot at all share those doubts. In the first place I may call attention to the investigations that I made in the year 1884 in a number of boys' schools in Stockholm, containing in all 704 pupils.[1] Among these boys I found, in the two highest forms, that 52·08 % were short-sighted, thus almost exactly the same result (51·9 %) as was arrived at the year before by an eye specialist in his tests.

On comparing my figures with those compiled by Key from 10 schools, containing 3,054 pupils, I find that mine are certainly considerably higher than his, viz. 52 % as compared with 42 %; but in reference

[1] J. Widmark: "Refraktionsundersökningar vid några skolor i Stockholm". Nord. Med. Ark. 1886. Vol. XVIII, No. 24.

to that discrepancy it is to be noted that at the investigations which form the basis of KEY's calculations the pupils' two eyes were tested together, and thus those who were short-sighted in only one eye were not included. Now if I exclude from my statistics those who were short-sighted in one eye only, I obtain 47 %, i. e. a figure which pretty nearly agrees with KEY's. In any case there is nothing in my investigations which tends to show that his figures were too high.[1]

I have endeavoured to control the most recent figures, those for 1905, in the following way: The total number of pupils in all the State secondary schools for boys in Sweden amounted in the year 1904 to 20,131; among them, according to the tests conducted by school medical officers, 18·8 % of those in the two highest forms were short-sighted. Since it seldom occurs that anyone begins to be short-sighted after having left school at the age of 18 or 19, short-sightedness amongst students at university colleges or similar establishments must be approximately as widespread as in the highest form of the secondary schools. A test of short-sightedness, therefore, among students, especially freshmen, must, one would think, serve as a check on the statistics compiled respecting the test carried out by the school medical officers. With this idea in my mind I tested, in the autumn of 1908, a number of medical students at the Caroline (Karolinska) Medical Institute in Stockholm, some of them engaged in working in the chemical laboratory, some doing dissecting-work, and others training to become dental surgeons. Dr. ÅKERBLOM, Assistant at the Eye Clinical Hospital, also tested the medical students studying there during the autumn term of the same year. The total number of those thus examined was 111, and of these 21, i. e. 18·9 %, were found to be short-sighted. Here also the figures agree fairly closely with those given by the school medical officers for the highest form of the State secondary schools (18·8).[2]

I give below a graphic Chart of the decrease in short-sightedness in Swedish secondary schools for boys during the period 1883—1905 inclusive. For the first-mentioned year I have taken the figures given by KEY, being the results of his test in 10 boys' schools, which moreover yield the lowest average of any obtained at that date with tests carried out by medical men and by exact methods. The figures for 1895 to 1905 are taken from the Swedish Official Statistics.

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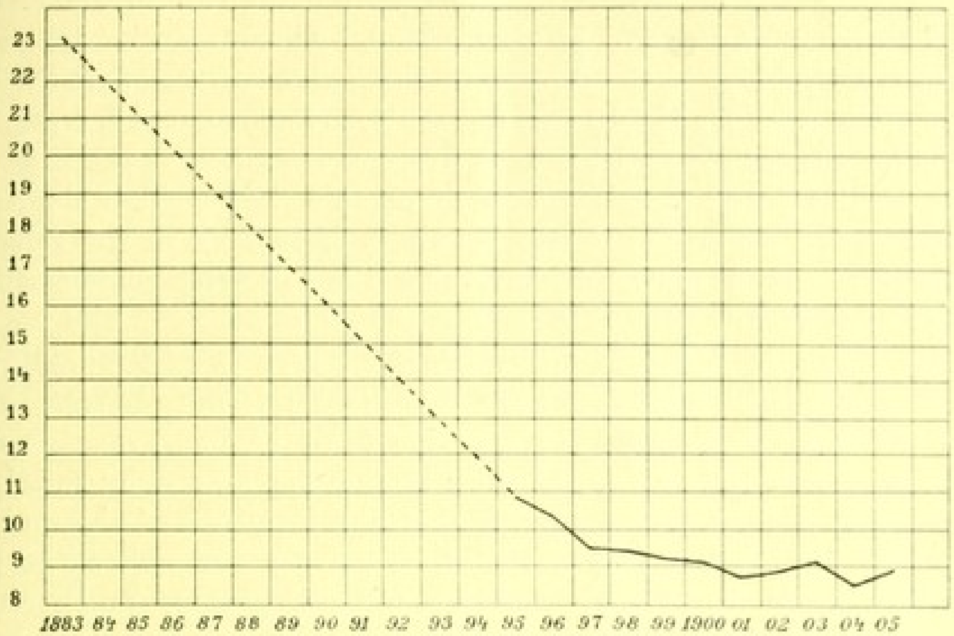
[1] I may point out that in my investigations astigmatism was also taken account of and that I made extensive controlling tests with the optic mirror besides.

[2] Figures respecting short-sightedness in medical students in 1908 are not inappreciably lower than those I obtained from my test in 1903. At that time the percentage for those doing dissecting and laboratory work was 28, and that for those working in the eye clinical hospital was 34. The explanation of that change is evidently to be looked for in the circumstance that all, or practically all, who were examined in 1903 had been on the classical side at school, whereas since then the obligatory study of Latin for prospective medical students has been removed, so that nowadays many medicals come from the modern side.

Decrease of Short-Sightedness in Swedish Secondary Schools for Boys in the Years 1883—1905.



From 1883 to 1895 the curve is only dotted, because for that period comprehensive investigations are wanting as to the prevalence of short-sightedness in the secondary boys' schools in Sweden. From the year 1895 onwards the figures are for all the State secondary schools for boys in Sweden, both 9-class and 6-class ones. The number of pupils in the year 1895 was 14,310, and in the year 1905 it was 21,425. We see from the Chart that short-sightedness decreased yearly from 1895 to 1901, after which date a slight increase took place. Regard ought, however, to be paid not only to the percentage of short-sightedness in the whole school, but also to the percentage of short-sightedness in the highest class of the school. As a matter of fact the last-named doubtless forms the most exact gauge of the effect that education at school has on the prevalence of short-sightedness. I have, therefore, collected particulars, in the Table given below, of the percentage of short-sightedness in the highest form in the schools for the 12 years, 1895—1906.

Table II.

Percentage of Short-Sightedness in the Highest Forms of All the State Secondary Schools for Boys in Sweden, 1895—1906.

Year	Percentage	Year	Percentage
1895	24.6	1901	19.5
1896	22.1	1902	20.2
1897	22.6	1903	19.5
1898	22.8	1904	18.8
1899	22.1	1905	18.7
1900	19.6	1906	16.9[1]

[1] Preliminary estimate.

We see from the Table that, even in the most recent years, a decrease, though only a small one, has taken place in the percentage of short-sightedness in the highest form, and that the returns for 1906 are the lowest occurring during the 12-year period. The diminution will appear particularly striking, if the figures in the Table are compared with the corresponding ones for the 10 schools mentioned above, which were tested in 1883, for they were registered as averaging 42 %.

In an earlier paper I endeavoured to explain the considerable decrease that has occurred in the number of cases of myopia in the schools in this country and I ventured to advance the following as contributory causes to that result:

1. *The hygienic improvements which have been effected during recent years in our schools and in all the conditions relating thereto.* Among these I should be disposed to mention first the improvements in the lighting of rooms and in the printing of the books used by pupils, and that for this reason among others, that the influence of these changes is of effect in the homes too, the strain on the eyes when the pupils are busy with the preparation of lessons being thereby much reduced. If a comparison is made between the methods of lighting rooms now and those of ten years ago, the difference is very striking, both at school and in the home. Not less significant is the change which has taken place in the printing of school-books. The old Gothic types have disappeared so entirely, that we have ceased in this country to call them Swedish any longer, referring to them now as German. Nowadays, excepting in textbooks in the German language, the Roman types are universally employed and the Swedish school-books at present in use may in general be considered to satisfy even exacting demands with respect to clear and distinct print.

2. *Decrease in the study of classical languages in our schools.* The result of a large number of investigations in Swedish schools goes to show that it involves a greater strain for the eyes to be a pupil on the classical side than on the modern side (i. e. at a "Gymnasium" than at a "Realschule"). Cohn's investigations, as I mentioned above, showed a difference of 15·8 % between the short-sightedness of boys in the top forms at a "Gymnasium" and a "Realschule" respectively, 55·8 % of the boys being short-sighted in the highest form of the classical "Gymnasium" as against 44 % in the highest form of the "Realschule" with its curriculum of modern subjects. In Key's statistics the difference in percentage between the classical and modern sides in the 9-year schools was as 37 is to 21.

Since then Ask has devoted further study to these conditions.[1] He both made comparisons between the short-sightedness prevalent on the classical and modern sides at the secondary schools for boys in Gothen-

[1] Fr. Ask: "Studien über die Myopie in den vollständigen höheren Lehranstalten für Knaben in Schweden". Nord. Med. Ark. 1904. Abt. 1. H. 3. N:o 10.

burg for the years 1894—1903, and investigated the prevalence of short-sightedness among the pupils on the modern and classical sides in the secondary school for boys at Lund in 1904. Finally he also worked out a comparison between the prevalance of short-sightedness among the pupils on the modern and classical sides in the upper six classes at nine State secondary schools for boys in Sweden for the year 1904.[1] The result was, that he found that a considerable difference prevailed without exception in the short-sightedness of the pupils on the classical and modern sides, the latter being always the better off in this respect. As a further illustration of this phenomenon the following Table may be of value, showing, as it does, the prevalence of short-sightedness in a Stockholm secondary school, a) with only a modern side, b) with both classical and modern sides, and c) with only a classical side.

Table III.

Prevalence of Short-Sightedness in Three Secondary Schools in Stockholm, 1894—1903.[2]

School Class	Realläroverk in Norrmalm, Stockholm % Short-Sighted Pupils	Secondary School for Boys in Södermalm, Stockholm % Short-Sighted Pupils	Latinläroverk in Norrmalm, Stockholm % Short-Sighted Pupils
1st.	2.6	10	10.1
2nd	6.4	11.4	11.4
3rd	7.2	13.6	12.8
4th	8.3	15.2	12.6
5th	10.5	17.2	17.1
Lower 6th	12.4	19.2	20.3
Upper 6th	16.7	24.2	24.9
Lower 7th	19.6	26.6	29.2
Upper 7th	20.7	29.2	33.4
Number of pupils tested	5,871	5,681	6,592

The Table shows a considerable difference in the prevalence of short-sightedness in the highest form of the Realläroverk (20·7 %) and that of the Latinläroverk (33·4 %). Between the two comes the third school, in Södermalm, which has both a classical and a modern side (29·2 % of short-sighted pupils in the highest class).

Naturally it is not necessarily the subjects studied on the classical side (or in the Latinläroverk) that are more exacting than those on the

[1] These schools are: The State secondary schools for boys at Kalmar, Jönköping, Hälsingborg, Linköping, Karlskrona, Örebro, Uppsala, Karlstad, Västerås. The number of pupils on the classical side was 966 and on the modern side 1665. The percentage of short-sighted pupils among the former was 18.84, among the latter 13.33.

[2] The percentages of short-sightedness have been calculated from the first-hand data given in the above-cited work by Ask.

modern side (or in the Realläroverk), but it is the greater strain on the eyes that the work there entails. It cannot probably be disputed that the studies pursued on the modern side, in mathematics, physics, and chemistry, do not strain the organs of sight to the same extent as does the study of Latin and Greek. For these subjects, as for languages in general, more actual reading in books is probably required, and the continual looking up of words in dictionaries, often printed in small type, is especially trying to the eyes. This applies particularly to the Greek language with its — for the pupils — entirely new letters.

