Original paper

Posture defects and visual refraction defects in school-age children

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Abstract

Introduction: In recent years, there has been a significant increase in posture defects among children and adolescents. The number of individuals with visual impairments is also on the rise. Both of these problems are interconnected and can exacerbate one another.
Aim of the research: To analyse the relationship between postural defects and visual refractive defects in school-age children.
Material and methods: The study was conducted on a group of 250 children aged 11–12 years. The study group consisted of 203 children with refractive errors, while the control group consisted of 47 children without refractive errors. Body posture was assessed using spatial photogrammetry with the Diers formetric III 4D.
Results: Among children with visual impairments, scoliotic posture was more prevalent. Analysis of correlations between body posture variables and refractive errors revealed strong relationships between the following: the scoliosis angle, kyphosis angle ICT-ITL, lordosis angle ITL-ILS, and visual refractive errors. In the group of 11-year-old girls, a strong correlation was found between visual refractive errors and the kyphotic apex, and the lordotic apex. In the group of 12-year-old girls, pelvic inclination was correlated with visual refractive errors. Among 12-year-old boys, an additional strong correlation was found between refractive errors and lateral deviation. Statistical significance ($p < 0.05$) was observed in all respondents concerning the scoliosis angle variable. Children aged 11–12 years with refractive errors more frequently exhibit scoliotic posture than children with normal vision. A significant relationship was found between the presence of visual refractive errors and body posture parameters.
Conclusions: Visual defects affect posture control and asymmetries in the musculoskeletal system in the studied age group.

Introduction

Body posture is a dynamic process that develops from foetal life and depends on many factors, including the proper functioning of the visual system [1, 2]. The visual system plays an essential role in posture regulation by providing sensory information that influences body stabilisation and motor coordination [3]. Refractive errors, such as myopia, hyperopia, or astigmatism, can disrupt this process and contribute to posture abnormalities in children [4]. Multiple studies on body posture [5] have demonstrated that there are differences in the sagittal plane between females and males. These differences may be modulated by specific compensatory strategies arising from visual demands – namely, the adoption of particular head and body positions to enhance visual acuity. This is especially relevant in children and adolescents, in whom the visual system is undergoing intense development and the final postural pattern is being established [5].

The correct development of body posture is crucially influenced by the antigravity system, which relies on appropriate muscle tension control, neuromuscular coordination, and correct sensory integration [6, 7]. Body posture regulation is reflexive and based on the integration of information from various sensory systems, including proprioceptive, labyrinthine, and visual systems [8, 9]. The visual system is directly responsible for image perception and controlling precise eye movements. Body posture affects eye positioning, which in turn can influence the development of refractive errors. This phenomenon is particularly evident in children aged 11–12 years, who are in an intensive developmental phase for their visual system [10]. Studies indicate an increasing number of children with refractive errors associated with improper postural habits [11]. The visual system plays a significant role in the control of body posture [12]. It is worth emphasising that the prevention and correction of refractive errors should constitute a fundamental component of health programs for school-aged children. Early diagnosis and treatment can help prevent both progressive changes in the visual system and their consequences for the postural system [13]. Based on the above information, it can be assumed that refractive errors have a significant impact on the occurrence of postural disorders in school-aged children [14].

Aim of the research

The aim of the study was to analyse the relationship between postural defects and visual refractive defects in school-age children.

Material and methods

Material

The study was conducted on a group of 250 children aged 11–12 years from the Świętokrzyskie Voivodeship and aimed to determine the relationship between body posture variables and refractive visual impairments. All research procedures were carried out in accordance with the 1964 Declaration of Helsinki and were approved by the University Bioethics Committee for Scientific Research at Jan Kochanowski University in Kielce (Resolution No. 30/2017). The study was conducted with the informed consent of parents or legal guardians between March and September 2019 at the Posturology Laboratory of the Collegium Medicum, Jan Kochanowski University in Kielce.

