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A Device Design based on Transcutaneous Electrical Nerve Stimulation System: An Approach to Technophobia (Case Study: Young Old People)

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Abstract

As the global population ages, there is a growing need for technologies that improve the well-being and independence of older adults. This project investigates the development of a device following the principles of transcutaneous electrical nerve stimulation (TENS) with a focus on optimizing usability for the elderly population. This approach aims to foster a sense of independence and well-being among the elderly and aligns technological advances with the diverse needs of the aging demographic. This study targeted 65-75 people (young and old) to investigate their perception of using a transcutaneous electrical nerve stimulation (TENS) device. 26 participants, recruited through online platforms and healthcare centers and interaction with a 3D prototype, about various aspects of the device, including complexity, confidence with assistance, discomfort with technology-based devices, and learning time, they expressed confusion with features, concern about mistakes, clarity of instructions, anxiety, moderate perceptions of home-based medical technologies, and a preference for a simpler design.

Keywords

Geriatric Technology, Neurostimulation, Technophobia, Human-Centered Design.

Introduction

The anticipated surge in the population of individuals aged 80 or above from 2020 to 2050 is projected to triple, reaching a staggering 426 million. This impending demographic shift poses significant challenges for nations worldwide, compelling them to address and enhance their health and social systems to effectively accommodate this substantial change (WHO, 2022). As the elderly population continues to experience consistent growth, there is a rising need for comprehensive elderly health management services (Talukder et al., 2021). Technology now supports or simplifies many everyday activities. This continued development of technology occurs alongside the aging of the world's population. New technology also has the potential to provide timely interventions to help older adults maintain health and independence for longer (Geraedts et al., 2014). Older adults are slower to adopt new technologies than younger adults (Czaja et al., 2006), but they will do so if these technologies appear valuable, for example in maintaining their quality of life (Heinz et al., 2013). The adoption of technology holds the promise of enhancing the quality of life for older adults and fostering prolonged independent living. Specifically, designed technologies for the elderly should prioritize being useful, socially engaging, and easy to use, ensuring their effectiveness and accessibility (Martinez-Martin et al., 2019). As per the International Pain Society, individuals often become more susceptible when experiencing pain, a phenomenon particularly pronounced among the elderly. Aging is frequently linked with delayed and less effective recovery from injury or acute illness, potentially increasing the likelihood of developing persistent pain issues. The convergence of heightened risk for distressing pain and diminished coping abilities underscores the unique vulnerabilities faced by older members of society, accentuating the importance of addressing their specific needs (IASP, 2021). In addition to diminishing physical and cognitive capabilities, the elderly often encounters challenges in embracing and utilizing new technologies (Kaufman et al., 2002). It is undeniable that mental and physical health can influence each other (Fu et al., 2021). Technophobia, characterized by a reluctance or aversion toward emerging technologies, is increasingly acknowledged as a novel risk factor for older adults (Cavdar Aksoy et al., 2020; Di Giacomo et al., 2020). Leonardi et al. (2008) thought that the main reason for the potential *technophobia* of the elderly is that user interface design ignores their specific needs and is not suitable for them. In their work, an attempt was made to design a suitable interaction method for communication between machines and the elderly to give them access to techniques. They summarized and focused on the factors that hinder the elderly's access to and adoption of new techniques and pointed out the principles of human-computer interaction for the needs of the elderly, which include considering the changes related to aging that motor, cognitive and perceptual perspectives, it covers issues related to acceptance and emotional experience. As the population ages, there is a growing demand for various types of medical support services to assist individuals in performing essential daily activities and enhancing their overall quality of life. Home care emerges as a critical healthcare concern for maintaining the health and survival of the elderly. In addressing the diverse array of technologies employed by older adults for sustaining a healthy lifestyle, such as telecare, care robots, and wearable health devices, it is essential to consider technophobia as a comprehensive approach encompassing various technological aspects. Previous research indicates the presence of *technophobia* among older individuals, reflecting unfavorable attitudes towards emerging technologies and their societal implications (Erhong & Xuchun, 2023). The hesitancy of older individuals to adopt new technologies not only reduces their overall quality of life and autonomy but also has detrimental effects on their mental well-being. This encompasses psychological stress arising from the challenges posed by emerging technologies and the struggle against stereotypes associated with aging (Freeman et al., 2020; Pirhonen et al., 2020; Xi et al., 2022).

