Dear Professor Sándor Manó,

I hope this message finds you well.

I would like to sincerely thank you for your careful review of my doctoral dissertation and for your highly positive evaluation. Your comments regarding the limitations of the single-participant wearable validation, the long-term durability of TPU-based lattice structures, the practical issue of printing time, and the formatting quality of the document are highly valuable. These suggestions have helped me further clarify both the current scope of the dissertation and the most important directions for future development.

1. The primary limitation is the use of a single participant for the in-depth validation study. While this case-study approach is well-justified for demonstrating the proof-of-concept and validating the methodology by minimizing inter-subject variability, it naturally limits the statistical generalizability of the specific footwear prototype's effectiveness across a broader population.

Thank you very much for pointing out this important issue. I fully agree that the final physical wearable validation was mainly based on one healthy male participant. Therefore, from the perspective of statistical inference and population-level generalizability, the sample size is indeed limited. This design is more suitable for demonstrating methodological feasibility and prototype validation, rather than serving as sufficient evidence for population-level effectiveness.

In the revised dissertation, I have further clarified that three participants were included in this study for individualized biomechanical assessment, finite element modeling, and multi-objective structural optimization: one healthy male participant, one female participant with severe flexible pes planus, and one male participant with Becker muscular dystrophy accompanied by pathological flatfoot. However, due to safety considerations and the physical demands associated with dynamic wearable testing, the final fabrication of the 3D-printed footwear prototype and the laboratory-based gait validation were conducted only with the healthy male participant.

The wearable experiment in this dissertation should therefore be understood as a proof-of-concept and methodological validation study, rather than a large-scale clinical validation. Its main purpose was to demonstrate that the proposed workflow can integrate foot morphology, gait data, finite element simulation, machine-learning-based optimization, 3D printing, and actual gait validation into a complete closed loop. Although single-participant wearable validation limits statistical generalizability, it also allowed the modeling, optimization, fabrication, and testing procedures to be conducted under relatively consistent conditions. This reduced the interference caused by inter-subject variability and made it possible to observe more clearly the relationship between lattice structural parameters and gait function.

I have also further emphasized in the limitations and future research sections that future studies should expand the sample size and include populations with different arch heights, foot widths, body masses, ages, soft-tissue thicknesses, gait strategies, and pathological conditions. Through larger and more representative cohort studies, the adaptability of the proposed optimization framework to different foot types and user populations can be further validated, thereby improving the population-level generalizability and clinical application value of personalized lattice footwear design.

2. The study focuses on the immediate biomechanical performance of the prototype. The long-term durability of the TPU-based lattice structures under high-cycle fatigue, i.e., months of daily use, is not assessed. This is a crucial consideration for real-world application but falls outside the scope of this foundational work.

For the present study, the dissertation is still at the stage of methodological validation and prototype development. Its main objective is to establish a closed-loop workflow that links parametric lattice design, finite element analysis, machine-learning-based optimization, 3D printing, and short-term gait validation. Therefore, the TPU material used in this study was mainly intended for prototype fabrication and laboratory validation. Its service performance under months of daily use, high-cycle loading, long-term wear, and complex environmental conditions has not yet been systematically evaluated.

For long-term real-world use, both the material system and the manufacturing process need to be further upgraded. The TPU 95A used in this dissertation is not necessarily the final industrial footwear material most suitable for prolonged wear. In future work, 3D-printable footwear materials with better fatigue resistance, more stable rebound performance, stronger wear resistance, and improved long-term dimensional stability could be adopted, such as high-performance TPU, E-TPU, flexible photopolymer resins, multiphase elastomers, multi-material composite systems, or industrial-grade footwear printing materials. For the design framework proposed in this dissertation, changing the material would not alter the overall methodological logic. It would only require re-measuring the mechanical parameters, compressive response, rebound behavior, fatigue life, and printing accuracy of the new material, and then incorporating these data into the finite element model and the machine-learning training database. Subsequently, the surrogate model could be retrained, and the structural parameters could be re-optimized according to the characteristics of the new material.

