Mrozkowiak Mirosław. Relationships between selected parameters of pelvis in children and adolescents aged 3–20 years of age in the context of gender and environment. Pedagogy and Psychology of Sport. 2021;7(2):79-93. eISSN 2450-6605. DOI http://dx.doi.org/10.12775/PPS.2021.07.02.006
https://apcz.umk.pl/czasopisma/index.php/PPS/article/view/PPS.2021.07.02.006
https://zenodo.org/record/4742272

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.

Received: 07.02.2021. Revised: 26.02.2021. Accepted: 20.03.2021.

Relationships between selected parameters of pelvis in children and adolescents aged 3–20 years of age in the context of gender and environment

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Abstract

Introduction: Pelvis is a part of the skeletal system. It is a pelvic ring composed of the sacral bone, coccygeal bone and two pelvic bones, the right one and the left one. When walking, pelvis undergoes angular displacement in the frontal, sagittal and transverse planes.

Material and methods: The studies were conducted in randomly selected kindergartens and schools from the urban and rural environment in the Warmia and Masuria region and the Pomerania region among 1832 male and 1974 female subjects at the age of 3 – 20 years. The photogrammetric method was applied to diagnose the angle of pelvic torsion to the left and to the right side in the frontal plane.

Results: The general analysis of the correlation coefficient including positive and negative correlations suggested that the values ranged between 0.43 and 0.44 for KNM and KNM-, from -0.1 to 0.1 for KNM and KSM-, and from -0.08 to -0.04 for KNM and KSM. Spearman's rank correlation coefficient for KNM- and KSM- ranged between -0.11 and -0.1, for KNM and KSM from -0.14 to 0.11, and for KSM- and KSM -0.72 to -0.7.

Conclusions: A high degree of negative correlations was recorded between the angle of pelvic torsion in the transverse plane to the left and the angle of pelvis twisted to the right side.

A poor degree of positive correlation was observed between the parameters of KNM and KSM- as well as KNM- and KSM. A poor negative correlation was reported between the parameters of KNM and KSM and the parameters of KNM- and KSM-. The correction procedure for the pelvic position should consider mutual interdependencies of tilt angles in the frontal plane and of torsion angles in the transverse plane.

Key words: pelvic torsion angle, pelvic tilt angle; mora projection.

INTRODUCTION

Pelvis is a part of the skeletal system. It is a pelvic ring composed of the sacral bone, coccygeal bone and two pelvic bones, the right one and the left one. It reveals considerable sex differences. The female pelvis is short, broad and vast, whereas the male one is high, narrow and tight. In both sexes the lesser pelvis has the shape of the cone section: closer to the base in women and closer to the top in men [1].

The examination of pelvis includes its frontal, sagittal and horizontal position. Any deviation in pelvic spatial orientation, structure and function is reflected in the structure and function of the spine and vice versa, changes in the axial organ lead to pelvic disorders. The correct pelvic tilt forward depends on age and sex [2]. Pelvis is twisted forward when the heel strikes the ground and backward when toes leave the ground, which effectively increases the length of the limb on the verge of stance and swing. Effective length of the lower limb is also increased by tilting pelvis forward during the heel strike and toe-off phases [3]. Staszkiewicz et al. report that changes in sagittal pelvic tilt in racewalkers range between 4°–19° [4]. The gait range during natural walking is ca. 4° [5]. The authors claim it is the effect of aiming to reduce the vertical oscillation of the centre of gravity. The scope of pelvic movement in the frontal plane during natural walk is scarce amounting to 10° [5, 6]. Perry reports that pelvic movement in the frontal plane when walking at low speed is ca. 7° up and the same down [5]. Pelvic motion in the transverse plane allows an individual to increase the length of steps by 50% [7]. Pelvic movements in this plane enable to develop considerably greater speed of walking at a lower energy cost. During physiological gait at a low speed, pelvic rotation one way is estimated to range between 3°–7° [8].