3. *The increased pursuit of sports and games by Swedish schoolboys.* It has been pointed out by many writers that short-sightedness is comparatively rare among schoolboys in England, this favourable state of things being attributed to the large number of hours devoted by boys in English schools to bodily exercise.

DÜRR stated in 1883 that the pupils in German schools from the age of 10 to 19 had 20,000 working-hours and only 650 hours for gymnastics, whereas pupils in English schools had 16,500 hours for school-work and 4,500 hours for gymnastics, etc. In England, at the beginning of the eighties, the time devoted by schoolboys to gymnastic exercises and outdoor games was 7 times as great as it was in Germany.

During the last 30 years a considerable change, as is well known, has taken place in the way in which our schoolboys spend their out-of-school hours, for they give up much more time to sport, especially to games involving bodily exercise in the open air, than was formerly the case. But it is quite clear that short-sightedness in schoolboys does not depend only on the work done in the schools themselves and on the preparation of lessons at home; it is also affected by the way the boys have of employing their leisure time. If this leisure time is spent in reading novels, studying music, and so on, this will form a serious addition, as regards the strain on their eyes, to their school-work proper. On the other hand, time spent in the open air, when the eyes are directed for the most part upon distant objects, forms a relief for the eyesight after close study.

That a judiciously planned open-air life during leisure hours has a beneficial counter-effect on those who are carrying on strenuous school-work, can surely scarcely be denied. But what, among other factors, has confirmed my conviction of its importance as an antidote against myopia at school, is the favourable state of things as regards short-sightedness which I found to prevail at the Djursholm secondary school. In the year 1904 I had the opportunity (in the Swedish Journal: "Hygiea") of publishing the results of the remarkable observations I had made regarding the prevalence of short-sightedness in that school for the years 1903 and 1904. Both the percentage and the degree of short-sightedness there were unusually small. In the year 1903 the percentage of short-sightedness in the whole school amounted to 4 only, and in 1904 to 2.6, i. e., for 1904, to less than the average in the lowest class in the State secondary schools (4 %). The degree of short-sightedness was also strikingly low and in 1903 exceeded only in the case of one pupil 1 dioptric.

These uniquely favourable conditions as regards short-sightedness could not naturally be ascribed to the excellence of the school building at Djursholm, for at that time it was far from being ideal in the modern sense. Neither could it be owing to the curriculum being more circumscribed than in the State schools, for the courses of study etc. must of necessity be the same to all intents and purposes, since the goal aimed at — the matriculation examination — is the same there as elsewhere. I assumed, therefore, that the real cause was the great opportunity that school-children in a residential suburb enjoy for indulging in games and recreation in the open air during their out-of-school hours.

The favourable conditions as regards short-sightedness, according to the reports of Dr. Lychou, the medical officer of the school, have existed there ever since the school was started in 1890; for recent years too they remain practically the same. In the year 1905 there were 6 short-sighted pupils out of 206 (2.9 %), in the year 1906 7 short-sighted pupils out of 258 (2.3 %), and in the year 1907 7 pupils out of 281 (2.1 %).[1]

In 1908 I again had the opportunity of taking some share in the testing of the pupils at the Djursholm school. Before stating the results, I will first give a few facts of interest concerning the school itself in addition to what I have already mentioned.

The school has always been a modern-side school (Realläroverk) for both sexes; but it is now divided from the fourth class onwards into two parallel departments. The one, Department A, forms a Preparatory School for the Real-Gymnasium or Upper School, the other, Department B, is transitional to a two-class Continuation School. In Department A and the Upper School there are chiefly boys, while in Department B and in the Continuation School the pupils are girls almost exclusively

The result of the tests is shown by the following Table:

Table IV.

Prevalence of Short-Sightedness in Djursholm Secondary (Mixed) School

	School Class	Number of Pupils	Age of Pupils	Number of Those Short-Sighted	% of Short-Sighted Pupils
Preparatory Classes	1st	37	7	0	0
	2nd	29	8	0	0
	3rd	41	9	0	0
		Total 107			

[1] From information supplied by Dr. Lychou.

School Class	Number of Pupils		Age of Pupils	Number of Those Short-Sighted		% of Short-Sighted Pupils	
1st	33		9	0			
2nd	31		10	1		3	
3rd	41		11	1		2.5	
	Dept. A	Dept. B		Dept. A	Dept. B	Dept. A	Dept. B
4th	20	6	11—12	2	0	10	0
5th	16	6	13—14	1	0	6.6	0
6th	15	9	14—15	2	0	13	0
Total	177			7		3.9	
Continuation School	12		16—17	0		0	
Upper School	17		16—18	2		11.8	
Whole School	313			9		2.9	

Thus, from the tests we learn that among the 107 pupils in the Preparatory School none were short-sighted; that among the 177 pupils in the Lower School 7 (i. e. 3.9 %) were short-sighted; that among the 12 pupils in the Continuation School none, and among the 17 pupils in the Upper School 2 (i. e. 11.8 %), were short-sighted.

It is noteworthy that among the 33 pupils in Dept. B and the Continuation School none were short-sighted, while in each of the classes of Dept. A and of the Upper School there were a certain number of cases of short-sightedness. One might be tempted to trace the cause of this state of things to the fact that in Dept. A and the Upper School the schoolwork was directed towards preparing for the matriculation examination and was therefore more trying. I have, however, had another explanation given me by Dr. Lychou, to the effect that the majority of the short-sighted pupils (6 out of 9) at the Djursholm School belonged to families who have moved there from elsewhere, and the pupils, on entering the school, were already afflicted with myopia. Three of the six belonged, moreover, to the same family, in which both father and mother were short-sighted.

The same circumstance, the moving to Djursholm of families with children already afflicted with myopia, is furthermore responsible for the fact that short-sightedness was somewhat more marked in 1908 both in degree and percentage than in the years immediately preceding. Deducting the pupils belonging to families that had moved into the district, there were only 3 short-sighted pupils (i. e. 1 %), in the whole school. I attribute these favourable conditions respecting short-sightedness at the Djursholm School to the circumstance that the pupils, after school hours and home lessons are over, have abundant opportunity to be out in the open air, indulging in health-promoting physical exercises. If that supposition is justified, other schools too, whose pupils can and do enjoy an outdoor life during their leisure time, ought to show the same favourable state of things. Now of such schools there is at any rate one in this country, the Lundsberg Boarding School in Värmland.

It was clear to me, therefore, that it would necessarily be of great interest to know the prevailing conditions in this regard at that school. I was successful, moreover, through the kind assistance of one of the masters at the school (Herr ARRHENIUS) in obtaining permission from the headmaster (Herr DANIELSSON) to carry out the requisite investigation. Before entering into details, however, concerning the testing of the pupils there, I will first say a few words about the school itself.

The Lundsberg Boarding School was founded and endowed, in the year 1896, by WILLIAM OLSSON, a Swedish merchant. It has as the aim and purpose of its existence: "To afford an all-round and harmonious training to the intellectual, moral and physical powers of future citizens". It consists of: *a*) a Lower School of six classes with a curriculum drawn up with a view to impart a sound general education as an equipment for practical life, and *b*) a superstructure, an Upper School of three classes, in which the pupils are prepared for the matriculation examination on pretty much the same lines as at the State secondary schools. At the beginning of 1908 the school was accorded the privilege, for a period of five years from 1908 onwards, of holding a matriculation examination on its own premises, superintended by the Visiting Examiners appointed by the Government, and it has availed itself thereof each year since. The school is situated on the shores of a lake in a well-watered, hilly district, 10 kilometres from the nearest railway station and about 30 kilometres from the nearest town. The school buildings stand by themselves with an unimpeded view of the lake and round about are "the Houses", where the pupils reside and are boarded.

The curriculum of the school differs, it is true, in many respects from that of the State schools, but since the total school period lasts for 9 years, i. e. for as long a time as at the State schools that prepare pupils for matriculation, the difference cannot be very considerable in respect to the actual school teaching. It ought to be noted, though, that nearly all the pupils are on the modern side. One feature, however, that is particularly characteristic for the school is its laying very much stress on the physical training of the boys. When the season of the year admits, there are arranged on four days a week open-air games (tennis, football, etc.) or training in rowing, athletics, etc., in which all the boys have to take part. On the two other days, furthermore, the pupils in the higher classes (V—IX) have voluntary shooting-practice. In addition to this, athletics or games form the principal amusement of the boys during their leisure hours. During the winter particularly they have excellent opportunities for outdoor sports, such as ski-running, tobogganning and skating. Generally speaking, it may be said of the school, that it endeavours to unite the best features of

Swedish and English education into a scheme of general development that shall remain truly Swedish.

My tests of short-sightedness among the pupils in the school were carried out towards the end of September 1908 and gave the following results:

Table V.

Prevalence of Short-Sightedness at the Lundsberg Boarding School, September 1908.

School Class	Number of Pupils Tested	Age	Number of Short-Sighted Pupils
1st	6	10	0
2nd	16	11	0
3rd	20	12	2
4th	21	13	0
5th	17	14	0
6th	17	15	0
7th	8	16	1
8th	7	17	0.5
9th	3	18	0
	112	—	3.5

Thus, on the whole, Lundsberg School shows a striking resemblance to Djursholm School in this particular. Among the 112 pupils there were only three who were short-sighted in both eyes, and one besides, short-sighted in one eye. The percentage of short-sightedness for the whole school totalled only 3.1 %, i. e. less than that for the first class alone of all the State secondary schools in 1904.

But in this connection there is an important circumstance to be noted. The three pupils who were short-sighted in both eyes had formerly been at a different school and were already short-sighted when they entered Lundsberg School. Deducting these three, there remains therefore only one pupil, who was short-sighted in one eye. It can thus be said that the school, practically speaking, was free from short-sightedness at the time of the test.

Cohn, in his pioneer labours on the subject of short-sightedness in schools, extended his investigations to embrace elementary schools also, and found that the failing was much more general in urban elementary schools than in rural ones. In the former the percentage varied between 1.8 and 15, averaging 6.7, while in the latter it was between 0.8 and 3.2, averaging 1.4.

Thus we have here too the same state of things as before, viz. that in schools of a like type short-sightedness is more prevalent in towns than in the country. The cause of this, in my opinion, is the better opportunity that exists in the country for the scholars to be out-of-doors enjoying the fresh air.

Regarding the matter then from the point of view of the eyes — and indeed from that of the general health — secondary schools ought properly speaking to be located in the country. But were such a change to be contemplated, it would naturally from other points of view cause great inconvenience. First and foremost such schools would be too costly and therefore only available for the children of well-to-do people. It would probably be more practicable to transport, as it were, a piece of the country into the town and in that way arrange play-grounds on a large scale for the children. Large open spaces or recreation areas, duly provided with supervisors and game-organisers, to which parents without the least apprehension could send the children to spend a portion of their out-of-school hours in playing health-giving, invigorating games, that is what we need; and we are indeed in a certain degree on the way to obtain it.

At my examination of the eyesight of the pupils at the Djursholm School in the year 1903, I noticed that they were singularly well off as regards keenness of vision, no less than 96 % — after the correction of an existing defect in some as regards refraction — proving to have normally or abnormally good eyesight. I obtained almost the same result when testing the pupils at Lundsberg School, where 95 % had normally or abnormally good eyesight. This is a considerably higher percentage than the one I obtained in 1884 in a number of Stockholm schools, for there the percentage of normally keen eyesight varied between 63.56 and 86.97.

