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ORIGINAL ARTICLE

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Spine: posture, mobility and pain. A longitudinal study from childhood to adolescence

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Abstract A longitudinal study was undertaken to analyse the development of posture and spinal mobility during growth and its relationship to low back pain and sports activities. A total of 90 children were examined at 5–6 years of age and re-examined at 15–16. Sagittal configuration and mobility were measured using Debrunner's kyphometer. Information about pain and activities was acquired by interview with the parents of the 5- to 6-year-olds and by a questionnaire to the 15- to 16-year-olds. Posture changed significantly during the study period: thoracic kyphosis increased by 6° and lumbar lordosis increased by 6°. The relationship between kyphosis and lordosis was independent of gender at age 5–6, but kyphosis in relation to lordosis was significantly lower in girls among the 15- to 16-year-olds. The total sagittal mobility of the spine decreased significantly during the 10-year study period: in the thoracic spine by as much as 27° and in the lumbar spine by 4°. About one-third of the children at the age of 15–16 years stated that they had occasional low back pain. This complaint was more frequent in those stating they had suffered some type of back injury, but low back pain was not related to gender, regular physical training, posture or spinal mobility. The results of the study showed that kyphosis and lordosis increased and mobility decreased in the 90 children who were examined both at age 5–6 and 15–16 years. The relationship between kyphosis and lordosis decreased in girls but not in boys. Occasional low back pain was reported by 38% of the children at the age of 15–16 years, but back pain was not related to posture, spinal mobility or physical activity.

Keywords Low back pain · Posture · Kyphosis · Children · Mobility

Introduction

Back pain is a rare complaint in pre-school children, and when it occurs it may signal a serious condition. During the first years at school, abdominal pain and headache are frequent complaints; later, at high school level, the situation changes and becomes more like that of adults, with symptoms especially from the musculoskeletal system [13, 18]. In the early teens, during the period of rapid growth, posture and sitting habits often deteriorate, making parents and gym teachers worry that the faulty posture may lead to back problems later in life [11].

Posture was previously generally believed to be important in the pathogenesis of back pain, and in many countries routine school examinations of spinal configuration were based on this assumption [10, 16]. However, there are no studies showing that physiotherapeutic intervention improves the posture and reduces related problems, and screening is justified only if some type of intervention will reduce the risk of future back problems [2, 3, 11].

The attitude to sports has recently become more "professional", and injuries and overexertion syndromes are common – even in youngsters. Whether there is an increased risk of back pain from sports activities or whether

physical training can promote health by increasing mobility and strength of the spine remain controversial issues [12, 16, 21].

The aim of this investigation was to study the alteration in kyphosis and lordosis during growth and the relationship between spinal mobility, sagittal configuration, and back and leg pain. An additional aim was to elucidate how these parameters are related to frequency and type of sport on the one hand and anthropometric measurements on the other. The hypothesis that there is a relationship between "growing pain" in pre-school age and back or leg pain in adolescence was also tested.

Materials and methods

Over a period of 1 year, every newborn baby at a selected hospital was examined by an orthopaedic surgeon in order to register all types of foot deformities and other conditions. The study population was selected out of this cohort, and comprised both a random sample of those with normal feet and those with minor foot deformities at birth.

At the age of 5–6 years, spinal mobility and posture were examined in 116 children. By the age of 15–16 years, seven of these 116 children had moved out of the area and another19 did not attend re-examination. Thus, 90 children (46 male, 44 female) were examined at 5–6 and re-examined at 15–16 years of age.

Forty-two percent of the subjects were from the random sample and 58% from those with minor foot deformities at birth. All foot deformities had been resolved by the second examination. Analysis of these two groups separately showed no difference in outcome in the studied parameters. Therefore, the results are only reported for the total material.

Examination at age 5–6 years

Information on pain and motor development was obtained by interview with either parent according to a standardized question procedure. Standing and sitting height and body weight were registered, and BMI (kg/m^2) was calculated. Range of motion in the hip, knee and talocrural joints and straight leg raising (SLR) were measured with a special ruler in supine position. Posture and spinal mobility were assessed using Debrunner's kyphometer.

