Differences in growth process in children aged 8–10 years practicing various sports

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Summary
Background. Knemometry is a non-invasive method of precisely determining short term changes in the lower leg length. This method is more frequently applied in many countries.
Objective. The goal of this study was to evaluate the influence of physical activity on growth process in children aged between 8 – 10 years.
Material. During 2 – years longitudinal study we measured 66 children group both sexes. The experimental group consisted of children who were active in gymnastics or swimming. The control group consisted of children not routinely engaged in sport activities.
Methods. Knemometry measurements were collected every two weeks except on winter and summer holydays.
Results. The highest growth dynamic was observed in control females ($\overline{x}$ = 0,47 mm/week) and the lowest in the group of the female gymnasts ($\overline{x}$ = 0,39 mm/week). There were no statistically significant differences in the average body height in children from the entire tested group.
Conclusions. The main conclusion is that the intense and type of physical activity differ growth process of the lower leg in girls aged from 8 to 10 years.
Key words: knemometry, growth, children

INTRODUCTION

Human growth is a very complicated process. Anthropometers or stadiometers have most frequently been used to evaluate the kinetics and dynamics of growth during anthropological studies. Studies by means of these devices are most frequently conducted every six or twelve months. This period is shortened to three or one month during some studies. On the basis of the studies conducted at the Fels Institute which were done as part of the Health Examination Survey carried out in the United States of America, Malina et al. [1] have reported that the margin of the measurement error ranges from 0.2 to 0.5 cm. Therefore, some authors suggest that the frequency of measurements lower than six months is futile because one cannot detect increments smaller than 0.5 - 1 cm with the use of a stadiometer [2]. In their paper, Hermanussen and Burmeister [3] have reported, however, that a period of intermission between measurements shorter than one month is too short because the margin of the measurement error exceeds the size of increments.

The traditional method applied during studies focusing on the process of growth in children and teenagers cause that many crucial changes happening during this process are overlooked because their duration is shorter than the period between measurements. Measurement techniques have been gradually perfected so that measurements are more frequent and accurate.

In 1983, the prototype of a device measuring the length of the lower leg was constructed to an accuracy of 0.01 mm with a technical error of 0.09 - 0.16 mm [4, 5]. The lower leg was chosen as the body part for measurements because it is accessible, there are few joints and because of the fact that it is the growth of long bones that mainly influences the size of increments. Besides, these measurements are non-invasive and can be repeated many times. This method has been called knemometry from the Greek word „*knkmh*" which means the lower leg.

Knemometry is a method that is more and more frequently applied in many European countries and the U.S.A. so as to determine short-term changes in the dynamics of growth in children and adolescents. This method is often applied during researches in the field of endocrinology [6, 7 and others].

The designing of the mini-knemometer, which was described for the first time by Michaelsen et al. [8], made it possible to extend the range of research to new-born babies and children up to the age of three. Some studies have also involved children born prematurely as well as those with low birth weights [9, 10; 11; 12; 13 and others].

Many papers have dealt with the problem of the influence of steroid drugs administered against various forms of allergy [14; 15; 16; 17 and others].

In Poland, knemometers have also been used to evaluate the differences in growth rates observed in children who are diversified in terms of the level of their physical activity [18; 19; 20]

The purpose of this study was to evaluate the influence of diverse physical activities on the process of growth in children aged between 8 and 10. We analyzed the course of the growth process in boys and girls who practiced swimming or gymnastics as well as the growth process in children who did not practice sports on a regular basis.

MATERIAL AND METHODS

The measurements taken in a group of children of both sexes aged between 8 and 10 years have provided material for this paper. The mean age on the day of the beginning of the study amounted to 7.7 years and it was 9.7 years at the end of it. The study was conducted from January 2002 till January 2004. The measurements were started in January and they involved the children whose parents gave informed consent to their children's participation in the research.

The experimental group comprised the children who practiced gymnastics or swimming at the TS „Wisła" Sports Club in Kraków. Those sports had been selected because of the inherent diversity of static and dynamic workloads affecting the locomotor system and also the different environments wherein body movements were performed. All the children frequented the same primary school in Krakow. The children's sport-related activities, which were organized by their school, lasted from 7 hrs 30 min to 11 hrs 15 min every week (number of the training hours depended on the sports results achieved by a given child). Additionally, some children took part in sports competitions, training camps and extracurricular physical fitness activities.

The control group comprised children of the same age who attended the same school but they did not practice sports so intensely. The number of hours of physical activities in this group amounted to 2 hrs 15 min. Additionally, some of those children were involved in extracurricular physical fitness activities.