I believe that the main contribution of this dissertation is not to prove that a specific TPU material already fully satisfies the requirements for long-term wear, but rather to propose a parametric design and optimization framework that can be extended to different material systems. When higher-performance materials and more mature printing processes are adopted in the future, the framework can continue to operate by supplementing the corresponding material parameters and experimental data, and can generate personalized lattice structural designs adapted to the characteristics of the new material.

Certainly, future research should further include high-cycle compression tests, repeated bending tests, long-duration walking or running wear tests, and damage observations of lattice struts, nodal connections, and interlayer printed structures. The evaluation metrics should include stiffness degradation, changes in energy absorption capacity, changes in rebound performance, permanent deformation, crack initiation and propagation, and whether the plantar-pressure regulation effect decreases after long-term use.

To the best of my knowledge, there are already a number of footwear-related 3D-printing factories and companies in China that are capable of producing 3D-printed shoes or footwear components with relatively good durability. This suggests that, from the perspectives of manufacturing capability and material application, durable 3D-printed footwear already has a certain practical foundation. In the future, combining these more mature industrial materials and manufacturing processes with the biomechanical optimization algorithm proposed in this dissertation would help promote the transition of this framework from laboratory prototypes to long-term wear and practical application.

3. The document contains several formatting and typo errors, including orphan and widow lines and large white-space imbalance.

Thank you very much for pointing out the formatting and typographical issues in the dissertation. I also sincerely apologize for not noticing the attachment you had sent earlier. Following your suggestions, I have carefully checked and revised the formatting of the dissertation.

I reorganized the list of abbreviations in alphabetical order to improve readability and consistency. I also adjusted the font style of the figure and table captions so that they are visually distinguishable from the main text. In addition, I revised the formatting of the section headings by removing full justification and reducing excessive spacing in the title lines. I also checked the dissertation page by page and adjusted the orphan lines, widow lines, large blank spaces before figures, and local white-space imbalance.

Furthermore, I checked and corrected several formatting issues in the reference list, including the incorrect author conjunctions caused by the Zotero language setting, spelling issues in individual author names, and inconsistent expressions such as Adidas/adidas. These revisions were made to further improve the visual consistency, readability, and overall professional presentation of the dissertation.

Once again, I sincerely apologize for the oversight, and I am very grateful for your careful comments.

4. Your validation was based on a single-subject design, which was effective for validating the framework itself. If you were to design a follow-up study with a cohort of 50 individuals, how would your data-driven workflow adapt?

If a follow-up study involving several dozen participants were to be designed in the future, I would extend the current proof-of-concept personalized design workflow into a two-level framework that combines population-level pattern learning with individual-level precise optimization.

The design of a 50-participant cohort should cover biomechanically meaningful inter-individual variability as much as possible. For example, participants could be categorized according to foot morphology, including normal arch, flexible flatfoot, high arch, and pathological foot types. Basic factors such as sex, age, body mass, foot width, and soft-tissue thickness should also be considered. In addition, gait-related features should be included, such as walking speed, pronation/supination pattern, loading rate, forefoot propulsion strategy, and the presence or absence of pathological gait. In this way, a more diverse database could be established to represent population variability that cannot be captured by a single-participant experiment.

Each participant could undergo the same data-acquisition workflow established in this dissertation, including three-dimensional foot scanning, plantar-pressure measurement, ground-reaction-force recording, motion capture, and, where feasible, medical-image-based reconstruction. Based on these data, subject-specific finite element models could be constructed, and optimization objectives could be defined according to the biomechanical needs of different participants. For example, for healthy participants, rearfoot cushioning, midfoot stability, and forefoot propulsion could be considered simultaneously. For participants with flatfoot, diabetic foot, or neuromuscular disorders, greater emphasis should be placed on pressure offloading, arch support, and safety.