Own studies [9] revealed that pelvic torsion angles in the transverse plane to the left or right side significantly and positively affect the following: tilt angle of the thoracolumbar region, total length of the spine (C_7-C_1), length and depth of thoracic kyphosis, length, depth and height of lumbar lordosis. Pelvic torsion angle in the frontal plane to the left side has a significant and positive impact on: the total length of the spine (C_7–S_1), length and height of thoracic kyphosis, and length of lumbar lordosis. Pelvic tilt to the right side positively and significantly influences the following: total length of the spine, dept, length and height of lumbar lordosis.

The aim of the study was to determine mutual correlations between the angles of pelvic torsion to the left and right side in the transverse plane, pelvic tilt angles twisted to the right and left side in the frontal plane among children and adolescents aged 3 – 20 years of both sexes and environments.

MATERIALS AND METHODS

The studies were conducted in randomly selected kindergartens and schools from villages, towns and cities in the Warmia and Masuria region and the Pomerania region: 10 kindergartens, 20 primary schools, 6 lower secondary schools, 1 upper secondary school, after obtaining the consent of the Board of Education in Olsztyn, the principal of school or kindergarten, the teacher responsible for the relevant department, the parent and the child. The approval of the Bioethical Committee was also obtained. General eligibility criteria for the research were based on revealing a sufficiently large number of similar body postures in healthy children. The study involved 18 946 male and 21 356 female subjects. Respondents were recruited from the urban (26 420 subjects) and rural environment (13 882 subjects) – Table 1.

TABLE 1. General structure of the study group

Age range	Environment			
	Urban		Rural	
	Gender			
	Female	Male	Female	Male
3–20 years	13760	12660	7596	6286
Total	26420		13882	
Total	40302			

Based on interviews with parents and school health records, all students with the history of musculoskeletal anomalies were excluded from the studies. On the first research day, in the light of medical diagnosis, the subjects were healthy in a general sense, therefore, it was assumed that study results and all subsequently diagnosed postural defects would be within the range of physiological deviations relevant for the represented population and age range. This applies to insignificant functional deviations of the vertebral process from the anatomical spine axis and torso flexion in the frontal plane, flexion and extension angles in the sagittal plane, and the longitudinal arch of the foot.

Research tools and subject

The measuring station consisted of a computer, a card, software, a display monitor, a printer and a projection-reception device with a camera to measure the selected parameters of the pelvis-spine complex. Obtaining the spatial picture was possible thanks to displaying the line of strictly defined parameters on the child's back and feet. The lines falling on the skin of the child got distorted depending on the configuration of the surface. The applied lens ensured that the imaging of the subject could be received by a special optical system with a camera, then transmitted to the computer monitor. The distortions of the line imaging recorded in the computer memory were processed through a numerical algorithm on the topographic map of the examined surface [10]. The obtained image of the torso and pelvis surface enabled a multi-faceted interpretation of body posture. The accuracy of measurement and the assessment of spatial parameters may lead to conclusions different from those published so far. Short time of recording the silhouette of the subject allowed to avoid postural muscle fatigue occurring during examinations conducted by means of somatoscopic methods. The essential part of this method was the simultaneous measurement of all real values of the spatial location of individual body sections. When conducting the studies, generally adopted rules and procedures were observed [11]. Measurements included the pelvic torsion angle to the left in the transverse plane

(KSM-), to the right (KSM) – Figure 1, pelvic tilt to the right (KNM), to the left (KNM-), Fig. 2. Sadly enough, the applied method did not measure the angle of pelvic rotation in the sagittal plane.

