

Footwear Design Considerations for an Aging Population from User Experience, Service, and Technology Aspects

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Growth of the aging population is a systemic, social-technological challenge facing the world. Typical ways of designing and developing products for older adults have been disrupted by this demographic shift and the introduction of new technologies. This study focuses on indoor footwear design for an aging population to help designers consider aspects of user experience, service, and technology. We investigated older adults' use and purchasing behavior through surveys and semi-structured interviews. We presented ten smart footwear concepts and ideas around internet-of-things (IoT) wearable devices, data privacy, and security issues to help identify their unmet desires and pain points. We conclude that, for older adults, wearing shoes represents their independence in life, that their foot healthcare problems vary widely, and that they are not equipped with the proper/optimal knowledge to choose the right footwear. Designers need to consider their physical limitations and cognitive load while conducting such research.

INTRODUCTION

Footwear design is similar to architecture design. It is a complicated process with diverse considerations: people's needs, behavior, culture, and assisting technologies. One reason is that human feet are a sophisticated part of the body, each consisting of 26 bones, 33 joints, and more than 100 soft tissues, muscles, skin, tendons, blood vessels, nerves, and ligaments. All components interconnect to form a flexible structure that can do multiple complex actions such as movement, balance, and body support (Tomassoni et al., 2014).

Designers of indoor footwear, particularly for an aging population, need to consider different types of home scenarios and user behavior, lifestyle, and health condition (Petersen et al., 2020; Burnfield et al., 2004). Research shows that footwear has been viewed as an environmental risk factor for both indoor and outdoor falls (Menant et al., 2008; Koepsell et al., 2004; Hourihan et al., 2000), which increases the importance of redesigning indoor footwear for older adults (Jellema et al., 2019). There is also a cognitive significance to consider, as for older adults, continuing to wear shoes is a sign of independence (White & Mulley, 1989).

Past studies also reveal that many older adults wear inappropriate footwear (e.g., wrong size, safety concern, different purpose) both inside and outside of their home, which is indicative of a widespread lack of education around the process of selecting and purchasing suitable, safe shoes (Menant et al., 2008). This makes consumer education another critical aspect to consider when designing indoor footwear.

Older adults in particular are a high priority group in footwear design as they are more susceptible to falls, and their feet are more prone to injury when not wearing footwear. Also, it is more difficult for older adults to take care of their feet in general (less mobility as they age). Additionally, the majority of older adults are not aware of the essential standards in choosing appropriate shoes. Therefore, there is a crucial need for foot-care consultation for the aging population (Jalali et al., 2020), covering topics like aging foot evaluation, foot pain assessment, and management (Chaiwanichsiri et al., 2009; Barton et al., 2009).

Using results from a survey and a series of semi-structured interviews, this study views footwear design from a holistic angle that goes beyond the physical ergonomics and design of the form factor. It focuses on indoor footwear design for an aging population to help designers think about key considerations from the levels of product, user experience, service, and technologies. We also discussed how advanced technologies such as internet-of-things (IoT) devices, and data collection and analytical capabilities may be integrated into indoor footwear for older adults.

The following four research questions were framed to help designers understand what they should consider in the indoor footwear design process for an aging population: 1) What is the current user experience of older adults when they purchase and wear footwear? 2) What is older adults' knowledge about choosing suitable footwear? 3) How do the technology and service impact the approach of footwear design for older adults? Finally, because this research was conducted during the COVID-19 pandemic, 4) What insights and implications are there around the design of indoor footwear for older adults, and how do we gather insights from older adults using remote technologies?

METHOD

User Survey










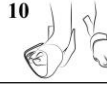
An online survey was conducted to explore 1) footwear wearing behavior among different generations, 2) people's footwear purchasing behavior and decision-making process, and 3) perspectives toward new smart footwear concepts. Users' footwear usage behavior was studied, including the number of pairs of shoes they currently own, the indoor footwear they have that is worn exclusively indoors, and their perception of what constitutes an indoor space. We also probed to understand why people wear indoor footwear at home, especially for an aging population, and what kinds of indoor footwear people are interested in e.g., slippers, flip-flops, boots, sandals, sneakers, and non-skid socks.

