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The influence of body posture parameters on selected parameters of the dynamic foot analysis

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Abstract

Introduction and purpose of work. The correct body posture and its evaluation in children of all ages is of great importance. Special attention should be paid to two critical periods, when the posture may deteriorate significantly. Monitoring the body posture makes it possible to detect any abnormalities at an early stage that may subsequently lead to other health problems. The aim of the paper was to analize the connections between the body posture parameters and the selected parameters of the dynamic foot examination.

Material and methods. 106 children at the age of 10-15 years old from schools located in the Świętokrzyskie Voivodeship took part in the study. The posture of children assessed with the use of the Diers system is analyzed using a three-dimensional light-optical system. The next stage of the research was to conduct the dynamic foot analysis on the FreeMed platform.

Results. No dependence between the majority of the studied body posture parameters and the parameters of the dynamic analysis was found. A statistically significant dependence was observed between: the right foot surface and the pelvic tilt, the right foot surface and the rotation surface, the number of steps per minute and the pelvic tilt, the contact time of the right foot surface and the pelvic tilt. When the pelvic tilt was standard, the authors observed a smaller surface while loading the right foot, a greater number of steps, and a shorter right foot contact time. The standard surface rotation affected the larger foot surface in the dynamic analysis.

Conclusion. The study needs to be continued and extended in order to verify if there are any dependencies between the body posture parameters and the selected parameters of the dynamic analysis of the foot and gait pressure in children.

Key words. Body posture, dynamic foot analysis, children

Introduction

The correct body posture and its evaluation in children of all ages is of great importance. Special attention should be paid to two critical periods, when the posture may deteriorate significantly. Monitoring the body posture makes it possible to detect any abnormalities at an early stage that may subsequently lead to other health problems [1, 2, 3]. The data regarding the occurrence of body posture defects among children and adolescents differs and estimates up to 50-60% of children [4, 5, 6, 7]. Health prophylaxis regardingthe correct body posture should be implemented not only by qualified physiotherapists, but also at school or home, so in the daily environment of children [4, 6, 8, 9]. The authors also deal with factors contributing to the development of incorrect body posture, i.e.: too little physical activity, obesity, socio-economic status, lifestyle, sex, age and many others [5, 10, 11, 12].

Purpose of work

The aim of the paper was to analize the connections between the body posture parameters and the selected parameters of the dynamic foot examination.

Material and methods

The consent to conduct this study was obtained from the Bioethics Committee located at the Jan Kochanowski University in Kielce. 106 children at the age of 10-15 years old from schools located in the Świętokrzyskie Voivodeship took part in the study. The including criterion was the consent given by parents or legal guardians to conduct the study and the lack of current orthopedic problems related to the motor system, i.e. fractures or dislocations. No consent granted by parents or legal guardians of children to conduct the examination and current orthopedic problems related to the motor system, i.e. fractures or dislocations constituited the excluding criterion. The children were tested using the Diers device and the FreeMed platform.

The posture of children assessed with the use of the Diers system is analyzed using a three-dimensional light-optical system. A naked patient faces backwards the device, which consists of a camera and a projector. Measuring lines are emitted through the projector and a three-dimensional image is transmitted to the computer. The software analyzes the obtained data and gives a full picture of the posture. The next stage of the research was to conduct the dynamic foot analysis on the FreeMed platform. The children wore sport clothes without shoes for the examination. After the examination, the patient was asked to walk on the platform. The examination of children was conducted in the Posturology Laboratory at the Faculty of Medicine and Health Science.

MS Office Excel and statistical program R.3.3.1 were used to analyze the research.Basic measures of descriptive statistics were calculated for all parameters, i.e. arithmetic averages, standard deviation, minimum and maximum for the entire group. While studying thedependencies between the variables,non-parametric tests were applied: the Mann-Whitney-Wilcoxon U test and the Wilcoxon test for pairs of observations. The result when the level of significance amounted to $p<0.05$ was considered as statistically significant. The dependencies between the selected parameters of the dynamic foot analysiswere examined, i.e. maximum foot load, average foot load, feet load surface cm^2, ground contact time, steps per minute, and the body posture parameters: deviation from the vertical VP-DM [mm], pelvic tilt DL-DR [mm], pelvic torsion DL-DR [°], surface rotation (rms) [°], lateral deviation

VPDM (rms) [mm], kyphosis angle ICT-ITL (max.) [°], and lordosis angle ITL-ILS (max.) [°].

