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Original article

RELATIONSHIP BETWEEN PRESSURES EXERCISED ON THE FOOT PLANT AND THE DISTRIBUTION OF THE MUSCULAR FORCES AT THE TRUNK LEVEL

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Abstract

Aim. The aim of this study is to determine whether the values produced by static baropodometry are correlated with measurements made with the device for determining muscle imbalances present at the trunk level.

Methods. The study involved 41 handball players aged 12 to 16 years old. The pressures on the foot plant were measured by static baropodometry. They were applied 9 measuring tests for the muscular strength of the trunk, as follows: the muscle strength testing on flexion, from seated; the muscle strength testing on left lateral tilt, from seated; the muscle strength testing on extension from sitting; the muscle strength testing on the right side tilt, from sitting; the muscle strength testing on flexion, from standing; the muscle strength testing on left lateral tilt, from standing; the muscle strength testing on extension from standing; the muscle strength testing on the right side tilt from standing; the lumbar muscle strength testing (classic test). It was used the Pearson correlation coefficient (r).

Results. The values of **r** (0.37-0.77) prove the existence of strong relationship between muscle force distribution at the trunk level and values of the pressures exercised on the foot plant.

Conclusions. According to the research hypothesis, there is a strong link between the measured parameters, with large values of **r** (0.70) especially in the foreground and in the front of the body. The correlations are positive, so any movement of the trunk increases the values of the foot plant pressure points level. Significantly higher values of **r** are observed in case of the trunk muscle strength testing from sitting (0.61-0.77) compared to the values of **r** for tests on the trunk muscle strength from standing (0.36-0.59). The study results demonstrate the validity and the efficiency of the system for the measurement muscle forces at the trunk level.

Key words: static, muscle strength, trunk evaluation, baropodometry

Introduction

It was found that static disorders occupy an important place among the causes of legs injuries, so some researchers concerned with this issue, estimate these at about 90%. In humans, the foot is support and walking organ, with its own anatomical constitution of these functions.

During orthostatism not the entire foot plant has support on the ground, but only a part of it, with three points for maximum support. The way the foot rests on the ground can be studied by podoscopic examination or complex tests, which accurately inform about the pressures on each support area (baropodography).

Knowledge of static disorders allows time for measures aiming not only to improve these shortcomings at the foot plant level, but also to avoid predisposing factors (Scena & Steindler, 2008).

Poor posture in movement or at rest can lead to health problems (Chaudhry, Bukiet, Ji & Findley, 2011). By photography the soles and computerized data processing, it identifies points of the body weight.

After computerized measurements, the patient is recommended planting orthotics made of special materials for correcting these deficiencies. These orthotics aim to correct static body imbalances. There are different ways to measure the trunk strength, which includes legs force plates and pelvis fixation (Mockova, Greenwood & Day, 2005). Sommer, Hofmeier & Berschin (2002) brings to discussion a study on the importance of the muscles around the knee in the static and the dynamic of whole body.

Researchers continue to seek ways of clarifying the relationship between body segments and its static and dynamic aspects especially in children (McEvoy & Grimmer, 2005). This study will be used to assess the trunk muscle strength or force measurement on main directions of movement. The method offers the possibility of setting muscle imbalances targets in the levels of this important segment of the human body (Marcu, Stan, Baştiurea & Chiculiţă 2008; Stan, 2009).

A delicate problem of achieving measurements

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with dynamo-meters namely the influence of gravity on them, as the accuracy of the correction made by dynamo-meters for the trunk muscle strength during measurements on different degrees of motion is studied by Bygott, McMeeken, Carroll & Story (2001).

This testing method involves fixed starting positions on traction concerning the dynamo-meter, aiming that the trunk will not to use too much leverage to amplify the obtained values (Stan Baştiurea & Rizescu, 2015). The increasing of the trunk strength with age is evidenced by Manini, Sagendorf, Mayer & Ploutz-Snyder (2005), so it is also possible that influence of the imbalances on the foot plant and the influencing of the body statics to grow.

