Article

Characteristics of Body Posture in the Sagittal Plane in 8–13-Year-Old Male Athletes Practicing Soccer

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Abstract: Background: An important part of a healthy lifestyle for children and adolescents is exercising to satisfy the natural need for physical activity. However, young athletes should take special care when they participate in intense physical training, to ensure their proper physical development. The aim of this study was to evaluate the body posture in the sagittal plane of soccer players in comparison with healthy untrained peers. **Methods:** A total of 245 young males aged 8–13 who participated in the study were divided into two groups: “Group F—Footballer”, elite youth soccer players comprising 132 male athletes, and “Group C—Control group”, consisting of 113 boys from primary schools. The elite, youth soccer players played and trained in the Gold Standard Certificate Academy for their age group and belonged to the top 1% of all players from their category, respectively (Polish Soccer Association (PZPN)). The control group consisted of healthy boys from primary schools in Wrocław not practicing any sport. A photogrammetric method based on the projection moiré phenomenon was used to assess the body posture in all subjects. **Results:** The analysis showed statistically significant differences in body posture parameters in the sagittal plane between the trained (F) and non-trained (C) groups. In all age groups, a significantly higher value of the upper thoracic angle and a lower value of the trunk inclination angle were observed in the football players’ group. Significant differences were also observed for the thoracic spine in each age group. In the groups of 8–9 and 12–13 years, they concerned the angle of thoracic kyphosis, and in the group of 10–11-year-old, the depth of thoracic kyphosis. In the group of children with ages 8–9 and 10–11, significantly higher values of lumbosacral angle and upper thoracic angle were observed in the group of soccer players. **Conclusions:** The soccer training load can influence the anterior–posterior curvature of the spine. In the group of footballers in all age groups, higher angular values of thoracic kyphosis and greater tilt of the torso forward were found, compared with their untrained peers. There were also significant differences in body posture between children of different ages, both in the group of footballers and in the group of untrained children. In the group of footballers, the differences concerned mainly the size of the lumbosacral angle and the depth of both curves, which decreased with the age of the players. A similar phenomenon was observed in the group of untrained boys but only in children in the older age groups.

Keywords: soccer player; body posture; training; photogrammetric method

Citation: Barczyk-Pawelec, K.; Rubajczyk, K.; Stefańska, M.; Pawik, Ł.; Dziubek, W. Characteristics of Body Posture in the Sagittal Plane in 8–13-Year-Old Male Athletes Practicing Soccer. *Symmetry* **2022**, *14*, 210. <https://doi.org/10.3390/sym14020210>

Academic Editor: Chiarella Sforza

Received: 15 December 2021

Accepted: 18 January 2022

Published: 21 January 2022

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1. Introduction

In subsequent stages of posturogenesis, physiological curvatures of the spine are gradually formed. The size of these curvatures depends on many factors, including somatic type, gender, lifestyle, and physical activity [1]. The body posture is constantly regulated by feedback reflexes, mainly arising from proprioceptors located in muscles, tendons, and joint

capsules. It is the proprioceptors that provide information to the central and peripheral nervous system regarding muscle tone and length and the position of the trunk and limbs in relation to each other [2,3].

Posture may become abnormal during the so-called critical periods of postural development, including sexual maturation. Sexual maturation is among the most dynamic stages of postural hazards, and therefore, the susceptibility to the formation and worsening of postural defects increases [4]. Spinal postural defects are one of the most common causes of back pain [5,6]. Regular sports effort, often leading to overloading of the osteoarticular structures, is a risk factor for spinal deformities, especially in the adolescent population [7].

Undertaken physical activity affects the processes of ossification and shapes muscle strength, and is one of the important elements shaping the body silhouette. Professional sport puts a strain on the muscles, skeletal system, especially the spine. Achieving a master's level in sports requires hard physical exercises, often one-sided and repeated many times. Intensive physical effort reduces the efficiency of passive elements of the spine, but also the muscles responsible for its shape [8–10].