All in all, there were 66 subjects in the examined group of children including: 12 girl gymnasts, 23 swimmers (17 boys and 6 girls) and there were 31 subjects in the control group (20 boys and 11 girls).

The study involved anthropometrical measurements and knemometric measurements. Anthropometrical procedures were performed every three months. During the two years of this study, nine series of measurements were taken.

Knemometric measurements were performed every two weeks at the same time of the day. It was only between the end of June and the end of August and during the first half of February that the study was not conducted because of summer holidays and winter breaks. The measurements were taken by means of a knemometer.

Five measurements of the lower leg length were taken in every child on every occasion. Every child performed several movements to loosen lower limb muscles between those measurements. The lowest and highest measurement readings were discarded and the remaining three gave an average that constituted the correct result of the measurement. During the two years of this study 33 series of knemometric measurements were taken. The number of measurement series in every child during the entire cycle of the study was different because none of those children participated in all those measurements. Fewer than 10 series of measurements were taken only in 3 children and 20 series were taken in 19 subjects. The greatest number of children (44) participated in 21 to 31 series of those measurements.

A survey questionnaire was addressed to the children's parents in order to obtain additional information because the lengthening of long bones is influenced by various factors such as: the history of diseases, growth hormone, life style, and nutrition. The questionnaire contained questions concerning: the previous diseases, medications administered, life style, nutrition, parents' education, social and economic status of the family that the child came from.

RESEARCH RESULTS

A technical error of the knemometer is defined as the average standard deviation of a series of independent measurements [21]. During the study described here, the margin of this error amounted to 0.17 mm.

The analysis of the data derived from the survey questionnaire allowed to evaluate the background the tested children came from and the conditions under which their development took place. No differences were observed in the economical and social status between the families of the children from the control groups and those from the sports groups.

Figure One presents the average body height of children from the individual groups at the beginning and at the end of the research. The average body height in the three groups that were formed at the beginning of the study was the lowest in the boys from the control group ($\overline{x}$ = 124.1 ± 5.8), and it was the highest in the case of the boy swimmers ($\overline{x}$ = 127.5 ± 5.0). In January 2004, the lowest average body height was found in the girl gymnasts ($\overline{x}$ = 134.7 ± 7.6) and it was the highest in the case of the girl swimmers ($\overline{x}$ = 138.9 ± 7.9). No statistically significant differences in the average body height were found in children from the entire tested group either at the beginning or at the end of the study. Intake into classes with an extended curriculum of physical education at the school that the tested children frequented was conducted on the basis of a positive opinion, issued by a sports physician, with no contraindications against sports practice. Neither body height nor body mass were the traits that determined the admission of the children to a sports class. This eliminated the selection to a given sport and it allowed to observe the changes in the process of growth that resulted from the sport those children practiced. The smallest change in body height was observed in the girl gymnasts after two years of the study (9.5 cm).

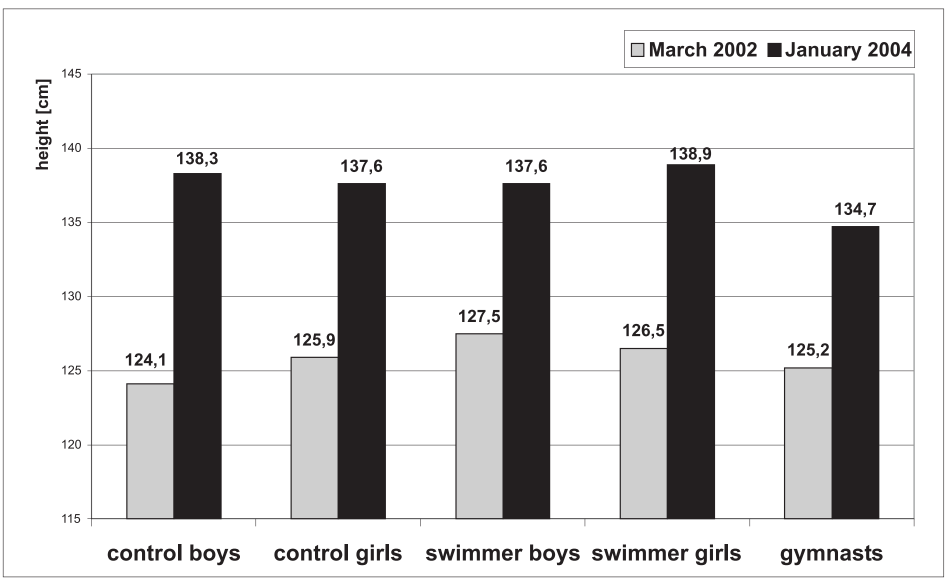

Fig. 1. Average body height of children from the individual groups at the beginning and at the end of the study

