

Assessment of Feature Requirements of Elderly for Walking Stick Design: A Kano Model Approach

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Abstract: A Walking stick is one of the most commonly used mobility devices by the elderly to prevent falls. However, many elder individuals face challenges while using walking sticks due to improper height adjustment, excessive weight, uncomfortable handles and a high risk of falling. To overcome these drawbacks, there is a need to understand the actual requirements of users before designing an assistive device. Therefore, the study was undertaken to identify the needs and feature expectations of the elderly for designing a walking stick. The study was conducted in the Dindigul district, Tamil Nadu. A total of 57 elderly respondents aged 60 years and above who were using walking sticks were purposively selected for the study. Face-to-face interviews were conducted by using an interview schedule and a Kano questionnaire comprising 11 attributes (A1-A11). Data collected through the interview schedule were coded, tabulated and analysed using Descriptive statistics such as frequency, percentage and mean. Data obtained from the Kano questionnaire were analysed using the Kano Evaluation Table. Further, Better-Worse coefficient analysis was used to prioritize the attributes. The study revealed that 73.7 per cent of the elderly respondents experienced difficulties while using existing walking sticks, with hand pain and difficulty in climbing bus steps being the major challenges. Kano analysis showed that strong and durable, ease of use and handling, safety features, long battery life and anti-slip base were classified as one-dimensional attributes, indicating that improved performance of these features directly enhances user satisfaction. Among the identified features, strong and durable has the highest SI (0.79) and highest DSI (-1.0), indicating that this feature has a strong influence on both satisfaction and dissatisfaction. Similarly, safety features have SI (0.649) and DSI (-1.0), highlighting the importance of safety in walking-stick design. Overall, the findings show that basic features should be provided, performance features should be improved and attractive features can be added to increase user satisfaction. Indifferent features can be given less priority. The findings can therefore guide the selection and integration of appropriate features in the design and development of an effective, functional, safe and user-centred walking stick that addresses the needs and expectations of elderly users.

Keywords: Mobility Challenges, Assistive Device, User Requirements, Elder- Friendly Design, User Satisfaction.

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I. INTRODUCTION

The proportion of the elderly population is growing worldwide (Hwang & Kim, 2023). By 2050, 2.1 billion people are predicted to be 60 years or above of age (WHO, 2025). In India, the ageing population, currently about 104 million, is expected to increase to 19.5 per cent by 2050 (Madan Gopal et al., 2024). As the elder population continues to grow, there is an increasing need for enhanced care, focused attention and timely interventions to effectively address the various challenges associated with ageing.

Many elder individuals experience difficulty in walking due to muscle weakness, joint disorders and other age-related health conditions (Maresova et al., 2023). The Longitudinal Ageing Study of India (National Programme for Health Care of Elderly & IIPS, 2021) indicates that 10.5 per cent of the

elderly suffer from at least one physical or mental impairment and 23.8 per cent face limitations in Activities of Daily Living (ADL). This challenges places elderly at increased risk of falls, reduced access to healthcare services, declining functional ability and poor psychological wellbeing (Musich et al., 2018). When elderly are unable to care for themselves, they become more vulnerable to psychological distress, particularly depression (Maresova et al., 2023). These findings underline the importance of interventions that enable elderly to maintain autonomy in daily activities. By using assistive technology, people can overcome these obstacles and improve their mobility and capacity to perform daily tasks (Sengupta et al., 2022).

Mobility aids such as walking sticks, walkers and wheelchairs helps to improving mobility and independence among the elderly. Among these devices, the walking stick is

one of the most commonly used mobility devices by the elderly to avoid falling. (Halim et al., 2019). Walking sticks are especially useful for individuals with weak muscles, poor balance, visual impairments and walking difficulty (Abdul Rahman et al., 2022). Walking sticks were used to reduce the fear of insecurity and improving confidence in movement. In cases of degenerative joint disorders affecting the lower limbs, as well as after hip surgeries, walking sticks assist in walking by transferring a portion of the body weight from the lower extremities to the upper limbs through the arms (Dogru et al., 2016). This redistribution of weight reduces stress on the affected joints and promotes safer and more efficient walking. A walking stick is frequently purchased for support and balance, which helps people get over falls and their fear of falling. Despite these benefits, existing walking sticks impeded mobility and increased the risk of injuries (Sengupta et al., 2022).