An important part of a healthy lifestyle for children and adolescents is exercising to satisfy the natural need for physical activity. However, young athletes should take special care when they participate in intense physical training, to ensure their proper physical development [11].

Many researchers have shown that high, targeted physical activity in the form of regular training can have a decisive impact on both the physical development of the young body [12] and posture [13–22]. One sport that enables the goal of the natural need for physical activity is soccer. It is the most popular sport, with approximately 5.5 million children and adolescents playing soccer worldwide [23].

Soccer is a speed-and-power sport, requiring athletic preparation, agility, the ability to tolerate repeated high-intensity efforts (repeated sprint ability), and an adequate level of perceptual and cognitive skills [24,25]. The soccer player's motor activity profile involves a large number of accelerations and decelerations of jumps, quick changes of direction of running and kicking the ball [26–28]. In addition, the player performing directional changes must have a high level of motor control, allowing for unilateral movements in unstable external conditions [29].

Soccer is primarily performed by asymmetrical movement of the lower limbs and symmetrical movement of the upper limbs. Shots on goal are mainly made with the dominant lower limb, although the best players can use both limbs effectively to play the ball. This limb dominance can affect the alignment of the hip girdle, placing it in an asymmetrical position [30,31].

Soccer-specific training in child and adolescent groups is characterized by comprehensive development of players' motor skills combined with technical–tactical education [32,33]. As players grow older, there is a change in the proportion between general and specific training, and there is specialization into positions (e.g., goalkeeper) [34]. The motor activity of young soccer players during training mainly includes sprints and changes in the direction of unilateral movements to complete a technical task with the lower limb [35]. In addition, the running activity profile refers to acceleration and deceleration (to the ball and to the opponent) and moving sideways, backward, and forwards to the running direction [36]. Jumping and one-legged landings appear in the oldest age categories and in professionals, as head play is inadvisable in youth groups for health reasons [37].

The body posture of athletes from various disciplines, and above all, the attempt to determine its possible influence on the results achieved or the incidence of musculoskeletal injuries has been the subject of many studies for years [2,15,38–42]. Despite the continuous development of research methods, an increasing number of injury prevention protocols, and permanent monitoring of athletes' training effects, there are still few reports in the global literature on the body posture of male and female athletes of various disciplines or on the comparison of the quality of body posture of athletes in different age categories [15,40–42].

Therefore, the aim of this study was to evaluate the body posture in the sagittal plane of soccer players in comparison with healthy, untrained peers.

2. Materials and Methods

2.1. Subjects

A total of 132 male soccer players aged 8–13 years participated in the study. The elite youth soccer players played and trained in the Gold Standard Certificate Academy for their age group and belonged to the top 1% of all players from their category, respectively (Polish Football Association, PZPN). Participants were divided into three subgroups: under 14, under 12, and under 10. None of the participants had injuries inhibiting maximal exertion or conditions likely to be aggravated by maximal exertion. Players who have not trained in the last 7 days with a full training load were excluded. Soccer participants, except from their school's physical education program, participated also in a soccer training program (4–5 per week). The control group (N = 113) consisted of healthy boys from primary schools in Wrocław not practicing any sport. This group was appropriately divided into three age subgroups: under 14, under 12, and under 10.

All boys from the control group participated only in compulsory physical education lessons conducted at school, 3 h a week. Moreover, no injuries or damage to the locomotor system were found in them.

The inclusion criteria in the control group were written consent of legal guardians to participate in the study, age 8–13 years, no training in any sports discipline, and no current injuries within the musculoskeletal system. The exclusion criteria from the control group were the lack of written consent to tests, injuries, or damage to the musculoskeletal system.

A detailed quantitative breakdown of the research and control group is shown in Figure 1. All of the participants agreed to the experimental procedure of the study that was specifically approved by the Ethics Committee of the University of Physical Education. All parents gave written informed consent for research.

Figure 1. Size and statistical characteristics of the study groups.

Detailed statistical characteristics of the individual groups of boys studied are presented in Table 1.

Table 1. Statistical characteristics of the study groups.