Tab. 1. Average size of increments in the lower leg length per week (mm/ week)

group	n	$\overline{x}$	s	min	max	M
control boys	20	0,42	0,30	0,34	0,50	0,42
control girls	11	0,47	0,39	0,37	0,58	0,48
swimmer boys	17	0,42	0,32	0,36	0,58	0,40
swimmer girls	6	0,44	0,29	0,35	0,57	0,42
gymnasts	12	0,39	0,25	0,35	0,45	0,41
all children	66	0,43	0,31	0,34	0,58	0,38

The changes in the lower leg length, measured by means of a knemometer are presented in Figure Two. The last knemometric measurement was taken in December 2003. At the beginning of this research, the highest mean value of the lower leg length occurred in the boys who practiced swimming ($\overline{x}$ = 392.1 mm ± 19.9) and the lowest one in the case of the boys from the control group ($\overline{x}$ = 378.9 mm ± 21.1). At the end of the measurements, the boys from the control group had the highest mean value of the lower leg length ($\overline{x}$ = 436.8 mm ± 22.4), whereas the lowest value was observed in the girl gymnasts ($\overline{x}$ = 421.6 mm ± 27.6).

The mean size of increments in the lower leg per week was calculated for each group (Table 1). Those measurements were taken every two weeks. However, due to illnesses and school excursions, the period between the tests occasionally amounted to three weeks and even to 15 weeks during summer holidays. Therefore, the size of increments between the consecutive tests was calculated by dividing them by the number of weeks. Thus, the size of increments per week was obtained. The greatest increment in the lower leg length per week amounted to 0.47 mm per week in the girls from the control group and the lowest one, 0.39 mm per week, in the group of the girl gymnasts. The mean size of increment in the lower leg length amounted to 0.43 mm per week for the entire group. The mean values in the five separated groups differ from each other in a statistically significant way (F = 2.79) at a significance level of α = 0.05. Duncan's test revealed significant statistic differences between the control group of girls and the control group of boys as well as between the control group of girls and the group of the girl gymnasts. (see Tab. 1.)

Fig. 2. Average lower leg length in the individual groups at the beginning and at the end of the study

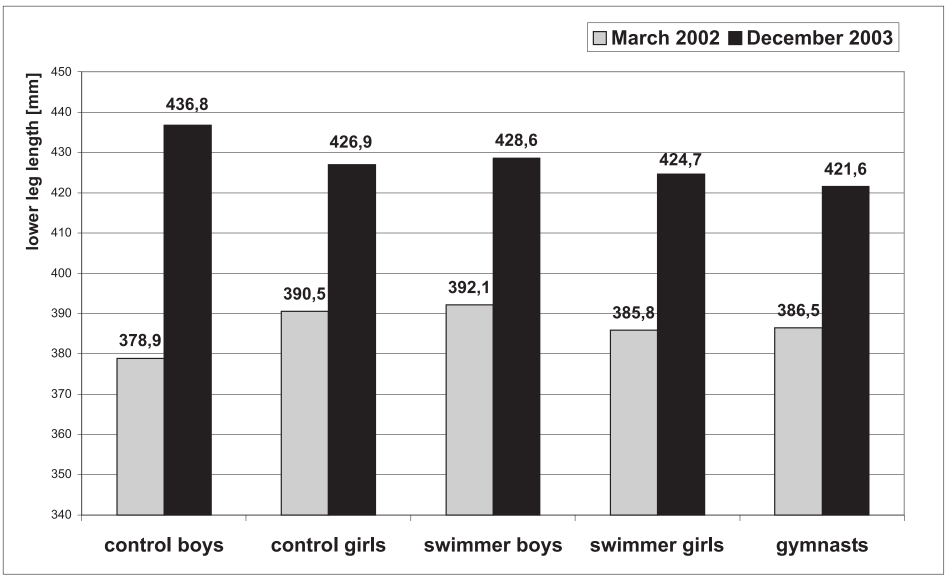

Fig. 3. Percentage distribution of the size of increments in the lower leg length (average per week)