A variety of walking sticks with different quality, design and suitability are available in the market, namely Traditional/ standard, quad, tripod, folding walking stick, etc., However, these sticks still have certain drawbacks, such as improper height, poor grip and slipping problems, which negatively impact the safety, stability and overall usability among elderly users (Abdul Rahman et al., 2022). The need for enhanced functionality in walking aids has led to the development of smart walking sticks (Bateni & Maki, 2005). Smart walking sticks incorporate advanced technologies such as sensors, Global Positioning Systems (GPS) and health monitors. However, these features increase cost, complexity

II. LITERATURE REVIEW

The use of walking sticks plays an important role in improving mobility and stability among elderly. However, existing walking sticks may have limitations related to grip, stability, weight, dimensions, comfort and ease of use. Previous studies have examined the physical and functional difficulties experienced by elderly users, as well as the role of ergonomic design and emerging technologies in improving walking sticks. Reviewing these studies helps to identify the major user requirements and design considerations for developing a safe, comfortable and affordable walking stick for elderly users.

Alam et al. (2012) found that chronic health conditions negatively affected the quality of life of elderly and increased their need for assistive devices. Ezugwu et al. (2024) reported that the walking stick usage improved stability and helped to minimize the falls injuries among the elderly. Chen et al. (2025) found that elderly users were more willing to accept smart canes when the devices were simple, safe and easy to use. Kumar et al. (2014) found that elderly individuals often used walking sticks based on their fear of falling rather than on recommendations from healthcare professionals.

Sengupta et al. (2022) evaluated existing walking sticks and recommended modifications from an ergonomic perspective. The study revealed that all participants required modifications to their existing walking sticks. The major problems identified were excessive length, handle slippage

and maintenance requirements, making them unsuitable for large segments of the elder population, particularly in low-income and rural communities (Dakopoulos & Bourbakis, 2010). To overcome these drawbacks, there is a need for understanding the actual requirements of users before designing an assistive device (Sengupta et al., 2022).

In India, a significant gap exists between the need and access high quality and affordable assistive technology (Senjam & Mannan, 2023). Furthermore, most studies focused primarily on advanced technological features, while relatively less focus has been given to designing simplified and affordable assistive devices suitable for low-income and rural areas. This technological gap underscores the importance of modifying existing walking sticks to align with the needs, preferences and economic conditions of the elderly (Sengupta et al., 2022). Therefore, the present research was undertaken to identify the needs and feature expectations of the elderly for designing a walking stick.

➤ Objectives of the Study

- To prepare the profile of the elderly using walking sticks in Dindigul District
- To identify the difficulties and challenges faced by the elderly while using a walking stick
- To determine the features and design preferences expected by the elderly.

during use and heavy weight. In addition, some participants reported palm and finger injuries during prolonged use. The study concluded that modifications to improve grip, stability, weight and ergonomic comfort are necessary to enhance the usability and safety of walking sticks among elderly users.

Overall, the reviewed studies highlight the importance of safety, stability, ergonomic comfort, appropriate dimensions and user acceptance in walking-stick design. These findings provide a basis for identifying and prioritizing the requirements of elderly users in the development of an affordable walking stick.

III. MATERIALS AND METHODS

The present research adopted a quantitative approach with a descriptive research design to assess the challenges experienced by elderly users of walking sticks and to identify and prioritize their preferences for improved walking-stick design. The study was conducted in Dindigul District, Tamil Nadu. A total of 57 elderly respondents aged 60 years and above who were using walking sticks were purposively selected for the study.