Results

Tables 1 and 2 contain the information regarding the characteristics of the selected body posture parameters and the dynamic foot analysis.

Table 1. The characteristics of the selected parameters of the dynamic foot analysis

Parameters of the dynamic foot analysis	Average	Standard deviation	Minimum	Maximum
Maximum load gr/cm^2 left foot	1200,43	224,81	700	1996
Maximum load gr/cm^2 right foot	1208,58	225,90	756	2220
Average load gr/cm^{2}leftfoot	443,13	75,59	300	655
Average load gr/cm^{2}rightfoot	429,13	67,16	275	601
Surface cm^2 left foot	134,31	22,39	88	203
Surface cm^2 right foot	135,37	21,42	81	202
Ground contact time – left foot	847,21	115,09	417	1137
Ground contact time – right foot	867,10	160,66	469	1660
Steps per minute	69,40	9,71	42	91

Table 2. The characteristics of the selected parameters assessing the body posture of children

The parameters assessing the body posture	Average	Standard deviation	Minimum	Maximum
Surface rotation (rms) [°]	3,80	1,62	1	10
Lateral deviation VPDM (rms) [mm]	3,54	1,74	1	9
Kyphosis angle ICT-ITL (max) [°]	47	6,22	35	66
Lordosis angle ITL-ILS (max) [°]	40,26	8,5	10	66

Tables 3-7 refer to the analysis of the dependencies of particular body posture parameters and the parameters of the dynamic foot analysis with the division into the right and the left foot.

Table 3. The analysis of the dependencies between the maximum foot load and the body posture parameters.

Right foot				Maximum load gr/cm^2	Left foot			
Standard	Non-standard	Z	p		Standard	Non-standard	Z	p
1184,9	1247,6	0,978	0,33	Deviation from the vertical VP-DM [mm]	1197,2	1205,8	-0,101	0,92
1228,9	1169,0	-1,174	0,24	Pelvic tilt DL-DR [mm]	1217,9	1166,4	-0,801	0,42
1233,7	1182,5	-0,847	0,40	Pelvic torsion DL-DR [°]	1224,0	1176,0	-0,521	0,60
1251,8	1171,4	-1,223	0,22	Surface rotation (rms) [°]	1235,0	1170,7	-1,239	0,22
1208,7	1208,2	0,489	0,62	Lateral deviation VPDM (rms) [mm]	1221,3	1139,4	-1,577	0,11
1210,1	1205,0	-0,260	0,79	Kyphosis angle ICT-ITL (maks.) [°]	1205,9	1187,3	-0,809	0,42
1222,3	1170,4	-0,899	0,37	Lordosis angle ITL-ILS (maks.) [°]	1209,6	1175,0	-0,394	0,69

Table 4.The analysis of the dependencies between the average foot load and the body posture parameters.

Right foot				Average load gr/cm^2	Left foot			
Standard	Non-standard	Z	p		Standard	Non-standard	Z	p
421,5	441,8	1,503	0,13	Deviation from the vertical VP-DM [mm]	441,9	445,1	0,117	0,91
432,3	423,1	-0,794	0,43	Pelvic tilt DL-DR [mm]	449,1	431,5	-0,754	0,45
436,1	422,0	-0,853	0,39	Pelvic torsion DL-DR [°]	450,9	435,1	-0,695	0,49
438,1	421,5	-0,919	0,36	Surface rotation (rms) [°]	459,4	429,2	-1,616	0,11
432,3	419,8	-0,471	0,64	Lateral deviation VPDM (rms) [mm]	449,1	425,7	-1,385	0,17
429,6	428,1	-0,229	0,82	Kyphosis angleICT-ITL (maks.) [°]	443,3	442,8	-0,365	0,72
427,3	434,2	0,366	0,71	Lordosis angle ITL-ILS (maks.) [°]	443,5	442,3	-0,272	0,79

Table5. The analysis of the dependencies between the feet surface and the body posture parameters.

