

# Usability and acceptance of an upper-limb exosuit in the home environment

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*Abstract: Exosuits show promise for daily assistance, yet real-world usability studies are scarce. A 14-day home case study evaluated the usability and acceptance of the Myoshirt for an individual with Bethlem Myopathy, marking its first deployment without a supervising expert. Questionnaires including the System Usability Scale and the Quebec User Evaluation of Satisfaction with Assistive Technology were collected. Results indicated good usability (SUS = 70) but low satisfaction (QUEST = 2.25). Critical issues included difficulties with donning, discomfort, and concerns regarding aesthetics. The preliminary findings highlight the necessity of designing exosuits for independent, long-term use to achieve higher user acceptance.*

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## I. Introduction

The upper limb is an essential part of daily life. Whether performing basic tasks such as holding an object or engaging in complex activities like writing, any impairment can lead to a significant decline in a person's independence and overall quality of life [1]. The extent of impairment varies from mild functional limitations to complete loss of limb mobility, depending on the underlying cause. Recently, exosuits have emerged as a promising technology for both in-clinic training and rehabilitation as well as home-based assistance. A systematic review by Bardi et al. identified 69 wearable robotic devices developed to support the upper-limb [2]. While many of these devices are still in the early stages of development, some (7/69 or ~10%) have reached Technology Readiness Level (TLR) 6, having been demonstrated and tested on healthy subjects or individuals with motor disabilities. However, none have progressed to TLR Level 7, where systems are tested in real-world rehabilitation or assistive settings for independent use. This work presents the preliminary results of a pioneering study deploying an upper-limb exosuit to the home environment to explore usability and acceptance of the technology.

## II. Material and methods

The Myoshirt is a cable-driven active exosuit developed by the Sensory Motor Systems lab at ETH. It is portable, lightweight, and a textile-based soft wearable robot designed to provide partial gravity support to the shoulders via tendons routed from the back, over the acromion, and attached to cuffs on the upper-arm (Fig. 1). Regulation of the tendon output tension is performed by a feed-forward torque controller with a inverse transmission and dynamic friction compensation model.

The 14-day home study was initiated with a supervised onboarding introducing the participant to the Myoshirt ecosystem and tailoring the fit of the textile interface.

During the 2 weeks, the participants could wear and use the Myoshirt. The participants also answer a personalized daily questionnaire to document how they used the Myoshirt, or why they chose not to. On Day 14 the study was finished and on Day 15, there was a final in-person visit again to collect the System Usability Scale (SUS) [3] and Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) [4] questionnaires, followed by an open-ended interview. The first participant recruited for this study was a 52-year-old man, first diagnosed with Bethlem Myopathy in 2016. This rare form of limb-girdle muscular dystrophy is caused by the body's inability to produce collagen and leads to progressive muscle weakness and joint stiffness. The condition degenerates over time, causing difficulty walking, gripping objects, or fully extending one's joints.

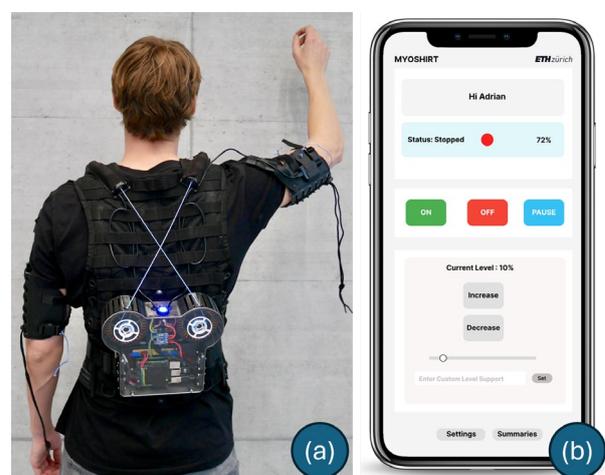


Figure 1: (a) the Myoshirt, (b) the MyoControl application, a mobile user interface with basic functionality to start, stop, pause the Myoshirt, and alter the support level.

