VERTEBRAL METRICS: APPLICATION OF A INSTRUMENT TO EVALUATE THE SPINAL COLUMN IN PREGNANT WOMEN

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Abstract: The published literature about the biomechanical alterations of the spinal column during pregnancy is scarce and disperses, being more qualitative and limited to partial analysis of the spinal column. The main justification for a global approach to be neglected could be related to the inexistence of a non-invasive instrument that evaluates the spinal column in an objective and complete way. Thus, in order to fill this gap, we built *Vertebral Metrics* – a device that allows the identification of the 3D position of the vertex of each of the spinal processes, from the first cervical vertebra to the first sacral vertebra and calculate the amplitude of the angles of curvature of the spinal column in the standing position. The present work has the objective of presenting the first application of this equipment to 49 pregnant women at four different moments of pregnancy (12, 20, 32 e 37 weeks of gestation). Analysing the results we can conclude that *Vertebral Metrics* – is an innovative instrument in the global evaluation of the spinal column in a standing position, allowing a quantitative analysis of its shape and temporal variations.

1 INTRODUCTION

In modern society, back pain is a problem relevant for the population in general and for pregnant women on particular, being a common symptom and frequently referred to in pregnancies without any pathology associated Studies indicate that 35 to 76% of pregnant women experience back pain during gestation. Although many women feel back pain during pregnancy, this has not been considered an important public health problem, not with standing the social and economic impact that this situation causes in the labour market if we take into account the levels of absenteeism resulting from that (Noren *et al., 1994*).

The majority of researchers attributes the etiology of back pain to the biomechanical alterations of the spinal columns during the pregnancy period, however, an in depth study of this analysis has been blocked by the fact that the encompassing analytical processes are of an invasive nature and, as such, cannot be applied to pregnant women. On the other hand, the non-invasive means of diagnostic only allow partial analyses of the spinal column, not presenting a global vision.

The published literature on this matter is scarce and disperse, being more qualitative and limited to partial analyses of the spinal column. The main justification for a global approach to be neglected could be related to the inexistence of a non-invasive instrument that evaluates the spinal column in an objective and complete way. Thus, and to achieve the main objective of the present study, we built *Vertebral Metrics* – device that allows the identification of the 3D positions of the vertex of each of the spinous processes, from the first cervical vertebra to first sacral vertebra, in the standing position (Quaresma *et al.*, 2009 a, b).

We stress that the quantitative characterization of the biomechanical alterations of the spinal column is fundamental to delineate prevention and

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intervention strategies in this domain.

Vertebral Metrics (Figure 1) is composed of two parts: one we call *Body* and another we call *Support* (Quaresma *et al.*, 2009 a, b).

Figure 1: Vertebral Metrics.

The *Support* is composed of a central piece that serves as the support for the vertical piece of the *Body* of the instrument, having as an aid to stability two lateral vertical pieces, two lateral oblique pieces and one base where the person to evaluated stands (Quaresma *et al.*, 2009 a, b).

In turn, the *Body* is composed of a vertical piece and 18 horizontal pieces that we call *2D Positioners*. The vertical piece of the *Body*, fits in the *Support*, and is composed of a fixed rack and a square base profile, four cylindrical solid bars, a graduated ruler and two support plates in the extremities of all these structures (Quaresma *et al.*, 2009 a, b).

Each *2D Positioner* is adjustable in a way to identify the x, y and z position of each vertex of the spinous processes, from the first cervical vertebra to first sacral vertebra (Quaresma *et al.*, 2010 a, b).

In the scope of the present work we also developed a mathematical model of the spinal column that aims to estimate the amplitude of the angles of curvature the data collected by *Vertebral Metrics* (x, y and z position of the spinous processes).

The model is composed of an *Hermitian cubic spline (*Sulij e Mayers, 2003).

