Pedobarographic Profile of Gait in Patients with Ankylosing Spondylitis

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Abstract: Ankylosing spondylitis (AS) is chronic inflammatory rheumatic disease which predominantly affects sacroiliac joints and spine and, during course of time, may also alter posture, movement patterns and regulation and quality of life. Clinical diagnostic tools for assessment of AS internalizations complement different qualitative and quantitative methods. Externalisations of axial skeleton alterations, followed by hip, knee, ankle and foot joints posture and movement adjustments, are quantified by conservative biomechanical approach. Items representing functional status and disease activity in AS patients correlated to pedobarographic status were anchored to previous research, i.e. Doward et al, 2003, Grazio et al, 2009, Aydina et al., 2015, Giacomozzi, 2010, Gruic et al, 2015, Gruic et al, 2016. Contrary to previous findings, multiple correlation between clinical scores and dynamic pedobarographic measurements was established.

1 INTRODUCTION AND OBJECTIVES

Ankylosing spondylitis (AS) is chronic inflammatory rheumatic disease which predominantly affects sacroiliac joints and spine and, during course of time, may also alter posture, movement patterns and regulation and quality of life. Clinical diagnostic tools for assessment of AS internalizations complement different qualitative and quantitative methods. Externalisations of axial skeleton alterations, followed by hip, knee, ankle and foot joints posture and movement adjustments, are quantified by conservative biomechanical approach.

Grazio et al., 2009, determined the reliability and validity of Croatian version of the Bath Ankylosing Spondylitis Functional Index (BASFI) and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) in patients with ankylosing spondylitis. Findings were affirmative, therefore appropriate for clinical trials, research and practice. In Aydina et al., 2015, plantar pressure distribution in patients with ankylosing spondylitis was measured. Findings revealed that no clinically significant correlation between clinical scores and static pedobarographic measurements have been found. Gruic et al., 2015, measured pedobarographic features of gait (by FDM1.5 PMD), and Gruić et al., 2016, compared pedobarographic profiles in young males with left and right scoliotic posture. Main objective was to determine feasibility and clinical standards for pedobarographic assessment of gait features. It was in line with conclusions of Giacomozzi (2010) that "PMD measurements are increasingly used – alone or in conjunction with other kinetic/kinematic parameters – to deeply investigate clinical outcomes of surgical interventions, rehabilitation treatments, preventive actions, disease evolution, as well as to implement new biomechanical models or validate novel methodological approaches".

Main objective of this research was to determine both contribution and influence of pedobarographic features of gait in results of clinical diagnostics procedures quantifying status and development of ankylosing spondylitis, i.e. to test appropriateness of usage of pedobarographic measure protocol as an extension of regular AS diagnostic tests/tools.

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2 METHODS

Sample consists of 10 male patients diagnosed with AS, age range between 18 and 65 years, regularly participating in rehabilitation program. Exclusion criteria were: lower extremity injuries (e.g. ankle distortion, knee trauma, etc.), postoperative procedures within 6 months (e.g. anterior cruciate ligament surgery, hip surgery, etc.), neurological diseases (e.g. neuropathy, cerebral palsy, etc.), vascular diseases (e.g. intermittent claudication), metabolic diseases (e.g. diabetic foot, obesity).

Sample of variables was comprised of three criterion variables assessing AS – BASMI, BASFI (Grazio et al, 2009) and ASQoL (a quality of life instrument specific to ankylosing spondylitis - Doward et al, 2003), and standard set of 63 quantitative variables and graphics assessing pedobarographic features of gait within protocol standardized for descriptive and inferential statistical methods (Gruić et al, 2015). Normality of distributions of results was tested with K-S test. Contributions of pedobarographic variables to results in dependent variables were tested by simple correlation and forward stepwise regression analysis.

3 RESULTS

Different pedobarographic variables have different power to explain AS status due to different measurement protocols, measuring devices and univariate and multivariate statistical tools used in analysis.

Descriptive statistics of subjects' basic morphology, AS and pedobarographic status, is presented in Table 1., along with regression analyses summary and partial contributions within forward stepwise regression analysis of contributions of pedobarographic variables to results in dependent variables: BASFI, BASDAI and ASQoL.

