Wyższa Szkoła Zawodowa
Instytut Rekreacji i Turystyki
Sulechów

MIROSŁAW MROZKOWIAK

Description of parameters characterizing the angle of chest kyphosis in both female and male populations aged from 3 to 20

Deskrypcja parametrów opisujących kąt kifozy piersiowej populacji obojga płci w wieku od 3 do 20 lat

INTRODUCTION

The spine is a unique organ of movement, as it is common to the left and the right half of the body. From the biomechanical point of view, the spine performs two distinct mechanical functions: 1. It is a pillar supporting the trunk and the head. Its basic required qualities include high efficiency, absence of buckling, especially under dynamic load, 2. it is the organ of movement of the upper part of the body and, consequently, it must be as flexible as possible so that its movement should require the minimum muscle strength. One of the systems which allows for the two opposite mechanical qualities to be united in one biomechanism is the spinal stabilisation system. In a mechanical analysis, the spine should be contemplated as a structure dependent on: pelvis, chest, skull and limbs. It makes up an entire counterbalanced static-dynamic system. The system is connected through stabilisers by a coordinated triple dynamic mechanism, which constitutes the first, second and third system of reference: 1 system of reference - system of stabilisation – this consists of short deep muscles of the back, with both attachments within the spine, connecting particular vertebrae, directly affecting the movements segment, 2 – system of reference – is a system which links the spine through the chest with the pelvis – it includes the muscles which affect the spine directly or indirectly; these are long muscles of the back, lumbar quadriceps, straight and oblique muscles of abdomen, 3 – system of reference – this links all the interrelated elements – it consists of the muscles which connect the spine, chest and pelvis with the lower limbs and the head with the upper limbs, establishing the position of particular body parts in relation to the ground. All of the three systems are functionally interrelated in terms of syntonia, synkinesis, alternate equilibrium of tonus and functional antagonism of deep muscles of the back in relation to the superficial ones in the thoracic part of the spine. This interrelation conditions eutonia in static conditions and ipsilateral cooperation in dynamic conditions. The muscles of the first and second system establish the position of particular parts of the body and the spine in three planes against the pelvis. The system of back muscles which stabilise and drive the spine can be compared to the rigging of a ship mast. The most important role is played by a muscle triad: m. multifidus, m. rotatores longi, brevis. The triads are an element of a system of overlapping and connected systems of movement. They greatly affect the operation of the entire system. Playing the role of stabilisers, the muscles are bey-

ond our control. Their contractions are stimulated by their previous stretching. If the body is bent to the side and muscles from the II or III system of reference are contracted, the muscles of the triad are stimulated for stretching so that a general balance of the "mast" is maintained. In the movement, the thoracic and lumbar sections of the spine are functionally opposite. In the thoracic section, the muscle fibres which run obliquely and, according to 1 Frayett's principle, the rotation of the vertebral bodies with spinous processes towards the roundness will cause triad muscles to stretch on the concavity side. In the lumbar section, stretching occurs on the rounded side. The muscular dystonia which is thus evoked, is restored by contraction of deep muscles on different sides - ipsolateral muscles in the thoracic section and counterlateral ones in the lumbar section. The supporting function of the spine is performed by vertebral bodies, intervertebral discs in 90% and by spinous processes in 10% Neuman H. – D [1992]Electro goniometric measurements taken by Lewandowski [2006] on angle values of physiological curvatures of the spine show that their development indicates more or less convergent processes in both genders, however, the total increase in angular values of particular curvatures is more significant in male individuals. In the initial stage of research, chest kyphosis is more deepened in the group of males, at the age of 10-12 - in females, whereas in the spring of puberty and during the post pubertal stage - again in males. Furthermore, electro goniometric studies in segments Th1-Th12 have not shown the lowest value of a given angle in both genders in the age of 3, whereas in the group of boys, the border values were between 19,0 and 32,5 degrees, and in a girls' group: 17 - 36,5 degrees. The highest values occur in female gender, i.e.: 17,0 – 43,0 degrees, and in male gender at the age of 17: 16,5 - 45,0 degrees. In the female group, significant statistical yearly increases occurred between 6-8, 9-12, 14-16 and 17-20 years of age , whereas in the male group between: 7-9, 12-16 and 18-20 years of age. Convergence of the mentioned age ranges is noteworthy. During the research, the most advanced deformity is cervical lordosis , followed by chest kyphosis , whose gradient reaches its maximum in a female group at the age 12, whereas in a male group it peaks at around 24-25 years of age. The greatest kyphosis deepening dynamics in males and females occurred between 9-12 years of age. Unconditional values of annual angle increases are the highest of all measured curvatures and they equal around 7 degrees. Establishment of the curvature in a male group occurred at the age of 18 whereas in the female group at the age of 20.