		Group F		Group C		F vs. C	
		Median	IQR	Median	IQR	<i>p</i> U MW Test	d Cohen's Test
All	Age [years]	10.00	3.00	10.00	3.00	0.9301	0.02
	Body weight [kg]	35.00	13.30	35.00	14.00	0.0357 *	0.27
	Body height [cm]	143.75	15.00	140.00	14.00	0.0039 *	0.17
	BMI [kg/m ²]	17.29	2.57	17.08	3.61	0.1995	1.38
	Training [years]	5.00	3.00	0	0	-	-
8–9 years	Age [years]	9.00	1.00	9.00	0.00	0.6702	0.08
	Body weight [kg]	30.40	5.00	27.00	7.00	0.0147 *	0.52
	Body height [cm]	136.00	9.50	133.00	7.00	0.0064 *	0.58
	BMI [kg/m ²]	16.22	1.36	15.27	3.43	0.1366	0.31
	Training [years]	4.00	2.00	0	0	-	-
10–11 years	Age [years]	11.00	1.00	10.00	1.00	0.1929	0.29
	Body weight [kg]	37.00	8.00	35.00	13.00	0.1024	0.36
	Body height [cm]	147.00	10.00	140.00	11.00	0.0013 *	0.75
	BMI [kg/m ²]	17.72	2.41	17.08	5.00	0.8230	0.05
	Training [years]	5.50	1.00	0	0	-	-
12–13 years	Age [years]	13.00	1.00	12.00	1.00	0.1784	0.34
	Body weight [kg]	46.00	15.35	41.50	7.00	0.0008 *	0.91
	Body height [cm]	158.00	13.00	151.50	9.00	0.0020 *	0.82
	BMI [kg/m ²]	19.01	2.53	17.56	1.45	0.0040 *	0.76
	Training [years]	8.00	1.00	0	0	-	-

Group F—Footballer group, Group C—Control group; IQR—interquartile range, *p* U MW test—*p* value of U Mann–Whitney's test, * *p* < 0.05.

2.2. Measurement Tools

A photogrammetric method based on the projection Moiré phenomenon was used to assess the body posture in all subjects [5]. The device for the Computerized Body Posture Assessment of the 4th Generation MORA system was used for the research. It is a modern device that combines the advantages of MORA/ISIS spatial analysis systems. The equipment and software used were from CQ Elektronik Systems, Czernica, Poland.

Each time, before the examination, the following points were marked on the trunk of the tested person with a black, washable marker: spinous processes of the spinal vertebrae from C7 to S1, thoracolumbar transition, the peak of the curvature thoracic kyphosis, and lumbar lordosis, shoulder processes, and lower angles of the scapula and the posterior superior iliac crest. The subject stood in a relaxed posture in the field of view of the camera at a distance of 2.6 m. The subject's feet were placed on a line parallel to the measuring station, hip-width apart. The knee joints were straightened and the body weight was evenly distributed on both lower limbs. The upper limbs were positioned loosely along the torso, the head was positioned loosely, and the gaze was directed forward. After assuming this relaxed habitual posture, the image of the back was registered and further analysis was conducted without the presence of the tested person. On the basis of the entered data, three-dimensional coordinates of the body surface were obtained, and the parameters determining the anteroposterior curvature of the spine and the inclination of the trunk in the sagittal plane were calculated (Figure 2).

All measurements were taken by the same investigator at the same time of day (early afternoon hours) and in similar conditions (dark room with controlled ambient temperature). Spinal posture was recorded continuously for 3 s at 4 Hz to capture 12 images, from which the 6th image was extracted for subsequent analysis. The participants were not aware of when the recording was performed. For the sagittal plane, the accuracy of the mathematical calculations after the recorded image is 1 mm or 1 degree.

Figure 2. Scheme of the research stand [43].

The following angular and length parameters of spinal curvatures were evaluated and analyzed in the sagittal plane (Figure 3).