Examination at age 15–16 years

Low back pain, pain in the legs knees or feet, physical activity, injuries and sports activities were assessed by a questionnaire filled in at the hospital and „checked" at the physical examination. Standing and sitting height and body weight were registered and BMI (kg/m^2) was calculated. Range of motion in the hip, knee and talocrural joints and SLR were measured using a special ruler in supine position. Posture and spinal mobility were assessed using Debrunner's kyphometer.

Debrunner's kyphometer has a protractor with a 1° scale at the end of two double parallel arms connected to two blocks [4]. To increase the range of measurement in extension, a slight modification was made. A cut-out in the frame increased the measurement range by 20° in extension [17].

Kyphosis (marked with a plus sign) was measured from a point between the spinous processes of the T2 and T3 vertebrae and from a second point between T11 and T12. Lordosis (marked with a minus sign) was similarly measured between T11 and T12 and S1 and S2. Absolute figures for the degrees of lordosis were used calculating the relationship between kyphosis and lordosis and the correlation coefficients between kyphosis and lordosis.

The neutral zero standing position was defined as the spinal posture in the erect, barefoot, standing, relaxed position. The subject was asked to look straight ahead and to stand relaxed. Sagittal range of motion was assessed separately in the thoracic and lumbar spines. Total forward bending as well as the total backward bending were recorded, and the total sagittal range of motion was calculated.

The reproducibility for measurements with this modification of Debrunner's kyphometer has been evaluated in young adults, but not in young children [9, 17]. In young adults, the reported coefficients of variation were low: 8.4%, 7.4% and 5.4% for kyphosis, lordosis, and sagittal mobility, respectively [17].

Statistical methods

Student's *t*-test of paired observations was used to analyse the difference between age 5–6 and 15–16 years in posture and spinal mobility. Linear regression was used in analysing the relationship between kyphosis and lordosis, either within or between the two age groups and also the relationship between SLR at 5–6 and at 15–16 years of age.

The chi-square test was used to ascertain the relationship between nominal variables such as pain, trauma, physical activity, type of sport and gender. Analysis of variance was used in analysing the relationship between pain and posture, spinal mobility, height and body weight.

$P<0.05$ was considered as statistically significant

Results

Posture

Posture changed significantly during the periods of growth that were studied; thoracic kyphosis increased by an average of 6° and lumbar lordosis by an average of 6° ($P<0.001$) (Table 1).

Table 1 Thoracic and lumbar spine: mean (SD) values in flexion, kyphosis, lordosis, and extension

	Thoracic spine			Lumbar spine		
	Flexion	Kyphosis	Extension	Flexion	Lordosis	Extension
Boys 5–6 yrs	55.3° (7.0°)	30.1° (8.7°)	0.0° (16.8°)	46.5° (10.7°)	–31.2° (8.6°)	–50.5° (8.9°)
Boys 15–16 yrs	50.8° (8.8°)	37.0° (8.3°)	22.5° (12.7°)	35.8° (9.3°)	–35.2° (7.9°)	–60.2° (7.8°)
Girls 5–6 yrs	52.4° (8.4°)	28.4° (9.3°)	–3.4° (16.3°)	46.9° (8.5°)	–31.6° (9.9°)	–53.0° (11.1°)
Girls 15–16 yrs	49.6° (5.4°)	33.7° (6.6°)	20.7° (12.2°)	28.3° (8.4°)	–39.9° (5.5°)	–65.2° (5.1°)
All 5–6 yrs	53.8° (7.8°)	29.2° (9.0°)	–1.7° (16.5°)	46.7° (9.6°)	–31.4° (8.2°)	–51.8° (10.1°)
All 15–16 yrs	50.2° (7.3°)	35.3° (7.6°)	21.6° (12.4°)	32.0° (9.6°)	–37.6° (7.2°)	–62.7° (7.0°)

