DOCTORAL DISSERTATION REVIEW

PhD Candidate: Li Xin

Dissertation Title: *Biomechanical Analysis of Walking Stability During Pregnancy and the Fall-Prevention Effects of Negative Heel Shoes*

Supervisors: Dr. habil. Gusztáv Fekete and Dr. András Kovács

The doctoral dissertation provides a detailed investigation of pregnancy-related changes in movement mechanics. The research addresses several biomechanical aspects of gait and stability during pregnancy and employs comprehensive experimental and analytical methodologies. The candidate demonstrates proficiency in the use of state-of-the-art biomechanical instrumentation and appropriate data processing techniques. Furthermore, the candidate has established an excellent publication record directly related to the dissertation topic, demonstrating the ability to conduct and disseminate high-quality scientific research in internationally peer-reviewed journals.

The research topic is relevant. The candidate adopts a practical approach to investigate the biomechanical adaptations associated with pregnancy and their implications for walking stability and fall prevention. While the findings are promising, further research is required to validate and implement the practical applications of the proposed interventions. Nevertheless, the work provides valuable scientific contributions and meets the expectations of a doctoral research project. The dissertation consists of three studies, each of which satisfies the fundamental requirements of originality, methodological rigor, and scientific relevance.

Following the home defense, the candidate has made a substantial effort to address the major concerns raised by the opponent. In particular, significant improvements have been made regarding formatting, editing, writing quality, and the consistent use of terminology. These revisions have noticeably enhanced the overall quality and readability of the dissertation. The candidate is to be commended for the diligence and commitment demonstrated in responding to the feedback. The length of the dissertation is appropriate, the overall structure is satisfactory, and the number and quality of references are adequate. The majority of the cited literature is recent and relevant to the research topic. The candidate has successfully addressed the major issues identified during the home defense. However, several minor points and details still require clarification or correction before the dissertation can be considered fully finalized. These comments are provided below.

Specific comments (these are mostly marked as a comment in the thesis file):

Page 4. First study: The single subject design violate the criteria of such statistical method. Hence, you are not estimating population-level effects, and there is no biological variability. Statistical inference (p-values, confidence intervals) does not have the usual meaning here. Your regression is describing the behavior of that one modelled foot, not pregnant women in general. Therefore, you should adjust your statement.

Page 4. Second study: Still, from the description it looks like you estimate joint contribution not muscles contribution.

Page 5 regarding to the first study: Because you have a single subject design, all FEA results restrict to the individual who you actually measured, nobody else.

Terminology should be consistent. You should use either ‘Pregnancy-related changes in body mass’ or ‘Gestational weight gain ’ in the whole text.

Section 1.1.1. Gaining weight means adding mass to the original body mass. I believe you intended to state, that it does not express the uneven distribution of the additional mass. However, I would argue that, because everybody know that pregnant woman gaining weight around the belly. Redistribution would mean that the already existing mass are getting reallocated.

1.1.2. subtitle: I believe it’s not an adaptive response, but a natural response to pregnancy. From the beginning of pregnancy hormonal changes occur way before than the additional gain in mass is present.
Define joint laxity?

1.1.2. Okay, so in the previous paragraph (1.1.1) you state that the additional weight increase the load on the lower leg. This should stimulate the ligaments as well, however you are indirectly suggest that ligaments in the distal lower leg become more compliant despite of the increased mechanical load? You should explain this contradictory logic.

Page 11. This could be a better approach, as the location of the bones changing, so the origin and insertion points of the ligaments become further or closer (depending on where are these points). Reasonable to think that some of the ligaments elongated become more stiff but some of them getting shorter and become less stiff. In case of the plantar fascia if the foot arc flatten, then the plantar fascia should be more stiff (stretched out), but this could be counteracted by the assumed hormonal regulation of tissue stiffness. Based on this no study investigated before how much the plantarfascia compliance changed during pregnancy. So where the data come from that you used to change the stiffness? What is the difference in dimensions and morphology?

1.3.2. These are related, cannot considered separately. Muscle controlled by the nervous system, activating the muscle which generate force, and hence the movement. The spatiotemporal variables describe the quality of this movement outcome.
In the previous section you mentioned the foot is the main site of changes.