➤ Data collection and Analysis

Face-to-face personal interviews were conducted by using an interview schedule to collect data. Each interview was conducted in the local language (Tamil) at the residence of the respondents to ensure comfort and better response. Adequate rapport was established before the interview and the purpose of the study was explained. Descriptive statistics,

including frequency, percentage and mean, were used to analyse the collected data.

To identify and prioritize the design requirements of the walking stick, a Kano model based questionnaire was developed using eleven attributes. These eleven attributes were identified from literature review. Each attribute was assessed through a pair of functional (positive) and

dysfunctional (negative) questions. Respondents indicated their preferences using five response categories: Like, Must-be, Neutral, Live with and Dislike. The paired responses were evaluated using the Kano evaluation matrix and each attribute was classified as Must-be (M), One-dimensional (O), Attractive (A), Indifferent (I), Reverse (R) or Questionable (Q).

Table 1 Comparison Table of Kano Model Evaluation Results Classification

Respondent Requirements		Dysfunctional (If feature absent)				
		Dislike (1 Point)	Live with it (2 Points)	Neutral (3 Points)	Must-be (4 Points)	Like (5 Points)
Functional (If feature present)	Dislike (1 Point)	Q	R	R	R	R
	Live with (2 Points)	M	I	I	I	R
	Neutral (3 Points)	M	I	I	I	R
	Must-be (4 Points)	M	I	I	I	R
	Like (5 Points)	O	A	A	A	Q

M=Must be, O=One Dimensional, I=Indifferent, R=Reverse, A=Attractive and Q=Questionable

Source: Berger, C., Blauth, R., & Boger, D. (1993). *Kano's methods for understanding customer-defined quality*. Center for Quality Management Journal, 2(4), 3–35. <https://www.walden-family.com/public/cqm-journal/2-4-Whole-Issue.pdf>

➤ Kano Categories and Explanation

- **Must-be (Basic):** Basic requirements provided that user expect in a walking stick. If absent, user may highly dissatisfied, but their presence does not increase satisfaction
- **One-dimensional (Performance):** More is better; less is worse. Satisfaction increases proportionally with performance.
- **Attractive (Delighters):** Unexpected features that satisfy users when present. Absence does not cause satisfaction, if present significantly enhance satisfaction.
- **Indifferent:** Features that neither increase nor decrease satisfaction whether present or absent
- **Reverse:** In the design of the walking stick, features that cause dissatisfaction when present but do not increase satisfaction when absent.
- **Questionable:** If the feature is not met, it will not affect user satisfaction, but if it is met, it will be greatly improved the user satisfaction.

After classifying the user responses into kano categories using the Kano model, the Satisfaction Index (SI) and Dissatisfaction Index (DSI) are calculated for each feature requirement of the walking stick to measure the level of user satisfaction and dissatisfaction.

➤ Calculation of Satisfaction Index (SI)

Use to measure how much satisfaction increases when the feature is present.

$$SI = \frac{A+O}{A+O+M+I}$$

The SI values represent positive user satisfaction and range from 0 to 1, where values range between 0-0.25 indicate a lower level, 0.25-0.50 indicate a moderate level, 0.50-0.75 indicate a higher level and 0.75 to 1.0 indicate a very higher level of influence on user satisfaction.

➤ Calculation of Dissatisfaction Index (DSI)

Use to measure how much dissatisfaction occurs when the feature is absent. DSI values closer to -1 indicate a stronger contribution to dissatisfaction when the feature is absent, whereas values closer to 0 indicate a lower-level influence on dissatisfaction.

$$DSI = - \frac{O+M}{A+O+M+I}$$

➤ Scatter Plot of User Satisfaction

After the SI and DSI calculation, a scatter plot was developed to visually classify and interpret the user requirements. The SI values were plotted on the X-axis and DSI values were plotted on the Y-axis. Based on the position of each feature on the graph, the features were classified into kano categories.