TENS and Pain Management

Transcutaneous Electrical Nerve Stimulation (TENS) is a non-pharmacological intervention employed in the treatment of both acute and chronic pain conditions. TENS units, characterized by their safety, affordability, and accessibility as over-the-counter devices, administer pulsed alternating current through electrodes placed on the skin (Johnson et al., 2015; Vance et al., 2021).

Pulse frequency and pulse intensity parameters are adjustable and are related to TENS efficiency. TENS can be applied with low frequencies (LF), >10 Hz, high frequencies (HF), >100 Hz, or mixed frequencies (LF and HF). TENS units typically use adhesive electrodes that It is applied to the surface of the skin to deliver pulsed electrical stimulation that can be modified in terms of frequency (stimulation rate), intensity, and duration (Sluka et al., 2013). Studies show that HF TENS (more than 50 Hz) increases the concentration of beta-endorphin and methionine-enkephalin in the spinal cord. TENS produces analgesia by activating endogenous inhibitory mechanisms in the central nervous system, including opioid, GABA, serotonin, muscarinic, and cannabinoid receptors. Proposed analgesic mechanisms for TENS include transient increases in serotonin levels, increased cellular ATP, and reduced inflammation (Chandran & Sluka, 2003; Leibano et al., 2011). Studies show that the benefits of utilizing Transcutaneous Electrical Nerve Stimulation (TENS) parallel those of drug treatments commonly employed for chronic pain. Moreover, TENS is deemed less risky, offering a significantly safer alternative to pharmaceutical treatments. The accessibility and affordability of TENS, available over-the-counter in many countries, make it a viable component of self-management strategies, akin to approaches involving heat, cold, and the use of acetaminophen or nonsteroidal anti-inflammatory drugs (NSAIDs) (Cording et al., 2015; Cording et al., 2016; Derry et al., 2017). Carol et al. (2022) reported that minor side effects reported included itching and redness at the site of TENS stimulation or dislike of the TENS sensation. In a study conducted by Naeser et al. (2002), the combined application of cutaneous electrical nerve stimulation (TENS) and a low-power laser proved to be effective in managing carpal tunnel syndrome (CTS), resulting in positive outcomes. The benefits observed included a significant reduction in the McGill pain questionnaire score, median nerve sensory delay, and a decrease in Fallen’s and Tinel’s symptoms following active TENS treatment sessions. These findings highlight the effectiveness of this approach in alleviating pain and improving the symptoms associated with CTS. It emphasizes that the use of TENS can be recognized as an impactful therapeutic modality for addressing the management of this condition.

Carpal Tunnel Syndrome

CTS is the most frequent entrapment neuropathy and some reports pointed out that about 3.8% of the general population suffers from the mentioned problem (Ibrahim et al., 2012) and can impact up to 5% of individuals in specific occupations. The condition is more prevalent in patients aged 55 years and older (Fung et al., 2015). CTS as one of the main musculoskeletal disorders not only creates severe limitations for people but also is known as a costly problem (Sadeghi Naeini, 2014). Carpal tunnel syndrome (CTS) is a median nerve entrapment neuropathy at the wrist due to compression of the median nerve as it passes from the forearm to the palm, below the transverse carpal ligament (Stevens, 1997). A significant improvement in pain scores has been reported in patients treated with splints for 4 months compared to the control group. The use of a splint helps to maintain the strength and immobility of the wrist and also helps to improve the user’s neurological condition by reducing the compression of the nerves inside the tunnel (Akalin et al., 2002). Common symptoms of carpal tunnel syndrome include gradual onset of numbness, pain, burning, or tingling in the fingers, especially the thumb, index, and middle fingers (carpal tunnel syndrome can occur in one or both hands), and weakness when grasping objects with one hand. or both hands, pain or numbness that worsens at night and disturbs sleep, and swelling in the fingers that can affect either the non-dominant hand or the dominant hand first or more severely. If left untreated, patients may experience permanent numbness in these areas of the hand and a size reduction (atrophy) of the thumb muscle with permanent weakness (Currie et al., 2022).