Simple relation trough inferential statistics reveal that results in *BASFI* were found to be in positive correlation with results in time to achieve maximal force with right heel (FTMF1R: r=0,69; p=0,03), time to change load from left heel to forefoot (LTPL: r=0,76; p=0,01), maximum force in left midfoot (MML: r=0,68; p=0,03), absolute difference in average time in the gait cycle, at which the maximum forces were measured for left and right forefoot zones (TMAXF_D: r=0,69; p=0,03), in the average time in the gait cycle, at which the maximum force was measured for left midfoot zone (TMAXML: r=0,66; p=0,04), and contact time for left heel (CHL: r=0,76; p=0,01), and in negative correlation with results in left leg step length (GSLL: r=-0,78; p=0,01), right leg step length (GSLR: r=-0,77; p=0,01), and stride length (GSL: r=-0,80; p=0,01). Results in *BASDAI* were found not to be in simple correlation with results in pedobarographical variables. Results in *ASQoL* were found to be in positive correlation with results in the average time in the gait cycle, at which the maximum force was measured for left midfoot zone (TMAXML: r=0,64; p=0,05), in the average time in the gait cycle, at which the maximum force was measured for left heel zone (TMAXHL: r=0,64; p=0,05), and contact time with left midfoot (CML: r=0,76; p=0,01), and in negative correlation with results in absolute difference in maximum pressures of left and right forefoot (MAXPF_D: r=-0,75; p=0,01), and absolute difference in left and right step length (GSL_D: r=-0,69; p=0,03).

4 DISCUSSION & CONCLUSION

Appropriateness of usage of pedobarographic measure protocol as an extension of regular AS diagnostic tests/tools was tested.

Contrary to findings of Aydina et al., 2015, i.e. there is no clinically significant correlation between clinical scores and static pedobarographic measurements, and of Gruić, et al. 2016., i.e. plantar pressure and force gait parameters seem to have no diagnostic value in determining scoliosis-specific gait, initial findings in this research, within forward stepwise regression analysis, found clear statistical multiple correlation between clinical scores and dynamic pedobarographic measurements.

Sample size calculations, however, do not allow immediate and final conclusions about effects and applicability of final results. Also, additional static and dynamic tests should complement the diagnostics that assesses a complex phenomenon such as AS

Partial contribution of individual pedobarographic variable and limitations to statistical reasoning of this relation lay within many statistical tools which are found to be uncommon in research covering AS and plantar pressure measurements.

Table 1: Descriptive statistics - subjects' info, AS status, pedobarographic variables; Regression summary and partial contributions within forward stepwise regression analysis of contributions of pedobarographic variables to results in dependent variables: BASFI, BASDAI and ASQoL.

N=10	Mean	SD	max D	K-S	Regression Summary (forward stepwise) / b* (standardized beta regression coefficients/weights); p-value (t)		
Age	41,60	8,76	0,1920	p > .20			
BM	76,70	18,29	0,2388	p > .20			
BH	174,80	9,74	0,1056	p > .20			
BMI	24,91	4,37	0,1755	p > .20			
ASQoL	5,40	3,50	0,0955	p > .20			Adj.R2=,99*; F(8,1)=1453E5 p<0,00006
BASDAI	1,82	1,04	0,2498	p > .20		Adj.R2=1,00; F(8,1)=160E10 p<0,00000	
BASFI	3,98	1,75	0,2203	p > .20	Adj.R2= ,99*; F(8,1)=1007E5 p<0,00008		
BSL	129,52	12,48	0,2294	p > .20	0,01; 0,04		
CH_D	6,22	6,25	0,3648	p < ,15		0,12; 0,00	0,14; 0,00
CHR	57,41	11,13	0,2196	p > .20			0,00; 0,01
CML	72,04	4,01	0,1662	p > .20			0,29; 0,00
CMR	71,94	5,59	0,1611	p > .20		-0,02; 0,00	-0,02; 0,00
FTMF1L	16,30	3,33	0,1831	p > .20	-0,24; 0,00		
FTMF2L	48,10	2,73	0,1567	p > .20			0,50; 0,00
GFRR	16,07	4,67	0,2060	p > .20		-0,92; 0,00	
GSL	123,80	17,64	0,1374	p > .20	-1,11; 0,00		
GSL_D	3,20	2,70	0,2717	p > .20			-0,69; 0,00
LT_D	0,04	0,05	0,3807	p < ,10		-0,57; 0,00	
LTP_D	5,56	5,76	0,2593	p > .20		0,42; 0,00	
MAXPFL	43,48	13,69	0,2609	p > .20		0,29; 0,00	
MAXPFR	46,05	12,54	0,1881	p > .20	0,31; 0,00		
MAXPHR	29,87	8,77	0,1307	p > .20		0,15; 0,00	
MFL	736,36	144,48	0,1645	p > .20	0,20; 0,00		0,23; 0,00
MHL	518,80	89,90	0,2406	p > .20	0,00; 0,02		
TMAXFL	76,36	2,27	0,2280	p > .20	0,50; 0,00		
TMAXML	52,09	13,05	0,2148	p > .20	0,07; 0,00		
TST_D	0,02	0,02	0,3334	p < ,20			-0,41; 0,00
TSTR	0,54	0,05	0,1326	p > .20		0,96; 0,00	

