Potential of Exoskeleton Technology to Assist Older Adults with Daily Living

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Abstract
Mobility impairments can prevent older adults from performing their daily activities which highly impacts a person's quality of life. Exoskeleton technology can assist older adults by providing additional support to compensate for age-related decline in muscle strength. To date little is known about the opinions and needs of older adults regarding exoskeletons as current research primarily focuses on the technical development of exoskeleton devices. Therefore, the aim of this paper is to inform the design of exoskeletons from a human-centered perspective. Interviews were conducted with seven older adults and six healthcare professionals. Results indicated that exoskeletons can be a valuable addition to existing mobility devices. Accepting the need for mobility aids was found to be challenging due to associated stigmas. Therefore, an exoskeleton with a discreet appearance was preferred. Ultimately, the willingness to use exoskeleton technology will depend on personal needs and preferences.

Author Keywords
Older adults; Assistive technology; Exoskeleton; User perspective; Mobility

ACM Classification Keywords
H.5.2 [User Interfaces]: User-centered design; K.4.2 [Social Issues]: Assistive technologies for persons with disabilities

Introduction

In an aging population mobility impairments are prevalent [15, 16, 17]. When physical deficiencies make it increasingly more difficult to move, people stop moving, which increases both the risk of diseases associated with a sedentary lifestyle (e.g. cardiovascular disease, type 2 diabetes and obesity) and the risk of withdrawing from participation in society [15, 16, 17]. Moreover, mobility loss prevents people from performing their daily activities which highly impacts a person's quality of life and often increases the dependency on others [9, 16, 17]. Assistive technology can help individuals with reduced mobility to perform their daily activities [4]. Increasing the mobility of older adults[1] can increase their level of physical activity and can have a positive effect on their well-being [15, 17]. However, traditional mobility aids have their disadvantages. For example, the four-wheeled walker, commonly used by older adults, has been criticized for being heavy and bulky making it difficult to handle and transport the device [2]. Additionally, most walking aids such as canes and walkers do not provide sufficient support during sit-to-stand transfers which are an integral part of daily life [11]. For these reasons, powered exoskeletons, which are worn on the body, might be a suitable mobility aid for older adults.

The aim of the study presented in this paper is to inform the design of exoskeleton devices for older adults. Currently, exoskeletons are being developed for the military, industry and for medical applications such as rehabilitation [5]. As technology advances, exoskeletons can also assist older adults with daily living by providing additional support during standing, walking, sit-to-stand transfers and climbing stairs, to compensate for age-related decline in muscle strength [11]. Besides the technical developments of exoskeletons it is important to focus on the user's perspective.

[1] We will use the term older adults to refer to people aged 65+

User acceptance and usability are critical factors in the successful adoption of any assistive technology, therefore it is important to involve end users and other stakeholders in the development process [4, 9]. To this end we will explore the views of older adults (i.e., primary users) and their caregivers (i.e., secondary users) on exoskeleton technology to assist with daily living.

Related work

Several exoskeleton prototypes are being developed to assist older adults. For example, the EXPOS is a lightweight exoskeleton designed to support older adults and rehabilitating patients to sit down, stand up and walk [7]. The exoskeleton is attached to a walker which carries the electronics, hereby reducing the weight of the exoskeleton. Age-related changes in gait function (e.g. decreased walking speed, shorter step length, increased step variability and reduced range of motion at the hip, knee and ankle joints) and decreased metabolic efficiency for walking strongly affect the ability to perform daily activities [8, 13]. Improving walking function is therefore an important focus when developing exoskeletons for older adults (e.g. [8, 12, 13]). More recently, soft exoskeletons – often referred to as exosuits – are being developed by replacing rigid structures with garment-like textiles integrated with compliant sensors and actuators to interface with the human body in a more comfortable manner [1]. For example, Jin et al. showed that older adults can benefit from wearing a soft robotic suit that provides assistive force for hip flexion during walking, both in terms of reduced energy expenditure and improved gait characteristics [6].