Right foot				Surface cm^2	Left foot			
Standard	Non-standard	Z	p		Standard	Non-standard	Z	p
135,0	136,1	0,606	0,54	Deviation from the vertical VP-DM [mm]	132,4	137,5	1,294	0,20
131,3	143,2	2,299	0,02	Pelvic tilt DL-DR [mm]	131,0	140,8	1,962	0,05
136,8	133,9	-0,724	0,47	Pelvic torsion DL-DR [°]	135,6	133,0	-0,496	0,62
139,6	131,7	-2,257	0,02	Surface rotation (rms) [°]	138,4	130,8	-1,813	0,07
136,6	131,8	-1,041	0,30	Lateral deviation VPDM (rms) [mm]	135,0	132,2	-0,656	0,51
135,6	134,8	-0,205	0,84	Kyphosis angleICT-ITL (maks.) [°]	134,0	135,1	0,108	0,91
137,3	130,0	-1,272	0,20	Lordosis angle ITL-ILS (maks.) [°]	136,5	128,4	-1,832	0,07

Table6. The analysis of the dependencies between the foot contact time and the body posture parameters.

Right foot				Ground contact time	Left foot			
Standard	Non-standard	Z	p		Standard	Non-standard	Z	p
864,7	871,2	0,209	0,83	Deviation from the vertical VP-DM [mm]	835,4	866,7	1,300	0,19
855,5	889,7	2,038	0,04	Pelvic tilt DL-DR [mm]	836,3	868,4	1,538	0,12
851,0	883,9	1,321	0,19	Pelvic torsion DL-DR [°]	834,7	860,2	1,194	0,23
860,6	872,7	-0,551	0,58	Surface rotation (rms) [°]	849,3	845,4	-0,447	0,66
877,2	837,6	-0,406	0,68	Lateral deviation VPDM (rms) [mm]	846,1	850,3	0,522	0,60
868,1	864,8	-0,674	0,50	Kyphosis angleICT-ITL (maks.) [°]	850,8	838,5	-0,233	0,82
873,2	850,2	-0,365	0,71	Lordosis angle ITL-ILS (maks.) [°]	850,2	838,9	-0,491	0,62

Table 7. The analysis of the dependencies between the steps per minute and the body posture parameters.

Steps per minute				
	Standard	Non-standard	Z	p
Deviation from the vertical VP-DM [mm]	69,6	69,0	-0,313	0,75
Pelvic tilt DL-DR [mm]	70,5	67,2	-2,157	0,03
Pelvic torsion DL-DR [°]	70,7	68,1	-1,373	0,17
Surface rotation (rms) [°]	69,8	69,0	0,219	0,83
Lateral deviation VPDM (rms) [mm]	69,6	68,7	-0,657	0,51
Kyphosis angleICT-ITL (maks.) [°]	69,3	69,6	0,268	0,79
Lordosis angle ITL-ILS (maks.) [°]	68,9	70,8	0,452	0,65

Table 8 compares the parameters of the dynamic foot analysis with the division into the right and the left foot. The dependence between the average load of the right and the left foot, and the foot contact time is noticable.

Table 8. The comparison of parameters for both feet- the Wilcoxon test for pairs of observations (WilcoxonSigned-Rank Test)

The comparison of feet – the Wilcoxon test for pairs of observations (Wilcoxon Signed-Rank Test)				
	left	right	Z	p
Maximum load gr/cm^2– the dynamic examination	1200.4(SD=224.8)	1208.6(SD=225.9)	-0,5768391	0,56
Average load gr/cm^2– the dynamicexamination	443.1(SD=75.6)	429.1(SD=67.2)	2,6303907	0,01
Surface cm^2- the dynamicexamination	134.3(SD=22.4)	135.4(SD=21.4)	-0,7256938	0,47
Groundcontacttime	847.2(SD=115.1)	867.1(SD=160.7)	-2,3341206	0,02

Figures1-4 show statistically crucial dependencies between the posture parameters and the dynamic foot analysis.