The study group consisted of 203 children with diagnosed refractive errors, while the control group included 47 children without visual impairments. The majority of participants were girls – 108 (53.20%) – while boys accounted for 102 (46.80%). The age distribution was nearly equal: 102 (50.25%) children were 11 years old, and 101 (49.75%) children were 12 years old. Among the girls, 55 (53.92%) were 11 years old and 53 (52.48%) were 12 years old. Among the boys, 47 (46.08%) were 11 years old and 48 (47.52%) were 12 years old.

In the control group, boys slightly outnumbered girls – 25 (53.19%) boys compared to 22 (46.81%) girls. There were 23 children aged 11 years (48.94%) and 24 aged 12 years (51.06%). Among 11-year-olds, there were 11 (47.83%) girls and 12 (52.17%) boys; among 12-year-olds, there were 11 (45.83%) girls and 13 (54.17%) boys.

Participants were randomly selected in accordance with the principle of randomisation, following the prior establishment of inclusion criteria for both study and control groups. Before initiating the study, the purpose, procedures, and duration were clearly defined and explained.

Inclusion criteria for the study group included the following: diagnosed refractive error, absence of physical or intellectual disability, absence of congenital defects of the central nervous system or the musculoskeletal system, and written consent from a parent or legal guardian. Exclusion criteria included the following: absence of refractive error, age under 11 or over 12 years, congenital defects of the central nervous system, and congenital musculoskeletal disorders. Dependent variables were the parameters of body posture, while independent variables were the presence of refractive visual impairments.

Methods

Body posture was evaluated using the DIERS Formetric III 4D device. The test lasted approximately 15 minutes, and body posture was examined twice. During measurements, the patient was asked to undress down to their underwear and position their back against the camera at a distance of 2 metres [16]. The following body posture parameters were analysed: trunk length VP-DM (mm) and VP-SP (mm), trunk inclination VP-DM (mm) and (°), trunk imbalance VP-DM (mm) and VPDM (°), trunk torsion (°), pelvic tilt (°) and (mm), pelvic torsion DL-DR (°), pelvic inclination (°) (dimples) and (symmetry line) (°), inflection point ICT (mm), ILS (mm) and ITL (mm), kyphotic apex KA (VP-DM) (mm), kyphotic angle ICT-ITL (max) (°) and VP-ITL (°), lordotic angle ITL-ILS (max) (°) and ITL-DM (°), lordotic apex LA (VP-DM) (mm), surface rotation (rms) (°), lateral deviation VP-DM (rms) (mm) and (max) (mm), and dimple distance DL-DR (mm). The normal values for the kyphotic and lordotic angles were 47–50° and 38°–42°, respectively. The norms for other body posture variables included the following: trunk inclination: VPDM ≤ 5 mm, ≤ 5°, trunk imbalance: VP-DM ≤ 4 mm, ≤ 4°, pelvic tilt: DL-DR ≤ 4°, ≤ 4 mm, (°) ≤ 4°, pelvic inclination (dimples): ≤ 4°, pelvic torsion: DL-DR ≤ 2°, surface rotation (rms): ≤ 4°, and lateral deviation: VP-DM (rms): ≤ 4 mm, VP-DM (max) ≤ 4 mm. Scoliotic posture occurred when the pelvic tilt was 1–5 mm and lateral deviation between 1 and 5 mm with surface rotation between 1 and 5°. For scoliosis or scoliotic posture, all 3 conditions had to be met. In the absence of these requirements, scoliotic posture or scoliosis was not assumed [10].

The diagnostic survey was based on the analysis of data on visual refractive errors, which were examined and confirmed by an ophthalmologist. The examination performed by the doctor included both subjective and objective assessments, which involved skiascopy and refractometry.

Statistical analysis

Multivariate regression models and ANOVA (analysis of variance) were used. The assumption of normality for all analysed variables was assessed using the Shapiro–Wilk test. For variables that violated the normality assumption, appropriate non-parametric statistical methods were applied, or data were subjected to transformation prior to further analysis. Multiple linear regression models were employed to evaluate the effect of refractive errors (independent variables) on body posture parameters (dependent variables), with age and sex included as covariates.

Model adequacy was assessed using the coefficient of determination (R^2) and the adjusted R^2. A significance threshold of $p < 0.05$ was applied.