It was studied the possibility of reducing these muscle imbalances in the trunk (Baştiurea, Stan & Andronic, 2009), but without making a correlation with the health of the foot plant. Also, for the handball players was analyzed the relationship between posture changes, the number of injuries, landings influence on knees and ankles (Santos Detanico, Graup & Reis, 2007).

In case of this study, the strong correlation between the muscle trunk imbalances forces and pressures measured at the foot plant level, would offer new possibilities for preventing and resolving human body statics disorders. It follows in which side of the trunk (upper or lower) and which plane (sagittal and frontal) is influenced more pressure on the foot plant.

The existence of high levels of correlation between the measured parameters will demonstrate the validity and efficiency measurement system of muscle forces at the trunk level.

Methods

Subjects

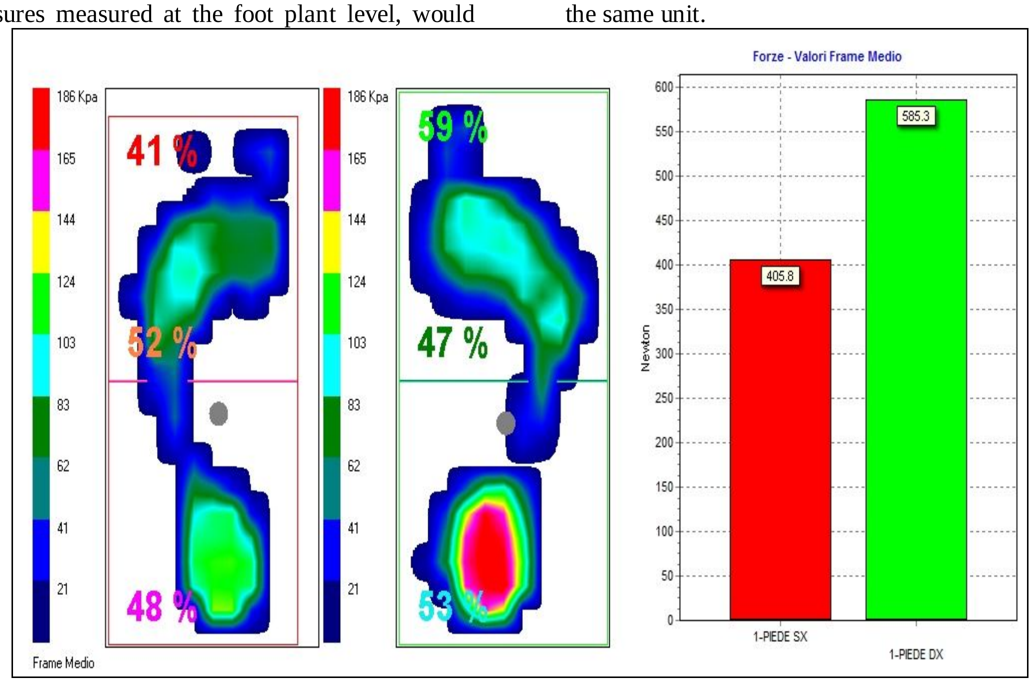
The study involved 41 handball players, aged between 12 and 16 years old.

Test procedure

The Static Baropodometry, that shows the weight distribution at foot plant level, provides data about supporting surface and the forces that support the body (Danelciuc, Danelciuc & Betiuc, 2011).

By photography the soles (Figure 1) and processing computer data, it identifies points of the body weight. They are used for correlations averaged per plant (abbreviations are found in Table 1).

The values were obtained have Newton as measurement unit and are converted to kgf to use the same unit.



When assessing the trunk (Figure 2) they were applied 9 measuring tests for the muscular strength of the trunk, as follows: the muscle strength testing on flexion, from seated; the muscle strength testing on left lateral tilt, from seated; the muscle strength testing on extension from sitting; the muscle strength testing on the right side tilt, from sitting; the muscle strength testing on flexion, from standing; the muscle strength testing on left lateral tilt, from standing; the muscle strength testing on extension from standing; the muscle strength testing on the right side tilt from standing; the lumbar muscle strength testing (classic test).