The aim of the conducted research was to specify the changes of parameter values characterizing chest kyphosis in populations of children and young adults aged from 3 to 20 of both genders from the province of Warmia and Mazury.

MATERIAL AND RESEARCH METHOD

The research covered 19134 persons aged from 3 to 20 from randomly selected kindergartens and schools from the province of Warmia and Mazury, including 10,135 females and 8,999 males. Statistical analysis of the obtained study results was conducted based on those cases in which a doctor did not find significant defects in body posture.

Research methodology covered measurement of linear and angular parameters characterizing chest kyphosis. To assess the value of selected parameters, a computer stand for the evaluation of body posture and a posture meter M was used. The examination methodology and technique conformed to the adopted rules [Mrozkowiak 2003]. The obtained study results, in the form of a spatial, graphic image, enabled a numeral description of the researched parameters to be conducted.

Statistical analysis was carried out to measure: length, angle, height and depth of chest kyphosis in relation to the total backbone length (from C7 to S1).

OBTAINED RESULTS

The study results have been analyzed statistically. Figure 1 and 2 show the course of changes of mean values in male and female population, whereas Figure 3 shows the variability of parameter values of both genders.

DCK – total backbone length (C7-S1), mean value M: 346,13, K: 340,32. Values of the parameter show an almost symmetrical process and stable increasing tendency in both genders. Their values are congenial up to 162 month. Up to 180 month, the length of the backbone in the female group is greater, however after that time, males predominate. DThe diagram finishes with the values from the last edition M: 421,76, K: 406,65.

DKP – length of chest kyphosis, mean value M: 313,39, K: 308,03. In every edition of population research, this parameter showed a stable increasing tendency with M: 267,66 and K: 278,28 in the first edition up to M: 380,1 and K: 334, 98 in the last one. The diagram course of both genders is similar for 186 months, and after that greater values occur in the male group.

KKP – angle of chest kyphosis, mean value M: 167,21, K: 167,64. Major symmetrical variations occur in the diagram course. It starts from similar values M: 158,0 and K: 157,28. In the 60 month female diagram, it approaches its lowest level with K: 154,05 and a low in the 66 month in with M: 155,51, whereas up to the 90 months, a gradual increase occurs with K: 162,0 and M: 160,36. Following the decrease up to 102 month in both genders, values gradually increase up to 150 months with M: 159,76, and K: 160,45. After approaching the maximum value in 198 month of K: 162,19 and in 216 month in M: 161,62, the diagram finishes at the high level in the female group K: 161,1 and on the lowest level in the male group M: 153,7.

RKP – height of chest kyphosis, mean value M: 217, 05, K: 212,37. Diagrams for both genders start from points with values approaching M: 186,33, K: 170,71 in the first measurement and up to 42 month their course is almost mirror-like, whereas the height of kyphosis in the male group is greater. Following that period, values successively increase up to 186 month, in the male group until the last edition M: 274,1, and in the female group diagram finishes with lower values K: 184,0.

GKP – depth of chest kyphosis, mean value M: 21,3, K: 21,72. In every edition of research, diagrams of population with minor deflections coincide, cross or intersect with each other. Diagrams starting from the same point of M and K: 21,42, finish at the level M: 25,1 and K: 30,43. Between 150 and 186 month the depth of chest kyphosis in the male group showed lower values.

Measurement results of chest kyphosis' parameters show convergence of angular values of curvatures in both genders with the total backbone length. The general course of mean angular values of chest kyphosis shows its insignificantly greater level in the female group. Its mean value is as follows K: 167,64 and M: 167,21. Research has shown the lowest value of the given angle in the female group at the age of 5, in the male group - at the age of 6, whereas the highest respectively at the age of 17 and 20. Total angular increase in both genders is statistically insignificant and it measures about 1 degree. Detailed analysis of the period between 7 and 15 years of age has shown that the mean angle of chest kyphosis in females is larger until the age of 13. At the age of 14 its value drops by less than 1 degree in order to, during the next year, take the value very similar to the angle occurring in the male group. Boundary values for females are 157,2 up to 161,8 degree, for males from 156,8 up to 159,5. The highest values in the during the mentioned period occur in the female group at the age of 12, in the male group at the age of 13, the lowest respectively at the age of 7 and 9. The greatest kyphosis deepening dynamics in females occurs between 11-12 years of age, whereas in males at the age of 12-13.