To date little is known about the opinions and needs of older adults with respect to exoskeleton technology for home use, as this topic has only been addressed by a few studies. In a questionnaire older adults rated the importance of different body motions needed to perform their daily activities [9]. The results indicated that assistance would be required during actions such as sitting down, standing up, standing, lifting, carrying and bending. In other work, the European XoSoft project aims to develop an exosuit for the lower body to assist (older) adults with mobility impairments [10]. Potential users (i.e., people recovering from a stroke, people with incomplete spinal cord injuries and older adults) and their (in)formal caregivers were asked to give their opinions on the XoSoft concept design. The soft wearable assistive device was generally well received although frail older adults tended to be less positive about the concept. The main design requirements listed were comfort (e.g. lightweight, compatible with usual clothing/ footwear and even the option to wear the device underneath normal clothing), ease of use (e.g. independent donning and doffing, easy to clean, not bulky and no extensive training required) and affordability (either by a low purchasing cost or reimbursement). In contrast to previous studies, we will specifically focus on the needs and preferences of older adults and we will explore the views on exoskeleton technology in general instead of asking for opinions on one specific exoskeleton concept. The aim of the study presented in this paper is to inform the design of exoskeleton technology that can help older adults with reduced mobility to perform their daily activities. In addition, we will explore the most promising situations in which older adults would use such a device.

Methods

Participants

Interviews were conducted both with older adults (i.e., primary users) and their caregivers (i.e., secondary users) to gain a better understanding of the user's needs from different viewpoints. Seven older adults (2 male, 5 female) and six healthcare professionals (2 male, 4 female) volunteered to take part in the interview. The age of the primary users ranged between 68 and 94 ($M = 85, SD = 9$). Most primary users (6) lived in their own apartment within a care facility and received help with activities such as dressing, cleaning and grocery shopping whereas the one other participant lived independently. The age of the secondary users ranged between 27 and 68 ($M = 39, SD = 15$). Their experience with older adults working as physical therapist (3), occupational therapist (1) or nurse (2) ranged from 2 to 44 years ($M = 14, SD = 16$).

Procedure

Written informed consent was obtained from all participants. A semi-structured interview was conducted in two versions to either cover the personal experiences of primary users or the experiences working with older adults for secondary users. During the interview the researcher took notes and audio recordings were made for later analysis. At the start of the interview both user groups were asked to provide basic demographic information and to rate their general interest in technology. In addition, primary users were asked about their daily functioning, the problems they encountered regarding mobility and their experiences with mobility devices. Secondary users were asked about the mobility problems faced by their clients and their experiences with mobility devices used by their clients.

Next, both groups were asked to rate their familiarity with exoskeleton technology. Subsequently, all participants were introduced to the concept of exoskeletons by a short explanation including pictures and a short video featuring people wearing different exoskeleton devices. Both user groups were asked about the positive and negative aspects of exoskeleton technologies. Additionally, primary users were asked whether they or other older adults that they know would be interested in using such a device in their daily life and in which situations this technology would be used. Secondary users were asked the same question regarding their clients' interest in using exoskeleton technology. The entire procedure took approximately 30 minutes.

Results

Most older adults (6/7) experienced difficulties performing their daily activities due to reduced mobility. Walking, especially longer distances, was difficult for most participants (5/7). In addition, the general remark was made that all daily activities had become more difficult (3/7). Also, most participants (5/7) reported to be careful to avoid falling. The care providers indicated that their clients had difficulty with walking (especially longer distances and walking outside) (6/6), sit-to-stand transfers (5/6) and standing for prolonged periods of time, for example when showering or cooking (3/6). Also, the risk of falling was highlighted (3/6). Most older adults reported using at least one mobility device (6/7): 2 people only used a rollator, 2 used a rollator and cane, 1 used a rollator, cane and mobility scooter and the other participant only used a wheelchair. The care providers indicated that the rollator was the most used mobility device by their clients (6/6). Other mobility aids that were frequently used were mobility scooters (3/6), walkers (2/6), wheelchairs (2/6), crutches (2/6) and a cane (1/6).