Translations of data from a graph shows how the way the forces are acting on the spinal muscle (Figure 3).

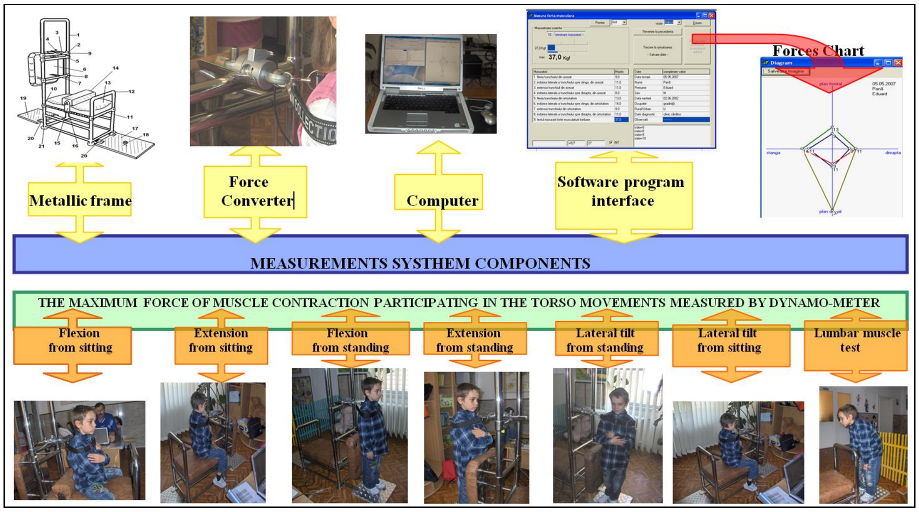


Figure 2. Evaluation system of muscle trunk's imbalances

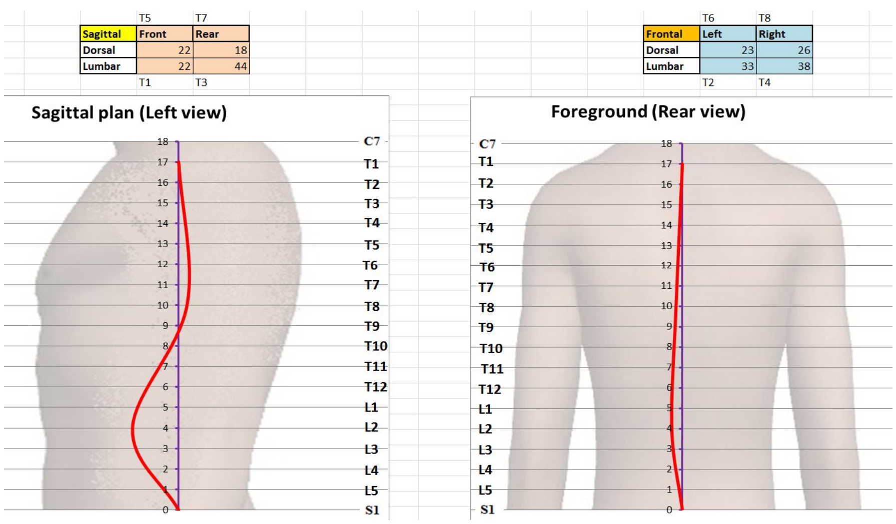


Figure 3. Representation of muscle forces measured at the trunk level

Table 1. Abbreviations used in this study		
Tests	Measurement unit	Abbreviations
Testing of the muscular force at the trunk level		
Muscle strength testing on flexion, from seated	**kgf**	**T1**
Muscle strength testing on left lateral tilt, from sitting	**kgf**	**T2**
Muscle strength testing on extension from sitting	**kgf**	**T3**
Muscle strength testing on the right side tilt, from sitting	**kgf**	**T4**
Muscle strength testing on flexion, from standing	**kgf**	**T5**
Muscle strength testing on left lateral tilt, from standing	**kgf**	**T6**
Muscle strength testing on extension from standing	**kgf**	**T7**
Muscle strength testing on the right side tilt from standing	**kgf**	**T8**
Lumbar muscle strength testing (classic test)	**kgf**	**T9**
Static Baropodometry		
Average values for the left foot plant	**Newton**	**P left N**
Average values for the right foot plant	**Newton**	**P right N**
Average values for the left foot plant (kgf)	**kgf**	**P left kgf**
Average values for the right foot plant (kgf)	**kgf**	**P right kgf**

Results

The data collected were processed using SPSS v. 20 for Windows.

Table 2 shows the measured values for each test.

Table 2. Abbreviations used in this study

Testing of the muscular force at the trunk level										Baropodometry			
Nr.	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**P st. N**	**P st. kgf**	**P dr. N**	**P dr. kgf**
1.	12	11	17	13	36	29	46	33	67	405.8	41.4	585.3	59.7
2.	14	14	29	14	21	30	30	32	72	439.7	44.8	534.9	54.5
3.	17	12	28	12	28	29	42	30	55	515.8	52.6	613.3	62.5
4.	15	9	32	10	15	23	32	23	64	407.3	41.5	523.9	53.4
