



**REVIEW and EVALUATION
of the PhD Thesis**

Research on musculoskeletal injuries in badminton: Based on a cross-sectional survey and biomechanical analysis

(by Shen Siqin)

1. Structural aspects, formal, quantitative requirements, style

The PhD thesis was written in English language. The composition, the style is logical and understandable. The thesis is well written in English, with minor grammatical errors. The construction, the design of the figures, and tables are good with several exceptions, which will be detailed in the comments of the different parts.

The structure follows the regulations of the Doctoral School of Chemical Engineering and Material Sciences from University of Pannonia.

The full length of the thesis is 101 pages (without references list). The dissertation starts with an introduction, research gaps and study justification, objectives. The introduction contains 23 pages (22 % of the work). The thesis has 5 main parts, list of tables and figures are added. The number of figures is 29, tables 15. The whole text and figures are clear and understandable.

2. References and publications

The references are edited to the end of the thesis, which are cited from the international literature involving the most relevant research studies, the reference format conforms to regulations of the Doctoral School of Pannonia University.

The list of bibliography contains 249 items, the references in the text are precise and correct. The candidate lists 6 publications (all with impact factor) related to this Thesis and 10 other publications in english (12 publications in Scopus, h-index 4). The publications are in peer-reviewed international journals with impact factor (Q1, Q2, Q4), in case of 3 publications the candidate is first author.



3. Contextual aspects, topic of the dissertation

The topic of the dissertation investigates the connexion between footwear characteristics and musculoskeletal injuries in badminton, integrating subjective athlete preferences with objective biomechanical evaluation. The results and conclusions are applicable in the future in case of the design of badminton shoes to optimize the balance between flexibility and stability for enhanced athletic performance and reduced injury risk.

The thesis work begins with badminton movements characteristics, aspects of biomechanics in badminton, constructions and biomechanical function of badminton footwear followed by the research gaps and study justification, objectives.

This research study was conducted at a recreational badminton match at Li-Ning Company (Beijing, China) in October 2019, with a total of 2,000 participants. The basic inclusion criteria were: above 18 years old and had been regularly participating in badminton for the past six months. The exclusion criteria were: lower limb surgery or neurological injury. The supervised questionnaire contained the basic profile (height, weight, age and racket-hand/dominant leg), the importance of shoe properties, shoe complaints, and pain or discomfort across foot regions. Ethical approval was approved by the institutional Human Research Ethics Committee (IRB-2019-BM-0013) in accordance with the Declaration of Helsinki principles.

This thesis provides new insight into human subjects' performance and protection by optimization of the design of badminton shoes to reduce injury risk.

4. Comments

Scientific comments:

Motivation and goals: The topic are up to date, the goals are clear, and logically connected to each other.

Literature review: Chapters 1.1. to 1.4.: It is an overview of the musculoskeletal injuries in badminton, with general critical evaluation of the kinetic analysis in badminton.



Research methods and validation: The informations about badminton shoes were obtained using questionnaire, wich stucture was organized into four sections: (1) participant profile, (2) importance of shoe properties, (3) shoe complaints, (4) pain or discomfort in different foot regions. The Bartlett's test result was $X^2 = 25553.553$, $df = 3003$, $P = 0.000 < 0.05$, confirming the validity of the questionnaire.

The data obtained were shown as means and standard deviations, as well as frequencies. Additional Shapiro-Wilk tests showed that the data violated the normal distribution ($P < 0.05$). Therefore, the gender differences in all variables were analyzed using the Mann-Whitney U test, and the differences between the dominant and non-dominant feet were analyzed using the Wilcoxon Signed Ranks Test. The significance level was set at $P < 0.05$. All statistical analyses were conducted using SPSS 21.0 (SPSS Inc., Chicago, IL, USA).

5. Concerning the specific questions and remarks made at the workshop defense, the final Thesis contains the following corrections:

5.1 The biomechanical research methods in badminton are presented as an overview, a new figure, **Figure 1** (page 20) titled "Comprehensive Overview of Badminton Biomechanics Research" was added. This addition aims to provide a more in-depth understanding of the current research landscape in badminton biomechanics, thereby addressing the need for a more detailed review

5.2 **Figure 2** (page 21) „Percentage in each month according to the total number of injuries during one year” – the figure presents only the injuries and the percentages during one year, we don't have informations about the months. The erroneous figure title has been corrected to "Body Sites Distribution of Badminton Injuries," offering a precise depiction of the figure's content.

