ORIGINAL ARTICLE

WALKING FRAME DESIGN RECOMMENDATION BASED ON EXPERIENCE OF ELDERLY USER, CARER, AND THE INDUSTRY IN KUALA LUMPUR & SELANGOR, MALAYSIA

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ABSTRACT

Previous studies have found several discrepancies regarding walking frames/walkers. The purpose of this study was to investigate the issues and challenges that the elderly face when using a walking frame/walker, as well as to identify potential solutions and considerations. The Focus Group Discussion (FGD) and the Quality Function Deployment (QFD) sessions were conducted in this study which involved seventeen respondents from various parties, including people aged 60 and above (current users of walking frames/walkers), their caregivers, industry people involved in the marketing and selling of walking frames/walkers and experts/researchers. Interview data as verbatim transcripts were analyzed thematically and gathered systematically into a specific classification according to the House of Quality (HoQ) for technical analysis. Findings on FGD showed that quality, design, and cost were key issues raised by respondents. Based on the HoQ analysis, it's indicated that the highest rank of customer requirements (CRs) for a new walking frames/walkers design requirement was safety (rank 1), stable (rank 2), suitable for outdoor use (rank 3), user-friendly (rank 4) and comfort design (rank 5). Meanwhile, the highest rank of technical requirements (TRs) are adjustable height and width (rank 1), design two-level handle walking frames/walkers and design 'R' shape walking frames/walkers (rank 2 & 3), design with ABS castor wheel (rank 4) which provided functional accessories such as seat, bucket, and pocket (rank 5). The information acquired would be useful as references for further studies on the development of suitable walking frames/walkers for the Malaysian elderly in the future.

Keywords: *Elderly, Malaysia, FGD, QFD, Walking Frame, Design*

INTRODUCTION

The aging trend has increased all around the world and the elderly is one of the fastest segments of the population. As projected by United Nations, older persons aged 60 years or over will rise from 962 million globally in 2017 to 2.1 billion in 2050 and 3.1 billion in 2100[1]. In Malaysia, the definition of older persons refers to individuals aged 60 years old and above, following the United Nations and the Ministry of Health recommendations[2]. Like other developing countries, Malaysia is experiencing a faster rate of aging in its population. According to population estimates for 2021, the population aged 60 and up increased from 8.1 percent or 2.4 million people in 2011 to 3.6 million people in 2021, representing 11.2 percent of the total population[3]. By 2034, Malaysia is expected to achieve aged nation status, with over 5.1 million older people accounting for 15% of the total population[4].

As individuals age, physiological and psychological changes will cause in difficulty when interacting within their environment due to functional impairment or decline in these aspects[5]. Psychological conditions such as dementia, agitation, anxiety, loneliness and social isolation have a consequent effect on the health of older people[6]. Physiological changes, however, are one reason associate with a reduction in muscle strength, motion, and posture[7-9] among the elderly due to this aging process. Unavoidably, elderly with physical, emotional and cognitive capacity limitations will be more vulnerable to the risks of falls and hazards along with a combination of other health problems[10]. This could lead to injuries or fatalities due to falls.

Falls are a significant public health problem and serious issue among the elderly globally, where an estimated 646,000 deaths from falls occur each year, making it the second leading cause of death after road traffic injuries[11]. In all regions of the world, death rates are highest among adults over the age of 60 years. Apart from mortality, serious falls, such as hip fractures in particular, can lead to potentially preventable public health problems[12] and reduced quality of life in older adults[13,14]. Moreover, the elderly and those at greater risk of falling may be vulnerable to instability during steps and other balance-correcting functions in general[15]. The lack of fall prevention initiatives would inevitably result in high medical costs[16] and a considerable burden on both the healthcare system and public health[17]. Thus, there is an urgent need to develop assistive devices that could help them avoid falling during walking.

A walking frame/walker is a tool for people who need extra support due to physical constraints to maintain their balance or stability while walking due to physical limitation[18]. Walking devices including canes, walkers, and crutches are often prescribed for and used by older adults to compensate for decrements in balance, coordination, sensation, strength, and risk of falls[19,20]. These walking aids vary in design, size, cost, wheel configuration, primary function, and availability. The most common types are the standard walking frames/walkers, 2-wheeled walking frames/walkers and 4-wheeled walking frames/walkers[18]. Although the findings of previous studies showed the benefits and advantages of using walking frames/walkers, other studies have reported several contradictions.