In addition to seeking insights about older adults' wearing and purchasing behaviors, four survey questions were designed to help designers envision ten footwear design

concepts (Table 1) for an aging population from indoor product design to a smart IoT wearable device: 1) What are people’s comfort levels with varying levels of automation embedded in their footwear? 2) What are users’ perceptions of data security and privacy? 3) What are the functions of IoT wearable devices that people want to have? and 4) What functions of smart footwear do they want to integrate?

Based on findings from a past expert-based study on the design of indoor footwear for older adults (Lee et al., 2021), 80 questions were asked to capture participants’ diverse and comprehensive perspectives, enriching the research content. The survey also included ten different smart footwear design concepts (see Table 1) to gather people’s initial reactions and perceptions. The survey questions were designed and curated to understand participants’ motivation, decision-making process, and actions regarding their footwear.

Table 1. Ten smart footwear concepts in the user survey

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| Concept 1, 3, 4, 9, 10 | Concept 2, 5, 7 | Concept 6, 8 | | |
| Prototyped footwear with strap to address the needs of users who have sensitive skin. | Applied materials to test the comfort level, adaptability, and foldability of footwear. | Created modular footwear designs to probe the functions that users need the most. | | |

A total of 495 responses were gathered initially. After filtering out incomplete responses, 115 valid responses were used for analysis, categorized into Group A (ages 18~30), Group B (ages 31~60), and Group C (ages 61~100). The participants from Group A and B were mainly recruited through emails to undergraduate and graduate student populations along with the personal networks of one of the authors, whereas Group C was recruited through personal connections and from the MIT AgeLab 85+ Lifestyle Leaders Panel, a national research panel consisting of adults aged 85 or older. In the study, we emphasized the aging population, Group C (ages 61~100), compared with the two other age groups to discuss their differences and relationships. The user survey results represented a quantitative source for future design considerations. Table 2 shows the demography of the survey participants.

Table 2. The demography of survey participants

| | Group A | Group B | Group C |
|---------------------|------------------------|------------------------|------------------------|
| Participants | n = 43 | n = 38 | n = 34 |
| Age Range | 18~30 | 31~60 | 61~100 |
| Gender | Male 33% Female 64% | Male 50% Female 50% | Male 50% Female 50% |

The majority of survey participants were from the metro Boston area in the United States and Taipei City, Taiwan. All participants volunteered to complete the survey online through

Qualtrics. On average, it took 30 minutes for each participant to finish the online survey.

Semi-structured Interview

A set of semi-structured interviews was also conducted to complement the user survey and gather additional narratives and related stories specifically from older adults. Due to COVID-19 restrictions and safety concerns, the 15-minute semi-structured interviews were conducted via video call and phone. Seven interviewees, four females and three males aged between 75 and 80, were invited from the user survey Group C to participate. We designed the interview discussion guide to include the questions about older adults’ wearing behavior, purchasing behavior, and footwear design concepts to understand their pain points with the product, service, and experience, and their ideas about the ideal indoor footwear they want to purchase.

The first part of the semi-structured interview included questions about participants’ indoor footwear usage. Do they wear shoes inside the home? Does their family also wear shoes inside their home(s)? Do they live with their family or with other people? Do they have footwear that they exclusively wear inside the home? Are they currently wearing or using them? How frequently do they wear their shoes at home? Are there certain scenarios during which they do and don’t wear shoes inside? How do they choose different kinds of shoes to wear inside?

Second, participants were interviewed about footwear service and experience. Purchasing and using footwear may include different services, such as shoe repair, upgrades, training, and other before- and after-sales services. Questions asked included: What kinds of services do users think the vendors or sellers of indoor footwear should provide? How do they make decisions around getting new footwear? Is their decision process different for different types of footwear (e.g., outdoors vs. indoors)? The participants were also asked to describe their ideal shoe with adjectives of their choice.

