Exploring Usability Standards in Robotic Rehabilitation: A meta-analysis of System Usability Scale scores

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Motivation

Evaluating the usability of rehabilitative robotics devices in clinical practice is crucial to identify potential gaps and drive the development of easy-to-use robots. One of the most popular tools to quantify device's usability is the System Usability Scale (SUS), a questionnaire of 10 questions to be answered on a 5-point Likert scale (from "Strongly disagree" to "Strongly agree"), that can be converted into a SUS score ranging from 0 to 100 [1].
Here, our goal is to quantify the usability of various types of robotic devices for rehabilitation reported in the literature in terms of SUS scores and to examine whether the widely used benchmark SUS distribution of 68 (SD 12,5) [2] can be reliably used for evaluating the usability in the field of robotics-assisted rehabilitation.

Research questions:



1. *What are the distributions of reported SUS scores across various types of robotics devices?*
2. *Is there a statistically significant difference between the distribution of SUS scores in robotics-assisted rehabilitation and the benchmark distribution [2] ?*
3. *Are there any differences in usability between patients and therapists?*
4. *Is there a difference in reported SUS scores when the usability study is conducted directly by robot developers?*

Materials and Methods

Document retrieval

✓ PRISMA Guidelines.
Inclusion: at least 1 reported SUS or SUS mean across participants

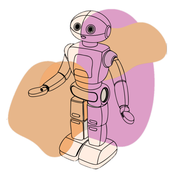
Query: Title, Abstract and Keywords: (System Usability Scale) AND Robot AND (Rehabilitation OR Cognitive

Scopus® · IEEE Xplore® · Google Scholar · Device-specific queries

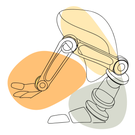
Device categorization

For each study, we categorized the evaluated technologies into the following eight categories of robotic rehabilitative devices. Categories are identified based on the device's functionality and/or the treated domain:

Assistive and mobile servants



Assistive UL or UL end-effector.



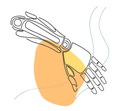
Proprioreceptive, stabilometric and balanced platform



Advanced treadmill



UL exoskeleton



sensor-based, virtual reality and cognitive robots



LL end-effector



LL exoskeleton

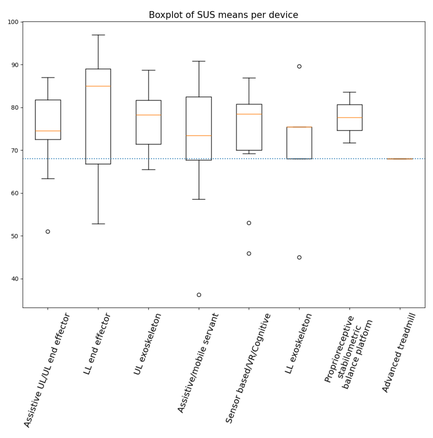


Extract reported SUS scores

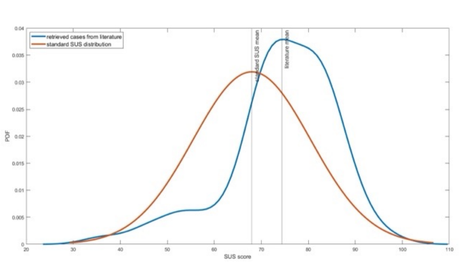
Results

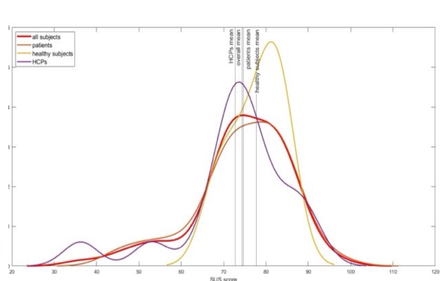
After screening 155 studies, 67 papers that matched our inclusion criteria were examined to answer the RQs.

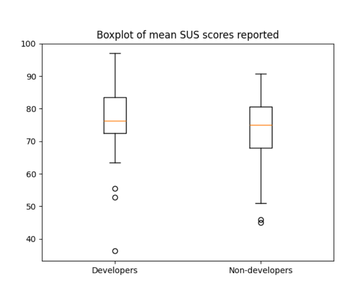
1. SUS scores of robotic devices in rehabilitation indicate good usability, with mean scores generally above the widely accepted threshold of 68
2. Significant difference in the SUS score distribution for robotics-assisted rehabilitation compared to the standard SUS benchmark (Kolmogorov-Smirnov test, p-value <5e-8)
3. We observed no statistically significant differences in SUS scores between therapists and patients, suggesting a generally consistent usability experience across these user groups
4. Studies conducted by developers tended to report slightly higher SUS scores compared to those conducted by external investigators. However, this difference was not statistically significant



Robotics device	Healthcare practitioners			Patients			Healthy participants		
	# of studies	*Mean # of participants*	*Mean SUS (std)*	*# of studies*	*Mean # of participants*	*Mean SUS (std)*	*# of studies*	*Mean # of participants*	*Mean SUS (std)*
Assistive and mobile servant	4	11,25	62,6 (17,6)	12	18,8	75 (10,7)	1	36	74
Advanced treadmill	-	-	-	1	6	68	-	-	-
UL exoskeleton	3	7	72 (6,2)	10	10,6	78 (6,7)	1	15	72
LL end effector	3	5,3	85,4 (6,6)	4	9,5	72,5 (22)	-	-	-
LL exoskeleton	-	-	-	6	17,3	70,7 (16,3)	-	-	-
Assistive UL or LL end effector	1	15	75,2	12	11,6	73,6 (10)	1	5	83,5
Proprioreceptive/Stabilometric/ Balance platform	-	-	-	3	20	77,65 (8,4)	-	-	-
Sensor-based/Virtual Reality/Cognitive	5	8,4	73,28 (12,8)	10	13,5	75 (11)	1	10	69,25







Conclusion

We retrieved available papers that report the usability of robotics devices in rehabilitation in terms of SUS scores. Our analysis revealed that, generally, robotics devices exhibit good usability across various types of devices, yet highlighted specific areas for improvement, especially for assistive and mobile servant robots when used by therapists. Future studies would benefit from expanding beyond developer-led investigations and increasing sample sizes, especially for clinical populations, thus validating findings across broader contexts and contribute to robust usability benchmarks tailored specifically for rehabilitation technologies

References

[1] John Brooke, 'SUS: A "Quick and Dirty" Usability Scale', in Usability Evaluation In Industry, CRC Press, 1996.
[2] J. Sauro and J. R. Lewis, Quantifying the User Experience: Practical Statistics for User Research.