Mechanical and Biofeedback Development of the In-bed Leg-press Device

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Introduction

To reduce prolonged bed rest-induced muscle atrophy and decreased mobility, early mobilization is essential, especially for elderly and critically ill patients [1]. Current methods, such as manual assistance and specialized devices, are labor-intensive and risky for those with severe mobility restrictions. This thesis focuses on the further development of an in-bed leg-press device, integrating biofeedback and exercise games as well as some mechanical improvements to enhance patient engagement and therapist utility. Through this, the thesis aims to gather insights, demonstrate potential for further innovation, and help refine the device into an affordable, user-friendly model, ready for widespread clinical use and market entry.

Materials and Methods

During an extensive analysis of the existing prototype, minor issues were resolved on the spot. The analysis identified three main mechanical work points: drive train redesign, monitor mount stability, and mechanical play of the ankle joint axis. These issues were addressed through reconstruction and implementation of new parts.
Software development utilized Python for the main program on a Raspberry Pi, with the library NiceGui for the graphical user interface (GUI). The motor controller, Maxon MiniMACS, was programmed with C-based code and an implementation of a PID controller. The exercise game was designed using the Godot Engine and integrated into the GUI via HTML export. The software architecture features CAN communication for the motor controller and a WebSocket for the game interaction.

Fig. 1 In-bed Leg-press prototype on a hospital bed.

The functioning of the data gathering system was evaluated, and user trials were conducted, with the experience assessed through a questionnaire.

Results

The evaluation indicates that the data collection process is effective, with the controller demonstrating quick response times and a steady-state error generally within 10%. Feedback highlights satisfaction with the device's appearance and the engaging nature of the game. However, there is a notable dissatisfaction with the devices transferability and the framerate of the game.

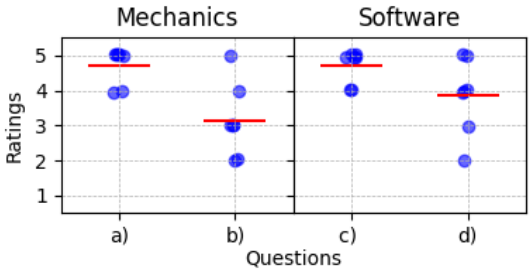

Fig. 2 Highlights of the questionnaire: Top- and Lowest-Rated questions. (n=7, mean=red) a) I like the appearance. b) I find it convenient to transfer the device. c) The game was engaging and held my interest throughout. d) The games functionality was smooth and without glitches.

Discussion

Integrating biofeedback and exercise games into the prototype has proven beneficial, effectively capturing user data and providing engaging gameplay that motivates users. While performance issues were noted, these features show promise for enhancing therapeutic use. Mechanical improvements have made the system more precise and smoother, though challenges with over-engineering, isolation. User trials generally provided positive feedback but reiterated previous concerns. The results underscore the need for further refinements to balance cost, performance, and durability.

References

[1] S. S. Kuys, U. E. Dolecka, and A. Guard, “Activity level of hospital medical inpatients: an observational study.,” *Archives of gerontology and geriatrics*, vol. 55, no. 2, pp. 417–421, Sep. 2012, doi: 10.1016/J.ARCHGER.2012.02.008.

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