RESULTS

Users’ Wearing Behavior

Perception of Indoor Space: Since the focus is on indoor footwear design for an aging population, we want to know participants’ perceptions and definitions of “indoor” space. The result shows that, unsurprisingly, the living room, kitchen, bathroom, and bedroom were aligned among all three groups. Older adults were also more likely than the younger groups to include their garage and porch or deck as part of their indoor space.

Indoor Footwear: In the study, indoor footwear is defined as being primarily worn indoors and not outdoors. In Group C, 63% of the older adults had two to three pairs of indoor footwear, whereas 48% of the younger generation in Group A had only one pair, and 46% of middle-aged people in Group B had two to three pairs. We also inquired about seven types of indoor footwear: slippers, flip-flops, boots, sandals, sneakers, non-skid socks, and others to understand which types people wear the most. All three groups agreed that they wear slippers the most and flip-flops the second most.

Reasons for Wearing Indoor Footwear: We also explored why people, especially an aging population, wear indoor footwear at home. As shown in Figure 1, for older adults (Group C), the top three reasons were that they thought that they could make their feet comfortable (23%), keep their feet and body warm (16%), and make their home clean and hygienic (16%).

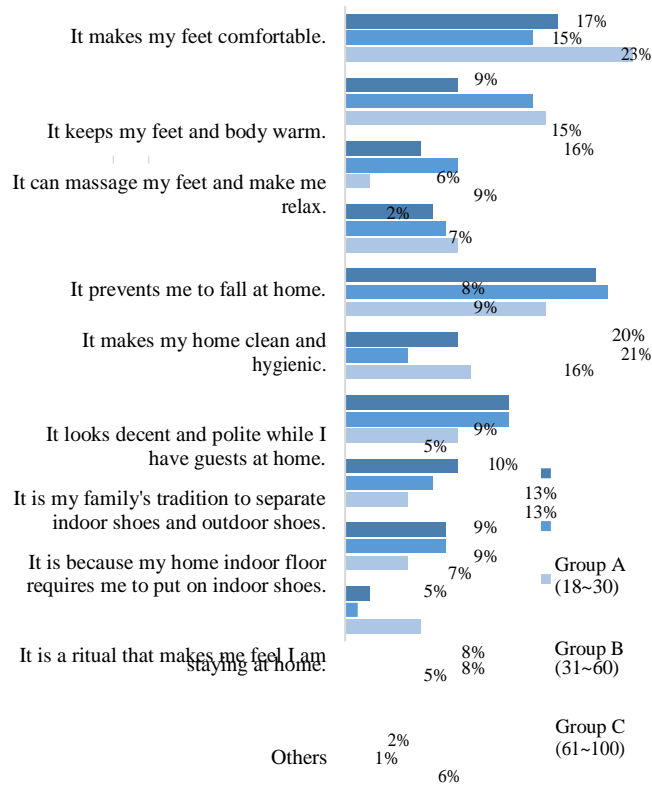


Figure 1. Why do you wear indoor footwear at home? Users' Purchasing Behavior

We also studied users' purchasing behavior: the price of shoes, brand awareness, frequency of replacing shoes, and their common pain points, which gave a holistic view of refined footwear design considerations for an aging population.

Price of Indoor Footwear: For the younger groups, the most suitable price range for indoor footwear was chosen as below \$10 (45% of Group A and 46% of Group B), whereas Group C was generally more likely to find higher price points suitable (32% choosing \$11~\$25 as most suitable, and 23% of indicating that \$51~100 was acceptable). Older adults' willingness to spend more money on indoor footwear may be due to their higher likelihood of having essential health-related needs and having a higher spending power.

Indoor Footwear Purchase Considerations: People do not replace their indoor footwear often: 50% of older adults reported replacing their indoor footwear less often than yearly and 38% said that they replace it one to two times per year.