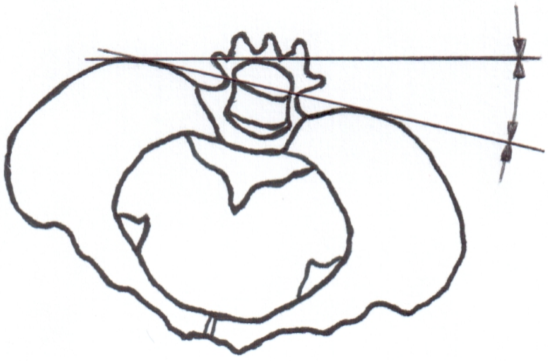

FIGURE 1. Angular parameter KSM

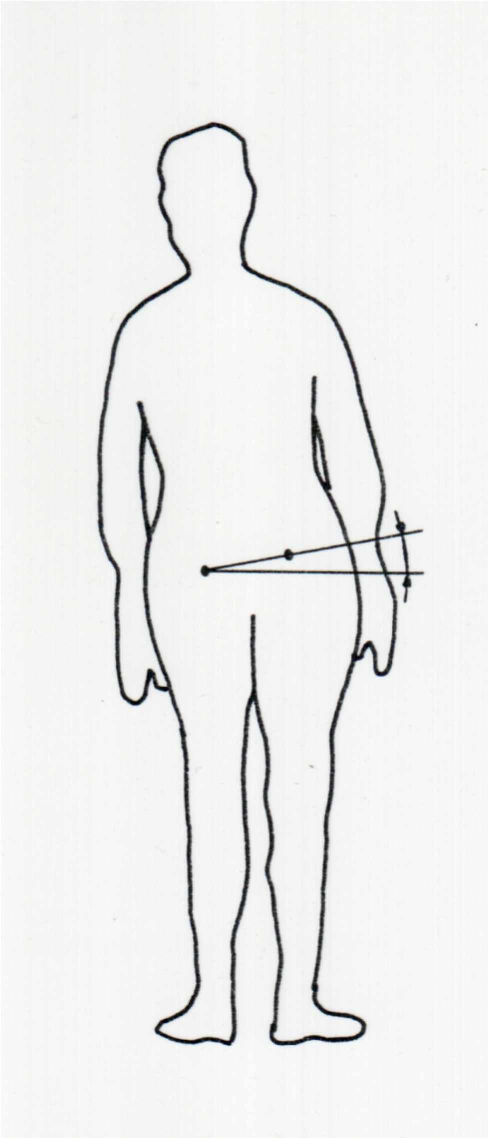

FIGURE 2. Angular parameter KNM

Statistical methods

The analysis covered four pelvic parameters, namely, KNM: the angle of pelvic tilt to the left in the frontal plane, KNM-: the angle of pelvic tilt to the right in the frontal plane, KSM: pelvic torsion angle to the right in the transverse plane, KSM-: pelvic torsion angle to the left in the transverse plane. The results of statistical analysis, Spearman's rank correlation coefficient understood here as the measure of monotonicity strength between two variables, i.e. an increase in the value of one variable normally corresponds to an increase in the other one. The coefficient takes values from -1 (this represents the strongest negative correlation between variables) to +1 (this represents the strongest positive correlation). The values of Spearman's coefficient for the examined pairs are displayed as matric colours, according to the scale on the right side of the figure. The red colour corresponds to coefficient -1 and blue means +1. Additionally, the figures of the coefficient are entered in the corresponding field with the proper number of stars representing the significance of correlations (Fig. 3-11). The list of Spearman's coefficients was also made (Table 2).

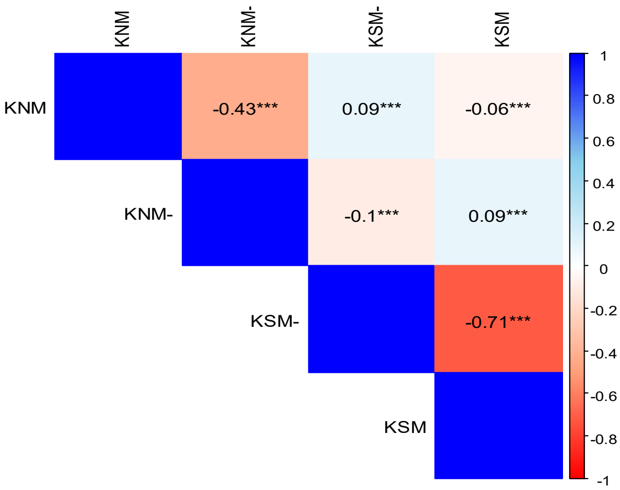

FIGURE 3. Correlations between pelvic parameters of male and female subjects from both environments aged 3–20 years (n = 21895)

