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Postural Deformities Influence at Qualitative Treadmill Walking Analysis

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Original scientific paper

Abstract
This scientific paper includes research of postural deformities influence at walking abilities. Research was provided at the sample of hundred and twenty male students, age between sixteen and seventeen years. Main aim of research is quantity finding of transversal and vertical amplitudes, for characteristic body parts, during the walking on running treadmill as well as determination of posture status influence at same phenomena. The level of departure was compared with assessment of body deformities according to the SAS method. After the all data input and statistical analysis of the results (descriptive statistics, canonic correlation analysis), at the statistical significant level $p \leq 0{,}05$, the conclusion can confirm the fact of existing postural deformities influence at transversal end vertical amplitudes, for characteristic body parts, measured during the walking on treadmill.

Key words: **posture, walking, body deformities**

Sažetak
Ovaj naučni rad sadrži istraživanje utjecaja deformiteta posture na kretne sposobnosti, konkretno, hodanje. Istraživanje je provedeno na uzorku od stodvadeset ispitanika, starosti između šestnaest i sedamnaest godina, muškog spola. Glavni cilj istraživanja bio je kvanifikacija transverzalnih i vertikalnih amplituda, za karakteristične dijelove tijela, u toku hodanja po pokretnom sagu, kao i determinacija utjecaja statusa posture na date amplitude. Nivo odstupanja upoređen je sa ocjenom stanja posture dobivenoj prema SAS metodi. Nakon unijetih podataka i provedenih statističkih metoda za analizu rezultata na nivou statističke značajnosti od $p \leq 0{,}05$ u zaključku se sa sigurnošću može potvrditi pretpostavka da postoji statistički signifikantan, negativan, utjecaj deformiteta posture na veličine transverzalnih i vertikalnih amplituda, za karakteristične dijelove tijela, u toku hodanja po pokretnom sagu.

Ključne riječi: **postura, hodanje, tjelesni deformiteti**

Introduction

Most frequent manner of controlling the space (movement) characteristic for human being is walking. Evolution of walking is long-term and it still lasts. It is a primary symbol of human movement and usual measure of universal health condition of persons of all age groups (Kovač, D. 1987; Kovač,S. 2002; 2005).

The empiric rule to expect a person with greater or several body deformities to have greater transversal and divergent departures when walking (Kosinac, 1994) or with evident departures in movement segments when walking is not sufficiently supported by experiments. This paper will present research results and analysis of cyclic type movement structure, and relations between different levels of body deformities with transversal departures when walking.

Primary goal of this research is to determine influence of posture status at measured departures from the model in case of moment of reflection and "carrying of limbs" when walking – of examinees for segments of feet, lower leg and amplitudes of hips and torso movements in aforementioned movement structure. The level of departure will be compared with assessment of posture deformities according to the SAS method.

Primary subject of this research is determining influence of prediction given to posture deformities and criteria valorized in the scope of departure from the model in given movement structures.

Methods

Sample of the examines

The sample of examinees presents the group of students of "Sarajevo Gymnasium" from second and third grades – male part of population. The sample includes 120 examinees of heterogenic composition according to their morphological strains.

Data analyzes method

Data analyzes, statistical, methods used in this research are as follows: cross-correlation matrix of two studied spaces and canonical correlation analysis.

Procedure

Procedures for assessment and valorization of posture status "SAS" method or "Spine Analyzing System", a software package is based on digitalized video recording from which we extracted interesting and significant parts for our research. Those parts present images of segments that we observe in given analysis. Moreover, segments present body parts of observant (examinees). In addition to spinal cord, other body parts are also observed – assessed under this method. Those parts are observed in the same manner as of spinal cord, frontally from the front and behind as well as sagittaly.
The method itself was created at the Institute for Sports Science K.F. of University in Graz (Austria). It was invented by O. Fleiss PhD, and Hans Peter PhD, from Biomechanics Department.
In the course of recording, examinees were instructed by cameraman or assistant speaking loudly about what positions and movements they should take or make. One of prerequisites for the beginning of recording is examinees' preparation including