Results

In the group of children with refractive errors, scoliotic posture was more frequent, especially in girls aged 11 years (52.73%), boys aged 11 years (63.83%), and girls aged 12 years (56.83%). In boys aged 12 years, correct posture was dominant (60.42%) (Table 1).

The results of the correlation analysis conducted in the group of 11-year-old girls between visual refractive errors and body posture variables in the sagittal and frontal planes showed statistically significant correlations between the following: the scoliosis angle and visual refractive errors (strong correlation), the kyphosis angle ICT-ITL and visual refractive errors (strong correlation), the sphere (strong correlation) and astigmatism; the lordosis angle ITL-ILS and visual refractive errors (strong correlation) and the sphere (strong correlation); the location of the curvature and astigmatism; the KA kyphosis peak and visual refractive errors and the sphere (strong correlation); and the LA lordosis peak and the sphere (Table 2).

The results of the correlation analysis conducted in the group of 12-year-old girls between visual refractive errors and body posture variables in the sagittal and frontal planes revealed statistically significant correlations between the following: the scoliosis angle and visual refractive errors and astigmatism (strong correlation); the kyphosis angle ICT-ITL, lordosis angle ITL-ILS, pelvic inclination – symmetry line, and visual refractive errors, as well as the sphere and astigmatism (strong correlation); and the pelvic inclination (dimples) and the sphere (Table 3).

In the group of 11-year-old boys, statistically significant correlations were demonstrated between the following: the scoliosis angle and the kyphosis angle ICT-ITL, the visual refraction errors, the sphere (strong correlation) and astigmatism; the lordosis angle ITL-ILS and astigmatism (Table 4).

The correlation analysis conducted in the group of 12-year-old boys showed statistically significant results between the following: the scoliosis angle and visual refractive errors; the kyphosis angle ICT-ITL, lat-

Table 1. The number of attitudes in the studied age groups

Group	Correct posture		Scoliotic posture	
	N	%	*N*	%
Girls 11 years old	26	47.27	29	52,73
Boys 11 years old	17	36.17	30	63.83
Girls 12 years old	25	47.17	28	56,83
Boys 12 years old	29	60.42	19	39.58

N – quantity/the size of the population.

Table 2. Correlations between visual refraction errors and the analysed body posture variables of 11-year-old girls

Variables	Refractive errors	Sphere (dioptres)	Astigmatism
Scoliosis angle	–0.71	–0.48	–0.31
Kyphotic angle ICT-ITL (max.) [°]	–0.81	–0.84	–0.56
Lordotic angle ITL-ILS (max.) [°]	–0.67	–0.73	–0.27
Curvature location	–0.42	–0.41	–0.53
Kyphotic apex (VPDM) [mm]	0.64	0.69	0.21
Lordotic apex (VPDM) [mm]	0.48	0.53	0.34

Table 3. Correlations between visual refraction errors and the analysed body posture variables of 12-year-old girls

Variables	Refractive errors	Sphere (dioptres)	Astigmatism
Scoliosis angle	–0.69	–0.34	–0.67
Kyphotic angle ICT-ITL (max.) [°]	–0.72	–0.90	–0.56
Lordotic angle ITL-ILS (max.) [°]	–0.56	–0.71	–0.54
pelvic inclination (dimples)	–0.40	–0.51	–0.37
pelvic inclination (symmetry line)	–0.54	–0.65	–0.52

eral deviation vpd max, visual refractive errors, as well as the sphere and astigmatism (strong correlation); the lumbar line and visual refractive errors (strong correlation) and the sphere (strong correlation) (Table 5).

The ANOVA indicated significant differences in postural variables between children with and without refractive errors. For example, in 11-year-old girls, the scoliosis angle was significantly greater in the refractive error group compared to the control ($p < 0.001$). Similarly, in 12-year-old boys, increased lateral deviation was observed in the refractive error group ($p = 0.001$). These findings suggest that visual impairments are associated with increased asymmetry and altered spinal curvature, especially in the frontal plane (Table 6).