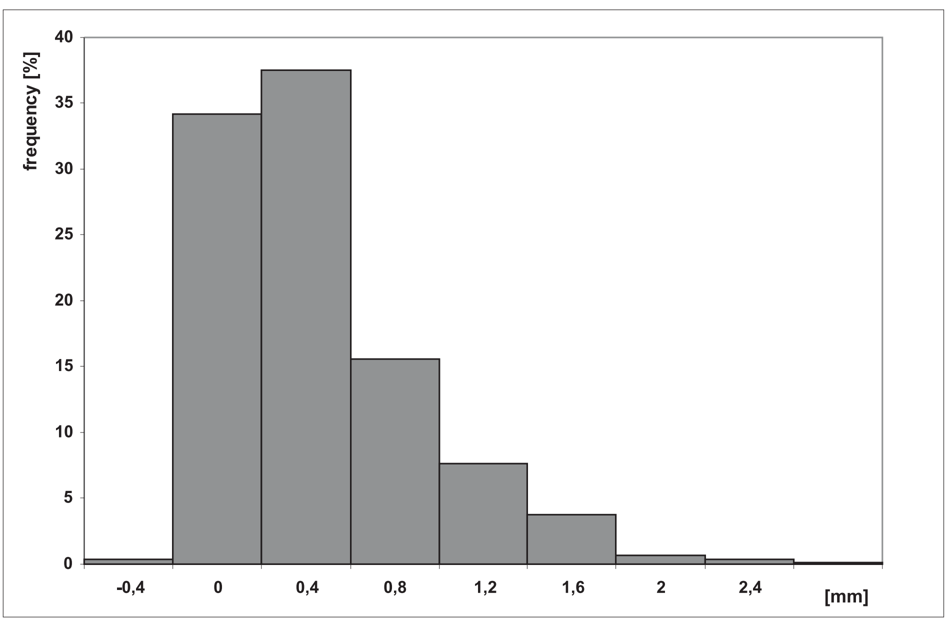

Figure Three presents a percentage distribution of the size of increments per week. The increments from 0.25 to 0.60 mm per week occurred most frequently in about 38% of cases. Given the fact that the size of an increment is influenced by the margin of the technical error, it is assumed that every increment in the lower leg length that is greater than the double value of the technical error is a real increment in the lower leg length [18]. Since the margin of the technical error during the research in question amounted to 0.17 mm, it should be assumed that every increment of more than 0.34 mm was a real increment.

The value of measurements is influenced not only by technical errors but by the thickness of soft tissues surrounding the knee joint as well. This may lead to „negative increments". They are not caused by decreases in the size of bones between measurements but by a decrease in the size of soft tissues. It is very difficult to determine the proportion of soft tissues during knemometric measurements. However, it can be assumed that they are responsible for the changes in the lower leg length proportionally to negative increments [18]. Measurements of the thickness of skin folds above the knee were taken throughout the period of this study in order to observe the changes affecting the soft tissues. Their mean values were similar and they ranged from 8 to 10 mm. The increments from -0.075 to 0.25 occurred with a frequency of about 35%. This figure shows that the percentage ratio of „negative increments" ranging from about minus 0.4 to minus 0.1 is insignificant.

DISCUSSION

The results obtained require some comparisons to the literature on this subject that has already been published. First of all, one should evaluate the accuracy of the measurements taken. The technical error during the study in question amounted to 0.17 mm. During other studies, the margin of the technical error found by Valk's et al. [22] amounted to 0.09 mm, it was 0.13 mm and 0.15 mm in the studies conducted by Ahmed et al. [23, 24] or to 0.16 mm as mentioned in the paper written by Hermanussen et al. (1985 quoted after Hulanicka). During the research conducted in the city of Wrocław by Hulanicka and her team, the standard error - defined as the median of standard deviations of five or six readings of all measurements - was calculated. Its margin amounted to 0.186 mm. Since the margin of the technical error found in the analyzed studies was only slightly higher, it can be assumed that our accuracy of measurements of the lower leg length was high and the results obtained were reliable.

The size of the average increment in the lower leg length per week, which amounted to 0.43 mm per week for the entire analyzed group (s = 0.31), is described below against the background of other studies conducted in the world. During the study conducted by Ahmed et al. [23] on a group of 44 primary school children, the average weekly increment amounted to 0.39 mm per week. In the course of the research conducted by Wolthers [15], the mean size of increment of the lower leg in healthy children ranged from 0.56 to 0.43 mm per week, depending on the week of measurements.

In 1995 some tests were conducted on a group of 32 healthy children of both sexes who were aged 2.11 - 14.7 [25]. Those measurements were taken every week for a period of 8 months. The mean size of increment per week amounted to as much as 1.24 mm (s = 4.68 mm).