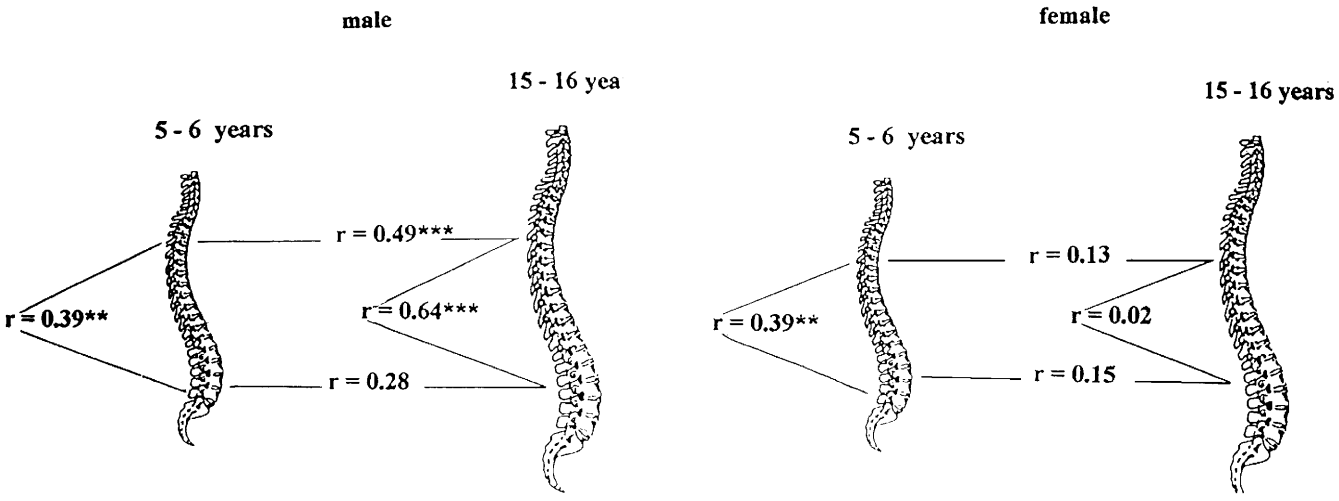

Fig. 1 Intraindividual correlation between kyphosis and lordosis calculated both at age 5–6 and at 15–16 years; correlation between kyphosis at age 5–6 and age 15–16 years; and correlation between lordosis at age 5–6 and age 15–16 years: data for male and female subjects (***P*<0.01; ****P*<0.001)

The relationship between kyphosis and lordosis was independent of gender at 5–6 years (female 0.96; male 1.03) while at 15–16 years of age, kyphosis in relation to lordosis was significantly less pronounced in girls (0.86) than in boys (1.08) (*P*<0.001).

Kyphosis at 5–6 years and kyphosis at 15–16 years of age were positively correlated (*r*=0.33; *P*<0.0015). Lordosis at the the age of 5–6 years and lordosis at 15–16 years showed a weak correlation (*r*=0.21; *P*<0.05). The degrees of kyphosis and lordosis for each subject correlated significantly, both at 5–6 and 15–16 years (*r*=0.38; *P*<0.0002 and *r*=0.31; *P*<0.003, respectively). However, when the analysis was made separately for boys and girls, the correlation coefficient was significant only in boys and young girls, but not in adolescent girls (Fig. 1).

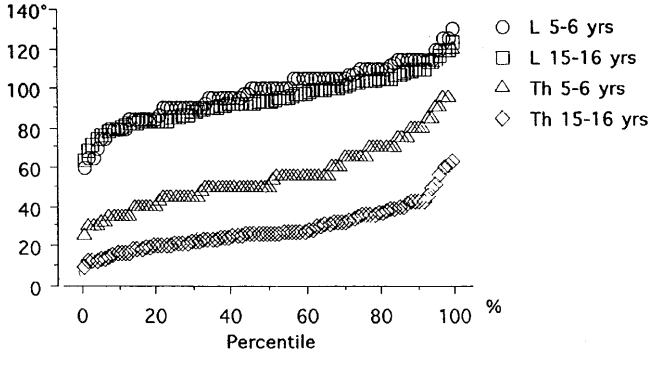

Fig. 2 Total mobility in the thoracic (Th) and lumbar (L) spine at age 5–6 and age 15–16 years in degrees: cumulative percentiles

Spinal mobility

In the thoracic spine, flexion from the relaxed position decreased by 9° (*P*<0.001) and extension decreased by 18° (*P*<0.001); in the lumbar spine flexion from the relaxed position decreased by 9° (*P*<0.001) and extension increased by 5° (*P*<0.001) (Table 1). Thus, the total sagittal mobility decreased during the 10-year period that was studied – in the thoracic region by as much as 27° (*P*< 0.001) and in the lumbar region by 4° (*P*<0.05) (Fig. 2).