2 METHODOLOGY

Vertebral Metrics was applied to pregnant women, without pathology associated, in four different moments of pregnancy without associated, in four moments of pregnancy (12, 20, 32 and 37 weeks of gestation).

Faced with the existence of certain variables whose identification or control was not always guaranteed, there was the need of establishing some rules with the purpose of diminishing the effects of the influence or bias of the results obtained. Thus we defined the following principles:

- data collection should be performed always by the same observer;
- random sampling method;
- evaluation to be performed on the same period of the day for each of the pregnant women;
- identification of the position of *Vertebral Metrics* through the use of markers on the floor;
- position of the feet always the same in all the moments of the evaluation, when applying *Vertebral Metrics.*

3 CHARACTERIZATION OF THE SAMPLE

The sample is composed of 49 women aged between 19 and 42 years, where the mean is 30 years. The prevalent nationality of the sample is Portuguese (73,5%) being almost all women Caucasian (91,8%). The majority of the women were married or lived maritally (79,6%) and has a family aggregate of two people (65,3%). Relative the education, the majority was educated to a level higher than the 3rd cycle of basic education (40,8% secondary education e 40,8% higher education). Regarding the exercise of the profession being standing or seated, about half worked mainly standing (51%) and 30,6% mainly seated.

4 RESULTS

The analysis of angles of the lumbar lordosis, dorsal kyphosis and cervical lordosis revealed that the average of the angles, as well as the respective dispersion, varies throughout pregnancy (Figure 2). Observation of data indicates, as well, that the behaviour pattern of the amplitude of the angle of each of the curvatures is distinct.

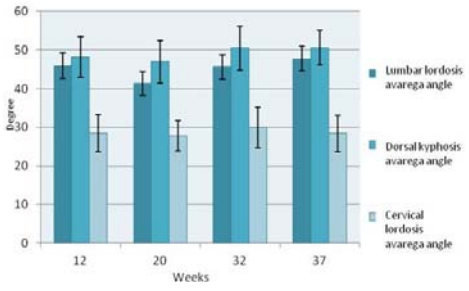

Figure 2: Averages and 95% confidence intervals for the angles of the Cervical Lordosis, Dorsal Kyphosis e Lumbar Lordosis at the 12th, 20th, 32nd and 37th week of gestation.

We observed that cervical lordosis decreases, on average, only 0,6° between the 12th and the 20th week of gestation, while from the 20th to the 32nd week it increases, on average, 2,2° and on the 37th week it decreases again, on average, 1,6°.

In relation to dorsal kyphosis, we observed that the angle at the 20th week of gestation begins increasing, on average, 1,3°, at the 32nd week it decreased, on average, 3,5° and at the 37th week continues to decrease with a smaller amplitude, on average, only 0,1°.

Relative to lumbar lordosis, we observed that the angle decreases at the 20th week, on average 4,6°, at the 32nd week increases, on average, 4,3°, and at the 37th week we found that it continues to increase (2,1°).

We concluded that, between the 12th and the 37th week of gestation, the angle of lumbar lordosis and dorsal kyphosis, on average, increases 1,8° and 2,4°, respectively. On the other hand, the angle of the cervical lordosis, on average, decreases only 0,1°.

Applying the linear regression correlation significance test from one moment of evaluation to the next, we noted that there are no significant differences in the angle of curvature throughout pregnancy, except for lumbar lordosis between the 12th and the 20th week of gestation ($p<0,05$).

During data collection, and only through clinical observation, we assumed that the difference of the angles between two successive moments could be different throughout pregnancy. Due to the absence of studies in this domain we decided to compare the difference of the angles between two consecutive moments of evaluation, with the homologous difference between the two moments of evaluation immediatly after. We oberved that there is a negative correlation ($p<0,001$).

We conclude that when the angle of curvature increases between the 12th and 20th weeks of gestation, it diminishes between the 20th and 32nd weeks and increases again between the 32nd and 37th weeks of gestation.