That the accuracy of the sight decreases with the advent and increase of short-sightedness has been established by a large number of investigators in this department of inquiry. It is clear that other circumstances too, besides short-sightedness, such as astigmatism, membranous specks, etc., are calculated to impair keenness of vision, and therefore, in comparing different schools with one another, we cannot lay down any constant ratio between short-sightedness and keenness of vision. A glance, however, at Table VI will give a clear and striking impression of the unfavourable influence of short-sightedness on keenness of sight; it shows the normal percentage of keen-sightedness among pupils in a number of schools that I have tested on different occasions.

The considerable difference in keen-sightedness between the pupils at Djursholm and Lundsberg schools, on the one hand, and the pupils at the other schools on the other, is striking, and there is no doubt that it is partly owing to the existing divergence in the prevalence of short-sightedness in the several schools.

As is well-known, pathological developments may supervene in conjunction with short-sightedness, that seriously reduce keenness of sight, and indeed lead to total blindness. Fortunately such serious complications are rare, especially in low and moderate degrees of short-sightedness. It is worth while noticing, moreover, that short-sightedness is apt of itself, without the supervention of any illness affecting the eyes, to diminish the keenness of vision, a circumstance that receives added importance from a fact that has been observed by numerous investigators, viz. that civilised peoples, even when not short-sighted, are less keen of vision than savage races.

Table VI.

Prevalence of Normal Keenness of Sight among the Pupils at some Secondary Schools in Stockholm in 1884, at two Djursholm Schools in 1903, and at Lundsberg School in 1908.

School	Number of Eyes Examined	Percentage Short-Sighted Eyes	Percentage of Eyes with Normal Keenness of Sight
Ladies' Training College and Normal School .	658	25.54	71.92
Wallin School (Girls)	402	25.12	63.56
"Nya Elementar" School (Boys)	572	24.65	77.64
Beskow School (Boys)	536	21.82	79.57
Lyceum for Girls	424	20.75	86.97
Djursholm Secondary School	302	4.00	96.07
Lundsberg School	224	3.10	95.00
Djursholm Elementary School	116	1.7	96.05

Travellers often state well-nigh incredible facts about the power of sight possessed by savage races. Thus, Humboldt relates that on one occasion some Indians were able, at 3.7 geographical miles' distance, to discern a man who had just ascended the cone of a mountain, quicker than he could with the aid of a telescope. Stanley too speaks of savages who could see better with the naked eye than he could himself with a good telescope. Kotelmann likewise reports that some elephant-hunters in East Africa often saw antelopes at a long distance off that he could not distinguish with a telescope.

Cohn has paid especial attention to this phenomenon and has both collected the observations of others, and himself made investigations as to keenness of vision in savages and in civilised peoples. According to him the keenness of sight among savage tribes does not very much exceed that of civilised peoples, for among 238 persons of the former category whom he tested 90 % were abnormally keen of sight, and among 2,620 persons of the latter category, tested out in the open air in clear daylight, there was also a percentage of 90 abnormally keen of vision. The cause of the superior power of vision alleged to be possessed by uncivilised races is more likely due to the alertness and power of observation that life in the open has developed in them to so high a degree of perfection. I have not myself been in a position to make any exact observations for the comparison of civilised with uncivilised people respecting keen-sightedness, but from my experience in other fields of investigation I have formed a definite impression that the superior sight of the latter must be due partly to their greater keenness of sight, partly to their extraordinary powers of observation.

As a young man I spent two summers botanising in the northernmost mountain regions of Sweden, and for some weeks on each occasion consorted daily with Laps. I had then the opportunity of observing truly marvellous exhibitions of their keen sight. For example, they could often detect the smoke from a Lap tent at an incredible distance off. Once, I recollect, they declared that they could see a reindeer herd on an expanse of snow on a far distant mountain-side. On looking in the direction in which they pointed, I could only discern (and I am possessed of a power of vision rather above the normal) a dark patch on the snow at the spot indicated, and it was only by gazing at the patch for a long time and noticing ultimately that it had moved, that I could satisfy myself that their statement must be correct. This circumstance can only be explained by the fact that their faculty of vision was far superior to mine.

But I also saw many cases of an unusual power of observation amid natural scenery. I will here only adduce one instance. We had once been encamped for a week on the shores of Lake Virijaur, out of which the Great Lule River takes its rise. At about 20 kilometres' distance from our tent there grew a small variety of sedge-grass (Carex bicolor), only three habitats for which were then known to exist on the Scandinavian Peninsula. I was naturally very eager to find and examine this rare plant, but none of the five Laps I had with me had any local knowledge at all of the district. It was absolutely unknown to them for they had never been in that part of Lapland before. Nor had I the least conception as to what the appearance of the plant was like. One of my followers, however, met a Lap who had some years before acted as guide to another botanist who visited the place where the plant grew, and he received from him a description of the locality. He then described the way there to yet another Lap, who did duty as my guide. We had to proceed through an absolutely desert mountainous tract of country without the least trace of any road or path. After walking along for some hours — without either compass or map — we came down on to a hillside sloping towards a lake. Suddenly the Lap dropped his staff on the ground and called out: "The plant is to be found here"; and, sure enough, on looking down, I saw thousands of specimens of it growing all over a space of ground about half an acre in extent.

I do not consider at all that this special power of vision or observation is due to any originally existing superiority in uncivilised races;

on the contrary I have the impression that this superiority of theirs is due to a general sharpening of their senses induced by their open-air life rather than to any advantage they possess at birth. I have several times observed that members of the Swedish race who live in distant parts and are compelled by circumstances to spend a great deal of time in the open air, are furnished with just the same keen powers of observation regarding objects and scenes in Nature. Of this I will only briefly give one example. Some years ago I went an excursion to a certain mountain peak noted for its fine view, that is situated in an extensive forest near the Norrland Coast but far away from the cultivated regions. The way there was by bad roads to a dairy-farm at the foot of the mountain, from which the ascent began. On descending again, we took another path with the intention of arriving towards evening at an old, disused iron-works, situated in the heart of the forest. About 5 kilometres from the said iron-works the little path we had been following terminated at a solitary homestead. It was therefore much to be desired that we should secure a guide for the rest of the way, but at the time there was only one woman on the farm and she did not think she could leave home. She was, however, kind enough to describe the route to us, doing so in the following way: "Walk on now for 10 minutes in this direction. You will then come to a brook. At one place there is a bridge across the brook". (In parenthesis it may be remarked that the bridge turned out to consist only of the trunk of a tree.) "Look well about you there, for yesterday a couple of women crossed the bridge and went on to the iron-works. Follow their footsteps and you are bound to get there all right".

Many of us have read about the Red Indians' wonderful power of following a track consisting of footsteps only. It seemed to that woman, belonging to the Swedish race, such a natural thing to be able to do so, that she could not doubt for a moment but that we should easily be able to find our way from her description. We, on the other hand, had actually the greatest difficulty and only reached our destination with the aid of maps and compasses after wandering about for many hours in rough and broken country. It is as a contrast to such cases of a highly developed sense of sight or keen powers of observation, that one ought to estimate the frequently occurring diminution in the keenness of vision of short-sighted persons and their clumsy awkwardness when face to face with external nature. Here too open-air life has a beneficial effect, training and sharpening the eyesight, thereby proving of great use to all in view of the activity of their future lives.

Objection might be raised to my investigations as to short-sightedness at the Djursholm and Lundsberg schools, inasmuch as they were made at small schools, so that accidental conditions might prevail and have a bearing on the result. In order, therefore, to obtain larger figures, I have collected in the following Table the whole of the results of investigations made at Djursholm school for the years 1903—8 (Spring Term) and at Lundsberg schools for the year 1908 (Autumn Term). By this means I obtain a total number of 1033 pupils tested. For comparison I have included in the Table both the testings for short-sightedness in 10 schools in Sweden in 1883—4 by KEY, mentioned above, and also the official statistics for short-sightedness for all the State secondary schools for boys for 1905.

Table VII.

Percentages of Short-Sightedness at 10 Secondary Schools for Boys in Sweden, 1883, at all the State Secondary Schools for Boys in Sweden in 1905, at Djursholm Secondary School in 1903—1908 and at Lundsberg School in 1908.

School Class	Ten Secondary (Boys') Schools 1883—4	All State Secondary (Boys') Schools 1905	Secondary Schools: Djursholm 1903—8, Lundsberg 1908
1st	16.4	4.4	0.3
2nd	13.6	5.0	1.5
3rd	17.7	6.7	2.3
4th	18.5	7.1	3.2
5th	24.2	9.5	2.4
6th	30.1	11.1	4.5
7th		15.0	9.7
8th	42.1	15.9	9.3
9th		10.7	
Total	23.2	8.9	3.5
Number tested	3,054	21,425	1,033

The figures for short-sightedness in the 10 schools in 1883—4 yield the lowest average which at that time was obtained by exact methods in Sweden. All other testings give a far higher result (cf. Table I). The difference nevertheless between these figures and those for 1905 is exceedingly great. And yet Djursholm and Lundsberg schools show still lower figures. This shows that we possess powerful means for counteracting myopia at school. But we ought not to limit our efforts only to improving school buildings. We must also reform the methods of work at school and choose the subjects and the methods of teaching so as to suit the capabilities of those who are growing up under our charge. Lastly, and not least important, we should give the children, during their leisure hours, plenty of opportunities to know "the wild joys of living" and to indulge to the full their healthy instinct to be out at play and to make merry with only the sky of heaven above them.

An Investigation Respecting the Influence of School-Work on Bodily Development

by

Dr. C. O. Elfström.

Introduction.

A leading idea in the planning and carrying out of the investigation reported upon in this paper, has been to endeavour to preclude the personal opinions of the medical officer engaged in the work from exercising any influence on the results obtained. To accomplish this end the following scheme was adopted: Two series of investigations, identical in method, were pursued parallel to each other, one dealing with boys attending school and the other with boys of the same ages employed in industrial work, doing that is to say healthy manual labour, definitely regulated as to amount. The results were then compared and conclusions were drawn. This mode of procedure is calculated to enable one to form an objective idea as to whether schoolwork and the kind of life that schoolboys lead can be shown to have any influence differing from that exercised by healthy, open-air life and work on lads and youths in the period of growth and development.

In order to find a sufficiently large and easily accessible number of suitable specimens of humanity for experimenting upon, resort was had to sawmills, where some of the hands are youths in their teens. It may be pointed out that, save for the differences in the kind of work they are employed in and their surroundings while carrying it on, these lads may very well be compared with boys at school. For instance, just as the would-be schoolboy, before gaining admission, must bring evidence to show that he is not afflicted with any illness or physical defect that will prevent him from taking advantage of the education imparted, so the lad who desires to enrol himself as a factory or mill hand must be able to prove that there is no reason to suppose that owing to any inherent disease or bodily debility he is liable to injury from undertaking the type of work in question.[1] Again, the working-hours of both categories are definitely prescribed, and annual medical examinations are obligatory for the one as for the other, to the end

[1] Pursuant to the Stipulations of the Workmen's Protection Act, Sweden.

that any injurious effects resulting from the work they are doing may be detected betimes, so that those suffering from them may in some way or other be exempted from continued exposure to those injurious effects, either by having a reduction of work granted them or by being given some other description of employment. Thus, disregarding such differences as may be due to the variety of the homes in which they live, it is evident that the only factors of their lives that differentiate the two categories, schoolboys and sawmill youths, one from the other, are the character of their work and the circumstances under which it is carried on: in the one case a sedentary, indoor, mental type of work, and in the other a healthy, manual form of labour, pursued in the open air or in premises to which sun and wind continuously have free access.