Pain

Low back pain was common; 38% reported occasional back pain at the age of 15–16 years. Pain in the leg, knee or foot was also frequent and was reported by 15–20% of the adolescents. Posture, mobility, standing or sitting height, or body weight at either 5–6 or 15–16 years of age

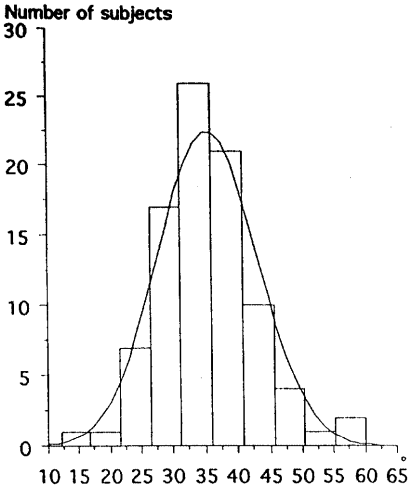

Fig. 3 Thoracic kyphosis at age 15–16 years

seemed to have no significant relationship to the likelihood of low back pain at the age of 15–16 years.

The incidence of low back pain at age15–16 years was not higher in the 19 adolescents who had a thoracic kyphosis of 40° or above (Fig. 3). Youngsters with a kyphosis of 40° or more were taller than those with a kyphosis below 40° ($P<0.02$).

According to their parents, 34% of the 5- to 6-year-old children had suffered from "growing pains". No relationship between growing pains in infancy and pain in the lower extremity or low back pain at 15–16 years was observed.

The degree of SLR at 15–16 years was not related to the frequency of back or leg pain. SLR was 2°–3° greater in girls than in boys, and there was a relationship between SLR at 5–6 and SLR at 15–16 years ($r=0.29$, NS for boys; $r=0.57$, $P<0.0001$ for girls).

Physical activity and trauma

Physical activity outside school had a binomial distribution. About 50% of the adolescents had no regular physical activity besides compulsory physical education at school. Those training regularly often did so three or more times a week. There was very little difference in frequency of training between the sexes, but the type of sport differed. Ice-hockey and soccer were more frequent among boys, and basketball and handball among girls. Regular physical activity did not influence the frequency of pain in the lower extremities or back, but low back pain was more frequent in the 11 adolescents stating that they had suffered some type of back injury ($P<0.01$). In the 43 subjects with active, regular, physical training, BMI was lower than among the 45 who had only the compulsory physical education at school ($P<0.03$).

Discussion

Posture

The results of this study show that the sagittal configuration of the spine changed during growth. Thoracic kyphosis and lumbar lordosis increased, but the relationship between these two parameters also altered. Kyphosis in relation to lordosis decreased with age in girls, but did not change in boys.

The observation that thoracic kyphosis increases during growth has been reported earlier. Thus, in a study comprising subjects of all ages between 8 and 16 years, Willner and Johnsson measured the sagittal curves using a pantograph. Thoracic kyphosis increased during growth, but contrary to the results of the present study, there were no differences in sagittal configuration between boys and girls at puberty [24].

Our results, which show that thoracic kyphosis decreased significantly in relation to lordosis during growth in girls but not in boys, agree with those in a study by Hellsing et al., who used the same type of measuring device as in the present investigation. In the cited study, thoracic kyphosis increased in boys but did not change in girls studied at 8, 11 and 15 years of age [9]. Mellin and Poussa also reported that thoracic kyphosis – measured by inclinometer – was less in girls compared to boys. The difference was most pronounced at the age of 13–14 years [14].

The reliability of these external techniques has proven satisfactory, but their validity considered in relation to the uniform "golden standard" (measurement on a lateral upright film according to Cobb) has only been evaluated in a few studies. Willner correlated kyphosis and lordosis recorded simultaneously by the pantograph and from radiographs [23]. Correlation between the internally and externally measured records was high for kyphosis but inferior for lordosis [15, 23].

Normative data of kyphosis and lordosis obtained from radiographs are scarce. It is considered unethical to expose children to radiation just to obtain normative data. Thus, the primary aim of the radiological examinations used in most reports was not to measure the normal sagittal profile, but to exclude a possible pathological condition.