The majority (85%) of older adults purchased their indoor footwear themselves. Only 8% said that their family purchased their indoor footwear for them. When asked about

on/off (4.09/5). Group A and Group B also showed similar findings, as shown in Figure 2.

Brand Awareness: Older participants were more likely to indicate that they prefer certain brand(s) of indoor footwear (29% of Group C) compared to Group B (7%) and Group A (0%). Drivers to higher brand awareness maybe include having more experience using indoor footwear, possibly having larger disposable income, and higher focus on functional and health-related needs.

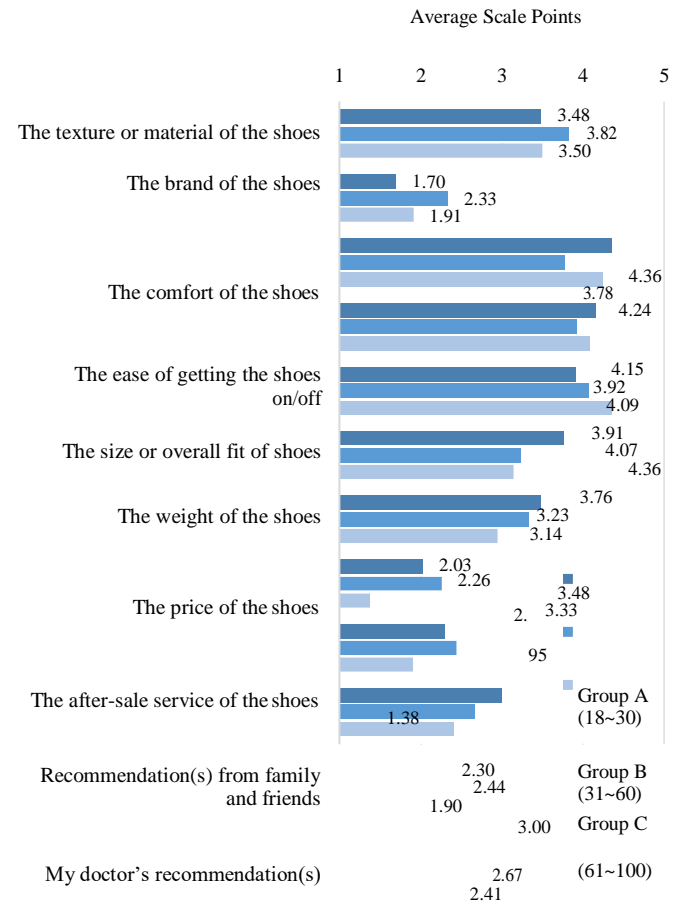


Figure 2. How important are each of the following factors to you when you are purchasing indoor footwear? (1: least important ~ 5: a critical criterion)

Users' Pain Points: Figure 3 shows people's pain points when they put on or take off indoor footwear. In Group A, 57% of the younger generation shared that it was not easy to find their own indoor footwear. In Group B, 41% of middle-aged people felt that their indoor footwear did not fit well. In Group C, older adults had various reasons (e.g., couldn't find the right size, didn't know how to select suitable shoes), which indicates that there are still many unmet user needs.

indoor footwear purchase considerations, using a 5-point answer scale where 1 means least important and 5 means that a factor is a critical criterion, the top three considerations for older adults were the size or overall fit of shoes (4.36/5), the comfort of the shoes (4.24/5), and the ease of getting shoes

it is not easy for me to find my indoor footwear inside of my home.

I feel my indoor footwear does not really fit my feet.

I don't have a habit of putting on indoor footwear while at home.