It should not, however, be forgotten that schoolwork occupies those engaged in it for only three quarters of the year,[1] and that a number of physical exercise subjects, such as gymnastics, fencing, and singing, are included in the curriculum, taking the place to some extent of manual labour; a young workman, on the other hand, does not participate in regular and obligatory holidays, nor does he have any sedentary occupations as a counterpart, so to say, to the physical exercises of the schoolboys. In addition to the differences mentioned above there is, therefore, this, that whereas schoolboys enjoy a regular alternation between work and rest or recreation, sawmill hands pursue their daily round of toil with unbroken uniformity throughout the year, and, furthermore, schoolwork proper is varied by the hours set aside for gymnastic and other exercises that are specially arranged to promote bodily health and strength.

The investigation has embraced boys and youths ranging in age from twelve to eighteen. Of schoolboys there might have been included both younger, of nine, ten, and eleven years of age, and older, of nineteen and twenty; that was not possible, however, as regards sawmill hands, for it is only very exceptionally that boys under twelve are allowed to enter a sawmill, and when they reach the age of eighteen the obligatory medical inspection ceases, and consequently the making of such investigations as the present becomes impracticable. The total number of youths examined was 925, of whom 316 were schoolboys and 609 sawmill hands.

In the Table and the Charts stating and illustrating the results of the investigation, the mill hands are classified in two groups, Category I[2] and Category II.[3] The reason for this sub-division is as follows: Lest the carrying out of so considerable an investigation of sawmill hands might give rise to inconvenience both to employers and workmen at the mills, where the examination was to take place in conjunction

[1] The school-year in Swedish secondary schools has a total length of 273 days.
[2] Prospective Sawmill Youths.
[3] Sawmill Youths in Employment.

with the prescribed annual medical inspection, and lest I might thereby be disappointed in the amount of material I required, I resolved to avail myself also of those young men that from time to time present themselves before me for medical examination in order to obtain the certificate of health that is obligatory for anyone seeking employment at a sawmill. I took it for granted that these young men, who were on the point of entering the employ of the sawmills, and who for the most part came from working-class homes and in some cases had already had experience of sawmill work elsewhere, would afford pretty much the same material for study as those youths who were actually at work in the sawmills. Another inducement for including this group was the fact that a testing of their eyesight and hearing could be much more easily accomplished in the consulting-room than in the sawmill premises. These considerations led to my examining all the young men who applied to me during the spring of 1910 for the health-certificates spoken of, the results being summarised with the idea of their being incorporated with those of the sawmill hands proper. So soon, however, as the working up of the statistics began in earnest, it appeared that there were certain points of difference between these two groups, which made it desirable to keep them separate one from the other. Of course one might have excluded the figures for those who were seeking admission at the sawmills, they not being, strictly speaking, sawmill hands, having indeed save in exceptional cases done no manual labour as yet. That course was not adopted, however, for two reasons: firstly, the statistics we possess for the sight and hearing of the working classes are largely based on the figures for this group, and, secondly, there appeared to be indications that this group was to be looked on as occupying an intermediate position in some respects between the sawmill hands proper and the schoolboys, a circumstance that promised to be of interest in the interpretation of the differences existing between the groups.

A detailed description of the execution of the inquiry will not be of any service, and so I pass it over. The measuring and weighing were done throughout with the same tape and weighing-machine, so that the results, which in many particulars proved to be rather awkward to obtain, might be as exact as possible. It should be mentioned in advance that the examination took place: of the schoolboys in January 1910, of the prospective sawmill hands, Category I, in the spring and summer, and of the sawmill hands proper, Category II, in the summer of the same year; that difference of date must be remembered when a comparison is drawn between the series of figures given below.

The result of the investigation I have drawn up in two sections. Of these the first contains the figures of the weights and measurements and the conclusions that a study of them suggests, while the second, under the heading of Bodily Constitution, deals with diseases, defects, injuries, and the conclusions to be formed from a consideration of them.

To render the reporting of the results of the investigation easier, the chief figures obtained have been put down in tabular form along with the averages and differences derivable therefrom. Any particular figure in the Table may easily be found with the aid of the number of the row. By 12, 13, and 14-year olds on the Tables and Charts are to be understood those boys who became 12, 13, and 14 respectively in 1910, irrespective of their ages at the date of the examination. This point too is of importance when a survey of the results is taken. Of course from being examined at the beginning of the year, instead of towards or at the middle of it, the schoolboys are relatively disadvantageously placed, the sawmill hands proper, on the other hand, being best off, they being presumably the most fully developed at the time of the examination.

The graphical method of representing the series of figures and averages adduced in Sections I and II of the Table has been resorted to, a series of curves being plotted out in the well-known and approved manner; these are to be found in charts I—X.

Part I.

Comparative Bodily Measurements of Schoolboys and Sawmill Youths.

In Chart I there are given the average increases in height, in width of chest and in weight respectively, that are yielded by a comparison of the figures for the representatives of each year in each of the three classes — schoolboys, millhands Categories I and II — separately; the average increases are registered for each year and for the period as a whole. The mode of representation is by straight lines parallel to each other and to the base line, on which the scale is marked off; the lines themselves are marked off according to the scale.

Thus, the left-hand end-points of the lines show the average height, width of chest and weight respectively at the first stage of the investigation, i. e. for those boys who were in their 12th year; the marks at intervals along the lines show the corresponding measurements at each subsequent stage during the period covered by the investigation, i. e. for the boys in their 13th etc. year, the right-hand end-points finally indicating the measurements at the closing stage of the investigation, i. e, for youths of 18; the whole length of the line gives the total increase.

On Charts II, III, and IV the three dimensions here dealt with are combined for each group for purposes of comparison, this being effected in the following way: The respective curves are thought of as being at the same starting-point (Origo), at the first stage. On one of the rectangular coordinates of this point, the horizontal one, there are set off the years of the period, and on the other, the vertical one, the annual increase in height, width of chest and weight (according to a scale: 1 c. m. = 1 kilogr.). The respective curves have then been obtained by using the coordinates thus determined of seven different points on the curve of each dimension.

On Charts V, VI, and VII the several dimensions (height, width of chest and weight) of the three groups are given separately for purposes of comparison with each other.

On Charts VIII, IX, and X each two of these three dimensions are combined together and shown for each group in comparison with the other two groups.

Sections I and II on the Tables, giving figures, on the one hand, for the calculated average height, width of chest, and weight respectively (Lines I, II, III) of each group of youths examined for each year of the period under review, and on the other, for the calculated increase per year (Lines IV, V, VI), prove that the total increase of the schoolboys in all the dimensions concerned is greater than that of either of the other two groups. This fact is clearly illustrated by the lines marked in on Chart I.

With reference to the mode of increase, it will be found, from the series of figures in the Lines last mentioned (IV, V, VI) and from the corresponding divisions of the height, width-of-chest, and weight curves, respectively (Chart II) that the increase in schoolboys is uneven, being now slower, during the 12th, 13th, 15th, and 17th years, now faster, during the 14th and 16th years, and that the total increase during the two years last mentioned is more them half the total increase, i. e. exceeds the increase attained during the other four years taken together; moreover, the variation between faster and slower increase is uniform and proportional in all the dimensions concerned.

As regards the millhands, Category I, the increase that is so marked in the schoolboys in their 14th and 16th years, is only noticeable on the height-curve in both those years (Chart III), the width-of-chest and weight curves only marking considerable increase in the 16th year. The total increase during the two years in question, when the increase is greatest, amounts in the height-curve to more than half the total increase for the six years but in the other two curves to less.

As regards Category II, the type of development appearing in the schoolboy curve is nowhere reproduced, save in so far as the increase in the 14th year is for all dimensions somewhat more marked. The total increase in those two years when the increase is greatest does not in any case attain to half the total increase for this group.

Respecting width of chest in Category II, the abnormally small increase in the 17th year is striking. What it is due to cannot be determined from any observations made during the examination. It is probable that I dropped upon a group of youths for that year of age, which was either preponderatingly made up of delicate individuals or else contained certain specially feeble members as regards physique.

The conditions as registered for the other dimensions do not, however, bear out this theory, they being normal. Another noteworthy point is the small number of sawmill hands in the 18-year old group. It may, of course, be assumed that perhaps as many as half of the youths completing their 18th year in 1910 had already done so by the date at which my investigation took place, and so escaped being examined, the obligatory inspection ceasing at the age of 18; there ought nevertheless, one would conclude, to have been a proportionately large number of 18-year olds to the 17-year olds, i. e. about 40 instead of only 23. Possibly the fact is to be explained as due to emigration.

Chart II, on which the three dimensions are combined for the sake of comparison, displays the uniform and simultaneous variations in the rate of development of the schoolboys; the same amounts of rise and fall are seen to recur on all the curves at the same points with but insignificant divergencies. On Charts III and IV, giving the corresponding curves for the mill hands, this parallelism is not so pronounced; an examination of the curves shows that the weight-curves approach straight lines, which must mean that the increase in weight attained by the mill hands proceeds far more uniformly then is the case with the schoolboys.

If one looks at Charts V, VI, and VII, where the corresponding dimensions of the three groups are placed side by side, viz. height of body curves on Chart V, width of chest curves on Chart VI, and weight curves on Chart VII, one notices that the three height and the three weight curves coincide from time to time, or at any rate intersect here and there. That is not so with the width of chest curves, inasmuch as the curve for the schoolboys never coincides with or intersects those for the other groups, running throughout the period above them. This shows that the schoolboys possess a superiority in this particular of width of chest over the other groups, entirely independent of the two other measurements. The coinciding or intersecting of the three curves for height and of those for weight occurs, as may be seen from the Chart, principally in the earlier part of the period; this denotes that the development is uniform and equivalent for the three groups at the beginning of the period; from the 14th year onwards, however, a divergence sets in, the schoolboy curve rising more steeply than those for the two groups of mill hands. The width of chest curve, too, for the schoolboys, which at first runs only a trifle above those of the other two groups, augments its distance from the other curves after the 14th year.

As may be seen from Charts VIII, IX, and X, in which two dimensions from each group are compared simultaneously with each other, the development after all turns out to be markedly regular, in spite of the apparent dissimilarity in the curves dealt with before. So great, indeed, is the regularity, that there seems a justification for assuming that the curves on Charts VII and IX are regular ones, probably of parabolic character, while those on Chart X approximate to straight lines. On a scrutiny of the details of these curves one perceives very clearly how pronouncedly superior the schoolboys are to the mill hands. This superiority may be stated as consisting of the following points: Subsequent to his 14th birthday the schoolboy develops more rapidly and vigorously in all three measurements here noticed than does the mill hand; he is, besides, better proportioned throughout the growing period, having a greater width of chest and greater weight in proportion to his height than the mill hand, and also greater width of chest in proportion to his weight than the mill hand. The line of a schoolboy's development, therefore, as it appears in these curves, is straighter and tends more upwards to the upper airs, where a higher and wider outlook, in a literal sense, obtains, while the line of development of the mill hand, with its shorter radius of curvature and less elevation, keeps nearer the earth.