The SI values represent positive user satisfaction and range from 0 to 1, where values closer to 1 indicate a higher level of influence on user satisfaction. Similarly, DSI values represent user dissatisfaction in a comparable range, where

values closer to 1 indicate a stronger contribution to dissatisfaction when the feature is absent or inadequate. A

value near zero indicates that the feature has minimal impact on user dissatisfaction if it is not fulfilled.

IV. RESULTS AND DISCUSSION

The results of the study have been presented and discussed under the following headings: Profile of the Elderly, Perceived Difficulties in Existing Walking Sticks Usage and Kano Model Analysis of Elderly Feature Requirements.

➤ Profile of the Elderly

The profile of the elderly is presented in Tables 2 and 3. This section describes the personal background of the respondents, including variables such as age, gender and family background.

Table 2 Personal Background of the Respondents

Variables	Respondents (N= 57)	
	n	%
Age (in years)		
60-70	4	7.0
70-80	25	43.9
80 and above	28	49.1
Gender		
Female	39	68.4
Male	18	31.6

Table 2 depicts the personal background of the respondents. Nearly half (49.1%) of the respondents belonged to the age group of 80 years and above, followed by 43.9 per cent in the age group of 70-80 years, while only four of them were between 60-70 years. The average age of the respondents was 80 years, indicating that most of them were in the advanced old age group. Individuals in this age group were more likely to experience limitations in physical activity

due to chronic health conditions such as arthritis, cardiovascular diseases, hypertension and sensory impairments, including hearing and vision loss.

Regarding gender, a majority (68.4%) of them were female, while 31.6 per cent were male, showing higher female representation in the study.

Table 3 Family Background of the Respondents

Variables	Respondents (N= 57)	
	n	%
Family type		
Nuclear family	47	82.5
Joint Family	6	10.5
Extended Family	4	7.0
Family Size		
Below 4	47	82.5
4-6	8	14.0
Above 4	2	3.5

Table 3 reveals that a significant majority (82.5%) of them were lived in nuclear families, 10.5 per cent of them were belonged to joint families and four of them lived in extended families. In terms of family size, majority (82.5%) of them had a family size of less than 4 members, 14 per cent

had a family size of 4 to 6 members and only two of them had a family size of more than six members. The average size of the family was three. This shows that a smaller family size was predominant among the respondents, which may limit the availability of caregivers within the households.

conventional walking sticks are commonly used, respondents reported several difficulties in their use.

➤ Perceived Difficulties with Existing Walking Sticks

Difficulties during daily walking can affect the independence and safety of elderly users. Although

Table 4 Difficulties Faced While Using a Walking Stick

Variables	Respondents (N= 57)	
	n	%
Difficulty in using walking stick		
Yes	42	73.7
No	15	26.3

Type of Difficulties faced while using walking stick (N=42) *		
Hand pain	33	78.6
Difficult to climb the steps of the bus	27	64.3
Difficult during fast walking	25	59.5
Instability while bus moving	16	38.1
Difficult on uneven surface	18	42.9
Scratches/ Injuries	15	35.7
Poor grip	12	28.6
Fall	7	16.7
Difficult during rainy season	7	16.7
Unstable base	5	11.9

*Multiple Responses

The Table 4 shows the difficulty faced by respondents while using walking sticks. A majority (73.7%) of the respondents reported experiencing difficulty, while only 26.3 per cent did not face any difficulty. Among those who reported difficulties, the most common problem was hand pain (78.6%), followed by difficulty in climbing bus steps (64.3%) and difficulty during fast walking (59.5%). Other notable issues include difficulty on uneven surfaces (42.9%) and lack of stability while the bus is moving (38.1%). Additionally, some respondents reported prolonged usage of walking stick caused scratches or injuries (35.7%), poor grip (28.6%), falls (16.7%), difficulty during the rainy season (16.7%) mainly due to slippery conditions and poor grip in

the walking stick. A smaller proportion experienced issues related to an unstable base (11.9%).