5.	20	12	27	10	27	23	33	25	64	455	46.4	449.1	45.8
6.	19	14	43	14	31	32	39	25	78	507.2	51.7	551.3	56.2
7.	16	11	24	11	30	22	24	20	77	458.7	46.8	559.3	57
8.	14	9	16	8	22	25	32	27	56	454.1	46.3	370.5	37.8
9.	15	10	31	9	26	21	27	20	50	473.2	48.3	623.3	63.6
10.	15	13	35	16	35	35	38	35	82	518.2	52.8	538.1	54.9
11.	9	8	12	9	27	24	22	21	38	353.7	36.1	403.3	41.1
12.	29	25	51	24	21	33	41	29	61	684.4	69.8	941.7	96
13.	16	12	25	12	25	28	33	22	40	454.6	46.4	550.2	56.1
14.	16	12	19	11	31	25	37	27	58	411	41.9	572.6	58.4
15.	17	9	19	8	28	29	29	25	43	415.3	42.3	602	61.4
16.	22	18	43	20	41	35	50	37	85	514	52.4	647.9	66.1
17.	18	12	22	11	34	35	42	31	78	568.9	58	588.1	60
18.	22	18	32	17	34	33	36	36	89	629.8	64.2	787.3	80.3
19.	12	7	26	9	20	20	34	22	49	427.2	43.6	504.5	51.4
20.	17	15	30	16	30	25	22	22	53	444.4	45.3	587.9	59.9
21.	19	11	26	10	29	18	31	17	61	407.9	41.5	470.4	47.9
22.	19	15	32	14	30	26	34	30	92	571	58.2	754.6	76.9
23.	17	12	32	13	34	28	35	32	65	439.5	44.8	512.7	52.2
24.	15	10	18	10	23	27	30	21	44	458.9	46.7	536.5	54.7
25.	13	12	24	14	26	30	32	29	56	491.4	50.1	532.5	54.2
26.	13	11	21	11	30	21	31	25	67	428.1	43.6	567.1	57.8
27.	19	15	22	12	24	24	33	26	76	570.6	58.1	762.9	77.7
28.	14	12	25	13	20	16	17	18	65	611.9	62.3	634.4	64.6
29.	17	12	39	11	31	21	32	27	71	486.8	49.6	664.6	67.7
30.	14	10	22	9	18	19	22	18	48	378	38.5	614.3	62.6
31.	23	17	31	20	30	28	35	32	68	661.8	67.4	568.7	57.9
32.	10	7	17	8	18	13	23	16	35	364.9	37.2	364.8	37.1
33.	11	7	14	8	13	15	20	15	44	387.3	39.4	481.7	49.1
34.	14	14	34	11	30	25	29	29	87	369.9	37.7	493.5	50.3
35.	22	19	39	16	40	35	55	34	107	622.3	63.4	749.2	76.3
36.	17	18	27	19	37	28	33	33	82	566.3	57.7	603.5	61.5
37.	8	6	12	5	14	15	18	16	43	344.8	35.1	331.1	33.7
38.	20	14	35	14	34	41	45	35	77	511.9	52.1	617.1	62.9
39.	8	6	9	7	16	16	22	17	40	310.4	31.6	327.1	33.3
40.	14	17	26	18	32	25	31	26	59	434	44.2	554.8	56.5
41.	22	15	29	13	42	39	40	35	89	472.7	48.2	570.2	58.1