Discussion

Postural defects are a significant health problem. Year by year, more children are diagnosed with scoliotic posture or postural defects in the sagittal plane. The percentage of children with visual refractive errors also shows an upward trend. The results of this study demonstrated that scoliotic postures predominated among the subjects. This is probably related to difficulties in spatial perception, which force children to adopt incorrect body positions to better adjust their vision to the environment. Similar results were obtained by Rosenbaum *et al.*, who found that children with refractive errors, including myopia and astigmatism, tend to display scoliotic postures more frequently than children with normal vision. The author noted several hypotheses explaining this relationship, including the idea that children with vision problems adopt unnatural body positions to improve visual acuity, which may lead to postural asymmetry [15]. Wilczyński *et al.* observed a significant relationship between sensory integration and balance deficits, as well as spinal curvature (°), vertebral surface rotation (°), pelvic tilt (°), and lateral curvature (mm). They demonstrated that increased deficits in sensory inte-

Table 4. Correlations between visual refraction errors and the analysed body posture variables of 11-year-old boys

Variables	Refractive errors	Sphere (dioptres)	Astigmatism
Scoliosis angle	0.72	0.76	0.68
Kyphotic angle ICT-ITL (max.) [°]	–0.76	–0.82	–0.62
Lordotic angle ITL-ILS (max.) [°]	–0.24	–0.32	–0.55

Table 5. Correlations between visual refraction errors and the analysed body posture variables of 12-year-old boys

Variables	Refractive errors	Sphere (dioptres)	Astigmatism
Scoliosis angle	0.56	0.49	0.46
Kyphotic angle ICT-ITL (max.) [°]	–0.79	–0.75	–0.54
Lateral deviation VPDM (max.) [mm]	0.59	0.67	0.58
Lumbar line (VPDM) [mm]	–0.76	–0.67	–0.46

Table 6. Statistically significant differences in the tested body posture parameters in the individual age groups of girls and boys

Variable	*F*	*P*	Girls (n = 11)	Girls (n = 12)	Boys (n = 11)	Boys (n = 12)	*P*-value (Girls)	*P*-value (Boys)
Scoliosis angle [°]	13.0	23.5	6.9	11.5	0.000	0.000	0.01	0.001
Kyphotic angle ITL–ILS max [°]	13.4	0.6	10.9	9.8	0.000	0.45	0.001	0.003
Surface rotation max [°]	1.6	6.3	0.2	3.8	0.21	0.015	0.62	0.06
Dimple distance DL–DR (%)	0.8	9.8	0.8	3.5	0.36	0.003	0.39	0.07
Pelvic torsion DL–DR [°]	0.7	7.5	0.0	0.2	0.41	0.008	0.97	0.63
Pelvic inclination (dimples) [°]	9.8	4.1	2.2	4.6	0.003	0.05	0.15	0.04
Kyphotic apex (VPDM) [mm]	0.6	0.6	0.8	6.1	0.44	0.44	0.37	0.02
Pelvic inclination symmetry line [°]	1.4	7.9	3.3	6.6	0.24	0.007	0.08	0.01
Lateral deviation VPDM max [mm]	0.0	8.8	0.0	4.6	1.00	0.004	0.85	0.04
Lateral deviation VPDM RMS [mm]	0.8	15.5	2.8	11.8	0.37	0.000	0.11	0.001
Cervical line VP (VPDM) [mm]	4.2	2.7	0.8	9.5	0.04	0.10	0.39	0.003

F – distribution of variance analysis results; P – level of statistical significance.

gration and balance correlate with more pronounced scoliotic changes [16]. Yeh *et al.* also noted that visual defects can disrupt the ability to effectively control posture, which affects the development of motor system asymmetry [17].