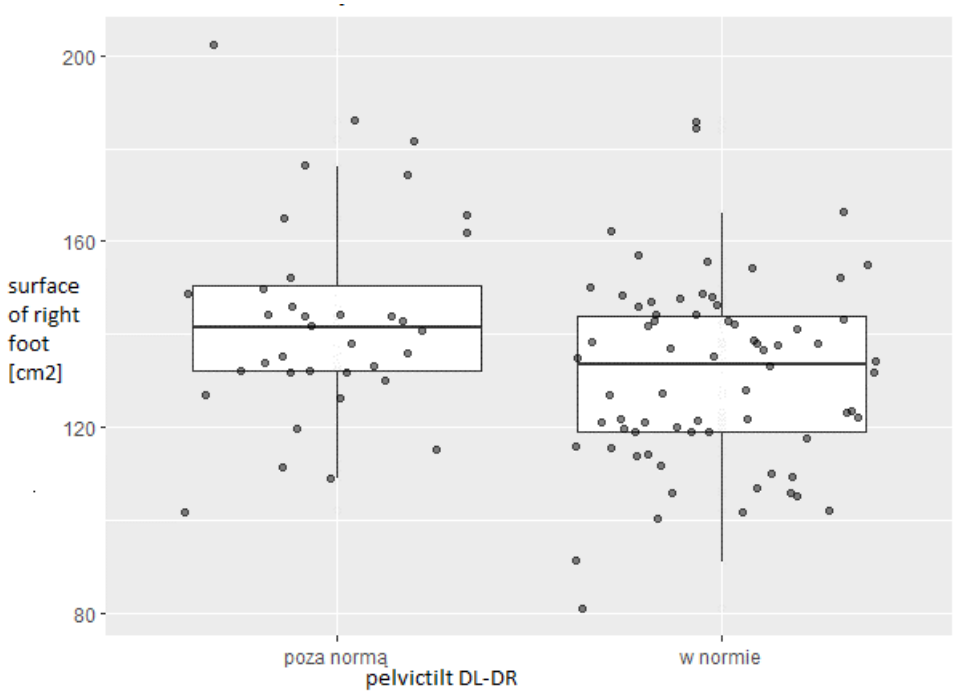

Fig. 1. The dependence between the right foot surface and the pelvic tilt

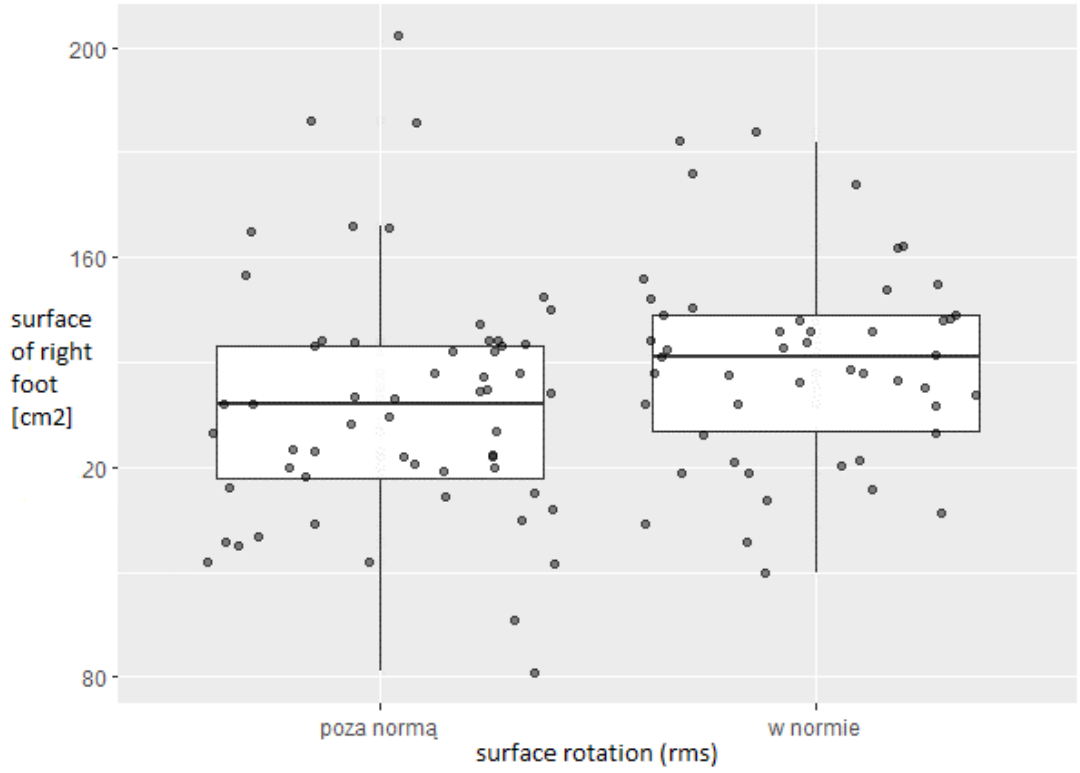

