

Opponent's Report on Revised PhD thesis

Wei Liu: "Developmental Gait Biomechanics and Task-Specific Plantar

Loading in Children: Implications for Sensory Processing Disorder and Balance"

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1. Relevance

This study is relevant because it advances understanding of how gait biomechanics, plantar loading, and balance control develop in children under different movement demands, and it also identifies potential biomechanical markers associated with sensory processing disorder. By examining straight walking, running, and directional turning tasks, the research highlights that mature locomotion is not solely defined by symmetry, but by the ability to adapt movement strategies to task-specific demands. The study is particularly significant for children with sensory processing disorder, as dynamically challenging tasks may better reveal deficits in sensory-motor integration, balance, and center-of-pressure control that are not apparent during normal walking assessments. These findings have important implications for pediatric biomechanics, rehabilitation, physiotherapy, and occupational therapy, as they may contribute to improved assessment methods, earlier identification of motor difficulties, and the development of targeted interventions to enhance balance and functional movement in children with sensory processing disorder.

2. Structure

The length of the work (with reference) presented in the thesis is 108 pages. The thesis has a clear structure, with distinct sections such as introduction, materials and methods, results, discussion, followed by conclusions and scope for future work. Each section is appropriately titled, helping the reader understand the thesis's organization. The thesis follows a logical flow of information, progressing from the introduction of the research problem to the presentation of the methodology, results, and discussion. The use of subsections within major sections enhances the logical organization of content. Ideas and concepts are presented coherently, with smooth transitions between sections and paragraphs. The introduction establishes the research context, explaining the issue and the impetus for the investigation. Section 1.14 enhances the

significance of the research by highlighting/documenting the research gaps, underscoring the necessity for investigation with value and practical significance highlighted in section 1.16. The background information provides context for the reader and creates a strong foundation for the proposed work.

3. Review of the literature

The incorporation of citations and references enhanced the credibility of the reviewed literature. By drawing on sources published between 1987 and 2025, the candidate demonstrates both extensive engagement with historical research and the inclusion of contemporary material relevant to the study, highlighting thorough processing of the literature in the subject area.

4. Research methods

42 participants were recruited across three distinct cohorts to address specific biomechanical and clinical research objectives while maintaining within-cohort comparability. Group A included 15 healthy female children for developmental plantar loading analysis; Group B consisted of 12 boys, divided into sensory processing disorder and healthy control subgroups for clinical comparison; and Group C comprised 15 healthy male adolescents for higher-demand kinematic and kinetic assessments. The baseline information was listed in Table 2.1.1. All participants were free of recent lower-limb injury and were identified as right-leg dominant. Written informed consent was obtained from participants and guardians, and the University ethics committee approved all procedures. All testing involved barefoot participants completing gait tasks on a 20-meter walkway at a comfortable speed, including straight walking and straight running, and 90° turns in both directions. Dynamic foot pressure data were collected using an RsScan FootScan plantar pressure plate with 16384 sensors at a sampling frequency of 480 Hz under consistent barefoot conditions. Motion capture involved a Vicon system recording kinematic data at 200 Hz, with 39 reflective markers on the lower limbs and trunk.

5. Original results

The results chapter is highly detailed and reports numerous significant intervals across stance for multiple variables (Center of pressure, foot balance index, pressure distribution, ground reaction forces, lower-limb kinematics and kinetics). This level of

detail demonstrates analytical depth. The results for Group C demonstrated significant bilateral asymmetries in joint kinematic and kinetic variables during walking, running, and turning tasks, with the most pronounced differences observed during running. Statistical significance (p-values and % stance intervals) is thoroughly reported. The main kinematic and kinetic asymmetry findings in the evaluated Groups A, B, and C are now summarized in Tables 3.4.1-3.4.3. Overall, the Group C findings suggest that the observed bilateral asymmetries are primarily functional and task-dependent rather than pathological. Greater asymmetry during turning tasks reflected the unequal biomechanical roles of the inside and outside limbs, while dominance-related differences were evident during straight walking and running. Although these asymmetries appear to represent normal adaptations in healthy adolescent athletes, they may still serve as useful indicators for monitoring movement performance in athletic populations.

6. Questions

The thesis has been modified from the previous version following the recommendations during the workshop defense. Various improvements made by the candidate are:

- An introductory section has now been added, page 12.
- Recommended figures have been improved and are now reflected in the revised thesis.
- Consistencies are now made with the abbreviations without repeating the full form in the text.
- Research gaps (Section 1.14) and research objectives have been modified on pages 40 and 41.
- The thesis is modified in section 2.1.1 to address the rationale for cohort composition and between-group comparability.
- Summary tables 3.4.1 to 3.4.3 (pages 73-75) are now added for improved clarity and readability.
- The discussion section has been modified for clarity and better readability by summarizing the main findings of each task, as in section 4.1, summarized on pages 77 and 89. Good to see that a comparative synthesis of asymmetry

mechanisms across cohorts is also presented in Table 4.4.1 for better readability and direct takeaways.

Comments/suggestions

- In the thesis point section (pages 96-102), the candidate mentioned figures (like figure 3.1, 3.10.....), which are hard to find.

7. Language

The thesis is written in English. The use of clear and concise language contributes to the overall coherence of the thesis. Overall, the thesis is structured into five main sections (introduction (33 pages), materials and methods (8 pages), results (23 pages), discussion (19 pages), conclusions and future work (2 pages) and thesis points (7 pages). It is positive that the author has included the list of figures and tables at the beginning before main text. The number of figures is 32, and the number of tables is 5. The figures are modified in the revised thesis for better clarity. The figures and tables are clear and understandable.

8. Overall opinion

The candidate set four objectives to accomplish the research in Section 1.4, as follows.

first objective to characterize how plantar loading and center of pressure reflect developmental gait asymmetry in typically developing children.

second objective to determine how task demand, particularly running and turning, modifies interlimb asymmetry across locomotor conditions.

third objective to integrate foot-level and joint-level biomechanics to understand task-specific asymmetry and movement control strategies.

fourth objective to identify plantar loading and balance adaptations in children with sensory processing difficulties during dynamic tasks.

The candidate achieves these objectives by claiming new scientific results from thesis points presented on page 96-102.

In the **first thesis point**, the candidate concluded that gait asymmetry in children is primarily task-dependent, remaining minimal during straight walking but increasing significantly during running and turning due to higher coordination and balance

demands. Center of pressure and plantar loading show phase-specific, direction-dependent differences, indicating that asymmetry reflects normal developmental adaptation to complex locomotor tasks.

In the **second thesis point**, the candidate demonstrated that gait differences in sensory processing disorder are minimal during walking but become clear in running, where children show reduced push-off and a shift toward midfoot-dominant loading compared to controls' stronger forefoot propulsion. These findings highlight that high-demand tasks are necessary to reveal sensory-motor control differences in sensory processing disorder.

In the **third thesis point**, the candidate healthy adolescent athletes show widespread inter-limb biomechanical asymmetry at the joint level, which increases during turning and high-demand locomotor tasks. Time-series analyses reveal persistent stance-phase differences in angles, moments, and power, particularly between dominant and non-dominant limbs.

The publication emphasizes the significance of the study undertaken, since the resultant scientific findings are published in two Q2, one Q3 journals, as well as in one conference proceedings. In total candidate have 10 Scopus index publications with h-index 6 and total citations of 106.

Statement

This PhD thesis demonstrates novel scientific findings; all recommended revisions from the reviewers have been included; peer-reviewed journal articles substantiate the results, hence I propose that this thesis be submitted for public defense.

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