them being dressed in bathing suit with bare feet, with reference points on their back according to the following procedure. Reference points are the type of circular stickers of 5mm diameter made of reflecting or white material (self-adhesive paper). We put these stickers on their back on each vertebrae of spinal cord from the sacral up to the beginning of the upper third of the cervical part. In addition, we stick them on most inserted spots of ilium bones observed from behind, and on the upper beginning of anal fold. We connect digitalized segments of the recording into several images that we process according the order of assessment. It is possible to draw real lines on images for which the program provides deviations and angles in relation to vertical or horizontal line. The lines we mark on the image from both sides of frontal images immediately show departures in the symmetry of given segments. The status of feet rist and feet inclination for the variable OSTOP, where the area of foothold can be precisely determined, is obtained with the procedure of taking footprints on the paper. Assessment is performed on given "image" using the Mayer's line and simple formula for calculating the amount of possible deformity (Hadžikadunić & Balta, 2000). The curves we obtained with the position of reference point and their departures from vertical or horizontal line in deformed segments can serve us for exact measurement taking account of the ratio of the image size and actual size of observed segment. Such metrical characteristics with exact departures can relatively compare and assess body deformities of group of examinees. The grades we provide for individual segments are negative and they range from 0 to 3. The sum of negative points (grades) provides the final aggregate amount based on which we calculate final grade of the body position according to the "SAS" method (Fleiss & Holzer, 1998). Grades are ranging from 1 to 5, and in comparison to grades by segments, they are positive. Therefore, examinees without identified deformities have grade 5, whereas those with negative graded segments have grades from 4 to 1.

Sample of the "SAS" variables

Variables recorded in the "SAS" program include the following segments (body parts with observation directions): OGLFR – assessment of head position from the frontal point of view, OGLSAG – assessment of head position from the sagittal point of view, ORAFR – assessment of shoulders position from the frontal point of view, ORASAG - assessment of shoulders position from the sagittal point of view, OKSFR – assessment of spinal cord position from the frontal point of view, OKSSAG – assessment of spinal cord position from the sagittal point of view, OSTSAG – assessment of stomach position from the sagittal point of view, OSIMTR – assessment of torso symmetry from the frontal point of view, OGRFR – assessment of chest position from the frontal point of view, OGRSAG – assessment of chest position from the sagittal point of view, ONOGFR – assessment of legs position from the frontal point of view, OSTOP – assessment of feet position.

Procedures for biomechanical analysis of walking

Biomechanical analysis of walking is implemented gradually with smaller groups of examinees in conditions identical to those for the "SAS" analysis, or recording of material for processing in "SAS" software. Examinees were dressed in the same manner as for aforementioned analysis, and for the purpose of more exact identification of departures in movements, reference points were set in the form of round, white stickers of 5mm diameter. Reference points were put on characteristic positions on the torso and on lower limbs as well. White, circular stickers presenting reference points on the recording, and for the purpose of easier and more precise determining of position, are placed on the following positions on the torso: spinal cord – from the seventh cervical vertebrae until the fourth lumbar vertebrae on each posteriously protruding point of the vertebrae, ilium bone – illiace posterior superior on two posteriously most protruding points – left and right. Position of reference points on limbs: projection of the centre of the knee's ankle from behind (one reference point per one knee), centre of the heel's size frontally from behind (per one reference point) and two additional reference points on the heel from the back side positioned on ultimate visible points from the camera position (per two reference points). Recording is done in frontal plane, from behind, on a treadmill positioned horizontally. Position is marked on used treadmill in which segment the examinee is moving. Examinees walk for 4 minutes with the speed of 75 steps/minute. All records are processed in the SAS programme, where it is possible to make exact measures of distance on the frame net that is positioned above required recording. All extracted recordings are made in proportion in accordance with the camera distance from the object and position of the camera "zoom". The zooming option on the digital camera blend cannot be used for the recording credibility in regular measure for SAS and biomechanical analysis of deformities, and other movement structures with their departures. The "frame net" is positioned over extracted characteristic images where departures given in measure in order to present the size in centimeters are presented (Mikić & Bjeković, 2004).