Figure 3. Angular parameters of spinal curvature in the sagittal plane (A) and trunk tilt angle in the sagittal plane (B). Legend: C7—spinous process of the seventh cervical vertebra; KP—the peak of thoracic kyphosis; PL—thoracic–lumbar spine transition; LL—peak of lumbar lordosis; S1—the base of the sacrum; α —angle of inclination of the lumbosacral spine; β —angularity of the thoracolumbar spine; γ —angle of the upper thoracic segment.

The following angular parameters (expressed in degrees) were used:

- (1) The angle of inclination of the lumbosacral spine (α);
- (2) The angularity of the thoracolumbar spine (β);
- (3) The angle of the upper thoracic segment (γ);
- (4) Torsion angle of the trunk in the sagittal plane (KPT);
- (5) Negative values of the angle indicate the anterior tilt of the trunk relative to the vertical;
- (6) Thoracic kyphosis angle (KKP);
- (7) Lumbar lordosis angle (KLL).

Depth parameters (expressed in mm):

- (1) Depth of thoracic kyphosis (GKP);
- (2) Depth of lumbar lordosis (GLL).

2.3. Statistical Analysis

The Shapiro–Wilk test was used to check the distribution of all measured parameters. Depending on the results of the study of the distribution of variables, appropriate descriptive statistics were used—namely, mean, standard deviation, or median and quartile range (IQR). Student’s *t* test for independent samples or Mann–Whitney *U* test were used to check the statistical significance of mean differences observed between the groups. One-way ANOVA or a Kruskal–Wallis ANOVA, followed by a multiple comparisons test of mean ranks, was performed to determine the significance of the effect of age and training on posture. When the analysis of variance showed significant differences between the groups, the Scheffe post hoc test or the multiple comparison test of the mean rank was used. Both post hoc tests used included corrections for multiple comparisons [44–46]. The effect size was calculated for each comparison. Cohen’s *d* coefficient [47] was used as a measure of the effect.

The analysis was performed in Statistica version 13.3 (CA, USA) and with the use of online statistical calculators http://www.psychometrica.de/effect_size.html (accessed on 22 November 2021) [47]. The level of significance was $p < 0.05$.

3. Results

The analysis showed statistically significant differences in body posture parameters in the sagittal plane between the elite youth soccer group (Group F) and the untrained children group (Group C). In all age groups, a significantly higher value of the upper thoracic angle and a higher value of the trunk inclination angle were observed in all soccer subgroups. Significant differences were also observed for the thoracic spine in each age group. In the groups of 8–9 and 12–13-year-old, they concerned the angle of thoracic kyphosis, and in the group of 10–11-year-old, the depth of thoracic kyphosis. In the group of 8–9 and 10–11-year-old children, significantly higher values of lumbosacral angle and upper thoracic angle were observed in the group of soccer players (Table 2).

Both in the study and control group, significant differences were registered between children of different ages. In the group of elite youth soccer players, the differences concerned mainly 8–9 and 10–11-year-old children, while in the control group, the differences were in 10–11 and 12–13-year-old groups. Between the 8–9 and 10–11-year-old soccer players and the 10–11 and 12–13-year-old children in the control group, a significant decrease in the lumbosacral angle, an increase in the trunk tilt angle, and a decrease in the depth of thoracic kyphosis and lumbar lordosis were observed (Table 3).

Table 2. Body posture characteristics in the sagittal plane in the group of soccer players (Group F) and in the control group (Group C).

		Group F		Group C		F vs. C	
		Mean/ Median	SD/ IQR	Mean/ Median	SD/ IQR	<i>p</i> Test T/ UM Test	<i>d</i> Cohen's Test
8-9 years	Lumbosacral spine inclination angle (alfa) [°]	11.08	3.92	8.99	4.73	0.0216 *	0.48
	Thoracolumbar spine inclination angle (beta) [°]	9.95	3.79	9.93	3.23	0.8387	0.01
	Superior thoracic spine inclination angle (gamma) [°]	18.27	2.94	13.96	2.50	0.0000 *	1.57
	Compensation index	6.83	5.25	4.95	5.46	0.0857	0.35
	Torso inclination angle [°]	−5.20	3.60	−1.60	4.00	0.0000 *	1.06
	Thoracic kyphosis angle [°]	151.85	5.15	156.12	4.90	0.0002 *	0.85
	Thoracic kyphosis depth [mm]	11.40	9.50	14.75	8.55	0.2119	0.27
	Lumbar lordosis angle [°]	158.69	6.32	161.08	6.16	0.1067	0.38
	Lumbar lordosis depth [mm]	13.29	5.86	14.95	6.06	0.1689	0.28

Table 2. Cont.