Methodology

This study targeted people 60 years and older who were potential users of home medical care devices with different levels of use of health care technologies. Participants were recruited through online platforms and healthcare centers to obtain research-matched samples.

Table 1: *Benchmarking competitive analysis according to the "Medical News Today" (Medical News Today, 2023).*

	Who it is best for	Number of Modes	Pros	Cons	Price
 Therabody PowerDot	People who want support during the use	12	- Personalized setting suggestions - Comes with an app	- Expensive in comparison to competitors - Negative reviews focus on problems connecting to smart devices	349$
 Healthmate Forever	People who want massage simulation	15	- Includes a range of massage types - Lifetime warranty	- Not rechargeable - More expensive	99.99$
 iReliev	People needing pain relief on the go	14	Long warranty	Price is high compared to other products	189$
 HiDow	People needing short-term pain relief	4	- Rechargeable - Wireless - Portable - Large surface area	Maximum of 4 modes	119$
 TENKER	People on a budget	24	- Affordable - Rechargeable - 24 modes	Users report poor electrode quality	39.99$
 Omron	People with foot pain	10	- Preset programs for targeted pain relief - Affordable - Portable - Discreet size	- Fewer modes than other units - Comes with one pair of electrodes - Negative reviews mention the wiring is not durable and it may not be powerful enough for some	47.25$
 AUVON	People want dual channels	20 intensity, 24 massage	- Pocket-sized and portable - Affordable - Three color options	Reviewers mention receiving faulty devices and that the machine gives off electric shocks	37.99$
 TechCare	People want a lifetime warranty	24	- Has FDA approval - Comes with both small and extra-large pads - Affordably priced - Lifetime warranty	Reviewers mention needing to sign up for the warranty, poor customer service, and receiving faulty devices	37$

To ensure the relevance of our study to the current market landscape, we selected one of the 8 TENS devices available in the market (Medical News Today, 2023). The selection was made based on a comprehensive analysis reported by *Medical News Today* taking into account factors such as price, brand reputation, and safety. The selected TENS device was used as the investigated model for our study. Before implementing the questionnaire, the selected device was 3D prototyped and presented to the participants in the form of video and photos. This approach gives users a better understanding of its design, features and functions. During this session, participants were encouraged to explore the product, ask questions, and voice any initial concerns or observations. Participants were asked to provide demographic information including age, gender, and frequency of use of healthcare technologies. A structured questionnaire was developed to measure technophobia regarding TENS devices among the target population. This questionnaire includes 15 questions; 9 questions were on a Likert scale and 6 included demographic information and additional questions related to technology usage habits and previous experience with TENS devices. Participants were given a clear explanation of the purpose of the study. Informed consent was obtained from each participant before administering the questionnaire, and participants were encouraged to answer each question honestly. Responses to questions were numerically coded on a Likert scale (1. Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly agree). Demographic information was appropriately coded. The obtained data were analyzed using statistical analysis methods. Mean and standard deviation, variance, mode and median were calculated for each Likert scale question to measure the overall level of technophobia.