Sample of the biomechanical analysis of walking variables

Departures are given in directions – left and right for variables: BAOTD – biomechanical analysis of torso departures right, BAOTL – biomechanical analysis of torso departures left. For variables in directions upwards – right and left side:
BASIPSD – biomechanical analysis of posterior superior iliac spine, right, BASIPSL – biomechanical analysis of posterior superior iliac spine left. For variables with data on feet divergentions medially right and left: BADSUD – biomechanical analysis of feet divergentions inside right, BADSUL - biomechanical analysis of feet divergentions inside left. For variables with data on feet divergentions laterally right and left: BADSVD - biomechanical analysis of feet divergentions outside right, BADSVL - biomechanical analysis of feet divergentions outside left.

Results and Discussion

Relations between examined spaces are shown in cross-correlation matrix (Table 1). Relations, which can determinate the influence, with relatively low but significantly indicated values of coefficient in these two spaces make the following indications: Variables OKSFR and OKSSAG, providing data on spinal cord deformities with variables BAOTD and BAOTL – torso deviation to one side while walking, have cross-correlation coefficients with values 0.30 and 0.31. Such relationship of aforementioned variables can be interpreted with given significance as mutual dependence of assessed spinal cord deformities and indicated swinging of torso when walking, valorized in biomechanical walking analysis. Such interpretation confirms the relationship – statistically significant influence of spinal cord deformities on amounts of transversal torso departures, right and left, when walking. Variables ONOGFR describing the status of leg deformities in frontal plane and variable BAOTD offering data on torso deviations have cross-correlation coefficient of 0.37. Such value indicates that leg deformities correlate with amounts expressed in the segment of transversal torso movements during walking.

__Table1.__ Cross-correlations of variables of posture deformities given by SAS method and variables of walking analyses.

Variables	BAOTD	BAOTL	BASIPSD	BASIPSL	BADSUD	BADSUL	BADSVD	BADSVL
OGLFR	,23	,24	,15	,28	,23	,17	,12	,14
OGLSAG	,16	,12	,18	,06	,01	,03	,17	,13
ORAFR	,07	,00	,03	,03	-,07	-,06	,25	,22
ORASAG	,12	,18	,13	,08	,02	,02	,08	,05
OGRFR	,09	,12	,15	,26	,16	,21	,14	,18
OGRSAG	,22	,23	,29	,40	,09	,16	,13	,23
OKSFR	,28	**,31**	,13	,00	,12	,17	,13	,18
OKSSAG	**,30**	,22	,10	,15	,12	,15	,16	,22
OSTSAG	,15	,21	,19	,30	,02	,06	,29	,25
OSIMTR	,11	,16	,13	,20	-,02	-,02	**,31**	**,30**
ONOGFR	**,37**	,28	-,00	,03	,18	,24	,01	,04
OSTOP	,19	,10	,10	,08	,07	,14	,04	,08

With the use of canonical analysis, two characteristic roots are obtained, indicated in Table 2 on the significance level of 95% or $p<0.05$ of coefficient value. First and second canonical factor are obtained with high factors of canonical correlation from 0.62 or from 0.51. The amount of joint variance (determination coefficient) in the first case amounts of 0.39 and in the second case 0.26. Obtained results from this Table show the existence of influence and connection between posture deformities phenomenon with departures in movement segments in case of biomechanically analyzed movement structures.

On grounds of two characteristic roots, the assumption of this research on statistically significant influence as well as relation between posture deformities of examinees with departures in movement segments in case of biomechanically analyzed movement structures when walking is hereby confirmed.

__Table 2.__ Canonical correlation analysis of influence and relations between body deformities variables and walking analysis variables.