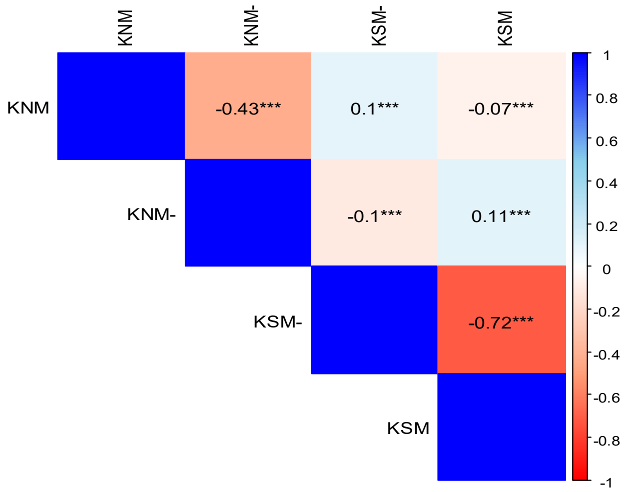

FIGURE 4. Correlations between pelvic parameters of girls from both environments aged 3–20 years (n = 11683)

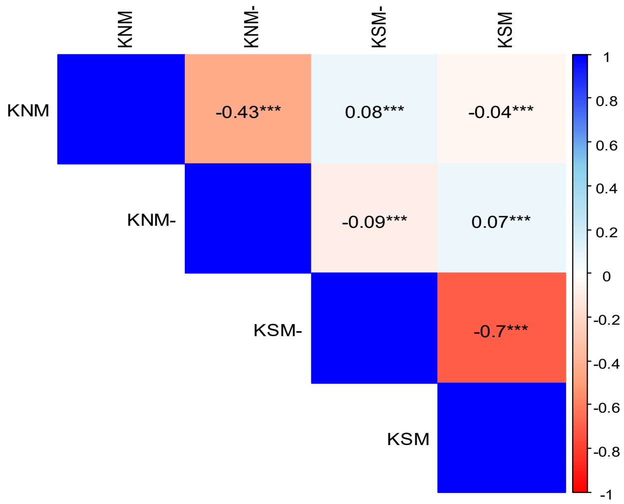

FIGURE 5. Correlations between pelvic parameters of boys from both environments aged 3–20 years (n = 10212)

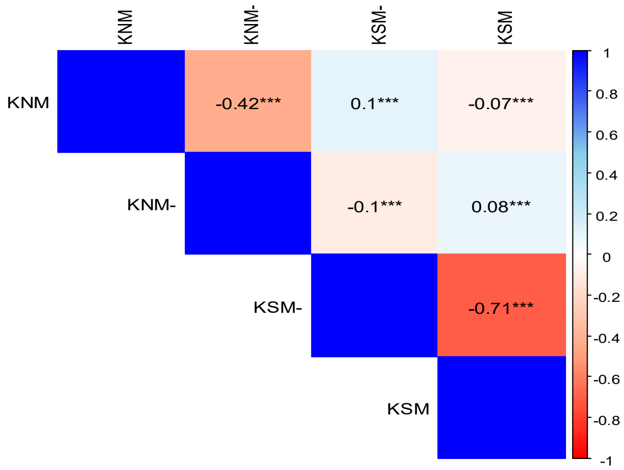

FIGURE 6. Correlations between pelvic parameters of male and female subjects from towns and cities aged 3–20 years (n = 13625)