Overall, the findings indicate that users face several practical challenges while using a walking stick, particularly in public transport use and uneven environments, highlighting the need for improved design and safety features.

➤ Kano Model Analysis of Elderly Feature Requirements

The Kano model was adopted in this study to evaluate and classify the feature requirements of walking stick by elderly. It provides a systematic approach to understanding how different product features affect user satisfaction by grouping them into kano categories.

Table 5 Kano Questionnaire Responses for the Features

Code	Customer requirements	Type	Like	Must be	Neutral	Live with it	Dislike
A1	Strong and durable	Functional	45	12	-	-	-
		Dysfunctional	-	-	-	-	57
A2	Ease to use and handle	Functional	32	25	-	-	-
		Dysfunctional	-	-	-	3	54
A3	Height Adjustability	Functional	25	27	3	2	-
		Dysfunctional	-	-	3	2	52
A4	Safety features	Functional	37	20	-	-	-
		Dysfunctional	-	-	-	-	57
A5	Ease of storage	Functional	20	22	2	13	-
		Dysfunctional	-	-	-	24	33
A6	Foldability	Functional	27	19	-	11	-
		Dysfunctional	-	-	-	11	46
A7	Multiple features	Functional	25	6	15	-	3
		Dysfunctional	3	6	8	15	25
A8	Rechargeable battery	Functional	35	7	-	12	3
		Dysfunctional	-	-	-	15	42
A9	Anti slip base	Functional	44	-	8	5	-
		Dysfunctional	-	-	8	5	44
A10	Attractive design	Functional	14	5	8	30	-
		Dysfunctional	-	-	8	30	14
A11	Easy to carry	Functional	28	20	-	9	-
		Dysfunctional	-	-	-	9	48

Table 6 Kano Classification of Elderly Requirements Features

Code	Respondents Requirements feature	A	O	M	I	R	Q	Kano category
A1	Strong and durable		45	12				O
A2	Ease to use and handle		32	22	3			O
A3	Height Adjustability		25	27	5			M

A4	Safety features		37	20				O
A5	Ease of storage	2	18	15	22			I
A6	Foldability	11	16	30				M
A7	Multiple features	25	19	9	4			A
A8	Rechargeable battery		35	7	12	3		O
A9	Anti slip base		44		13			O
A10	Attractive Design		9	5	30	13		I
A11	Easy to carry		20	28	9			M

The Table 6 shows the Kano classification of elderly requirement features based on their perceptions. The results indicate that a majority of the features such as Strong and durable (A1), Ease to use and handle (A2), Safety Features (A4), Rechargeable battery (A8) and Anti slip base (A9) are categorized as One-dimensional (O) attributes. Improvements in these features will directly enhance user satisfaction, while their absence may lead to dissatisfaction. Height Adjustability (A3), Foldability (A6) and Easy to carry (A11) are identified as Must-be (M) attributes, indicating that these features are basic requirements expected by elderly. Their absence would result in dissatisfaction, although their

presence may not significantly increase satisfaction. Multiple Features (A7) was fall under the category of Attractive (A), suggesting that it has the potential to satisfy users when present, but its absence does not cause dissatisfaction. On the other hand, Ease of storage (A5) and Attractive Design (A10) is classified as an Indifferent (I) feature, indicating that it has minimal influence on user satisfaction and can be given lower priority in design considerations. Overall, the findings show that basic features should be provided, performance features should be improved, and attractive features can be added to increase user satisfaction. Indifferent features can be given less priority.