The results of our study indicate that the children exhibited postural disorders in both the sagittal and frontal planes, which may be a result of compensation for visual disorders by the postural system. Müller *et al.*, in their studies on the influence of visual defects on body posture and postural stability, emphasised that postural reflexes may be impaired due to the weakening of the visual system's ability to provide information about the body's position in space [18]. Jiang *et al.* also found that changes in vision can affect posture, forcing the body to adapt in order to achieve better visual acuity, which can lead to the development of postural defects [19]. Studies by Xiao *et al.* showed that body asymmetry, particularly in the lower limbs and trunk, may result from the need to compensate for difficulties in spatial perception and environmental awareness [20]. ANOVA analysis revealed significant differences in postural variables between children with refractive errors and those without. Among 11-year-old girls, the scoliosis angle was significantly greater in the group with refractive errors compared to the control group ($p < 0.001$). In 12-year-old boys, increased lateral deviation was observed in the group with refractive errors ($p = 0.001$). These results suggest that visual impairment is associated with increased asymmetry and altered spinal curvature, particularly in the frontal plane. Confirmation of these relationships can be found in the study by Puszczalowska-Lizis *et al.* (2024), who analysed sagittal curvature patterns in young female volleyball players and reported excessive kyphosis and lordosis. Although the examined cohort consisted of athletes, the mechanism – frequent trunk flexion – may be comparable to that observed in children with visual impairments, who attempt to compensate for vision limitations by inclining their bodies. This similarity underscores the influence of habitual postures on the development of spinal deformities [21].

It is important to emphasise that a key factor in the proper morpho functional development of a child is preventive care related to the diagnosis and correction of vision defects, which can help prevent further postural problems [22]. Recent studies emphasise the significant impact of uncorrected refractive errors on the overall development of children, including their body posture. A study conducted in Greenland demonstrated that the implementation of comprehensive eye examinations, including autorefraction and stereopsis tests, improved the detection rate of refractive errors and amblyopia among schoolchildren [23].

Observations indicate that both spherical and cylindrical vision corrections affect body posture parameters, including spinal shape, head angle, and balance. In particular, individuals requiring correction for astigmatism, which involves irregularities in the shape of the cornea, may experience difficulties maintaining correct body posture, leading to compensatory movement patterns [24]. On the other hand, correction of myopia and hyperopia, although it improves vision, does not always resolve postural problems. Analyses suggest that even with proper vision correction, children with more severe refractive errors may still exhibit poor posture [25]. Furthermore, studies by Hsu *et al.* indicated that vision correction with glasses impacts body posture, but this improvement is less pronounced in individuals with a high degree of astigmatism [26]. Moreover, uncorrected hyperopia in childhood has been linked to spatial orientation problems and learning difficulties, which may indirectly affect posture due to compensatory behaviours. These findings are consistent with our study, in which we observed a correlation between refractive errors and postural abnormalities in school-aged children [27].

The obtained results highlight the need for additional diagnostic assessments regarding the variables discussed. It is worthwhile to expand body posture examinations to include further verification of parameters defining posture in the sagittal plane. Using the new typology based on body posture examinations with the Diers Formetric III 4D System, it is possible to identify up to nine types of body posture. This would allow for a more precise determination of the relationship between body posture and visual refractive errors. Body posture is genetically determined, but it is also developmentally variable and individually diverse. As a movement habit, it results from numerous conditioned and unconditioned reflexes. The individual differences make the construction of an "ideal" posture model both artificial and unhelpful today [28].

The significance of this study lies in demonstrating the relationship between the visual system and the musculoskeletal system in the context of child development. The results underscore the need for interdisciplinary screening programs in schools that integrate postural and vision assessments. This work contributes new knowledge by identifying specific postural parameters associated with types of visual impairments, which may serve as a basis for developing targeted preventive interventions.

Conclusions

The study demonstrated a clear and statistically significant association between refractive errors and postural abnormalities in school-aged children. Children with visual impairments, particularly those aged 11 to 12 years, more frequently exhibited scoliotic postures, pelvic asymmetries, and deviations in spinal curvature within the sagittal plane. These findings suggest that visual defects may contribute to impaired postural control and musculoskeletal asymmetries.

These conclusions underscore the importance of incorporating vision screening into routine postural assessments in schools. Early detection and intervention targeting both visual function and posture may reduce the risk of future complications and promote healthy development of the musculoskeletal system.

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Ethical approval

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Conflict of interest

The authors declare no conflict of interest.

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