Others

Group A (18~30)

Group B (31~60)

Group C (61~100)

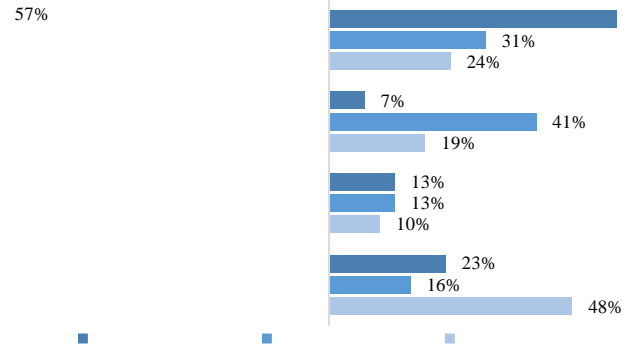


Figure 3. What are some of the most frustrating things you experience in regards to your indoor footwear?

We also asked participants to imagine in the future if they were to have a pair of high-end or better-quality indoor footwear, ideally which professional services and experiences they would be the most interested in (Figure 4). For example, professional service means that salespeople or shoe experts will not only help measure customers' feet size, but also provide advice around medical, behavioral, and after-sale service, and some useful tips.

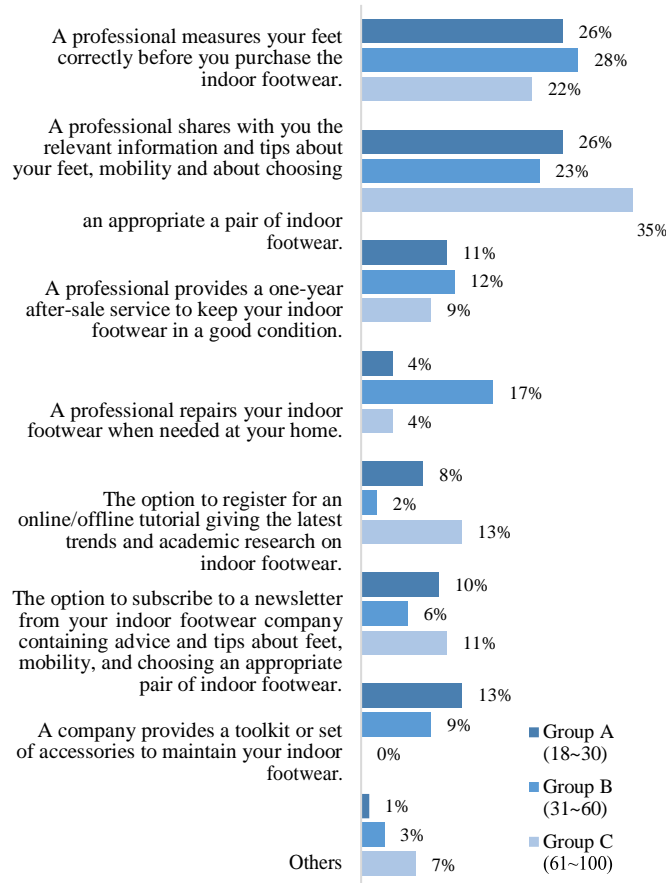


Figure 4. User preferences around professional services and experiences that may be offered for indoor footwear

The results connected with users' pain points in Figure 3, especially for Group C, showing that older adult had various reasons, among which 35% wish to have a professional service providing them relevant information and tips about their feet, mobility, and choosing an appropriate pair of indoor footwear.

Exploring a Smart Footwear Concept

The survey results helped to envision the future indoor footwear design for an aging population from technological and social perspectives.

Levels of Automation: We wanted to know about the levels of automation suitable for smart wearable devices, and asked what level of automation people would be comfortable having with their smart wearable devices. Among older adults in the survey, 33% showed they wanted to have full control of the device, which only aligns with a fixed program, whereas Group A and Group B revealed strong intention to trust the smartness of the device, with 28% and 33% of these groups,

respectively, accepting the concept of a smart device that improves itself based on user behavior.

IoT Wearable Device: Making life convenient is the most critical function that over 30% of all three groups wanted a IoT wearable device to achieve. A total of 19% of older adult have various unmet needs that were unlisted in the survey, which shows that there are many functions that the IoT wearable devices haven't integrated. We also want to know how comfortable users are with the idea of IoT wearable devices sharing the data they collect about them on the cloud. Half of older adults in the survey didn't want to share their personal data on the cloud and devices, whereas Group A and Group B, the younger generations, reported higher comfort with personal data sharing.