5.3 **Figure 6** (page 40) – the used questionnaire should be translated in english for a larger applicability of the proposed research methodology. A note was added to highlight that the questionnaire was bespoke for this research, its English version is now included in the appendix for wider accessibility.



5.4 The **body mass index (BMI)** of males was 23.3 ± 3.4 and 21.3 ± 2.7 for females, respectively (page 57). How do you evaluate the BMI of the subjects only from their age? (200 males, 126 females, their mean age were 30.9 ± 11.8 years and 33.18 ± 12.1 years, respectively) Additional details regarding the BMI calculation method have been provided, clarifying that it was based on actual height and weight measurements collected during the participant profile section, rather than mere estimations from age.

5.5 **Results** (page 58) – for a better overview of the results the referred Table positions (Table 3, Table 4, and Table 5) were reorganised.

5.6 Tables 4 to 7 and Table 16 were repositioned to immediately follow their relevant discussions. This reorganization, along with the clear specification of measurement units for all tables, ensures a logical flow and enhances the understanding of the presented results.

5.7 **Table 15** – page 69, Ground reaction force variables (Mean \pm SD) by different footwear conditions were given.

5.8. **Figures 20 to 25** (page 70 to 76) – in the printed version the values on the axes of the diagrams are difficult to read, maybe you could separate the figures in bigger images or use colours. In case of Figures 7, page 42 & Figures 21-26 the size of these figures has been modified for better readability and clarity.

5.9. The **kinematic and kinetic data** were collected simultaneously (page 45) with different sampling frequencies (200 and 1000 Hz). Please give details (tables or figures) regarding the kinematic and kinetic data and acquisition method. Kinematic and Kinetic Data Collection Details regarding the simultaneous collection of kinematic and kinetic data, the 8-camera motion capture system utilized was from Vicon, Oxford Metrics, Oxford, UK, with specified sampling frequencies. This detailed information, along with updated and new tables and figures, aims to clarify the methodology further.



6. Research objectives and Thesis points:

The candidate established **three research objectives**, which were achieved in the **three Thesis points** as follows:

- realyse a cross-sectional survey to assess the differences in shoe requirements, reported problems/complaints, and pain locations between male and female badminton players, as well as to compare the footwear feature needs of players' dominant and non-dominant legs, achieved by the **1st Thesis point**,
- identification of gender-related differences in badminton footwear needs, and assess the influence of torsional stiffness - a critical but less examined feature of badminton shoes - on the biomechanics of the lower limbs, achieved by the **2nd Thesis point**,
- empirically assess the effects of varying torsional stiffness levels in badminton footwear on the biomechanical functioning of the lower limbs during badminton-specific movements, achieved by the **3rd Thesis point**.

Final remark on the Thesis points:

In case of the proposed **Thesis points**, the **final text was reorganised**, in order to **highlight the obtained general applicable results** from the obtained experimental results.

In the final version of the Thesis we have three main research objectives and three Thesis points.

The realised corrections and the proposed reorganised Thesis points can be accepted.

7. Conclusions:

The topic of the thesis investigates the connexion between footwear characteristics and musculoskeletal injuries in badminton, integrating subjective athlete preferences with objective biomechanical evaluation.

Future research directions may include longitudinal studies across varying athletic levels and foot morphologies to further understand the biomechanical adaptations to footwear modifications and their implications for sports performance and injury rates.



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The obtained cumulative results underline the significance of gender-specific requirements and biomechanical factors in the design of badminton footwear. The results derived from this research are applicable for the development of innovative shoe designs that cater to the needs of badminton players, aiming to increase performance while reducing the incidence of injuries.

Significant new scientific results are proven in the evaluated PhD thesis, these new findings are sustained by the three proposed Thesis points and by journal papers with impact factor (Q1, Q2, Q4).

I recommend the acceptance of this PhD Thesis for final defense.

Szombathely,

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