SHOULD WE REVISE OUR IDEAS OF THE EFFECTIVENESS OF YOUTH TRAINING?

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This is a lecture given by Bengt Saltin at the Conference of the Sport Research Committee held in Bosoen, Sweden, in February 1982. It is included in the book “Child-youth sport” published by Lars-Magnus Engstrøm and Artur Forsberg and edited by Bengt Saltin. It is a survey of the studies concerning the effectiveness of physical training on children and youths. These studies are carried out to determine which of the changes in the examined subjects are due to their natural development and which ones are a consequence of training. The results of past investigations are compared to those of a more recent research undertaken by the University of Odense.

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At the end of the nineteen sixties, several articles were published in specialist publications which gave reason to believe that children at the beginning of puberty are particularly susceptible to physical training. The objective of this article is to give an overview of the existing literature in this field and to present the result of some investigations which have been conducted at the University of Odense in recent years.

In order to examine the trainability of individuals, two different methods of research are normally applied. The first one is the so-called cross-sectional study, which means that a certain number of experimental subjects of different ages are trained for a period of several weeks up to 3 or 4 months. The changes which can be observed in these investigations give reason for the assumption that they are caused only by training and that an actual developmental influence does not exist. Further, it is often (wrongly) assumed that the physical changes which a group
of young experimental subjects will possibly undergo in later years can automatically be predicted by looking at the state of physical development of a group of older experimental subjects. There are many investigations dealing with children’s and youths’ training which are based on this false assumption.

The other method of research is the longitudinal study. This means that the same individuals are observed and submitted to a training programme for a number of years. The changes which are identified by half-yearly or yearly tests are caused both by developmental influences and by training. The difficulty with the interpretation of the results of these studies is to decide which changes are caused by developmental processes and which are caused by training. In this context it is also problematic to have control groups since there is the risk that the experimental subjects are prompted to train much more than is normal for adolescents of the same age. Studies of this kind have been carried out by Ekblom, Eriksson, Kobayashi, Parizkova, Andersen, and Froberg. These investigations deal with two training forms: local muscle endurance training (Ikai and Lammert/Froberg) and general aerobic endurance training, i.e. training which improves the maximum oxygen uptake and the level of general fitness (Ekblom, Eriksson, Kobayashi, Parizkova, Weber, Andersen, and Froberg). It is typical of all these studies, with the exception of the studies by Kobayashi, Andersen/Froberg, and Lammert/Froberg, that they relate the measured changes of endurance or the maximum oxygen uptake only to the chronological age. As far as the age-group of the 10 to 16-year-olds is concerned, the relevance of these studies is doubtful since the physical development of adolescents of this age is extremely individual. For example, two 13-year-old children can be at completely different stages of development. Whereas one of them is physically completely mature, the other one has not yet reached puberty.

In the following part of this article, many results are related to the half-year in which the growth in height is the greatest (Hx).

Of the participants in an investigation on 25 boys of identical age at the end of 1975, one boy had reached puberty. Most of the other boys of the same group reached puberty in the following year, but at the beginning of 1979, 5 of the boys had not yet reached the end of puberty. If one looks at the changes which are caused by physical training and relates them to the chronological age, one comes to completely different conclusions. In a cross-sectional study, Ikai found that the training of the local endurance of the arm flexor muscles of 6 to 19-year-old adolescents led to a significant improvement of the endurance of 12-year-old children after 7 weeks. This is explained by the fact that children of this agegroup (boys as well as girls) are particularly susceptible to physical training (Lammert, 1970). This result is in accordance with the results of a long-term investigation (covering 34 months) on boys by Ekblom and a cross-sectional study (covering 4 months) by Eriksson dealing with the improvement of the maximum oxygen uptake through physical training. Further investigations, however, could not corroborate these results. Changes of the maximum oxygen uptake were examined by Weber et al. with groups
of identical twins (boys), one of the boys controlling his training brother. In this study, the authors used a mixture of cross-sectional and longitudinal research methods. They found that the changes observed in the 13-year-old twins could be regarded as purely genetically determined. Other investigations on Czech (Parizkova et al.) and Japanese children (Kobayashi) showed that with hard as well as with moderate training there was a clearly distinguishable period in which there was no increase in performance, but a decrease in maximum oxygen uptake in spite of training.

In our study we therefore tried to identify the changes of the local muscle endurance of 9 to 16-year-old boys and girls with a cross-sectional study as well as the changes of the maximum oxygen uptake of boys from the age of 10 upwards with a longitudinal study relating the results to the children’s biological age instead of to their chronological age. The measuring criteria for the biological development were the leap in growth, the tooth age, the age of the skeleton, the beginning of puberty, and the concentration of blood FSH and LH. Our article gives particular information on the variations which go hand in hand with the leap in growth. For the experimental subjects of the longitudinal study the beginning of the maximum growth in height (Hx) was determined. The results of the half-yearly measurements were then put in before or after Hx, respectively.

With a cross-sectional study it is not possible to observe the beginning of the leap in growth. On the basis of x-ray diagnosis, however, it was possible to identify the beginning of the leap in growth by examining the extent of ossification and by looking at the development of the epiphyses and diaphyses of certain bones.