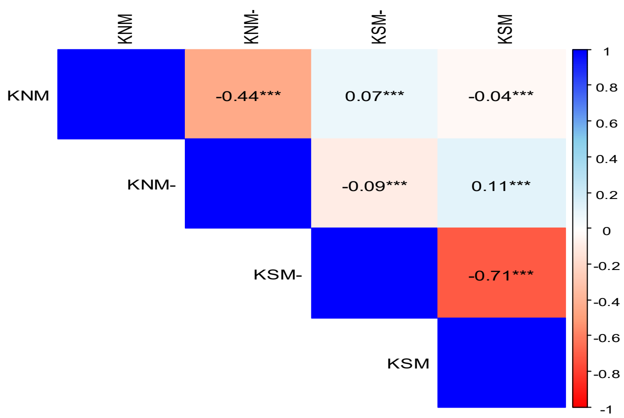

FIGURE 7. Correlations between pelvic parameters of male and female subjects from the rural environment aged 3–20 years (n = 8270)

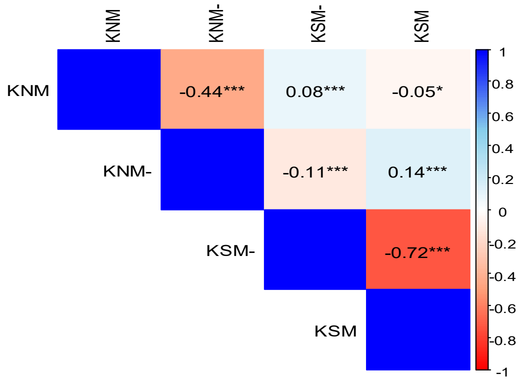

FIGURE 8. Correlations between pelvic parameters of female subjects from the rural environment aged 3–20 years (n = 4484)

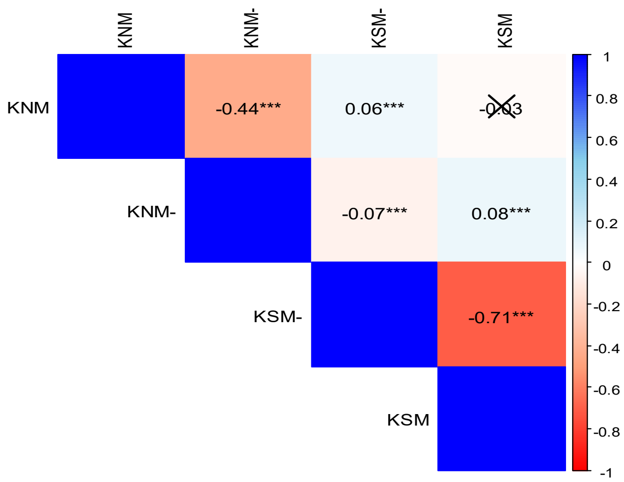

FIGURE 9. Correlations between pelvic parameters of male subjects from the rural environment aged 3–20 years (n = 3786)

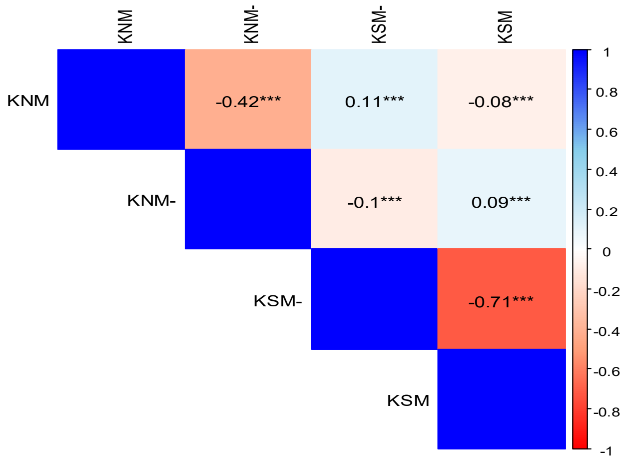

FIGURE 10. Correlations between pelvic parameters of female subjects from both the urban environment aged 3–20 years (n = 7199)