Table 3 shows the observed the association strength of the measured parameters. The highest value of **r** (0.77%) shows a very strong correlation between the measured variables.

Table 3. The correlations between the muscular forces imbalances at the trunk level and the pressure measured on foot plant

	T1	T2	T3	T4	T5	T6	T7	T8	T9
P st. kgf	0.77	0.77	0.61	0.74	0.39	0.52	0.50	0.55	0.59
P dr. kgf	0.74	0.77	0.65	0.66	0.37	0.47	0.48	0.48	0.53

The values represent the correlation percent between the somatic parameters and technical parameters; $p<0.05$.

T1, Muscle strength testing on flexion, from seated; **T2,** Muscle strength testing on left lateral tilt from sitting; **T3,** Muscle strength testing on extension from sitting; **T4,** Muscle strength testing on the right side tilt, from sitting; **T5,** Muscle strength testing on flexion, from standing; **T6,** Muscle strength testing on left lateral tilt, from standing; **T7,** Muscle strength testing on extension, from standing; **T8,** Muscle strength testing on lateral right tilt, from standing T; **T9,** Lumbar muscle strength testing (classic test); **P left kgf,** Average values obtained for the left plant (kgf); **P right kgf,** Average values obtained for the right plant (kgf).

After studying the tables above, we can review the following results:

- The frontal plan correlations are strong and positive. They are observed equally strong correlations (0.77) on the left side on the trunk, on both plants.
- Correlations related to the anterior torso have values as high as those on the left side (0.74-0.77).
- They are observed significantly higher values of **r** in case of the trunk muscle strength testing from sitting (0.61-0.77) compared to the values of **r** for tests on the trunk muscle strength in standing (0.36-0.59).
- The lowest correlations are observed in the assessment of the trunk flexion in standing.

Discussions

Significantly higher values of **r** in case of the trunk muscle strength testing from sitting shows the big influence of the pelvis and lumbar muscles, confirmed by studies conducted by Anker et al. (2008).

A more pronounced asymmetry is observed from a sitting position also in the case of the research is carried out Biały, Kłaptocz & Gnat (2010). In this case they were underlined also the differences on the side. The study notes higher correlations on the left side, which has to do with the predominance of dexterous arm.

Importance of the lumbar, pelvic and femoral areas for fixing the correct posture is evidenced by Husson et al. (2010). Higher values involving these findings strengthen their conclusions.

Moreover, the authors have studied the role of vertical abdominal straight muscle chains, antagonistic to the extensor muscles of the spine (Baştiurea, Stan, Gutiérrez & Andronic, 2010) and their relation to the harmony of the trunk development.

It should be noted the average correlation values of lumbar muscles (T9) with the plant pressure. Instead, it appears that large load is projected on the front of the body (T1).

Conclusions

According to the research hypothesis, there is a strong link between the measured parameters, the values of **r** being higher (0.77) mainly in the frontal plane and in the front of the body. The correlations are positive, so any movement of the trunk increases the values of pressure points at the plantar level.

The conclusions must be accepted with care, as it concerns only this group of athletes, while the correlations obtained indicates the degree of association between the variables used, and not the cause of those connections.

The study results demonstrate the validity and the efficiency of the measurement system of muscle forces at the trunk level.