During the research carried out by Hulanicka et al. [18], the size of increments amounted to 0.34 mm per week (s = 0.706) in girls and it equaled 0.42 mm per week (s = 0.750) in boys. In the course of the research carried out in Krakow [19] conducted on a group of boys who practiced handball, the size of increment per week amounted to 0.45 mm per week. From what it has been said so far it is obvious that the average change in the lower leg length per week was similar in the majority of studies. The research carried out by Hermanussen is an exception wherein so large a size of increments might have been caused by the long span of the children's age range.

When analyzing the growth rate in the sports groups measured during our study, some diminished increments were observed in the group of girl gymnasts. This difference was statistically significant at the level of á = 0.05 in comparison with the control group of the girls. This indicates that the girls who practiced this sport grew slower than their coevals did. In the literature, there are very few reports dealing with the differences in growth rate of children, who practice various sports, measured by means of a knemometer. Yet, a research like this was carried out at a school in Krakow. Those measurements involved a group of 19 boys who practiced handball and 21 boys who formed a control group aged 10-11. The results were presented at the Conference of the Polish Anthropological Society, which was held in the city of Toruń in 2001 [19]. The analysis of the data did not reveal any statistically significant differences in the growth rates between the two analyzed groups: 0.45 mm per week in the sports group and 0.49 mm per week in the control group.

During the studies cited above which were conducted in Wrocław, the influence of physical activities on the growth process was analyzed. Some different forms of motor activities were distinguished on the basis of a survey questionnaire and they ranged from avoidance of motor activities of any kind to engagement in sports training sessions in spare time. An increase in physical activities, particularly in the case of the boys, was accompanied by an increase in increments in the lower leg length. The values of Spearman's correlation coefficients of ranks for 21- and 28-day increments amounted to r = 0.218 and r = 0.270 ($p<0.001$) respectively. Although those test were not conducted on children involved in sports practice, this result turned out to be an important one because it shows some correlation between intensified physical activities and growth.

In his paper Malina, [26], emphasized the influence of selection to sports on the differences present in body height of children engaged in sports practice. Damsgaard et al [27] observed some statistically significant differences in the body height of 9-13 year-old boys who practiced swimming, tennis, handball, and gymnastics. Those differences became visible as early as at the age of 2-4, long before those children began to practice sports. This proves that there exists some influence of selection to a given sport. In the same year, the results of the research conducted by Daly et al. were published [28]. On the basis of the measurements taken in 31 boys who practiced gymnastics and 50 boys from the control group, they inferred the conclusion that shorter body height in boy gymnasts was caused to a greater degree by selection to this sport rather than by the effects of their training sessions.

Theintz et al. [29] noticed that girl gymnasts were shorter than girl swimmers and also shorter than girls from the control group. At the beginning of the 1990s, the same team conducted a study on a group of 22 girl gymnasts and 21 girl swimmers [30]. They measured body height every six months for a period of 2 - 4 years. The peak height velocity in girl gymnasts was significantly lower in terms of statistics than in girl swimmers because it was at a level of á = 0.05. The authors have come to believe that the cause of these differences in peak height velocity lies both in the workload affecting the endocrine system and diet.

On the basis of their research on 232 boys who practiced gymnastics, swimming, tennis, and soccer, Baxter-Jones et al. [31] noticed that the boy gymnasts were shorter than their coevals. This difference was significant in comparison with the boy swimmers because it was at a level of á = 0.001

Undoubtedly, selection to sports has some influence on competitors' body height. However, it should be emphasized that during the enrolment to sports classes, at the school, where our measurements were conducted, body height was not a very important factor. The most important were the positive opinions issued by sports physicians and the parents' declarations that their children wanted to practice sports.

CONCLUSIONS

Our study was carried out on a group of children between their pre-school growth spurt and pubertal spurt. The group was diverse in terms of their involvement in physical activities. The analysis of the collected data led to the following conclusions:

1. The type of undertaken physical activities has different effects on the lengthening process of the lower leg in girls aged from 8 to 10 years. Girls who practice gymnastics are characterized by a slower growth rate (0.39 mm per week) than girls who practice swimming (0.44 mm per week). The highest growth rate can be observed in the girls who practice sports regularly (0.47 mm per week).
2. No differences were found in the average growth rate between the boys of this age who practiced swimming and the boys from the control group, who do not practice sports systematically (0.42 mm per week).

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