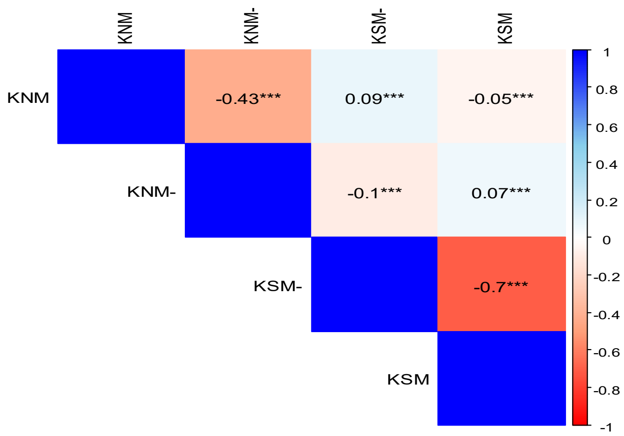

FIGURE 11. Correlations between pelvic parameters of male subjects from the urban environment aged 3–20 years (n = 6426)

TABLE 2. Figures of Spearman's rank correlation coefficient for **KNM-, KSM-, KNM, KNM-**

Male and female subjects from rural and urban environment			
	KNM-	KSM-	KSM
KNM	0.43	0.09	-0.06
KNM-		-0.1	0.09
KSM-			-0.71
Male sex			
KNM	-0.43	0.08	-0.04
KNM-		-0.09	0.07
KSM-			-0.7
Female sex			
KNM	-0.43	0.1	-0.07
KNM-		-0.1	0.11
KSM-			-0.72
Urban environment			
KNM	-0.42	0.1	-0.07
KNM-		-0.1	0.08
KSM-			-0.71
Rural environment			
KNM	-0.42	0.1	-0.07
KNM-		-0.1	0.08
KSM-			-0.07
Urban environment, male sex			
KNM	-0.43	0.09	-0.05
KNM-		-0.1	0.07
KSM-			-0.7
Urban environment, female sex			
KNM	-0.42	0.11	-0.08
KNM-		-0.1	0.09
KSM-			-0.71
Rural environment, male sex			
KNM	-0.44	0.06	none
KNM-		-0.07	0.08
KSM-			-0.71
Rural environment, female sex			
KNM	-0.44	0.08	-0.05
KNM-		-0.11	-0.14
KSM-			-0.72

RESULTS

The general analysis of the correlation coefficient including positive and negative relationships calculated for all subjects, considering sex and environment, revealed that the rate ranged from -0.44 to -0.42 for the couple KNM and KNM-, then from 0.06 to 0.11 for KNM and KSM-, and from -0.08 to -0.04 for KNM and KSM. Spearman's rank correlation coefficient in case of KNM- and KSM- ranged between -0.11 and -0.07, for KNM- and KSM from 0.07 to 0.14, and KSM- and KSM from -0.72 to -0.7 (Table 2). Nearly all the studied results turned out to be highly significant. The correlation between all the couples of four analysed parameters was not significantly affected either by sex, environment or the interaction of these factors. A detailed analysis covered positive and negative relationships of the assessed parameters measured in both male and female subjects from both types of environment. All the results were characterised by high degree of significance. However, they differed in the value of Spearman's coefficient. Namely, the rate was -0.43 between the features of KNM and KNM-, 0.09 between

KNM and KSM-, -0.06 for KNM and KSM, -0.1 for KNM- and KSM-, 0.09 for KNM- and KSM, and -0.71 for KSM- and KSM (Fig. 3). With regard to the analysed parameters of female subjects from both types of environment, all results were highly significant. The following values of Spearman's rank correlation coefficient were achieved: -0.43 between KNM and KNM-, 0.1 between KNM and KSM-, -0.07 between KNM and KSM, -0.1 between KNM- and KSM-, 0.11 between KNM- and KSM, and -0.72 between KSM- and KSM (Fig. 4). All studied results had high statistical significance level among the analysed parameters of male subjects from both types of environment. The correlation level of parameters KNM and KNM- was -0.43, KNM and KSM-: 0.08, KNM and KSM: -0.04, KNM- and KSM-: -0.09, KNM- and KSM: 0.07, and KSM- and KSM: -0.7 (Fig. 5). The parameters results concerning male and female subjects from urban and rural areas turned out to be highly significant. Yet, they differed in the values of Spearman's coefficient – r. Namely, the rate was -0.42 for KNM and KNM-, 0.1 for KNM and KSM-, -0.07 for KNM and KSM, -0.1 for KNM- and KSM-, 0.08 for KNM- and KSM, and -0.71 for KSM- and KSM (Fig. 6).