All primary users and most secondary users (4/6) were unfamiliar with the concept of exoskeletons. The other two care providers reported to have seen exoskeletons on pictures and/or video. All participants (13/13) were positive about the general concept of exoskeletons. Most older adults (5/7) indicated that they would wear an exoskeleton device if needed. However, none of these participants felt that they needed such a device at the moment. One of the other participants (1/7) felt too old to try a new device as she would not be going out anyway and the last (1/7) preferred doing everything herself instead of being dependent on exoskeleton technology. Some participants (3/7) argued that other older adults would be open to try an exoskeleton device. All care providers (6/6) indicated that the suitability of an exoskeleton device would be person-dependent. Accepting the need for assistive technology was described to be a difficult process both for an older adult and their relatives as the device can be perceived as a sign of deteriorating health (2/6). This was illustrated by some older adults (2/7) mentioning that they would have to be "far gone" before needing an exoskeleton. Care providers experienced that change, especially involving new technology, was often met with resistance which might cause people to refrain from adopting a mobility device (5/6). For this reason, exoskeletons were perceived to be more suitable for younger generations who are more familiar with the current state of technology (4/6), especially compared to people aged 80+ (3/6).

Regarding the appearance of exoskeletons older adults stated that the device should not be conspicuous (3/7). One participant (1/7) mentioned that she would try to conceal the device with her clothes for as much as possible. However, some participants (3/7) indicated that they would wear an exoskeleton device if they would need it, regardless of its appearance. According to some of the care providers an exoskeleton that could be worn underneath regular clothing would be preferred by their clients as this would make the device invisible to others (3/6). Alternatively, the exoskeleton could be worn as clothing making the device less noticeable and look less complicated (2/6). Other design requirements include that the device should be compact (3/6) and lightweight (2/6) and is easy to put on and off, preferably independently (5/6). Practical issues raised by the care professionals included the costs involved for acquiring an exoskeleton (4/6) and the need for sufficient battery life for example to be able to use the device during shopping (2/6).

Older adults indicated that they would be willing to wear the device during the entire day if necessary (3/7). Both older adults (2/7) and care providers (5/6) indicated that an exoskeleton would be used for support during walking, especially longer distances. Care professionals mentioned that an exoskeleton could help older adults to increase their endurance (4/6) and might be used during the recovery from injuries or illnesses (2/6). According to the care providers exoskeletons might also support older adults during lifting (1/6), prolonged standing (2/6) and climbing stairs (1/6). Also, it was stated that exoskeleton technology could help older adults stay independent for longer (2/6).

Discussion and conclusion

Reactions towards exoskeleton technology were generally positive indicating that exoskeletons can be a valuable addition to existing mobility devices to assist older adults with daily living. Design requirements for exoskeletons focused mainly on two aspects: ease of use especially regarding donning and doffing and various ways to make the appearance of the device as inconspicuous as possible (e.g. compactness and integration in clothing). Interestingly, older adults reported that they did not perceive the need for wearing an exoskeleton device despite their reported difficulties performing daily activities. This paradoxical finding might be understood in light of previous work on Technology Acceptance Models (TAMs) that describe the factors that influence user acceptance of technologies [14]. Indeed, the need for assistive technology might be perceived as a sign of deteriorating health forming a barrier to its adoption. Therefore, it is important for developers of mobility aids and care professionals who prescribe these devices to be sensitive to the stigmas that people might associate with the use of assistive devices. For example, designers of exoskeletons can help to reduce the resistance towards wearing such a device by aiming for a discreet appearance. Additionally, co-design methods can be used to involve older adults in the development process (e.g. [3]). In the end, it will be dependent on someone's personal preferences, health condition and living situation whether the use of an exoskeleton device is a suitable option. Offering older adults a diverse range of assistive devices can help to suit their individual needs.

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