In the description of the portion of the investigation now concluded, little has been said about the mutual relationship of the two mill hand Categories as regards development. In comparing the results for all three together, one cannot fail to notice that Category I occupies an intermediary position between the other two; in many cases the curves for Category II follow the rises and falls of the schoolboy curves with unmistakeable parallelsim though they keep on the level of the curves for Category I, meandering across its path and finishing up at about the same height. The explanation of this is probably to be sought in the fact of Category I being constituted of elements drawn from both schoolboys and mill hands proper — presumably mostly from the latter, since their figures for height coincide more closely with those of Category II than with those of the schoolboys. Category I is recruited from schoolboys who take up manual labour and from those lads who obtain employment at sawmills during their school holidays.

Summary.

From what has been stated concerning the development of the youths examined, the following conclusions may be drawn:

a) That school-work and the mode of life entailed thereby lead to a development of body that proceeds uniformly as far as the three dimensions here noticed are concerned, but unevenly as respects time, there being so to speak alternating broad and narrow year's growths. Manual labour, on the other hand seems to lead to a more even, and as regards time more uniform development of body, with year's growths of pretty much the same breadth; monotony or uniformity of work is here accompanied by uniformity of development.

b) That school-life favours the production of tall, broad-chested and well-proportioned youths, whereas those working at mills, by the time the last stage is reached, prove to be comparatively speaking short of stature and ill-proportioned in growth.

c) That schoolboys, quite independently of the other dimensions, possess a manifest superiority to the mill hands in width of chest; this can hardly be accounted for in any other way than as being a direct result of the influence exerted by the obligatory physical exercises and gymnastics upon the supple frame of the growing child.

d) That the above-stated divergencies in development are only apparent after the 14th year has been attained, except as regards width of chest; by that age the mill hand has definitely left school, and so the respective influences of the types of work begin to tell on the representatives of the several groups.

Part II.

Comparative Bodily Health of Schoolboys and Sawmill Youths.

Having now given an account of the results of the measuring and weighing and of the conclusions to be drawn from them, I propose to pass on to state what observations were made during the investigation respecting the bodily constitution, the general state of health, deformities, malformations, and injuries. The statistics on these points are given on the Table, Sections III—VII, Lines 7—40.

Bodily Constitution.

In Section IV there will be found a summary with percentages of the estimate formed by eye of the bodily constitution of the youths at the date of their examination or inspection by myself. The classification was as follows: Athletic, Good, Poor, Bad (Lines 9—14). From the percentage figures it will be seen that from 12 to 14 the schoolboys and the mill hands Category II are approximately alike as regards bodily constitution, while Category I are somewhat inferior to the others. Between the ages of 15 and 18 the state of things is different, inasmuch as the percentage of schoolboys characterised as Poor or Bad is almost doubled, while those for the two groups of mill hands are a trifle lower.

The total result for the period taken as a whole is that rather more than $^1/_4$ of the schoolboys were registered as Poor or Bad, the proportion for the mill hands being rather less than $^1/_4$ of Category I and only $^1/_6$ of Category II. Schoolwork seems thus to somewhat seriously deteriorate the bodily constitution. Before arriving at any definite judgment on this matter, one should recall to mind that that part of the period that is marked by a high percentage of schoolboys with poor or bad bodily constitution, is also characterised in the same group by an exceptionally rapid bodily development; these two facts should undoubtedly be taken in conjunction with each other. Experience shows, as we know, that boys who are growing fast frequently present during this period an angular and badly proportioned appearance, which is apt to give the impression of an unsatisfactory bodily constitution, but that, when the tissues and humours of the body have again become normal, the boys turn out to be of quite a different bodily constitution. That this is of importance in the present case would seem to be very probable, and this supposition is confirmed not only by the fact, that all trace of stagnation or retrogression in bodily development is wanting in the corresponding sections of the development curves previously drawn out, but also by the circumstance that at the 18th year, when a decrease in rapidity of development becomes apparent, the percentage of those registered as poor or bad in bodily constitution rapidly sinks to the same level as that of the mill hands Categories I and II. If schoolwork had caused a really essential deterioration in the bodily constitution of the boys, then 18 year-olds, who as a rule of course have been longest subject to the specific school influences, would naturally display a percentage of poor and bad specimens greater than, or at least nearly as great as, that registered for the youths in the other parts of the period; but this is not the case.

It may thus be deduced from the examination carried out that schoolwork has an enfeebling effect upon the bodily constitution during certain years of the boys' growth, but that this deterioration towards the conclusion of the growing-period turns out to have been only apparent and evanescent in character.

Statistics respecting Freedom from Defect or Disease.

A statement of the numbers of those youths for whom in the report of the investigation there is no notification as to illness or defects of any sort, i. e. youths sound in health and limb, will be found in Section V on the Table, Line 15, while on Line 16 some percentages are given. It appears from the figures last mentioned that the proportion of schoolboys in the earlier portion of the period who are quite sound in health and limb amounts to $^2/_5$ of those examined, that of the mill hands Category I is $^1/_2$, and that of Category II is $^2/_3$. During the later part of the period the conditions as regards the schoolboys are 10 % worse, Category I 15 %, and Category II 20 %. The final result for the whole period is that only $^1/_3$ of the schoolboys, $^2/_5$ of Category I and $^1/_2$ of Category II showed "a clean bill of health". If we eliminate Category II, for whom the statistics are not equally full, by reason of the testing of their sight and hearing having been incompletely accomplished, and if we assume that the percentage of immunity from disease and defect may be represented by the figures for Category I, we discover that the divergence between schoolboys and mill hands only amounts to 5 %, which may fairly be considered to be covered by possible errors or miscalculations in the investigation, which is the more reasonable from the fact that the state of health of schoolboys, owing to the annual inspections to which they are subjected, cannot but be better known than that of mill hands, who were only once examined by myself.

From what has been stated it thus appears that the percentage of those who are sound in health and limb, both among mill hands and schoolboys, amounts to about 33, and that in this respect there is no great difference between the two groups.

Illnesses, Deformities, Malformations, Injuries.

Before passing on to a statement respecting illnesses, injuries, etc., I may be permitted to point out that I have included not only all those existing at the time of the examination, but also some complaints already cured, such as poliomyelitis, rickets, and diseases leading to operations, such as appendicitis, effusions in the pleural sac, rupture. etc., whenever traces of these diseases having been had were apparent in one form or another, or when information was forthcoming of their occurrence.

A summary of all the illnesses met with during the investigation will be found entered on the Table, Line 7, the cases of deformity, injury and malformation being given on Line 8. On Lines 17—20 will be found statistics of sick and deformed youths and also some percentages. From these figures it is evident that the numbers of the illnesses recorded and the percentages of those suffering from disease and of those deformed, injured or maimed, are higher for the schoolboys than for the mill hands. Seeing, however, as above pointed out, that the numbers of those who were sound in health and limb are about the same for both groups, this circumstance leads to the supposition that more schoolboys than mill hands were both diseased and deformed or injured. School-life would thus seem to be less healthy than work at a saw-mill. Since a return of all reported cases of illness and deformity would be of little interest, I confine myself to such affections as present a possibility of a real comparison being drawn between them in regard to frequency of occurrence.

Consumption. See Lines 21, 22, 23. This disease was encountered in the course of the investigation almost equally frequently among schoolboys and the mill hands proper, Category II. The largest number of cases relatively was found among Category I. Of all the youths examined there were 1.2 % that proved to be suffering from lung phthisis, discoverable clinically. The percentage of tubercular disease present in some other organ, either then or at an earlier period, turned out to be about the same. Thus the total percentage of tuberculous youths of all those examined was 2.27, which was approximately the same as for the scholboys alone, 2.22. So far as one can see from this investigation the percentage for tuberculosis does not seem to be influenced in any appreciable degree by schoolwork.

Rickets. This disease, which attacks children in early life, is due to unsuitable diet. It often leaves behind it traces of its ravages in the form of permanent deformities in the anatomy, such as narrow chest, curvature of spine, legs etc. The cases of this disease that have been recorded here (See Lines 24, 25 on the Table) only comprise narrowness of chest. Other deformities, very possibly also due to rickets, are recorded under other headings, such as crooked back, flat-footedness, etc. The figures here given cannot therefore be considered as giving the actual number of rachitic cases; on the other hand they are probably tolerably reliable for the proportionate prevalence of rickets in the respective groups. The infrequent occurrence of the complaint among the schoolboys should not of course be ascribed to any influence the school exerts, for this disease, as above stated, is one of early childhood, over and done with long since when the child begins attending school, save for certain ill effects that it not infrequently leaves behind it. The percentages on the other hand may very fairly be regarded as indicating the character of the homes from which the children come.

Chlorosis. This disease shares with Bright's disease, to judge by the results of this investigation, the premier place among complaints affecting the young. It is principally a schoolboy illness, as the figures show (See Lines 26, 27 on the Table). The percentages for schoolboys and mill hands Category II are uniform throughout, but the former are about three times as large as the latter. This disproportion in frequency between schoolboys and mill hands Category II makes it clear that the disease is one fostered by schoolwork much more than by manual labour. The fact of the percentage remaining uniform for each group seems to denote on the other hand that the boys who were free from this complaint on commencing their work were not as a general thing liable to incur it under the influence of the work they were set to do. The conclusion to be drawn is surely that chlorosis only appears in those youths in whom there existed an inherent predisposition to the disease which they brought with them to school or mill, but which their work has brought to light. The probability of the disease making itself felt is much greater with schoolboys, among whom a very slight tendency will probably be sufficient to induce an attack in the course of the years spent at school, whereas with the mill hands the tendency must be fairly pronounced for risk of an attack to be serious. Again, we seem entitled to assert that those who lack all predisposition to the complaint are not likely to fall with it whether they are at school or in a mill.

Bright's Disease. Seeing that the occurrence and degree of severity of this disease in the youths subjected to examination could be more objectively studied than was the case with any of the other diseases above mentioned, it is deserving of special attention. Its presence is recorded on the Table (Lines 28, 29, 30), now by the epithet "traces", when an analysis of the urine actually yielded evidence of it, and now by in "considerable quantity", when a strong reaction immediately set in.

An examination of the figures given on the Table for this disease yields the following results:

a) That albumen is present in the urine about equally often in both groups of youths, schoolboys and mill hands Category II; it occurs with less frequency in Category I, who at the time they were examined were not engaged in work.

b) That the frequency of the occurrence of albumen in the urine is considerably greater in the later part of the period than in the earlier.

c) That the occurrence of albumen in the urine, in respect to quantity, leads to the conclusion that manual labour tends to increase the amount much more than does schoolwork; the figures show that in schoolboys albumen is present just as often in small quantity ("traces") as it is in large ("in considerable quantity"), whereas the ratio for Category II is 1:3, instead of 1:1.

On the strength of the results of the testings for albumen in the urine, one might thus be justified in drawing the conclusions that labour, whether mental or manual, more readily gives rise to albumen in the urine than unemployment; that albumen occurs as often in those engaged in mental as in manual labour; that the quantity is increased more by manual than by mental work.

Among the defects registered at the investigation, *Short-Sightedness* is naturally the one to which attention is first directed, it having long been recognised as a defect concomitant with schoolwork. For the figures see Table, Lines 31, 32. The present investigation by no means belies this belief, for while short-sightedness very seldom occurs in the saw-mill hands, it makes its appearance in 6 % of the schoolboys in the earlier part of the period, and in 10 % of them in the later.

Impaired Hearing (See Lines 33, 34). To judge by this inquiry this is a very common complaint, yet more often met with among mill hands than among schoolboys.

Curvature of Back. This is the defect that was most often come across in the progress of the present inquiry. It occurred in 127 cases in all, i. e. in 14 % of the youths examined. The figures entered on the Table, Lines 35, 36, show: That it occurs twice as often among schoolboys as it does among mill hands Category II; that it is about as frequent in the earlier as in the later part of the period.