On the other hand, analysis of the data raised doubt relative to the amplitude of the angles throughout pregnancy.

To test this hypothesis, and taking into account the angles registered in two consecutive moments, using as reference the 12th week, two groups of pregnant women were formed: one where the angle increases between two consecutive moments; another where the angle decreases between those two moments.

We compared the angle of each of the curvatures in the four moments of evaluation and we observed that there are significant differences in the two groups in the various moments, relative to all the angles. We observed, for example, that the average of the angle of lumbar lordosis at the 12th week is the following:

- 36,9° (IC95% 27,0–46,8) – group of women where the angle increases from the 12th to the 20th week
- 50,6° (IC95% 41,4–59,8) - group of women where the angle decreases from the 12th to the 20th week

We conclude that, although there are no significant differences in the angles of curvature throughout pregnancy, we saw that those same angles oscillate in a significant way throughout the gestation period. That is, when they increase from the 12th to the 32nd week, they decrease from the 20th to the 32nd and increase again from the 32nd to the 37th week of gestation.

We also noted that the referred alteration in the angle form the 12th to the 20th week behaves in the opposite way taking into account the angle that each pregnant woman presents on the 12th week. Thus, for example, if the average value of the amplitude identified in the first moment of evaluation is 50,8°, we observe that that angle will decrease in the following period, increasing again in the following one.

5 CONCLUSIONS

With the building of *Vertebral Metrics* – innovative instrument for a global evaluation of the spinal column, we produced for the first time a systematic and global study of the spinal column that contemplates the characterization of the amplitude of its angles of curvature.

In reality, the inexistence of studies that evaluate simultaneously the angle of the three curvatures of the spinal column at the same temporal period, limits in a certain way the comparability with other analyses, however it transforms this work in a reference in the Health area. As far as we know this is the first investigation that approaches in an integrated way the spinal column in its totality. Lack of consensus will probably be related to three crucial variables:

- the small number of quantitative studies;
- the methodology applied in the data collection;
- the not very expressive number of pregnant women involved in the majority of quantitative studies.

We highlight the fact that Vertebral Metrics represents an innovation in the field of prevention since it can be applied several consecutive times without harming the person. On top of that it is not expensive, easily transported and has few logistic demands. All this makes it possible to be used in different contexts like for instance the ambulatory: public, private (health centres / clinics) and hospitals.

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REFERENCES

Noren L, Ostgaard S, Nielsen T T, Ostgaard H C. Reduction of sick leaves for lumbar back and posterior pelvic pain in pregnancy. *Spine* 1994; 19 (8): 894-900.

Quaresma, C.; Forjaz Secca, M.; O'Neill, J.; Branco, J., 2009a. Development a mechanical instrument to evaluate biomechanically the spinal columnin pregnant women. *Proc. Internacional Conference Biodevice*, 310-113.

Quaresma, C.; João, F. Fonseca, M. Forjaz Secca, M. Veloso, A.; O'Neill, J.; Branco, J., 2009b. Validations of Vertebral Metrics: a mechanical instrument to evaluate posture osf the spinal column.. *O. Dössel and W.C. Schlegel (Eds.): WC IFMBE Proceedings* 25/VII, 711–713

Quaresma C, Forjaz Secca M, Goyri O'Neill J, Branco J. Vertebral metrics: Application of a Mechanical Instrument to Evaluate the Spinal Column in Pregnant Women. *Proc. Internacional Conference Biodevice* 2010a; 143 – 146.

Quaresma C, João F, Fonseca M, Forjaz Secca M, Veloso A, Goyri O'Neill J, Branco J. Comparative evaluation of the tridimensional spine position measured with a new instrument (Vertebral Metrics) and an Optoelectronic System of Stereophotogrammetry. *Medical, Biological Engineering and Computing* 2010b; 48(11): 1161-1164.

Sulij E, Mayers D. An Introduction to Numerical Analysis. Cambridge. 2003.