Fig. 2. The dependence between the right foot surface and the surface rotation

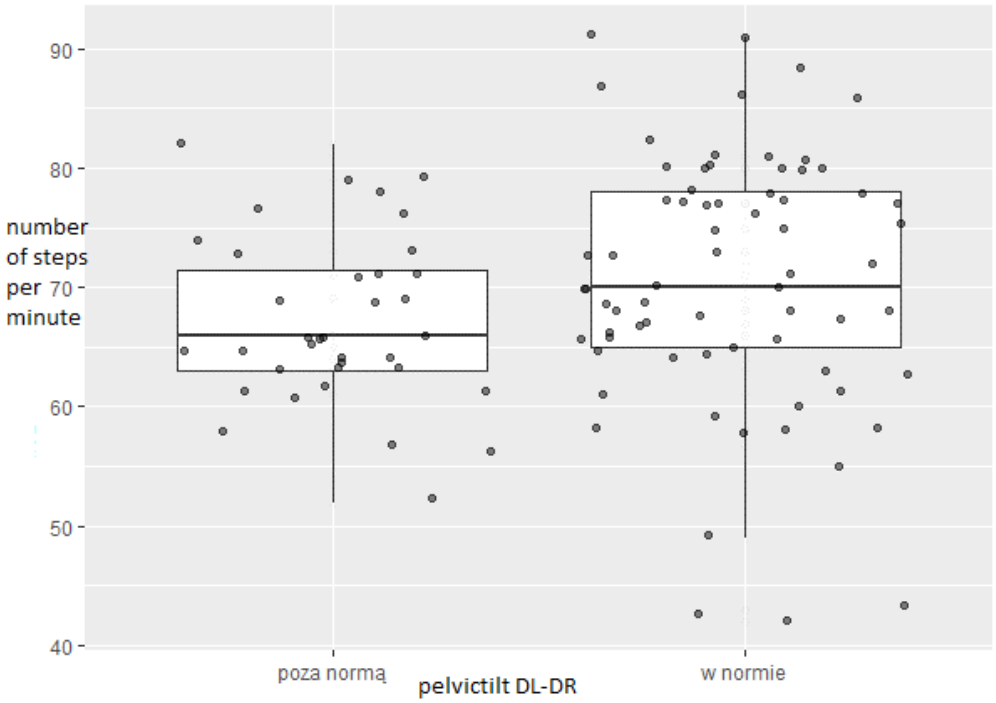

Fig. 3. The dependence between the number of steps per minute and the pelvic tilt