Results

In this study, we aimed to investigate the perceptions and attitudes of 65-75-year-old (young) people toward a specific transcutaneous electrical nerve stimulation (TENS) device selected based on key market considerations such as price, brand reputation, and safety. 26 participants, recruited through online platforms and healthcare centers, engaged with a 3D prototype of the selected device presented through videos and photos, while their behavior was observed and noted. Among the 26 participants, the gender distribution included 14 women and 12 men. A questionnaire was developed that included questions on demographic information, frequency of healthcare technology use, and previous experience with TENS devices, ensuring a comprehensive understanding of the participants' backgrounds. Participants answered a 15-question questionnaire that included 9 Likert scale questions and 6 additional information-gathering questions. Responses were systematically coded on a Likert scale (1= Strongly disagree, 5= Strongly agree). Statistical criteria including variance, standard deviation, mode, median and mean were used to analyze Likert scale questions. perceived complexity; Participants, on average, showed a moderate perception of complexity with a mean of 4.31, which emphasizes the need to balance device complexity, and trust with assistance. A mean score of 3.88 indicates a moderate level of confidence with assistance, which emphasizes the potential role of guidance and support in increasing users' confidence, and discomfort with technology-based devices. With a mean score of 3.77, participants expressed a moderate level of discomfort when using technology-based medical devices and emphasized the importance of user comfort in device design, and learning time. Participants found that learning to use the TENS device took a moderate amount of time, as indicated by a mean of 4.27, which emphasizes the importance of user-friendly interfaces and educational materials, not confusion with features. The mean score of 4.12 indicates a moderate agreement among the participants about possible confusion with specific features of the device and emphasizes the importance of visual design, and concern about mistakes.

Participants, on average, expressed moderate concern about making a mistake when using the TENS device, with a mean score of 4.15, emphasizing the need for clear instructions and user-friendly interfaces. The mean score of 3.96 indicates a moderate perception of unclear instructions, which indicates the importance of providing comprehensive and easily understood guidance, and anxiety about new technology. Participants reported a moderate level of anxiety about using new technology, indicated by a mean score of 4.35, emphasizing the need to address technological apprehensions in introducing the device, preferring a simpler design.

Participants, on average, showed a moderate to high preference for a simpler design, with a mean score of 4.5, emphasizing the importance of simplicity in device aesthetics and functionality.

Table 2: *Demographic data of respondents.*

Frequency	Frequency response	Gender
53.8%	14	Female
46.1%	12	Male
100%	26	Total

Frequency	Frequency response	Gender
0%	0	65
3.8%	1	66
11.5%	3	67
3.8%	1	68
15.3%	4	69
11.5%	3	70
15.3%	4	71
15.3%	4	72
11.5%	3	73
3.8%	1	74
7.6%	2	75
100%	26	Total

Variance	Standard Deviation	Mode	Median	Average
8.18	2.86	69.71,72	70	70.61

Table 3: *The results obtained from the questionnaire.*

Title	Variance	Standard Deviation	Mode	Median	Average
Using this device is perceived as complicated	0.3	0.55	4	4	4.31
Confidence in using the TENS machine increases with assistance	0.99	0.99	4	4	3.88
Discomfort is expressed with technology-based medical devices	0.9	0.95	4	4	3.77
Learning how to use the TENS machine takes time	0.68	0.83	4	4	4.27
Certain features of the TENS device are found confusing	0.51	0.71	4	4	4.12
Concerns about making mistakes arise when using the TENS machine	0.54	0.73	4	4	4.15
Instructions provided with the TENS device are considered unclear	0.36	0.6	4	4	3.96
Anxiety is felt about using new technology, such as a TENS machine	0.48	0.69	5	4	4.35
A preference exists for a simpler design of the TENS device	0.34	0.58	5	5	4.5

Design Suggestions

In addressing the technophobia associated with transcutaneous electrical nerve stimulation (TENS) devices, the proposed design focuses on ergonomic considerations as a cornerstone of a human-centric approach (Sadeghi Naeini et al., 2022). Recognizing the challenges identified with current TENS devices, the proposed product supports a prescription-based model that requires physician approval and guidance from a physical therapist to ensure safe use. This approach recognizes the importance of professional supervision in reducing potential risks and ensuring optimal treatment outcomes for elderly users. To address cognitive errors, especially among the elderly, the design includes three pre-set numerical ranges on these pieces, which are referred to as (pills) that look a lot like pills.

These numerical ranges are tailored to the individual needs of the user. This feature increases personalization and safety by simplifying device operation and reducing the possibility of user errors. Integrated seamlessly into a hand splint, these units prioritize ease of use and feature an automatic start-stop mechanism. This integration simplifies the treatment process and provides a more controlled and hassle-free experience for older users who may have dexterity or mobility limitations. This design emphasizes usability, accessibility, and reducing errors caused by wrong or complex devices in previous devices and seeks to overcome technophobia by making the TENS device more user-friendly. By meeting the specific needs of the target population, this approach aims to increase user acceptance and compliance with TENS therapy, and ultimately improve overall treatment outcomes and quality of life for the elderly.