Table 7 Kano Evaluation of Walking Stick Attributes

Code	Respondents Requirements Features	SI	DSI	Kano category
A1	Strong and durable	0.79	-1.00	One-dimensional
A2	Ease to use and handle	0.56	-0.95	One-dimensional
A3	Height Adjustability	0.44	-0.91	Must-be
A4	Safety features	0.65	-1.00	One-dimensional
A5	Ease of storage	0.35	-0.58	Indifferent
A6	Foldability	0.47	-0.81	Must be
A7	Multiple features	0.77	-0.49	Attractive
A8	Rechargeable battery	0.65	-0.78	One-dimensional
A9	Anti slip base	0.77	-0.77	One-dimensional
A10	Attractive Design	0.20	-0.32	Indifferent
A11	Easy to carry	0.35	-0.84	Must-be

The table 7 shows the Kano analysis of the respondents requirements for the design of the walking stick. The identified features were categorized as one-dimensional, must-be, attractive and indifferent attributes based on their Satisfaction Index (SI) and Dissatisfaction Index (DSI) values. The results indicate that strong and durability (A1) has the highest SI (0.79) and highest DSI (-1.0), indicating that this feature has a strong influence on both satisfaction and dissatisfaction. Similarly, safety features (A4) recorded an SI (0.649) and DSI (-1.0), highlighting the importance of safety in walking-stick design. Multiple features (A7) classified as an attractive feature, with a higher SI (0.77) with a lower DSI (-0.49). This indicates that providing multiple functions can considerably increase user satisfaction, although its absence may not cause the same level of dissatisfaction. The one-dimensional attributes, including ease of use and handling

(A2), rechargeable battery (A8) and anti-slip base (A9), shows moderate to high SI values and relatively high negative DSI values. This suggests that improvements in these features can increase user satisfaction, while inadequate performance may result in dissatisfaction. The must-be attributes, namely height adjustability (A3), foldability (A6) and easy to carry (A11), shows lower SI values but relatively high negative DSI values. This suggests that these features may not enhance satisfaction when adequately provided, but their absence or poor performance can result in dissatisfaction. Ease of storage (A5) and attractive design (A10) were classified as Indifferent (I) attributes. A5 shows SI (0.35) and DSI (-0.58), while A10 has the lowest SI (0.20) and the least negative DSI (-0.32). These findings suggest that, compared with the other attributes, these features had a relatively limited effect on overall user satisfaction.