Be careful because pelvic tilt is difficult to properly measure. Using only markers are not sufficiently good to describe pelvic tilt.

Page 22. It is expected to find. Increased mass requires higher force to produce, but the metabolic energy required for that is shared with the baby. Hence muscle strength cannot be increased, but the weight that need to be carry do, so ankle ROM should be decrease.

1.3.3. Unclear what do you mean by muscular changes. Do you mean changes in neuromuscular control?

1.5.2. I am still not convinced how this variable can be interpreted as muscle contribution. You could only say that this is an indicator of that. It seems like you can estimate joint contribution rather than muscle contribution.

Page 38. This cannot be called accuracy, since the two measurements does not measure the same thing. FE modelling directly measure pressure values at the bone surface, Pedar measure the pressure values over the feet, which contains all the soft tissues between the contact surface and the bones.

2.4.1. The statistical framework requires further clarification and justification. The regression analysis appears to be based on deterministic outputs generated from 16 full-factorial simulation conditions derived from a single subject-specific model, rather than independent biological observations. Under these circumstances, the use of inferential statistical terminology (e.g., significance testing with $\alpha = 0.05$) may not be appropriate, as there does not appear to be a stochastic error structure or sampling variability from which population-level inference can be drawn. The candidate should clarify whether the regression was intended purely as a descriptive/sensitivity analysis to quantify the relative effects of body weight, tissue stiffness, and their interaction within the simulated design space. If so, the manuscript would benefit from avoiding inferential language such as "statistical significance" and instead emphasizing effect sizes or standardized coefficients. Alternatively, if inferential statistics are intended, the authors should justify the underlying assumptions and explain the source of variability supporting hypothesis testing.

3.1.1. This does not calculate measurement error! You also mentioned that you compare two different methods. You can state that the difference in peak values around the same location are similar. Need to mark that these values are in the same area. But from the figure a clear difference can be observe about the location of peak values.

Page 63. You still did not explain how this can be interpret as muscle contribution. Without this explanation this section cannot be evaluate.

Page 64. The moment of inertia of each segment contributes to the angular acceleration which is not related to muscle work. How did you account for this?

Page 65. What do you think about walking speed. You did not control it so the comparison has bias.

Only in force, or did you calculate some work, or torque?

Page 65. The impulse data would be more interesting than the curve. What could say about the physiological or mechanical relevance of this beside its lower or smaller?

Page 65. Since most muscle work done against gravitation, this should be reported first.

Page 66. It's a t-test not ANOVA, so you cannot use the word effect.

Discussion:
You should follow the structure that you introduce:

1. FE study
2. Walking gait

3. Footwear study

4.1. Rewrite this in way that you collected data from literature to characterize what load could be during stance on the foot in the 3 trimesters. This has limits, since you did not measured these inputs, but you wanted to simulate these conditions. So rather then saying pregnancy related or induced changes you should say that based on the results of the model we could speculate that…

Page 72. You should mention that during daily life this have implication. So during walking when you push off from the ground the foot is not able to efficiently transfer the force to the ground, which could be one of the reason why you found smaller ankle torque in the ankle in pregnant vs. non pregnant.

Page 73. I am not sure that you can use this statistics. See comment at the statistics section.

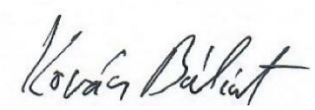
Page 73. Should be mention some implication; if arch is reduced inversion can be increased which could initiate a whole body level changes in posture.

Page 74. Focus more in the meaning of the data do not repeat the results. You repeat too much of the results instead of talking much more the meaning of the results.

Page 77. Gait alone is not meaning walking gait. You need to be more accurate.

Page 77. It is true, but changes the footwear, the walking speed should be the same in each condition. Otherwise how could you tell how much difference related to footwear and how much related to the different walking speed? It is biased by the different walking speeds, so this must be highlighted because this potentially undermine you final conclusion.
One paper related to this thesis point and also to the others. I don't see how the other papers present at this thesis.

I would like to conclude that thesis in the current form is suitable for public defense.



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