	Canonicl R	Canonicl R-sqr.	Chi-sqr.	df	p	Lambda Prime
0	**,624747**	,390308	155,2263	96	**,000128**	,245425
1	**,512640**	,262800	100,5507	77	**,037323**	,402540
2	,426180	,181629	66,8597	60	,253545	,546039
3	,383682	,147212	44,7111	45	,484152	,667227
4	,332332	,110445	27,1146	32	,712302	,782406
5	,240549	,057864	14,1824	21	,861591	,879548
6	,213757	,045692	7,5960	12	,815832	,933568
7	,147423	,021734	2,4280	5	,787289	,978266

Table 3 indicates canonical factors explaining mutual cross-variability between given variables. By analyzing the structure of canonical factors from the part of walking analyses variables, it is recognizable that this space is defined, in the first place, by variables indicating torso deviations to the right and left (BAOTD and BAOTL) with coefficients of 0.585 and 0.581. Such interpretation confirms the assumption on the influence of deformities on transversal torso movements when walking. In addition, space is also defined by variables indicating the status of examinees in terms of departures during vertical movement of ilium bones (BASIPSD and BASIPSL) with coefficients of 0.559 for the left side and 0.431 for the right side. The right group of variables also indicates medium-large values for variables describing the amount of feet divergentions in case of moment of reflection, towards inside (medially), therefore, variables BADSUD and BADSUL with values 0.376 and 0.511. These medium-large coefficients confirm the assumption with position that feet and leg deformities influence the size of divergent feet departures when walking.

__Table 3.__ Structure of canonical function in the space of walking analysis variables (right group)

Variables	Root 1	Root 2
BAOTD	**,585391**	-,128205
BAOTL	**,581176**	,197502
BASIPSD	**,431423**	**,442785**
BASIPSL	**,559008**	**,602341**
BADSUD	**,376685**	-,124669
BADSUL	**,511545**	-,125054
BADSVD	,107378	**,516132**
BADSVL	,346647	**,453126**

Table 4 indicates the structure of canonical factors that were analyzed in the space of "SAS" variables which evaluate posture deformities of examinees. The space of "SAS" variables is primarily defined by variables – chest appearance indicators – sagittal viewpoint (OGRSAG) and spinal cord position – sagittal viewpoint (OKSSAG) with values 0.728 and 0.542. Such high and medium-high coefficients confirm the assumption on statistically significant influence of spinal cord deformities on total spatial departures of movement segments when walking. The structure of canonical function is also defined with two variables describing the same body segment of examinees but observed in frontal plane. Those are the following segments: spinal cord – frontally and head frontally. In addition to aforementioned variables, medium-high values also have ONOGFR and OSTOP with 0.506 and 0.377. These medium-sized coefficients confirm the assumption with position that feet and leg deformities also affect the amount of divergent feet departures when walking.

Table 4. *The structure of canonical function in the space of "SAS" variables. (left group of variables).*

Variables	Root 1	Root 2
OGLFR	**,431096**	,189957
OGLSAG	,073874	,136959
ORAFR	-,001309	,114464
ORASAG	,051215	,250630
OGRFR	**,457736**	,319560
OGRSAG	**,728494**	,328002
OKSFR	**,409729**	-,063673
OKSSAG	**,542182**	-,142351
OSTSAG	,213728	**,654206**
OSIMTR	,175310	**,504327**
ONOGFR	**,506811**	-,473171
OSTOP	**,377298**	-,200889

Conclusion

Knowledge on direction, size of influence and relations of posture deformities on qualitative and quantitative analysis of walking, are mater of direct theoretical and practical significance for the area of anthropological and kinesiological sciences. Data on valorization of recorded material are primarily valuable segment in such type of research. These results are of direct interest for the area of kinesiology and especially for some of its applied disciplines such as biomechanical analyses and kinesiotherapy.

According to obtained results that are significant on the level $p \leq 0.05$, it can be established that there is statistically significant influence and relation between posture deformities and transversal / vertical departures, or divergent departures from the model of walking on a treadmill.

In the end, it is also important to emphasize that the sample of examinees with recorded body deformities and visible departures in qualitative analysis of cyclic movement in age category when their deformities are still reversible (Kosinac & Srzić, 2006). A good-programmed and aimed planning of body activities provides another assumption that it is possible to "correct" or alleviate the greatest part of aforementioned deformities and departures (Kosinac, 1994; (Medved, 1987).

During the examinees' recordings, conversations and explanations, and with the use of available literature, it can be concluded that population of tested and recorded sample pays more attention to physical appearance rather than functionality, rationality of movement structures with indicated divergentions as well as motoric qualities.

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Submitted: March 15, 2010.
Accepted: April 29, 2010.

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