### III. Results and discussion



Figure 2: On the left, the study participant using the Myoshirt to retrieve a drink from the fridge, in the center, retrieving a cup as they prepare an espresso, on the right, vacuuming.

The participant used the Myoshirt twice over the 14-day period. On Day 3 (1 hr. and 8 min.) for performing household tasks, and on Day 10 (1 hr. and 5 min.) for eating and testing with family and friends (Fig. 2).

The total SUS score resulted in a rating of 70, indicating good usability, however the responses showed an asymmetrical pattern, with some strong satisfaction with certain aspects and strong dissatisfaction with others (Table 2). While the participant found the device functional and safe, he expressed concerns about ease of use and overall user satisfaction, ultimately stating that he would not continue using the Myoshirt in its current state.

The QUEST questionnaire had a resulting score of 2.25 (Table 1). The responses also showed an asymmetrical pattern, with some usability aspects rated highly, such as safety and durability, while others, including comfort, dimensions, weight, and ease of adjustment, received the lowest scores.

From the interview, it was discovered that the participant did not use the Myoshirt on most days primarily due to difficulties in donning, followed by shoulder discomfort, and finally concerns about aesthetics. The participant required assistance from his wife, making it inconvenient for regular independent use. Discomfort as well prevented longer-term use. The reduced muscle and fat mass on the shoulder and arms of the participant caused higher levels of discomfort from the reaction forces of the tendon. Also, the participant felt that the Myoshirt was too visible and uncomfortable to wear in public, fearing unwanted attention. This highlights the need to consider visual design and discretion when developing assistive devices. Finally, the participant described the graphical user interface as intuitive, reliable, and easy to use without technical knowledge.

Table 1: QUEST results

How satisfied were you with...	Not at all				Very
1. The <b>dimensions</b> of the Myoshirt?	1	2	3	4	5
2. The <b>weight</b> of the Myoshirt?	1	2	3	4	5
3. The <b>ease of adjustment</b> of the Myoshirt?	1	2	3	4	5
4. The <b>stability and security</b> of the Myoshirt	1	2	3	4	5
5. The <b>durability</b> (hardness, resistance to use) of the Myoshirt?	1	2	3	4	5
6. The <b>simplicity</b> (ease of use) of the Myoshirt?	1	2	3	4	5
7. The <b>comfort</b> of the Myoshirt?	1	2	3	4	5
8. The <b>efficiency</b> (how well it could adapt to your needs) of the Myoshirt?	1	2	3	4	5

Table 2: SUS results

Question	Strongly Disagree				Strongly Agree
1. I think that I would want to use the Myoshirt frequently.	1	2	3	4	5
2. I found the Myoshirt unnecessarily complex	1	2	3	4	5
3. I thought the Myoshirt was easy to use.	1	2	3	4	5
4. I think that I would need the support of a technical person to use the Myoshirt.	1	2	3	4	5
5. I found the various functions in the Myoshirt were well integrated.	1	2	3	4	5
6. I thought there was too much inconsistency in the Myoshirt.	1	2	3	4	5
7. I would imagine that most people would learn to use the Myoshirt quickly.	1	2	3	4	5
8. I found the device very cumbersome to use.	1	2	3	4	5
9. I felt very confident using the device.	1	2	3	4	5
10. I needed to learn a lot of things before I could get started with the device.	1	2	3	4	5

Finally, the participant mentioned increased resistance in the tendon when lowering his arm, causing increased pressure and discomfort on the shoulder cuff. This is likely a result of stiction in the cable transmission that is not compensated for by the feed-forward torque controller, indicating that either it is necessary to develop a more advanced controller, or a load-cell should be used to regulate the tendon tension directly.

### IV. Conclusions

This home study successfully marked the first deployment of the Myoshirt for a longitudinal use-case without the presence of a supervising technical expert. More participants will be recruited moving forward. Such studies are essential as they allow users to interact with the technology independently, they provide real-world usability insights, and offer critical feedback for refining the technology. Unlike controlled laboratory settings, home environments shed light on challenges that must be addressed to improve the device’s usability and long-term acceptance.

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