CODE - description, unit, (L/R foot): **BSL** - Single support line, mm L; **CH_D** - Contact time H, % L/R, **CHR** - Contact time H, % R; **CML** - Contact time MF, %L*; **CMR** - Contact time MF% R *; **FTMF1**L - Time maximal force1, % L; F**TMF2L** - Time maximal force2, % L; **GFRR** - Foot rotation, degree R; **GSL** - Stride length, cm; **GSL_D** - Step length, cm L/R; **LT_D** - Time to change heel to FF, sec L/R; **LTPR** - Time to change heel to FF, % R; **MAXPFL** - Max pressure FF, N/cm2 L; **MAXPFR** - Max pressure FF, N/cm2 R; **MAXPHR** - Max pressure H, N/cm2 R; **MFL** - Maximum force FF, N L; **MHL** - Maximum force H, N L; **TMAXFL** - Time max force FF, %L*; **TMAXML** - Time max force MF, %L*; **TST_D** - Step time, sec L/R; **TSTR** - Step time, sec R; (*% of stance time; FF-Forefoot, MF-Midfoot, H-Heel); (**'_D** ' in name of variable means absolute difference between left and right - L/R)

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REFERENCES

Aydina E., Turana Y., Tastabana E., Omurlub I. K., and Sendura O.F. (2015) Plantar pressure distribution in patients with ankylosing spondylitis. Clinical Biomechanics, Vol. 30, Issue 3, March 2015, pp238-242,https://doi.org/10.1016/j.clinbiomech.2015.02.003

Doward L. C., Spoorenberg A., Cook S. A., Whalley D., Helliwell P. S., Kay L. J., McKenna S. P., Tennant A., van der Heijde D. and Chamberlain M. A. (2003) Development of the ASQoL: a quality of life instrument specific to ankylosing spondylitis, Ann Rheum Dis. 2003;62:20–26.

Giacomozzi, C. (2011). Potentialities and Criticalities of Plantar Pressure Measurements in the Study of Foot Biomechanics: Devices, Methodologies and Applications, Biomechanics in Applications, Dr Vaclav Klika (Ed.), ISBN: 978-953-307-969-1.

Grazio S., Grubišić F., Nemčić T., Matijević V., Skala H. (2009). Pouzdanost i valjanost hrvatske inačice Bath funkcijskog indeksa za ankilozantni spondilitis (BASFI) i Bath indeksa aktivnosti bolesti za ankilozantni spondilitis (BASDAI) u bolesnika s ankilozantnim spondilitisom (The reliability and validity of Croatian version of the Bath Ankylosing Spondylitis Functional Index (BASFI) and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) in patients with ankylosing spondylitis), Reumatizam (0374-1338) 56 (2009), 2; 63-76.