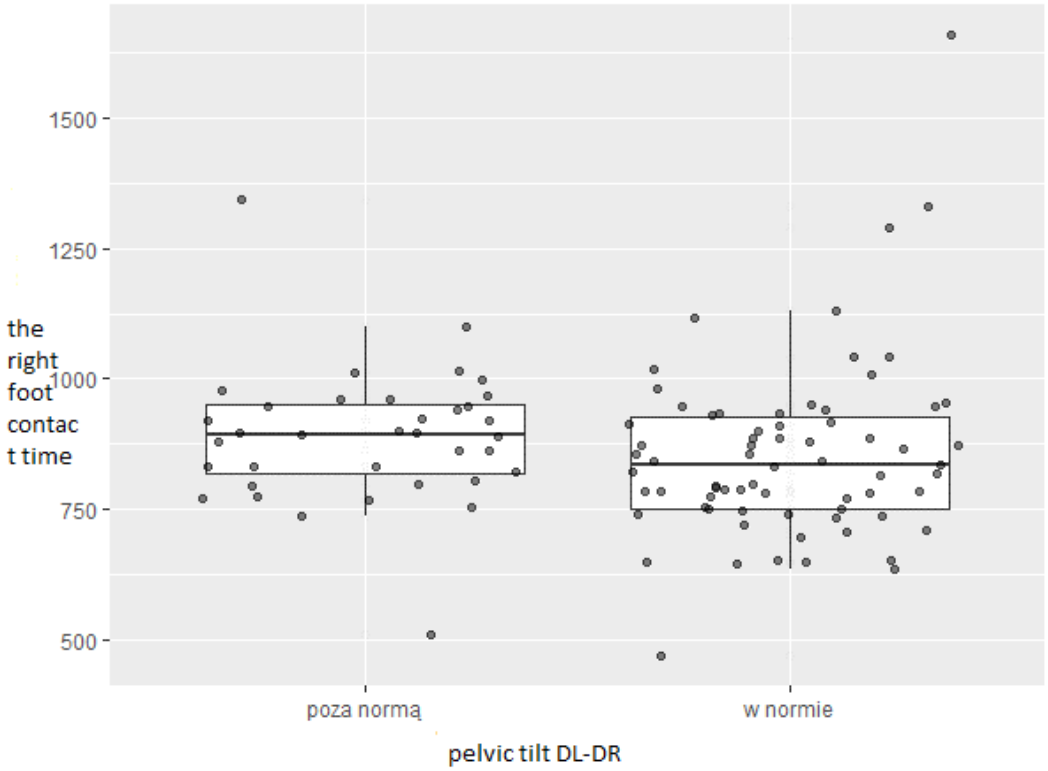

Fig. 4. The dependence between the right foot contact time and the pelvic tilt

Discussion

According to the meta-analyses of research, a human takes on average 10,000 steps a day [13], hence, the gait should be ergonomic, and should guarantee balance, adequate step

length and low energy consumption [14], but also provide proper conditions for shaping the body posture.

The majority of authors concentrate their dynamic analysis using pedobarographic patterns on analysing loads of particular foot zones in people with various problems. Articles refer the most frequently to the foot load of people with excessive body mass or feet irregularities [15, 16, 17, 18, 19]. Therefore, the authors have made an attempt to investigate the influence of body posture parameters on selected parameters of the dynamic foot analysis which are related to the gait.

Jaszczur et al. [20]in her research of people aged 22-27 did not notice any statistically significant differences between the maximum foot load, the ground contact time, and thus, found that the gait of the respondents was symmetrical. In this paper, the parameters such as the maximum load and the foot surface in the loading phase while differentiating the averages for both feet, showed no statistically significant differences, however, statistically significant differences were found while analyzing the following parameters, i.e.: the ground contact time, and the average foot load. The right lower limb came into longer contact with the ground, while the average load was higher for the left lower limb.

The number of steps per minute changes with age, and according to the standards [21] the number in the examined age group should fall between 100-162 steps per minute. On average the number amounted to 69 steps in the study group – while the results fall between 42-91 steps.

The authors here of were seeking the dependencies between the selected parameters of the dynamic foot analysis and the gait, and the body posture.

This paper attempted to assess how variable body posture parameters will affect the selected parameters of the foot load, as well as the number of steps per minute and the ground contact time. It was assumed that as the posture symmetry changes, the above-mentioned parameters should change as well. No dependence between the majority of the studied body posture parameters and the parameters of the dynamic analysis was found. A statistically significant dependence was observedbetween: the right foot surface and the pelvic tilt, the right foot surface and the rotation surface, the number of steps per minute and the pelvic tilt, the contact time of the right foot surface and the pelvic tilt. When the pelvic tilt was standard, the authors observed a smaller surface while loading the right foot, a greater number of steps, and a shorter right foot contact time. The standard surface rotation affected the larger foot surface in the dynamic analysis.

The authors emphasized the need to broaden the study regarding the foot load and increase the number of respondents, as well as suggestedan attempt to divide the test and the control group. In their opinion, the test group should comprise of people with posturalproblems.

Conclusion

The study needs to be continued and extended in order to verify if there are any dependencies between the body posture parameters and the selected parameters of the dynamic analysis of the foot and gait pressure in children.

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