		Group F		Group C		F vs. C	
		Mean/ Median	SD/ IQR	Mean/ Median	SD/ IQR	<i>p</i> Test T/ UM Test	d Cohen's Test
10–11 years	Lumbosacral spine inclination angle (alfa) [°]	10.79	3.23	8.45	3.97	0.0048 *	0.62
	Thoracolumbar spine inclination angle (beta) [°]	7.90	3.17	10.64	2.82	0.0001 *	0.87
	Superior thoracic spine inclination angle (gamma) [°]	18.25	2.99	14.42	3.24	0.0000 *	1.17
	Compensation index	7.47	4.96	5.97	5.77	0.3077	0.26
	<i>Torso inclination angle [°]</i>	−7.00	4.20	−1.52	−1.20	0.0000 *	1.84
	Thoracic kyphosis angle [°]	153.85	4.23	154.95	4.09	0.2652	0.25
	<i>Thoracic kyphosis depth [mm]</i>	10.50	5.70	16.10	8.10	0.0000 *	1.25
	Lumbar lordosis angle [°]	161.31	4.91	160.91	5.20	0.6839	0.08
	Lumbar lordosis depth [mm]	10.06	4.82	17.20	5.40	0.0000 *	1.33
12–13 years	Lumbosacral spine inclination angle (alfa) [°]	10.39	3.47	12.05	4.68	0.1192	0.35
	Thoracolumbar spine inclination angle (beta) [°]	8.99	3.82	8.55	2.68	0.4551	0.11
	Superior thoracic spine inclination angle (gamma) [°]	18.06	3.26	15.10	3.72	0.0025 *	0.72
	Compensation index	7.66	4.61	3.10	4.21	0.0002 *	0.87
	<i>Torso inclination angle [°]</i>	−5.65	2.70	−3.20	6.10	0.0497 *	0.36
	Thoracic kyphosis angle [°]	153.47	5.18	156.71	4.14	0.0077 *	0.57
	<i>Thoracic kyphosis depth [mm]</i>	11.40	8.05	11.60	10.70	0.9179	0.03
	Lumbar lordosis angle [°]	160.62	5.71	159.89	4.23	0.5886	0.12
	Lumbar lordosis depth [mm]	13.77	6.76	12.95	6.37	0.6522	0.11

Group F—Footballer group; Group C—Control group; IQR—interquartile range; *p* test T—*p* value of Student's *t* test; *p* U MW test—*p* value of U Mann–Whitney's test. Variables with a non-parametric distribution are marked in italics, * *p* < 0.05.

Table 3. Significance of differences between age groups.

	<i>p</i> ANOVA/ Kruskal Wallis Test	d Cohen's Test	Group F			<i>p</i> ANOVA/ Kruskal Wallis Test	d Cohen's Test	Group C		
			8–9 vs. 10–11	8–9 vs. 12–13	10–11 vs. 12–13			8–9 vs. 10–11	8–9 vs. 12–13	10–11 vs. 12–13
Lumbosacral Spine Inclination Angle (Alfa) [°]	0.6698	0.15	N	N	N	0.0037 *	0.71	N	0.0197 *	0.0047 *
Thoracolumbar Spine Inclination Angle (Beta) [°]	0.0395 *	0.46	0.0327 *	N	N	0.0186 *	0.49	N	N	0.0164 *
Superior Thoracic Spine Inclination Angle (Gamma) [°]	0.9401	0.05	N	N	N	0.3311	0.25	N	N	N
Compensation Index	0.7016	0.16	N	N	N	0.0772	0.50	N	N	N
<i>Torso Inclination Angle [°]</i>	0.0080 *	0.49	0.0060 *	N	N	0.0106 *	0.63	N	N	0.0117 *
Thoracic Kyphosis Angle [°]	0.1078	0.43	N	N	N	0.2162	0.35	N	N	N
<i>Thoracic Kyphosis Depth [mm]</i>	0.0440 *	0.57	0.049 *	N	N	0.0213 *	0.62	N	N	0.0198 *
Lumbar Lordosis Angle [°]	0.0712	0.49	N	N	N	0.6200	0.22	N	N	N
Lumbar Lordosis Depth [mm]	0.0166 *	0.50	0.0305 *	N	0.0499 *	0.0097 *	0.70	N	N	0.0074 *