Gruic I., Cebovic K., Radas J., Bolcevic F. and Medved V. (2015). Pedobarographic Features of Gait Measured by FDM1.5 PMD.In *Proceedings of the 3rd International Congress on Sport Sciences Research and Technology Support - Volume 1: icSPORTS*, ISBN 978-989-758-159-5, pages 66-71. DOI: 10.5220/0005662800660071.

Gruić I., Cebović K. and Medved V. (2016). Comparison of Pedobarographic Profile in Young Males with Left and Right Scoliotic Posture.In *Proceedings of the 4th International Congress on Sport Sciences Research and Technology Support - Volume 1: icSPORTS*, ISBN 978-989-758-205-9, pages 89-95. DOI: 10.5220/0006085400890095.

Specifications and operating instructions/software User manual, zebris Medical, Gmbh.

APPENDIX

A) Questionnaire: **BASFI** (Croatian version of the Bath Ankylosing Spondylitis Functional Index) (answers on a scale from 'Easy' to 'Impossible')

1. Putting on your socks or tights without help or aids (e.g. sock aid).
2. Bending from the waist to pick up a pen from the floor without aid.
3. Reaching up to a high shelf without help or aids (e.g. helping hand).
4. Easy
5. Getting up from an armless chair without your hands or any other help.
6. Getting up off the floor without help from lying on your back.
7. Standing unsupported for 10 minutes without discomfort.
8. Climbing 12-15 steps without using a handrail or walking aid.
9. Looking over your shoulder without turning your body.
10. Doing physically demanding activities (e.g physiotherapy exercises, gardening or sports).
11. Doing a full days activities whether it be at home or at work.

B) Questionnaire: **BASDAI** (Croatian version of the Bath Ankylosing Spondylitis Disease Activity Index) (placing a mark on line below to indicate answer to each question relating to the past week on a scale from 'None' to 'Very severe', and for q6: 0 hrs, ½, 1, 1½, 2 or more hours; add the sum of answers 5. and 6., first divided by 2, to answers 1.-4., and then divide total sum by 5)

1. How would you describe the overall level of fatigue/tiredness you have experienced?
2. How would you describe the overall level of AS neck, back or hip pain you have had?
3. How would you describe the overall level of pain/swelling in joints other than neck, back, hips you have had?
4. How would you describe the overall level of discomfort you have had from any areas tender to touch or pressure?
5. How would you describe the overall level of morning stiffness you have had from the time you wake up?
6. How long does your morning stiffness last from the time you wake up?

C) Questionnaire: **ASQoL** (Ankylosing Spondylitis Quality of Life Questionnaire) (answers are 'Yes' or 'No'; Each statement on the ASQoL is given a score of "1" or "0". A score of "1" is given where the item is affirmed, indicating adverse QoL. All item scores are summed to give a total score or index. Scores can range from 0 (good QoL) to 18 (poor QoL). Cases with more than three missing responses (ie more than 20%) cannot be allocated a total score. For cases with between one and three missing responses, the total score is calculated as follows: T=18x/18-m where: T is the total score, x is the total score for the items affirmed and m is the number of missing items; Doward et al, 2003)

1. My condition limits the places I can go

2. I sometimes feel like crying
3. I have difficulty dressing
4. I struggle to do jobs around the house
5. It's impossible to sleep
6. I am unable to join in activities with my friends/family
7. I am tired all the time
8. I have to keep stopping what I am doing to rest
9. I have unbearable pain
10. It takes a long time to get going in the morning
11. I am unable to do jobs around the house
12. I get tired easily
13. I often get frustrated
14. The pain is always there
15. I feel I miss out on a lot
16. I find it difficult to wash my hair
17. My condition gets me down
18. I worry about letting people down

D) Kinetic models for foot analysis (3 zones-forefoot, midfoot, heel

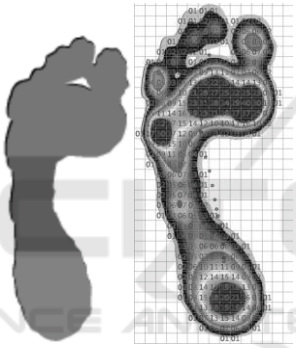

Figure 1: Kinetic models for foot analysis (Zebris: ref 7.).