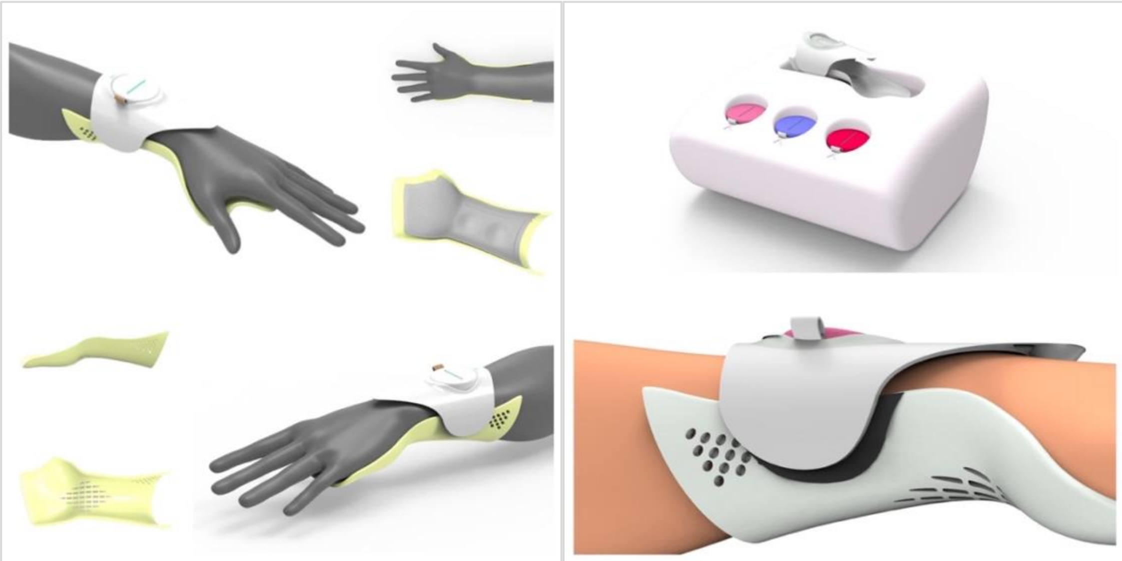

Figure 1: *Suggested design.*

Conclusion

The information gathered from this study provides valuable insights from older adults regarding transcutaneous electrical nerve stimulation (TENS). The observed cases regarding some aspects, such as perceived complexity and preference for simplicity, emphasize the importance of adapting medical devices to individual preferences. These findings contribute to future considerations in the design and implementation of home medical care devices for the elderly population. The results of this research emphasize the importance of incorporating user-friendly interfaces, providing clear instructions, and being sensitive to technophobia in the development of such devices. Addressing these factors is essential not only to increase usability but also to improve user acceptance and satisfaction, ultimately leading to better health outcomes and higher quality of life for older adults. Also, the potential of this topic goes beyond TENS devices. As the aging population continues to grow, there is a pressing need for user-centered design in all aspects of healthcare technology. By prioritizing the needs of elderly users, designers and healthcare professionals can create more effective and accessible solutions for a wide range of medical devices. In addition, other possible solutions are:

1. Simple design: designing medical devices with simpler interfaces and less complex features can help reduce user confusion and anxiety.

2. Personal training: Providing personal training sessions or training materials tailored to the specific needs and abilities of elderly users can increase their confidence and skills in using medical devices.

3. Remote Monitoring: Incorporating remote monitoring capabilities into medical devices allows healthcare providers to track patient usage and provide timely assistance or intervention when needed, increasing safety and efficiency.

give Overall, by embracing user-centered design principles and exploring innovative solutions, we can ensure that medical devices meet the diverse needs of older users and empower them to maintain independence and well-being as they age.

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