This method was used in a cross-sectional study of 240 adolescents between 9 and 16 years (Lammert, Froberg). The increase in peripheral muscle endurance was measured after a training of 6 weeks. The training programme and the tests were identical with the ones used by Ikai, who, however, divided the experimental subjects according to sex and related his results to the above mentioned developmental parameters. In figure 1, the results of the investigations on the girls are shown. Contrary to Ikai’s results, the slightest increases in muscle endurance were measured with the 13-year-olds (chronological age). In connection with the tooth age there was also a period in which the increase in muscle endurance was only slight. This happened at the age of 15 1/2. Since the increases were related to the biological age (as identified by x-rays of the bones of the forearm), no periods of reduced muscle endurance could be observed. The boys showed almost the same development as the girls (figure 2), but they also showed a marked period of reduced increase in muscle endurance in connection with the biological age. As far as the boys are concerned, the results which are related to the chronological age are not identical with Ikai’s results. It seems that there is also a period of reduced trainability. In figure 3, the improvement of muscle endurance has been related to the determined beginning of the leap in growth. It can clearly be seen that with the boys the influence of training 1/2 year before the leap in growth is only small. A corresponding period can be noticed with the girls when the leap in growth occurs. These periods of reduced traina-
Fig. 1 - The relative increase in the local muscle endurance of girls after 7 weeks of training related to the chronological age, tooth age, and biological age.

Fig. 2 - The same parameters as in figure 1 measured with boys in a cross-sectional study.
Fig. 3 - The relative increase in muscle endurance related to the maximum growth in height.

Fig. 4 - The observed leap in the growth in height is presented as a criterion of the relative percentage changes of the maximum oxygen uptake. The values of group 3 (control group) represent 100%. It is obvious that group 1 shows greater percentage changes than groups 2 and 3.
Fig. 5 - The percentage differences in the level of fitness between group 1 and 2 as compared with group 3 (= 100%) related to the observed growth in height.

Fig. 6 - The percentage changes of the mean values of the growth in weight and height of the 3 groups related to the maximum growth in height.
Fig. 7 - The average maximum oxygen uptake of the 3 groups (boys). Group 1 trained more than 7 1/2 hours per week, group 2 trained between 5 and 7 1/2 hours per week, and group 3 was physically active for less than 3 1/2 hours per week.

control group (group 3) were physically active for less than 3 1/2 hours per week, the boys of group 2 were physically active for 5 up to 7 1/2 hours per week, and the boys of group 1 trained more than 7 1/2 hours per week.

These boys were systematically trained by the staff of the University of Odense. In figure 4, the results can be seen in the form of the changes of the maximum oxygen uptake. The results are expressed as a percentage change with group 1 and 2 in relation to the control group, which represents 100%. In figure 5, the same results are shown, but here the body weight is taken into account, the maximum oxygen uptake being expressed in ml/kg x min. From figure 4 it becomes obvious that the development of the maximum oxygen uptake of the boys of group 1 starts 2 years before the leap in growth and ends 1 1/2 years after the leap in growth, the maximum oxygen uptake being 8% greater than that of the boys of the control group. This is not the case with group 2. This group shows a maximum oxygen uptake which does not differ from that of the control group. If one looks at the level of general fitness (ml/kg x min), one can see that with group 1 there is a culmination in relation to the control group 1 year before the leap in growth. With group 2, however, there is a decrease in the level of general fitness as compared with the control group 1/2 year before the increase in body weight caused by puberty. After this the curve rises again.

In figure 6, the percentage change of the groups as far as body weight and height are concerned is shown. It becomes obvious that whereas group 1
and the control group follow each other, there is no similar increase in body weight and height with group 2 during the period of 2 years before up to 1 1/2 years after the leap in growth.

In figure 7, the average maximum oxygen uptake of the 3 groups is presented in relation to the leap in growth. These 3 curves show an increase in the maximum oxygen uptake during the period before and after the leap in growth, which applies to all 3 groups. This – seen in connection with figures 4 and 5 – does not point to a changed trainability in the above mentioned period. This corresponds with the results of Weber’s investigations on twins and Parizkova’s long-term investigation on children. From figure 7 it follows that those who train the most (group 1) are able to preserve the improvement in performance and do not show any losses in the above mentioned period. This corresponds with the results of Weber’s investigations on twins and Parizkova’s long-term investigation on children. From figure 7 it follows that those who train the most (group 1) are able to preserve the improvement in performance and do not show any losses in the above mentioned period. Ekblom found in his investigation on training boys a changed proportion of height to weight as compared with a control group. This finding could not be corroborated by our investigation. Figure 6 shows quite clearly that the development of the 3 groups during the period of 2 years before up to 1 1/2 years after the leap in growth was exactly identical.

Summary

If one examines the effects of training on adolescents, one must look at the changes either in relation to the initial values or in relation to a control group. There are a number of recent investigations which have shown that in the period before and after puberty there are changes of trainability as far as local endurance is concerned. Our investigation shows that there is a decrease in the effects of training approximately 1/2 year before the beginning of the leap in growth.

There is a significant increase in the maximum oxygen uptake and the level of general fitness before and after the leap in growth, but the increase is obviously dependent on the change of dimension (general increase in growth). Furthermore, the results show that with the group of very hard training boys (more than 7 1/2 hours of training per week) there was an increase in the maximum oxygen uptake which was identical with that of the boys of the control group and the moderately training boys. The differences between the groups did not change in spite of the very intensive training of one group. A prudent interpretation of this finding is that there is not always a logical connection between the training and the observed results. It is important to point out that these conclusions are based on the analyses of change in relation to developmental stages and that the chronological age is not used as the basis of assessment since there was a temporal shift in the development of the examined boys. This could also be an explanation of the fact that the results of earlier studies (Ikai, Ekblom, Eriksson) do not correspond with the results of recent investigations (Parizkova, Weber, Kobayashi, Lammert/Froberg, Andersen/Froberg).