Group F—Footballer group; Group C—Control group; N—statistically insignificant value. Variables with a non-parametric distribution are marked in italics, * *p* < 0.05.

4. Discussion

The aim of this study was the comparative assessment of the body posture in the sagittal plane of young soccer players in comparison with their untrained peers. Significant differences between athletes and their untrained peers were already shown in somatic characteristics and in all analyzed groups. This difference may have been due to the fact that in soccer, as in all sports, young athletes are a highly selected group chosen on the basis of size and technical skills, which, in turn, can significantly influence the biological development of young people. A similar phenomenon was indicated by Mandroukas et al. [48]. Both body build and posture also play remarkable roles in injury prevention or performance of athletes.

According to the authors, physical activity is an important aspect of a healthy lifestyle for children and adolescents, and soccer, as the most popular sport in the world, affects

the speed, endurance, agility, and strength of these young people. To date, however, there are few publications that attempt to determine the effects of regular sports training on the posture of young soccer players.

The results of our study showed that in all age groups significantly higher values of the upper thoracic and trunk inclination angles were observed in soccer players, compared with their untrained peers. It may result from the fact that during the training and game, the athletes often adopt a running stance, forcing the trunk to lean forward in relation to the vertical. Frequent adoption of such a position may force a change in the habit of body posture, which may become fixed over time, introducing a new postural pattern in the athlete.

Differences in body posture in the sagittal plane were also applied to individual age groups, both soccer players and non-training boys. This was particularly true for the parameters of the lumbar spine. These differences may be caused by the period of ontogenetic development and boys entering puberty. Complementary sports training targeted at 2 h per week during adolescence may improve active postural straightening in a pain-free population. This skill carries over into adulthood, even if training is no longer regular. Subconscious posture (habitual posture) and closed-eye posture, both of which are regulated specifically by proprioceptive receptor systems, can also be improved by appropriate additional training but require continuous exercise if improvements are to be maintained [49].

There are definitely more studies on comparative assessments of body posture in the frontal plane. Grabara analyzed body posture in the sagittal, frontal, and transverse planes, using computerized posturography in a group of young football players aged 11–14 years and their untrained peers [11]. The results indicated that the pelvic position in the frontal plane was more symmetrical ($p < 0.001$) in soccer players, but the alignment of the other measured parameters was similar between both groups, except for the horizontal symmetry of the waist triangles (higher occurrence of symmetry in some age groups of soccer players) and the horizontal symmetry of the shoulder blades (higher occurrence of asymmetry in some age groups of soccer players). The football players' spinal alignment was characterized by a more flattened lumbar lordosis. However, the postural symmetry index created for the purpose of this study did not show any differentiation between the studied groups, but the author himself pointed out the ambiguity of the obtained results [11].

The type of training and the sports discipline practiced by the athlete also greatly affect body posture. In the case of sports such as volleyball, karate, or handball, the occurrence of trunk asymmetry associated with asymmetric work of the shoulder complexes was observed more frequently among these subjects [20].