DISCUSSION

Thanks to invasive roentgenographic methods, it was possible to determine the correct angular value of the thoracic kyphosis; according to the Scoliosis Research Society it lies between 20.0 and 40.0 degrees [Propst - Proctor ad Bleck 1983, Betz 2004].

Stagnara et al. [1982] restricted the interval to 30-50 degrees in segment Th4-Th12, adopting the mean value after the measurements conducted on individuals in the third decade of life at about 36.0 degrees.

Similar conclusions were arrived at by Korovessis et al. [1998] without observing any dimorphic differences. They showed a significant relationship between the kyphosis angle and the age of the examined individuals.

The authors of a study where 316 radiograms of individuals aged 2 to 77 were analysed showed that the mean kyphosis angle in children aged 2-9 was equal to 23.9 degrees in the group of girls and 20.9 degrees in the group of boys; in individuals aged 10-20 the values were equal to 26.0 and 25.1 degrees, respectively; in individuals aged 20-29 the increments in both genders were stabilised at 1 degree. It has also been shown that thoracic kyphosis increased in proportion to the age; only after the age of 50 was it significantly higher in the female group [Fon et al. 1980].

The measurements from the elliptic model of segments Th1 - Th12 are determined by the angle of 44.2, from segments Th2-Th11: 39.9, and from Th3-Th10: 33.3 degrees [Harrison et al. 2002].

Vedantam et al. [1998] determined the value of the discussed angle in segment Th3-Th12 as 38.0 degrees.

Other studies in a male population aged 18-29 determined the discussed angle as 26.9 degrees; the value for the female population – 25.0 degrees [Boyle et al. 2002].

A different value of the angle was obtained in measurements performed on a population of individuals aged 5 to 19 in segment Th2-Th12: 33.0 degrees [Boseker et al. 2000].

Voutsinas and Mac Ewan [1986] did not find any dimorphic differences in the age interval from 5 to 19 and determined the angular value in the same segment as 36.7 degrees.

Studies conducted on a population aged 5 to 29, with a comparative analysis of thoracic kyphosis, showed the angle in segment Th1-Th12 to be equal to 40.0 degrees and in segment Th3-Th12 = 36.0 degrees [Bernhardt and Bridwell 1989].

According to Stauffer [1997], the thoracic kyphosis angle assumes the values from 15 to 50 degrees.

However, Humphrey gives the average value as 42 degrees [after Kuński 1981], and White and Penjabi [1978] define the angle of 40 degrees as the acceptable for the curvature.

A measurement of the thoracic kyphosis angle by a non-invasive method – with an areometer – proved that at the age 13.0-15.5, a correct value should lie in the interval from 31.0-49.0 degrees [D'Osualdo et al. 1997].

Similar upper values of the intervals were determined in a raster-stereographic measurement [Thometz et al. 2000].

Pantographic examination of thoracic kyphosis on a population aged 8-16 has shown that its value is the lowest between the ages of 10 and 12, whereas for the ages from 8 to 14-16 its mean range increased considerably [Willner and Johnson 1983].

A study conducted by Nissinen [1995] confirmed the highest level of kyphosis at the age of 12.8; its value increased with age in both genders.

A study conducted with an inclinometer has shown a much smaller angle of thoracic kyphosis in girls than in boys, with the greatest gender differences of 8.2 degrees observed between the ages of 13 and 14 [Mellin and Poussa 1992].

The results of the author's own studies [2003a] into the body postures, conducted with the use of Posturometer M on a population of 800 children aged 4, 5, 6, 7 in an urban environment gave the average values of angles of thoracic kyphosis for the adopted age groups as 158, 155, 156 and 151 degrees.

The examinations of a body posture conducted with a Posturometer M on a population of 146 boys and 152 girls at the age of 7 produced the average values of the features describing thoracic kyphosis for each of the three types of body posture according to Wolański. The average angle of thoracic kyphosis in lordotic boys is equal to 159.77 degrees; for the equivalent type the value is 159.27 and for the kyphotic type - 154.52. In girls, the values are: 159.96, 157.97 and 154.88 degrees, respectively [Barczyk et al. 2005]..

The results of a study conducted with the use of a Debrunner kyphometer and a mathematical formula developed for the purpose have helped determine the interval of the kyphosis measured in segment Th4-Th12. According to Korovessis et al. [2001] the correct angle should lie within the interval from 27.0 to 62.0 degrees. The authors did not find any relationship between the value of the angle of the thoracic curvature and the age or gender of the examined individuals.

Widhe [2001] compared the results of a study conducted with the same instrument, measuring the angle of thoracic kyphosis in the same population of children aged 5-6, 15-16 and found the kyphosis angle in the second measurement to be much lower in girls.