Fon et al. used lateral chest radiographs to establish the range of thoracic kyphosis. Kyphosis, measured according to Cobb, increased with age, but did not differ between males and females in the younger age groups [7]. In contrast to the latter study, Propst-Proctor and Bleck did not find any influence of age or gender on kyphosis, measured between T5 and T12 according to Cobb, on standing full-length radiographs of "normal" and scoliotic subjects [19]. "Normal" was defined as subjects examined for a suspected spinal disorder but without any abnormalities diagnosed. The cited studies do not give a uniform picture of the alterations of spinal alignment during growth or between sexes, which is not unexpected, as varying techniques and definitions were utilised. We conclude that data from studies using external measurements of the sagittal configuration are in good agreement with the results of the present studies. However, in the radiological studies, compared to studies using external measurement, there were no differences in sagittal configuration between boys and girls. One reason for the discrepancy between the sexes could be that the adolescent growth spurt and completion of growth is 2 years ahead in girls. Thus, the mineralisation of the secondary ossification centre of the vertebra also differs between the sexes and the outline of the end plate is not so well defined. Most radiological examinations were also carried out with the subjects standing with arms raised, not taking into consideration that this may influence the posture in an unpredictable way.

Bad or faulty posture is usually synonymous with increased thoracic kyphosis or, according to some investigators, an increased lumbar lordosis. In the present study, using the same definitions, there was no relationship between posture, back pain or physical activity. In a cross-sectional material of children 11–17 years old, Salminen found that 29.5% had some functional, postural fault in the sagittal plane in a screening of 2075 pupils aged 10–17 years, and Nitzschke and Hildenbrand found an increased kyphosis in 12% of the girls and 15% of the boys [16, 20]. In both cited studies, bad posture was related to "negative factors," such as lower education and more frequent other orthopaedic problems both in the subjects and their families.

Mobility

The restriction of thoracic mobility during growth is considerable, especially when it comes to extension. Stiffening of the thoracic cage during growth is one plausible explanation for the reduced ability to extend the thoracic spine. Mellin and Poussa also observed restriction in thoracic movements that occurs during the time of the pubertal growth spurt, and speculated that this could contribute to a buckling of the spine, as seen in idiopathic scoliosis [14].

Pain

The high prevalence of occasional back pain in the present study of the 15- to 16-year-olds is remarkable; however, several reports using comparable methods have published similar figures [1, 6, 20, 21]. The important issue is whether the reported pain is due to some underlying pathological process that may lead to a chronic condition and a permanent disability later in life, or whether it is of a temporary nature.

Low back pain is uncommon in pre-puberty children, but the prevalence rises sharply during puberty [3, 13]. This rise may reflect the transition from "living in the present" to "bodily awareness", and thus may not represent a pathological condition of the spine itself, but a new dimension of the mind. This fact explains why it has been hard to find any "physical parameters" predicting future low back pain. Radiological abnormalities of the spine at the ages of 14 and 16 years could not predict the incidence of low back pain 25 years later in 640 subjects [8]. In another study, the predictive value of examination of the spine at the age of 16 was analysed. Neither posture deviation, muscular tension or tenderness, nor subjective complaints had any influence on the risk of low back pain 9–12 years later [10].

In a prospective study of 14-year-old adolescents, those with recurrent back pain were compared with those free of back pain. At the age of 18 years, disc degeneration in the lumbar spine was significantly more frequent in those with recurrent back pain than in those free of pain, indicating an organic origin of the symptom. However, disc degeneration was not uncommon in those free of back trouble [5]. In an ongoing prospective study, no correlation was found between radiographic measures or magnetic resonance imaging (MRI) findings and low back pain in young school children. It was concluded that decreased nucleus signal intensity of the lower lumbar disc on T2-weighted MR images is a common finding in young school children [22].

Thus, outcomes from studies on the relationship between physical findings and back pain in youngsters and back pain later in life depend greatly on the definition of back pain. Another problem in interpreting the results is the fact that back pain in adults often is defined by its consequences, e.g. work incapacity, rather than by objective findings. Maybe these facts explain why school reports, choice of profession and family are more important than posture, back pain or "black discs" in predicting work incapacity from back problems later in life [1].

Conclusions

In 90 children examined both at age 5–6 and at 15–16 years, kyphosis and lordosis increased and mobility decreased. The relationship between kyphosis and lordosis decreased in girls, but not in boys. Occasional back pain was reported by 38% at the age of 15–16, but back pain was not related to posture, spinal mobility or physical activity.

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