At the population level, the model would learn general relationships among foot morphology, gait characteristics, lattice structural parameters, and biomechanical outcomes. At the individual level, the lattice structural parameters would be further adjusted according to the data of each participant to achieve precise matching. This strategy would make it possible to summarize common design rules across different populations while preserving the advantages of individualized optimization.

Wearable validation should also be extended from a single participant to representative subgroups. By comparing changes in plantar pressure, joint kinematics, joint kinetics, comfort, and functional performance among participants with different foot types, body masses, and gait characteristics, the framework could be statistically validated. Therefore, a 50-participant cohort study would not merely increase the sample size, but would also transform the proposed method from an individualized proof-of-concept framework into a more general design system that combines population-level regularities with individual-level optimization.

4. The printing time of approximately 50 hours per shoe is a practical barrier to on-demand commercialization. Based on your knowledge of additive manufacturing, what are the most promising advancements in materials or printing technologies that could drastically reduce this time while maintaining the required geometric precision and mechanical properties?

The printing time of approximately 50 hours per shoe is an important barrier to the transition of the current method toward on-demand manufacturing and commercial application. In this study, FDM printing was selected mainly because the equipment is readily accessible, it can process flexible TPU materials, and it is suitable for laboratory validation of complex lattice footwear prototypes. However, from the perspective of industrialization and commercialization, conventional FDM is not the most efficient manufacturing method for lattice footwear.

In my opinion, the most promising future improvements include the following aspects:

Technologies such as Digital Light Synthesis, selective laser sintering, Multi Jet Fusion, high-speed vat photopolymerization, continuous liquid interface production, and multi-nozzle parallel printing may substantially shorten the manufacturing time of complex lattice structures while maintaining high printing accuracy and structural consistency. Compared with conventional FDM, these technologies are more suitable for the efficient production of personalized midsoles with complex internal architectures.

Future 3D-printable footwear materials should not only be printable, but should also possess good rebound performance, fatigue resistance, wear resistance, and long-term dimensional stability. High-performance TPU, E-TPU, flexible photopolymer resins, multiphase elastomers, and multi-material composite systems are promising directions. These materials could help lattice structures maintain the designed stiffness, cushioning capacity, and propulsive function during long-term use.

Future industrial products may not necessarily require the entire shoe or the entire midsole to be printed as a complex lattice structure. A more realistic strategy would be to adopt localized functional lattice design, in which 3D-printed lattice structures are used only in key functional regions such as the rearfoot, arch, lateral midfoot, and forefoot, while non-critical regions, the upper, or the outsole could still be manufactured using conventional high-efficiency processes. Through this hybrid manufacturing strategy, printing time and manufacturing cost could be substantially reduced while preserving the biomechanical advantages of lattice structures.

The digital manufacturing workflow also needs further automation and optimization. For example, automated slicing, support-structure optimization, reduction of support requirements, modular midsole design, automated post-processing, and quality-control systems could all improve production efficiency. In addition, manufacturability constraints could be directly incorporated into the optimization algorithm in the future, so that candidate structures are not only optimal in terms of biomechanical performance, but also more suitable for production with respect to printing time, support requirements, and manufacturing stability.

I believe that the realistic pathway toward commercialization is not to rely on a single printing technology, but to combine high-speed additive manufacturing, high-performance elastomeric materials, localized functional lattice design, and hybrid manufacturing workflows. Through this combination of technologies, manufacturing time and cost could be greatly reduced while maintaining the geometric precision and mechanical programmability of lattice structures, thereby promoting the transition of personalized lattice footwear from laboratory prototypes to practical applications.

Conclusion

Once again, I sincerely thank you for your careful review, positive evaluation, and constructive suggestions regarding my doctoral dissertation. These comments are highly valuable and will provide important guidance for my future research on personalized footwear design, biomechanical optimization, lattice structures, intelligent wearable systems, and digital manufacturing.

Yours sincerely,

Lu Zhenghui   Lu Zhenghui