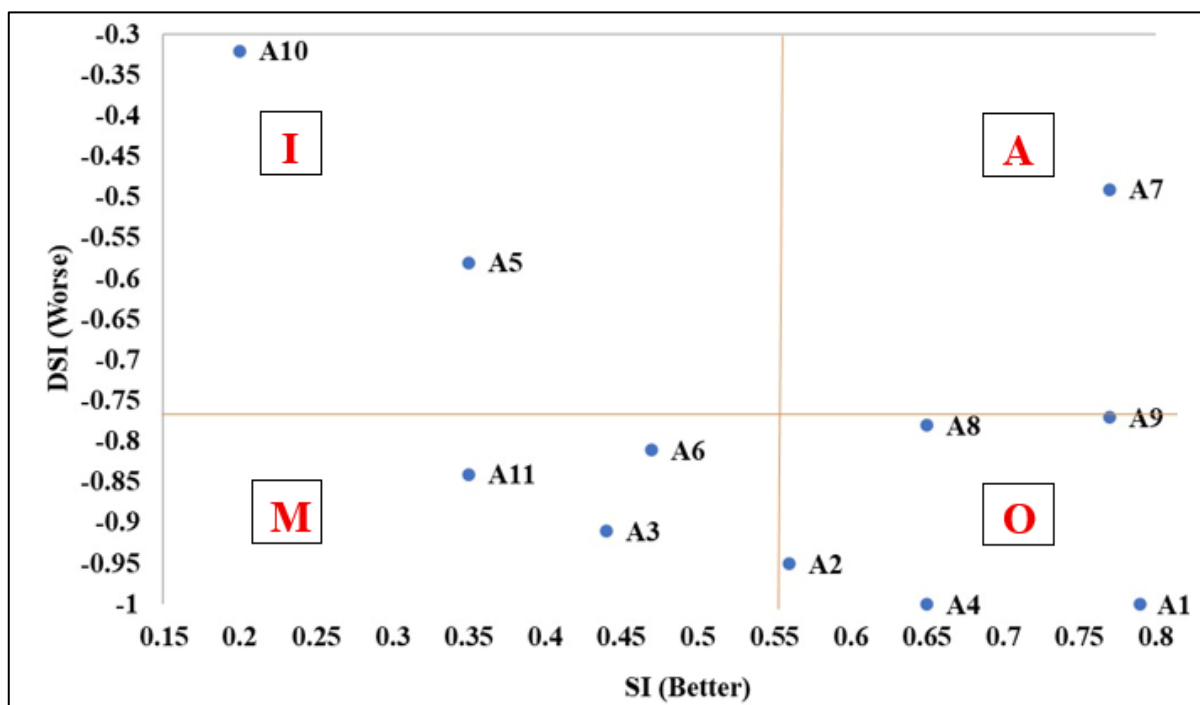


Fig 1 Distribution of Walking-Stick Feature Requirements Based on Better and Worse Coefficients

- Note: The vertical line represents the mean better coefficient (0.55), while the horizontal line represents the mean worse coefficient (-0.77). The four quadrants were formed using these mean values as reference points. A = Attractive, I = Indifferent, M = Must-be and O = One-dimensional.

Figure 1 presents the Better-Worse coefficient analysis of the identified walking stick features using the Kano model. The quadrants were divided using the mean better coefficient (0.55) and mean worse coefficient (-0.77) as reference values. The results indicate that A3, A6 and A11 were classified as Must-be attributes, suggesting that these features represent basic user requirements. A1, A2, A4, A8 and A9 were classified as One-dimensional attributes, indicating that user satisfaction varies according to the level of performance of these features. A5 and A10 was categorized as an Indifferent attribute, suggesting that its presence or absence has relatively little influence on user satisfaction. The multiple features (A7) were identified as an attractive attribute, indicates that users perceive multiple functions as an additional benefit that enhances satisfaction, while the absence of such functions has a relatively limited effect on dissatisfaction.

V. LIMITATIONS OF THE STUDY

The present study has some limitations such as the sample size was limited to 57 participants, which may restrict the generalization of the results to the wider elderly population. The study focused only mainly on the respondents reported preferences and difficulties and did not include prototype testing or long-term evaluation.

VI. CONCLUSION

The present study assessed the difficulties experienced by elderly users of existing walking sticks and evaluated their preferences for improved walking stick features using the Kano model. The findings revealed that a majority of the respondents experienced difficulties during daily use, particularly hand pain, difficulty climbing bus steps and difficulty during fast walking. These challenges highlight the need for improved safety, comfort, stability and usability in walking stick design. The study also identified the major feature requirements of elderly users for walking-stick design using the Kano model. The findings shows that strong and durable construction, ease of use and handling, safety features, long battery life and an anti-slip base were classified as One-dimensional attributes. Among these, strong and durable recorded the highest SI (0.79), while strong and durable and safety features shows a highest DSI (-1.0), indicating that inadequate performance of these features may result in dissatisfaction. Height adjustability, foldability and ease of carrying were identified as Must-be attributes. These features may not increase satisfaction when adequately provided, but their absence or poor performance can lead to dissatisfaction. Multiple features were classified as an Attractive attribute, with a high SI (0.77) and a DSI (-0.49), indicating that additional useful functions can enhance user satisfaction. Indifferent attributes (I) such as attractive design (A10) and ease of storage (A5) have minimal impact on overall satisfaction, suggesting lower design priority. These findings can guide the development of a user-centred walking stick that addresses the practical requirements of elderly users. Future studies may focus on developing and testing prototypes to evaluate usability, comfort, safety, durability and cost-effectiveness under actual usage conditions.

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