Hellsing et al. [1987] found considerable increase in the values of thoracic kyphosis in boys aged 8, 11 and 15.

Studies conducted on a population of 112 girls and 28 boys with scoliosis ranging from 10 to 90 degrees showed much reduced lumbar lordosis [Szczygieł 2001].

A study by Zeyland - Malawki [2003] conducted with the use of a pin apparatus on a population of 2268 males and 1601 females aged 7-35 have revealed great differences in the size of spinal curvatures: the highest in the sacral-lumbar section inclination: 3-32 degrees, and the lowest – in the thoracic-lumbar section: 0 – 20 degrees. The average angles of inclination of particular sections were similar for a given gender (except for the inclination angle of the lumbar-sacral section). The difference in the group of men between the highest (15.3) and lowest (13.1) arithmetic average for the upper thoracic section was 2.2 degrees. The average value for all the age groups – 14.2 degrees. In the female group it was smaller: 12.7 degrees, and the difference between the lowest: 11.9 degrees and the highest: 13.6 degrees was only 1.7 degrees. The average inclination of the thoracic-lumbar section was similar in both groups: males: 9.1 degrees, females: 9.4 degrees. A similar small difference was observed between the lowest and the highest average value: 1.7 and 1.2 degrees. The inclination of the lumbar-sacral section, calculated for males, was lower (12.9) than for females (14.3 degrees), and the difference between the extreme average values in the male group was 5.4 degrees, whereas in the female one – 3.4 degrees. It can be concluded that the inclination of the upper thoracic section in boys and men and that of the lumbar-sacral section in girls and women was greater, with the differences being statistically significant. An analysis of the average angles depending on the age shows that the differences between the youngest and the oldest age group did not exceed 2 degrees. The greatest difference in the inclination angle of the upper thoracic section: 1.9 was found in the male group, and that of the lumbar-sacral section inclination – in both genders, especially in men. Larger fluctuations were also observed during the puberty period.

A study by Łubkowska [2003] conducted with a spherosomatograph constructed by Iwanowski on a population of 1223 children from Szczecin, aged 7 to 15, of both genders, found that the average values range from 18.73 to 11.2 degrees; additionally, a tendency opposite to that observed in the upper thoracic section inclination was seen in all the examined individuals. The author remarked that the discussed angle decreases with age and sho-

wed considerable similarity with the average angles of lumbar-sacral section inclination in the examined individuals.

CONCLUSIONS

1. The value of the angle and depth of chest kyphosis in the researched segment of ontogenesis is not subject to major fluctuation, whereas the average value totals: 167,64 degrees and 21,72 mm in the female population and 167,21 degrees and 21,3 mm in the male population;
2. Progression of height and length of loin lordosis have very similar and characteristic dynamics in the period from 3 to 20 years of age both in the male and female populations;
3. Process of changes in values of length and height of chest kyphosis in the female population in the age from 15 to 20 are very similar.

LITERATURE

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ABSTRACT

The research covered 19134 children and youngsters aged from 3 to 20 from randomly selected kindergartens and schools from the province of Warmia and Mazury, including 10135 females and 8999 males. Conclusions: 1. The value of the angle and depth of chest kyphosis in the researched segment of ontogenesis is not subject to major fluctuation, whereas the average value totals: 167,64 degrees and 21,72 mm in the female population and 167,21 degrees and 21,3 mm in the male population; 2. Progression of height and length of loin lordosis have very similar and characteristic dynamics in the period from 3 to 20 years of age both in the male and female populations; 3. The process of changes in values of length and height of chest kyphosis in the female population in the age from 15 to 20 are very similar.

STRESZCZENIE

Badaniami objęto populację 19134 dzieci i młodzieży w wieku od 3 do 20 lat, z wybranych losowo przedszkoli i szkół regionu Warmińsko – Mazurskiego, w tym 10135 kobiet i 8999 mężczyzn. Wnioski: 1. Wartość kąta i głębokości kifozy piersiowej w badanym wycinku ontogenezy nie podlega dużym wahaniom, a wartość średnia wynosi odpowiednio: 167,64 stopni i 21,72 mm w populacji żeńskiej oraz 167,21 stopni i 21,3 mm w populacji męskiej; 2. Progresja wysokości i długości kifozy piersiowej mają bardzo zbliżoną i charakterystyczną dynamikę w okresie od 3 do 20 lat w populacji męskiej i żeńskiej; 3 . Przebieg zmian wartości długości i wysokości kifozy piersiowej w populacji żeńskiej w wieku od 15 do 20 lat mają bardzo podobny przebieg.