Thus, curvature of back seems distinctly to be a schoolboy complaint and, like chlorosis, which it closely resembles both in percentage and prevalence, it makes its appeatance at an early stage among those afflicted with a tendency to it. Youths possessed of an adequate power of resistance to the tendency during the first few years at school, do not appear, to judge by the percentages for the two parts of the period, to be affected in this direction by a continuation of their schoolwork.

Flat-Footedness. This failing also proved to be of frequent occurrence among those I examined. In certain respects it is the obverse of curvature of back. Thus, it characterises mill hands preponderatingly and it increases in frequency. With schoolboys it is hardly noticeable in the earlier part of the period, but here, as with the mill hands, the cases are more numerous among the older boys.

Injuries. The number of injuries met with in the course of the inquiry (See Table, Lines 39, 40) is relatively small; strangely enough they are more numerous among schoolboys than among mill hands in employment, Category II. For Category I the figures are about the same as for schoolboys. We may apparently draw the conclusion, even from the limited statistics here adduced, that the measures adopted in this country for safeguarding workmen while engaged in their employment work in a thoroughly satisfactory manner.

Summary.

From what has been stated above respecting bodily constitution, diseases, deformities, and injuries, it may be considered as proved:

a) That during certain years schoolwork is attended with a palpable, but probably only an apparent and transient, weakening of the bodily constitution.

b) That about 33 % of those examined were registered as free from illness and defects, and that the percentage of those sound in health and limb is about the same in schoolboys and mill hands.

c) That the percentages recorded of invalid and maimed youths, and also those of diseases and defects, are greater for the schoolboys than for the mill hands. Hence school-life must be considered less healthy than life at the saw-mills.

d) That the diseases and defects specially affecting schoolboys are chlorosis, curvature of back, and short-sightedness; that flat-footedness, on the other hand, is characteristic for mill hands.

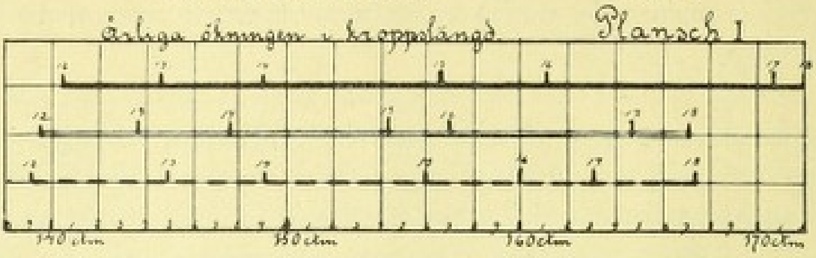
e) That in schoolboys the occurrence of or freedom from chlorosis or curvature of back is dependent upon whether they had an inherent tendency to either of those complaints when they entered the school; that a continuance of work does not seem to affect these diseases markedly, whereas with short-sightedness and flat-footedness it does, they being both acquired and intensified as a result of the work done.

f) That schoolwork and manual labour predispose in equal degree the youths engaged in them to albumen in the urine; that manual labour, however, tends to increase the quantity of albumen more than mental work.

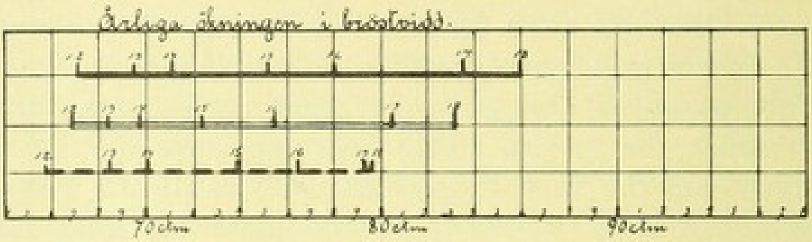
g) That the measures adopted in this country to insure adequate protection for workpeople while they are at work appear to be effective and satisfactory.

The comparative study of the health conditions of boys attending a secondary school and of youths engaged in sawmill work, of the results of which I have above rendered an account, shows in the main that the differences prevailing between the two groups as regards development of the body, general health, etc., actually arise and become marked at a period when the boys have got beyond the age for leaving a primary school, i. e. 14 years; any divergencies noticeable previously being insignificant. This state of things is in itself perfectly natural and contributes to render the results of this inquiry more reliable, for all the boys examined for the first stages, irrespective of the group to which they belonged, had been subject to pretty much the same influences, on the one hand at the secondary, on the other at the primary school, between which, as far as this matter goes, there is but little to choose. In one particular, however, the width of chest, a distinct difference could be pointed to even in the early part of the period; in the schoolboys this measurement showed more advantageously from the very first stage, and remained so throughout. The explanation of this must be sought, as already suggested, in the obligatory physical exercises prescribed for secondary schoolboys, especially gymnastics; at the primary schools the gymnastics, if I am rightly informed, are not carried on so energetically or under such favourable conditions as regards premises and apparatus, as is the case at the secondary ones. If the observation here made should prove to be confirmed on further investigation, it would seem to deserve considerable attention, for supposing Swedish gymnastics are capable of producing a pronounced and permanent widening of the chest, its importance as a factor in physical development must be regarded as very great. It is undoubtedly the case that a widening of the chest will bring about a number of other physiological effects of importance for the bracing up of the constitution and for the preservation of the health, such as a facilitation of the breathing-process, an improvement of the circulation, etc.

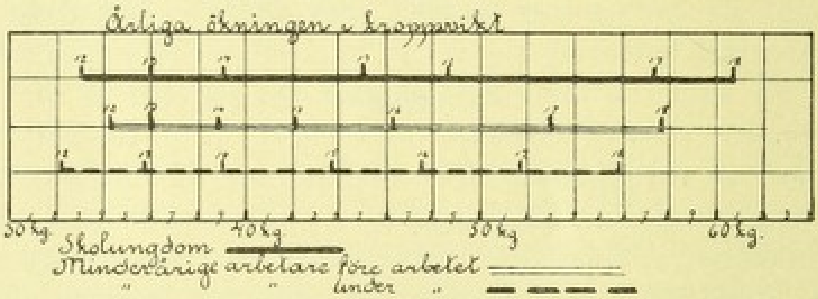
Annual increase in height Chart I



Annual increase in measurement of chest



Annual increase in weight

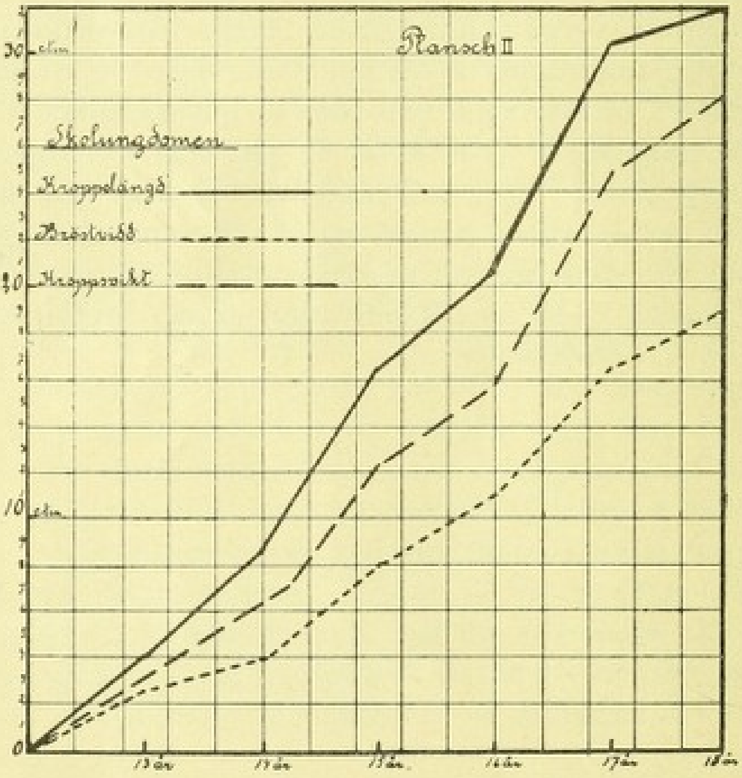


Schoolboys

Prospective Mill-hand Youths

Mill-hand Youths in Employment

Chart II



Schoolboys

Height

Chest measurement

Weight

13th year, etc.