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References

Anker LC, Weerdesteyn V, Van Nes IJW, Nienhuis B, Straatman H, Geurts ACH, 2008, The relation between postural stability and weight distribution in healthy subjects. Gait & Posture, 27(3), 471-477. doi:10.1016/j.gaitpost.2007.06.002

Baştiurea E, Stan Z, Andronic F, 2009, Study on increasing the values of force and correcting the muscular trunk imbalances in handball players. The Annals of the Univeristy "Dunărea de Jos" Galaţi, Fascicle XV: Physical Education and Sport Management, 181-184.

Baştiurea E, Stan Z, Gutiérrez AÓ, Andronic F, 2010, Study regarding the degree of correlation between the capacity of effort and the values of muscle strength measured on the main directions of the torso's movement at young handball players. Annals of "Dunărea de Jos" Galaţi, Fascicle XV: Physical Education and Sport Management, 1, 65-69.

Biały M, Kłaptocz P, Gnat R, 2010, Functional asymmetry of the spine in standing and sitting positions. Acta Universitatis Palackianae Olomucensis. Gymnica, 40(1), 53-60.

Bygott L, McMeeken J, Carroll S, Story I, 2001, Gravity correction in trunk dynamometry: Is it reliable?. Isokinetics and Exercise Science, 9(1), 11-19.

Chaudhry H, Bukiet B, Ji Z, Findley T, 2011, Measurement of balance in computer posturography: Comparison of methods - A brief review. Journal of Bodywork & Movement Therapies, 15(1), 82-91.

Danelciuc FT, Danelciuc EM, Betiuc M, 2011, Rehabilitation balance assessment in stroke patients using baropodometry. Romanian Magazine of Physical Therapy, 17(28), 5-9.

Husson JL, Mallet JF, Parent H, Cavagna R, Vital JM, Blamoutier A, Violas P, 2010, The lumbar-pelvic-femoral complex: applications in spinal imbalance. Orthopaedics & Traumatology: Surgery & Research, 96(4), Supplement, 10-16.
doi: 10.1016/j.otsr.2010.03.007

Manini T, Sagendorf K, Mayer J, Ploutz-Snyder L, 2005, Trunk extensor muscle function in young and old women: A pilot study. Journal of Back and Musculoskeletal Rehabilitation, 18(1, 2), 5-13.

Marcu V, Stan Z, Baştiurea E, Chiculiţă C, 2008, Determination of muscle imbalances present in the trunk. Method and apparatus, Galati: Academic Publishing, 150 p.

McEvoy MP, Grimmer K, 2005, Reliability of upright posture measurements in primary school children. BMC Musculoskeletal Disorders, 6:35. doi:10.1186/1471-2474-6-35

Mockova M, Greenwood RJ, Day BL, 2006, A method for quantifying directional strength and motor control of the trunk. Journal of Neuroscience Methods, 156(1-2), 211-217.

Santos SG, Detanico D, Graup S, Reis DC, 2007, Relation between posture changes, prevalence of injuries and impact magnitude on lower limbs as regards the handball athletes. Fit Perf J, 6(6), 388-393. doi:10.3900/fpj.6.6.388.e

Scena S, Steindler R, 2008, Methods for sitting posture evaluation: Static posture and applications. Journal compilation, 2008 Blackwell Publishing Ltd, Strain, 44(6), 423-428. doi: 10.1111/j.1475-1305.2007.00334.x

Sommer HM, Hofmeier A, Berschin G, 2002, Proprioception and thus muscle strength measurement of the knee joint. Isokinetics and Exercise Science, 10(1), 44.

Stan Z, 2009, Motor and functional assessment (course). Galati: Publisher Zigotto, 200 p.

Stan Z, Baştiurea E, Rizescu C, 2015, Sensitivity testing study proposed by method and apparatus for determining muscle imbalances at the trunk level. Ovidius University Annals. Series Physical Education and Sport/Science, Movement and Health, Constanţa, 15(1), 62-69.