Among the analysed parameters of male and female subjects from rural areas, all results were highly significant. The coefficient r was -0.44 for parameters KNM and KNM-, 0.07 for KNM and KSM-, -0.04 for KNM and KSM, -0.09 for KNM- and KSM-, 0.11 for KNM- and KSM, and -0.71 for KSM- and KSM (Fig. 7). With regard to the parameters of female subjects from rural areas, nearly all results were highly significant including one statistically insignificant result. Spearman's correlation coefficient between parameters KNM and KNM-was -0.44, between KNM and KSM-: 0.08, KNM and KSM: -0.05 (low degree of significance), between KNM- and KSM-: -0.11, KNM- and KSM: 0.14, and KSM- and KSM: -0.72 (Fig. 8). Among the analysed parameters of male subjects from rural areas, one result was statistically insignificant and the rest of the results had a high degree of significance. The correlation coefficient between parameters KNM and KNM- was -0.44, between KNM and KSM-: 0.06, KNM and KSM did not correlate, between KNM- and KSM- the coefficient was -0.07, KNM- and KSM: 0.08, and KSM- and KSM: -0.71 (Fig. 9). All the results of the analysed parameters concerning female subjects from urban areas turned out to be highly significant. However, they differed in the value of the correlation coefficient. Namely, the rate between parameters of KNM and KNM- was -0.42, between KNM and KSM-: 0.11, KNM and KSM: -0.08, KNM- and KSM-: -0.1, KNM- and KSM: 0.09, and KSM- and KSM: -0.71 (Fig. 10). Among the analysed parameters of male subjects from urban areas, all results were highly significant. The correlation coefficient between KNM and KNM- was -0.43, between KNM and KSM-: 0.09, KNM and KSM: -0.05, KNM- and KSM-: -0.1, KNM- and KSM: 0.07, and KSM- and KSM: -0.7 (Fig. 11).

DISCOURSE

The available scientific literature has not mentioned any studies on correlations between pelvic parameters. The results achieved by other researchers very often relate to body posture in a general sense. The analysis of research results achieved by Budrukiewicz et al. [12], Bibrowicz [13], Cieśla [14], Kabsch [15], Lewit [16], Saulicz [17], Tylman [18], Walker and Dickson [19], and Wielki [20], concerning the impact of the angle of pelvic tilt and torsion on spinal parameters found this influence definitely negative and multi-faceted. Own studies are partly consistent with the results achieved by the above-mentioned authors [11].

CONCLUSIONS

Similar results were obtained both within all respondents as well as in subgroups broken by gender, environment and the sum of both factors. An average level of negative correlation was observed between the angle of pelvic tilt to the left in the frontal plane and pelvic tilt to the right. A high level of negative correlation was reported between the angle of pelvic torsion to the left in the transverse plane and pelvic torsion to the right. A low level of positive correlation was observed between the parameters of KNM and KSM- as well as KNM- and KSM; whereas poor negative correlation was reported between KNM and KSM as well as KNM- and KSM-. Thus, the directions of changes in the pelvic position within both analysed planes revealed minor correlations, and asymmetries of the same direction appeared less often than the ones of the opposite direction. It was calculated that asymmetries of the same direction accounted for ca. 25% of cases and 16% of which corresponded to KNM- and KSM-, and 9% to KNM and KSM, whereas couples with asymmetries of the opposite direction comprised over 34% of cases including 25% of KNM and KSM-, and 9% of KNM- and KSM. When designing procedures to correct the pelvic position, one shall consider correlations between the tilt angle in the frontal plane and the torsion angle in the transverse plane.

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