Chart III

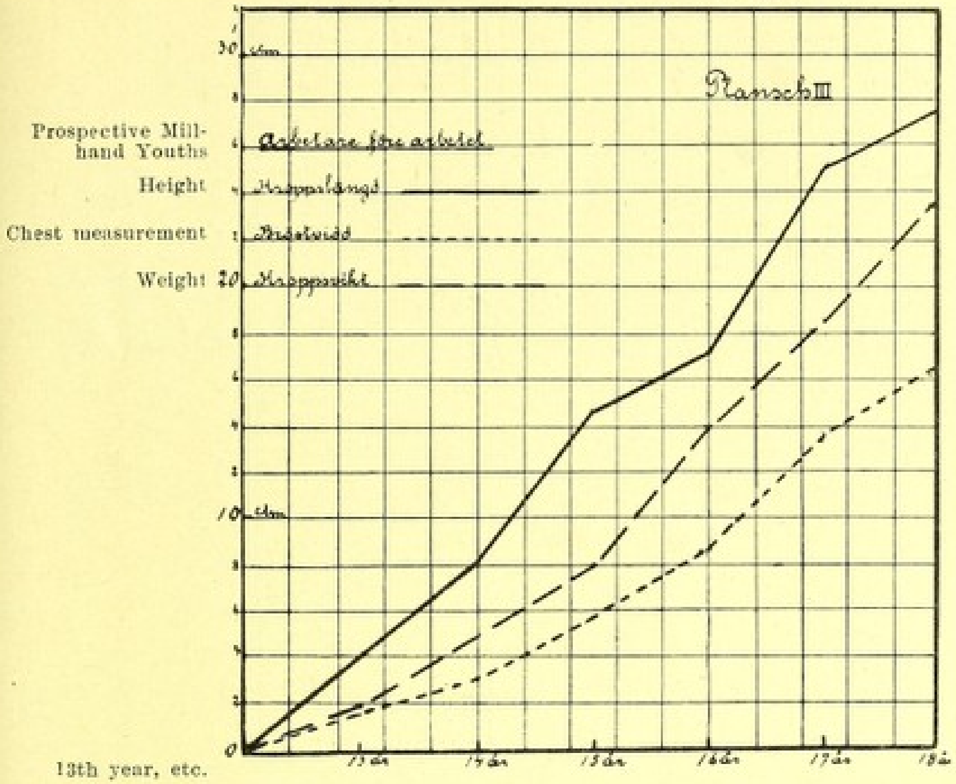


Chart IV

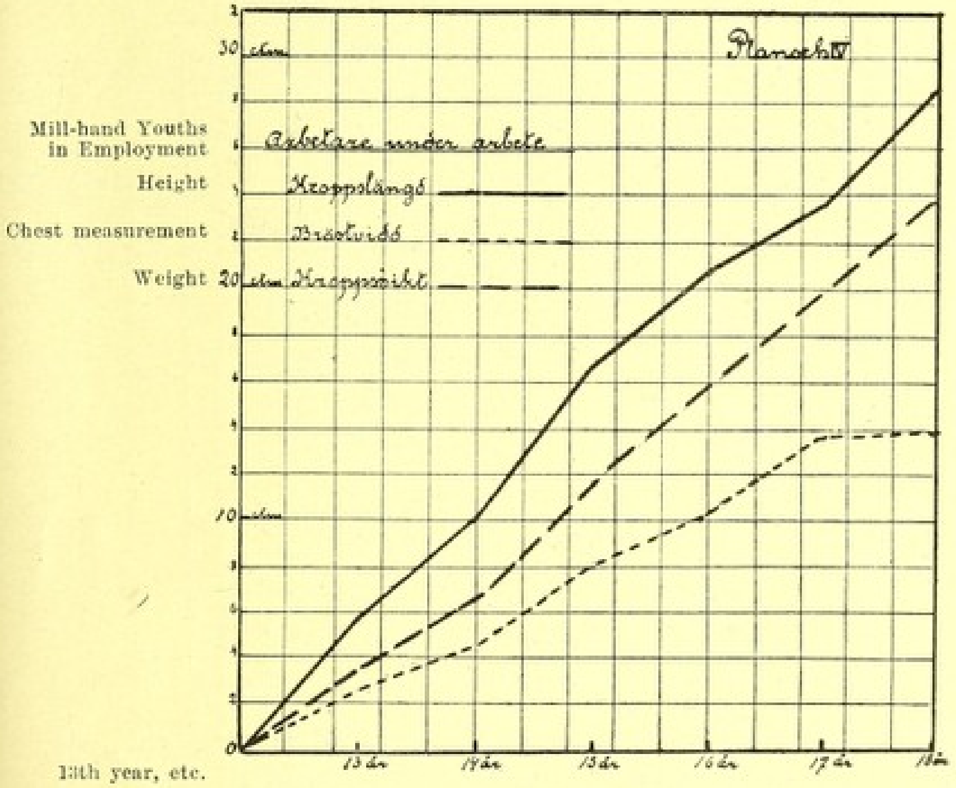
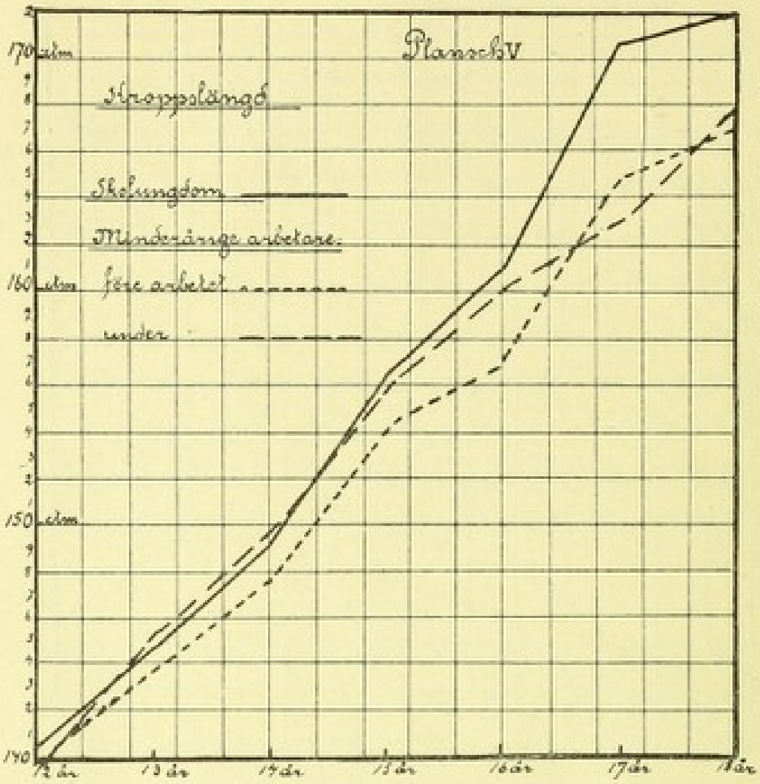


Chart V



Height

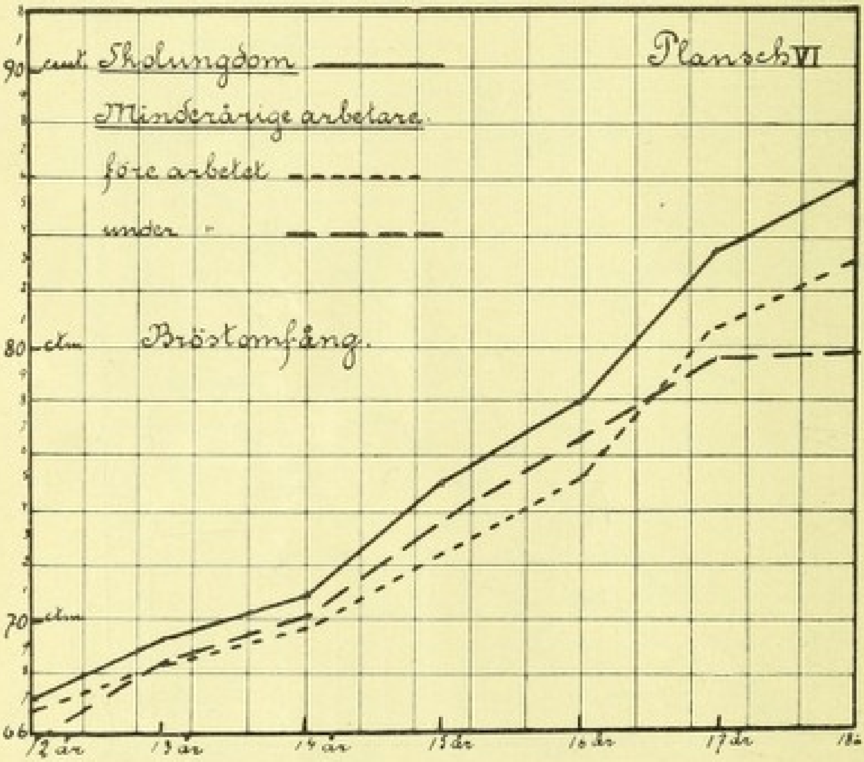
Schoolboys

Prospective Mill-hand Youths

Mill-hand Youths in Employment

12th year, etc.

Chart VI



Schoolboys

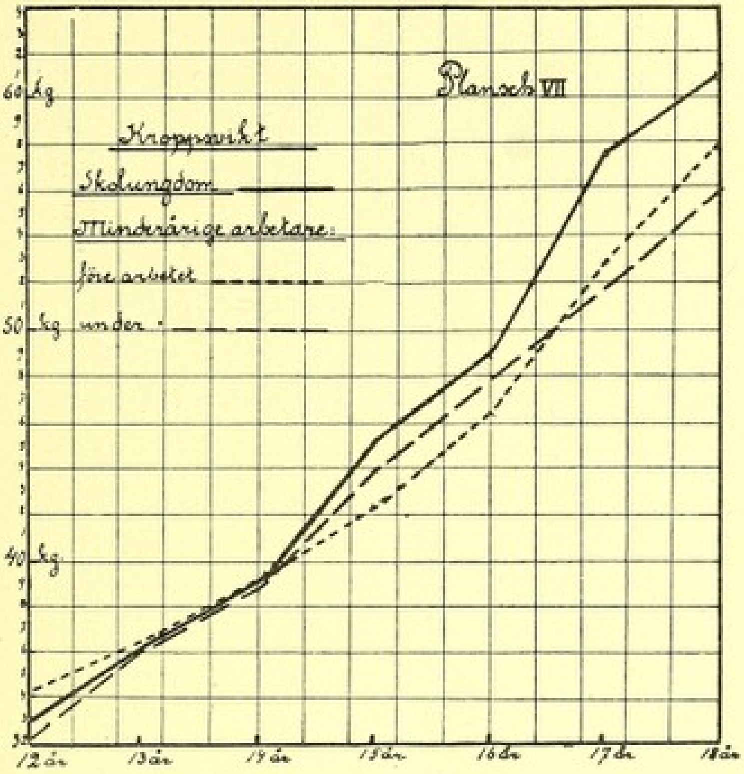
Prospective Mill-hand Youths

Mill-hand Youths in Employment

Chest measurement

12th year, etc.

Chart VII



Weight

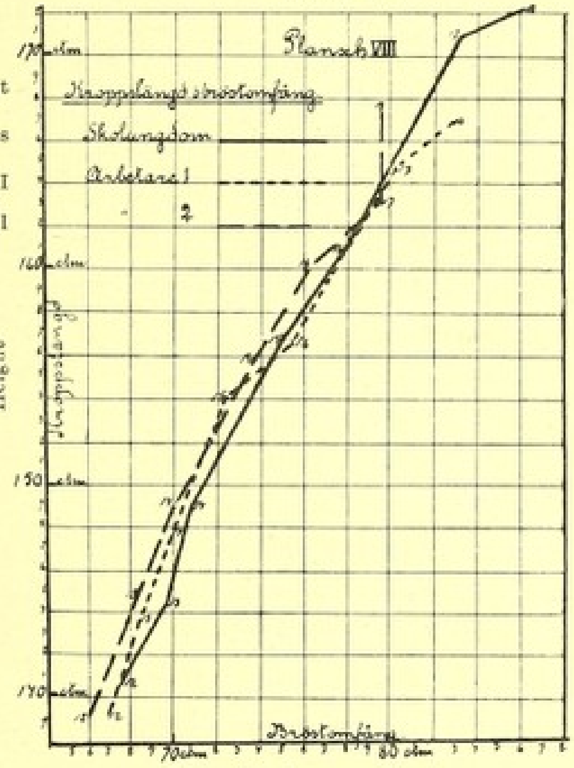
Schoolboys

Prospective Mill-hand Youths

Mill-hand Youths in Employment

12th year, etc.