Functions of a Smart Footwear: In Group A, the top three features of footwear desired by the younger generation were to make their life more convenient (29%), maintain their mental and physical well-being (23%), and assist with their daily routine (22%). This was very similar to Group B, whereas Group C cared more about their mental and physical health (21%) and how footwear could make their life convenient (19%).

DISCUSSION

The present research revealed that older adults wanted to have indoor footwear that not only makes them be comfortable, safe, and aesthetic but also makes them "feel" safe. One interviewee said, "The most important thing is comfort and safety, but I would appreciate it if you design something beautiful. Can you make a beautiful, sexy shoe that is also comfortable?" Others said, "If the footwear is comfortable, I will give you my money and tell all my friends." Interviewees also didn't like the indoor footwear design with the label of "aging" – "I don't want old-lady shoes. Please remember that we are all different in terms of our taste in shoes and our comfort level," said one interviewee, who has over 200 pairs of shoes at home.

Regarding indoor footwear design for an aging population, the elderly people had a high expectation of future design. Based on the survey, the top four features of smart indoor footwear that the older adults wanted to have are: prevent them from falling (19%), help them relax (17%), show health conditions (17%), and keep feet warm/consistent temperature (16%). Almost none of the footwear products on the market satisfy their needs as an aging population. One interviewee said, "I want something that I will not slip, but I also want something that is soft on the front that covers my toes." Another one said, "If the footwear is designed comfortably, I won't care much about the price and I definitely will tell everybody who needs them."

Future work will consider cultural differences while designing footwear products and services. Since the majority of participants were recruited from Boston, US and Taipei City, Taiwan, we can explore what are key design elements that we need to take into account for further studies.

Overall, findings from the user survey, semi-structured interview and discussion indicated that there is a huge potential around unmet user needs that older adults would want to have a great pair of indoor footwear that can solve

their pain points to meet the requirements of comfort and safety, without sacrificing their personality and taste.

CONCLUSION

The research provides designers with more comprehensive perspectives on user experience, service, and technology to optimize the design of footwear for an aging population. We covered older adults' wearing and purchasing behavior and selected ten design concepts (Table 1) with provocative questions to get interviewees' feedback by conducting user surveys and semi-structured interviews.

Implications and insights from this study can be summarized into the following three points to raise peoples' awareness and equip designers with a human-centered design mindset and capabilities.

1) *Older people can wear shoes, representing their independence in life.* One interviewee shared with us that wearing shoes indoors or outdoors also means they have the capability to walk, move, or exercise freely, which shows that their life condition is independent. They might need caregivers' or family's partial support but they can take care of the majority of the tasks in their life.

2) *Everyone's foot problems are very different.* There is no single solution or indoor footwear design that can resolve all. It is not easy to purchase tailor-made indoor footwear for an aging population on the market since the cost, time, product details (e.g., asymmetrical shoe design) to develop footwear products are still hard for the public to find.

3) *Older adults lack knowledge of how to choose the right footwear for themselves.* Especially for an aging population, there is not enough education about our feet's healthcare and appropriate footwear. When older adults talk about the problems around footwear, it is clear that there is not enough service around footwear products to support their experience. Footwear design for an aging population should aim not only to come up with great products and services, but also to take education into consideration.

Regarding the methodology implications, one lesson gained from this study is that researchers conducting user interviews with older adults need to consider their attention span, how difficult it may be for them to set up equipment or technology, and the language used for the interview. When we did the semi-structured interview via video or phone call, all the older adults had a serious hearing issue and the majority had problems setting up Zoom calls. Therefore, their family came to help us not only solve the technical issues but also interpret the questions we asked and explain or repeat to us their response. To optimize older adults' time and energy in calls, we made the interview more casual, to-the-point, and followed the flow of our conversation within 15 minutes.

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