The results obtained in the Gonzalez-Galvez study showed a large, statistically significant effect of exercise improving the thoracic kyphosis angle and no significant effect on the lordotic lumbar angle [50]. On the one hand, this suggests that strengthening may be more important than stretching the thoracic arch, or at least it is necessary to act both to reduce the thoracic angle arch. In addition, this study suggests that stretching and strengthening are important in the magnitude of the lumbar spine angle. The findings suggest that a frequency of 2–3 sessions per week for 8–12 weeks will be optimal to align the physiological curvature of the spine. However, further research is needed that evaluates the effects of strengthening and/or stretching program on the magnitude of thoracic kyphosis and lumbar lordosis to determine the type of exercise that is best for maintaining sagittal disposition within normal ranges and to compare different frequencies and durations of the exercise program [50].

Many authors have also studied the influence of sports on the body posture of young athletes. Grabara has shown that training in volleyball may result in asymmetry in the position of the shoulder or hip girdle [42]. The most frequent asymmetries concerned the position of shoulder blades and waist triangles. Asymmetries in pelvic alignment in the transverse plane were reported less frequently in volleyball players than in non-athletes.

Volleyball players were more likely than their non-athletic peers to report a loss of lumbar lordosis and an increase in thoracic kyphosis, whereas thoracic kyphosis angle did not differ between athletes and non-athletes. Given the asymmetric spinal overloads that often occur in sports training, we strongly recommend postural assessment in young athletes. If necessary, exercises to help maintain correct posture should be incorporated into training sessions [51].

Studies by Walicka-Cupryś have shown that traditional karate affects the change of pelvic tilt to the posterior inclination [51]. Among children practicing traditional karate, the height and weight of the body and BMI correlate with the parameters characterizing the curvature of the spine in the thoracic and lumbar–sacral sections. The values of lumbar lordosis and thoracic kyphosis in traditional karate practitioners are comparable with those in the non-athletic group. The frequent occurrence of decreased pelvic tilt in traditional karate practitioners requires the introduction of exercises activating the forward tilt in the training session [51].

Practical Application

This paper has several limitations. First, the soccer group data did not include weekly training load, which would allow for more precise group characterization. Second, the low number of participants after subgrouping did not allow for the use of advanced statistical analyses such as MANCOVA. Nevertheless, considering the findings and limitations of this study, we suggest the implementation of body posture tests during the selection of players for the academy and control of the moire projection method at the time of puberty rise/jump.

This research can be used in practice by coaches and practitioners, who can include in their training programs for young players, additional uni- and bilateral activities, influencing the improvement of the static posture of the pupils. Further research on posture should potentially include additional factors that may contribute to injury risk in young soccer players [52].

5. Conclusions

The soccer training load can influence the anterior–posterior curvature of the spine. In the group of soccer in all age groups, higher angular values inclination of the upper spine by nearly 5° in the younger and 3° in the group of older boys, and almost 3 times of thoracic kyphosis and greater tilt of the torso forward were found, compared with their untrained peers.

There were also significant differences in body posture between children of different ages, both in trained and untrained subgroups. In the group of elite youth soccer players, the differences concerned mainly the size of the lumbosacral angle and the depth of both curves, which decreased with the age of the players. A similar phenomenon was observed in the group of untrained boys but only in children in the older age groups.

Author Contributions: Conceptualization, K.B.-P. and W.D.; methodology, K.B.-P., M.S., K.R. and W.D.; validation K.B.-P., Ł.P. and K.R.; formal analysis, M.S.; investigation, K.B.-P., K.R. and W.D.; resources, K.B.-P. and K.R.; data curation, M.S. and K.B.-P.; writing—original draft preparation, K.B.-P., K.R., M.S., Ł.P. and W.D.; writing—review and editing, K.B.-P. and W.D.; visualization, K.B.-P. and W.D.; supervision, K.B.-P. and W.D.; project administration, K.R. and Ł.P. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the statutory funds from the Wrocław University of Health and Sport Sciences.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Senate Committee on Ethics of Scientific Research at the University School of Physical Education in Wrocław, Poland (No 9.02.15).

Informed Consent Statement: Informed consent was obtained from all subjects parents involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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