Chart VIII



Height and chest-measurement

Schoolboys

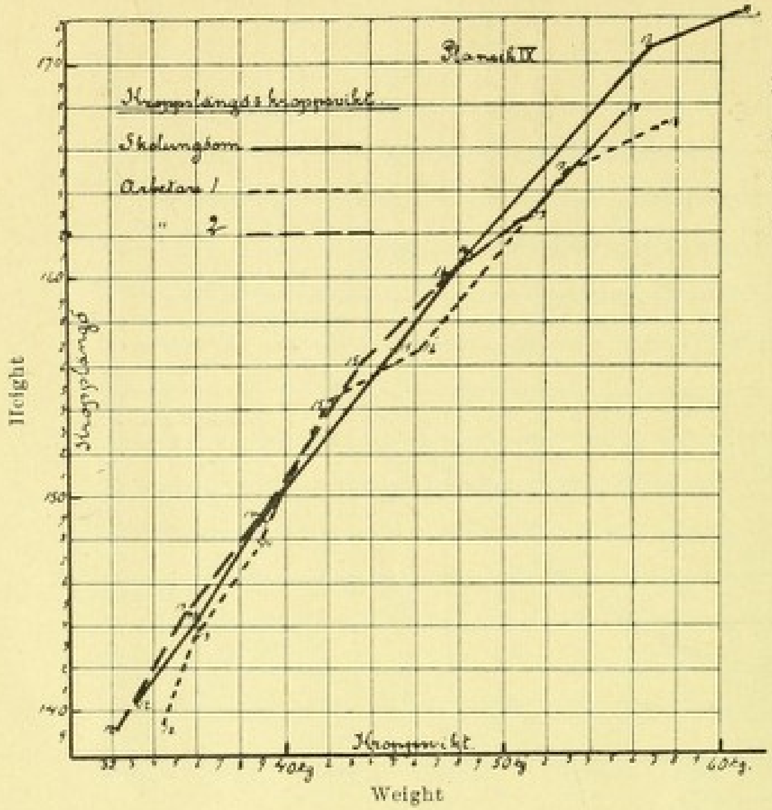
Mill-hand Youths, Category I

Mill-hand Youths, Category II

Height

Chest measurement

Chart IX



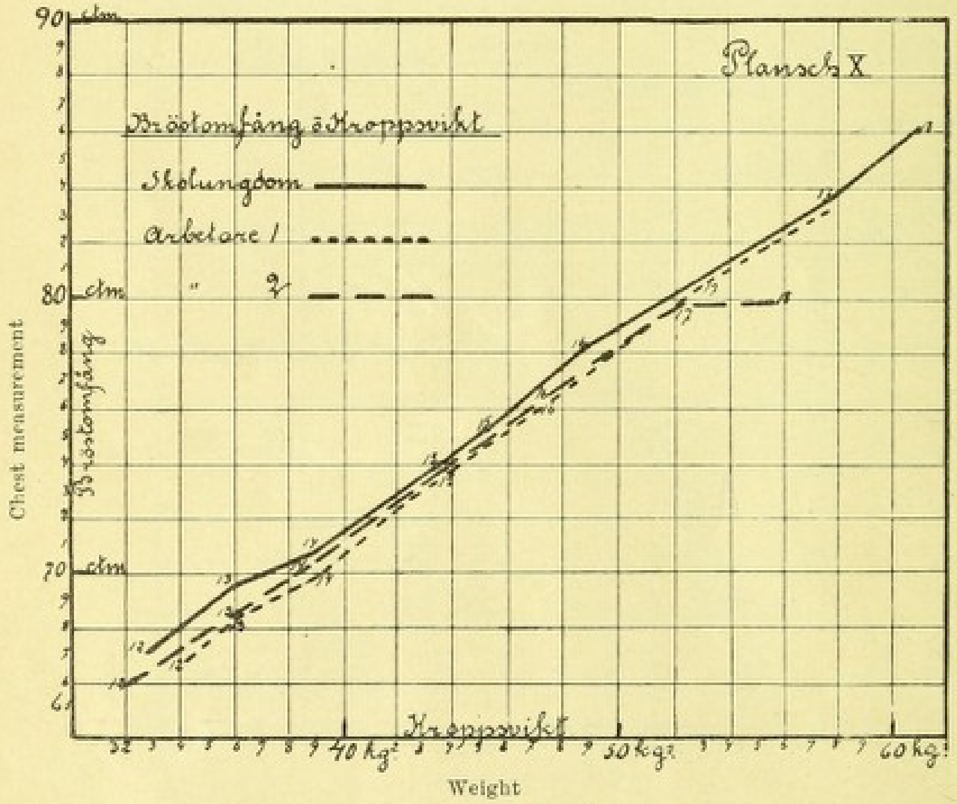
Height and weight

Schoolboys

Mill-hand Youths, Category

Mill-hand Youths, Category II

Chart X



Chest measurement and weight

Schoolboys

Mill-hand Youths, Category I

Mill-hand Youths, Category II

Tables Illustrating Dr. C. O. Elfström's

Comparative Investigation of the Physical Development of Schoolboys and Sawmill Youths

	12-year-olds			13-year-olds			14-year-olds			Total 12-14-year-olds		
	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II
Numbers Examined	37	9	14	48	23	68	55	24	79			
I												
1. Average Height (centimetres)	140,35	139,56	139,21	144,48	143,72	144,86	149,02	147,76	149,16			
2. Average Chest Measurement (centimetres)	67,01	66,77	65,91	69,41	68,23	68,27	70,85	69,72	70,11			
3. Average Weight	32,89	34,22	32,15	36,02	36,06	35,76	38,84	38,88	38,77			
II												
4. Increase in Average Height after 12th year		Origo		4,13	4,16	5,65	8,67	8,20	9,95			
5. Increase in Average Chest Measurement after 12th year		Origo		2,40	1,46	2,36	3,84	2,95	4,20			
6. Increase in Average Weight after 12th year		Origo		3,13	1,84	3,61	5,95	4,66	6,62			
III												
7. Total Number of Cases registered of Illness	12	6	1	25	7	12	25	6	19			
8. " " " " " of Bodily Defects, Injuries, Malformations	14	4	3	17	6	12	28	12	26			
IV												
9. Bodily Constitution: Athletic	—	—	—	1	1	4	1	—	7	2	1	11
10. " Good	31	7	12	35	16	52	47	17	52	113	40	116
11. " Poor	6	2	2	11	6	12	6	6	20	23	14	34
12. " Bad	—	—	—	1	—	—	1	1	—	2	1	—
13. % Athletic and Good										82 %	75 %	80 %
14. % Poor and Bad										18 %	25 %	20 %
V												
15. Total Number Free from Disease and Bodily Defect	18	3	11	16	14	49	23	10	43	57	27	103
16. % Free from Disease and Bodily Defect										41 %	48 %	64 %
17. Total Number Invalids	10	4	2	22	5	14	19	6	18	51	15	34
18. % Invalids										36 %	27 %	21 %
19. Total Number Maimed, Injured, Deformed	14	3	1	14	6	8	21	8	22	49	17	31
20. % Maimed, Injured, Deformed										35 %	30 %	19 %
VI												
21. Total Number Phthisical	—	1	—	—	—	—	1	1	—	1	2	—
22. Total Number Tuberculous in Other Organs	1	—	—	—	—	—	1	—	—	2	—	—
23. % Tuberculous												
24. Total Number Rachitic	—	1	—	3	1	2	—	—	1	3	2	3
25. % Rachitic												
26. Total Number Chlorotic	7	1	1	11	—	3	5	2	8	23	3	12
27. % Chlorotic										16 %	5 %	7 %
28. Total Number with Traces of Bright's Disease	2	1	—	2	—	1	3	—	1	7	1	2
29. Total Number with Considerable Albuminuria	—	1	—	—	1	4	2	—	4	2	2	8
30. % with Bright's Disease										6 %	5 %	6 %
VII												
31. Total Number Short-Sighted	4	—	—	1	—	—	4	—	1	9	—	1
32. % Short-Sighted										6 %	—	
33. Total Number Deaf	—	1	—	3	2	—	5	3	—	8	6	—
34. % Deaf										6 %	11 %	
35. Total Number with Curved Spine	8	1	1	7	3	3	11	5	9	26	9	13
36. % with Curved Spine										19 %	16 %	8 %
37. Total Number Flat-footed	—	—	—	—	1	3	—	1	8	—	2	11
38. % Flat-footed											4 %	6 %
39. Total Number Injured	—	—	—	1	—	—	2	2	—	3	2	—
40. % Injured												

	15-year-olds			16-year-olds			17-year-olds			18-year-olds			Total 15-18-year-olds			Grand Total		
	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II	School-boys	Sawmill Youths Category I	Sawmill Youths Category II
Numbers Examined	60	28	114	40	17	99	52	21	81	24	9	23				316	131	478
I																		
1. Average Height (centimetres)	156,61	154,23	155,93	161,05	156,76	160,05	170,83	164,71	163,12	172,00	167,10	167,50				155,60	153,03	155,39
2. Average Chest Measurement (centimetres)	75,13	72,48	73,83	77,97	75,42	76,24	83,56	80,53	79,64	85,93	83,05	79,72				75,15	73,23	73,96
3. Average Weight	45,12	42,21	43,76	48,75	46,24	47,60	57,54	52,90	51,88	60,80	57,56	55,73				44,90	43,25	44,18
II																		
4. Increase in Average Height after 12th year	16,26	14,67	16,72	20,70	17,20	20,84	30,48	25,15	23,91	31,65	27,54	28,29						
5. Increase in Average Chest Measurement after 12th year	8,12	5,71	7,92	10,96	8,65	10,33	16,55	13,76	13,73	18,92	16,28	13,81						
6. Increase in Average Weight after 12th year	12,23	7,99	11,55	15,86	12,02	15,45	24,70	18,68	19,73	27,91	23,34	23,58						
III																		
7. Total Number of Cases registered of Illness	24	17	44	21	12	37	48	10	29	11	3	11				166	61	153
8. " " " " " of Bodily Defects, Injuries, Malformations	38	20	42	21	11	36	31	19	35	16	4	14				165	76	168
IV																		
9. Bodily Constitution: Athletic	2	2	6	1	1	10	5	3	18	4	1	4	12	7	38	14	8	49
10. " Good	39	15	85	24	14	76	24	15	59	16	7	16	103	51	236	216	91	352
11. " Poor	17	10	22	14	2	13	22	3	4	4	1	3	57	16	42	80	30	76
12. " Bad	2	1	1	1	—	—	1	—	—	—	—	—	4	1	1	6	2	1
13. % Athletic and Good													65 %	77 %	86 %	73 %	76 %	84 %
14. % Poor and Bad													35 %	23 %	14 %	27 %	24 %	16 %
V																		
15. Total Number Free from Disease and Bodily Defect	17	7	52	16	4	49	10	8	32	10	6	10	53	25	143	110	52	246
16. % Free from Disease and Bodily Defect													30 %	33 %	45 %	35 %	40 %	51 %
17. Total Number Invalids	23	10	38	18	8	31	30	7	27	8	3	8	79	28	104	130	43	138
18. % Invalids													45 %	37 %	33 %	41 %	33 %	29 %
19. Total Number Maimed, Injured, Deformed	30	16	35	19	7	33	27	12	31	10	2	9	86	37	108	135	54	139
20. % Maimed, Injured, Deformed													49 %	49 %	34 %	44 %	41 %	29 %
VI																		
21. Total Number Phthisical	—	1	1	1	1	2	—	1	—	—	—	—	1	3	4	2	5	4
22. Total Number Tuberculous in Other Organs	—	—	2	—	—	—	3	2	—	—	—	—	3	2	3	5	2	3
23. % Tuberculous													2 %	7 %	2 %	2 %	5 %	1,5 %
24. Total Number Rachitic	—	1	7	—	1	3	1	—	—	—	—	3	1	2	18	4	4	21
25. % Rachitic																1 %	3 %	4,5 %
26. Total Number Chlorotic	4	6	7	9	2	9	15	3	2	2	1	2	30	12	20	53	15	32
27. % Chlorotic													17 %	16 %	6 %	17 %	11 %	7 %
28. Total Number with Traces of Bright's Disease	6	1	4	1	1	5	5	1	3	1	—	1	13	3	13	20	4	15
29. Total Number with Considerable Albuminuria	3	1	12	1	1	8	10	—	11	4	1	4	18	3	35	20	5	43
30. % with Bright's Disease													18 %	8 %	15 %	13 %	7 %	12 %
VII																		
31. Total Number Short-Sighted	8	1	—	3	—	1	5	—	—	2	—	—	18	1	1	27	1	2
32. % Short-Sighted													10 %			8,5 %		
33. Total Number Deaf	2	4	1	1	1	1	1	1	—	—	—	1	4	6	3	12	12	3
34. % Deaf																4 %	8 %	—
35. Total Number with Curved Spine	7	5	13	5	6	10	10	6	7	5	1	4	27	18	34	53	27	47
36. % with Curved Spine													19 %	24 %	11 %	17 %	21 %	10 %
37. Total Number Flat-footed	6	—	14	2	—	9	4	3	13	2	1	3	14	4	39	14	6	50
38. % Flat-footed													8 %	5 %	12 %	4 %	5 %	11 %
39. Total Number Injured	2	2	4	1	—	3	2	3	3	4	—	2	9	5	12	12	7	12
40. % Injured													5 %	7 %	4 %	4 %	5 %	3 %