The current design of the walking frame induces chronic lower back pain and encourages a slumping posture, which causes a curvature in the spine[21]. Besides, incorrect usage patterns on the design issues of walking frames also reported[22]. Furthermore, some walker designs did not consider the anthropometry and biomechanical aspects such as inappropriate height, width and weight[23-27]. These mobility devices as well have been associated with falls and injuries because the act of lifting and advancing the device can destabilize biomechanical forces, resulting in a loss of balance[28]. Studies also found that fatigue existed in fixed walkers due to the increase in heart rate and low walking speed than rollator walkers. This model may not be suitable for cardiac or respiratory disorder cases[29]. Hence, there is a need to investigate and improve the existing walking frames in terms of ergonomics, design, and evaluation of assistive technology-assisted walkers.

High injury rates and hospital admissions for falls associated with walking frames were prevalent in these vulnerable groups and mainly involved elderly women[30]. Some walkers may affect slow movement[31], are less versatile and could potentially cause problems on uneven surfaces or in tight spaces like doorways[32]. As more businesses realize that the emotional dimension has a significant impact on the product experience, stigmatizing older persons for perceived vulnerability in the walking frame should not be underestimated[33].

The advancements in the walking frame have been enormous and have proven to be of great assistance to people who have difficulty walking[34]. Thus, an ergonomically designed walking frame successfully reduced the risk of Musculoskeletal Diseases (MSDs), pain, and discomfort while making it easy to use[24]. This study explored issues and challenges faced by the elderly in their current use of walking frames/walkers and identifies solutions and considerations for improvement. The findings are expected to contribute towards the design of walking frames/walkers that cater to the specific needs of older people.

METHOD

Study design

One of the valuable tools for collecting qualitative data is Focus Group Discussions[35] and it has often been used to gain a deeper understanding of specific issues from selected groups of samples that statistically represent a larger population[36]. Thus, the purposive sampling method has been used in this study due to the specific target group population related to walking frame/walker only. Researchers contacted several aged care facilities, industries and experts in Kuala Lumpur and Selangor to gather information for identification of potential participants.

Sampel size

A total of seventeen respondents including older persons aged 60 years old and above living in aged care institutions in Kuala Lumpur and Selangor (who currently use walking frames/walkers as assistive tools for walking), their carers, industry people (who were related to marketing and selling of walking frames/walkers and experts/researchers (from various expertise such as engineering, product design and consumer studies) were involved in this study.

Data collection

At first stage, the Focus Group Discussion (FGD) was conducted to obtain information from the respondents. They were divided into groups of 2-5 participants each group. Before the session, the participants were given written information about the purpose of the study and they signed an agreement form to ensure the confidentiality of the entries. All FGDs were conducted by

trained Moderators and assisted by a Rapporteur (note-taker). The moderator starts the discussion session by welcoming participants and explaining the purpose of the study. Participants/respondents were invited to introduce themselves and were then asked questions related to the topic of study. The moderator guides the discussion and encourages all participants to share and ensures that there is sufficient time for each participant to express their views. The focus group lasted from one and a half hours to two hours. Each session was recorded using a digital voice recorder and the data taken was transcribed in text form.

Then, the Quality Function Deployment (QFD) session was conducted in the second stage to generate a design solution that considers the needs of the older persons walking frames/walkers. QFD is a tool that gathers the voice of the customer (VoC) while inducting the expected features in the final product[39]. Subsequently, its goals are to safeguard customer needs throughout the design process, promote communication between the design people (engineers, ergonomists, users, etc.) and highlight possible contradictions between the various design parameters, where the QFD supports more ergonomics consideration in product design[40].

Data Analysis

In this study, thematic analysis was used to analyze FGD transcripts information. This analysis was used because it analyses classifications, presents themes (patterns) pertaining to the data in great detail and uses interpretations to cover a wide range of topics. As mentioned by previous studies, thematic analysis is a useful and simple tool for analyzing qualitative data such as interviews, focus groups, observation, and field research that is widely used by qualitative researchers[37,38]. The six-phase framework (data familiarization, initial coding, search for theme, review themes, define themes, and write-up) was used to perform thematic analysis.

The QFD analysis focuses on the most important product or service attributes or qualities, starting with the initial matrix, commonly known as the House of Quality (HoQ) (as shown in Figure 1). However, for this project, the correlation matrix (Roof of the HoQ or interrelationship of Technical Requirements) was not considered and applied. This is because the purposed of interrelations of technical requirement (roof of HoQ) is just to prioritise the technical requirements. This study prioritises the Technical Requirement (TRs) based on outcomes of correlation between Customer Requirement (CRs) and Technical Requirement (TRs) through the ranking outcomes. Data collected from respondents during FGD relating to their needs and requirements, which is known as the Customer Requirements (CRs) or WHATs. These are given a priority rating based on their weighted importance. Then, it was translated into engineering considerations and specifications known as Technical Requirements (TRs) or HOWs.

This step was challenging because it requires respondents to work in groups or teams to identify the variables that may have the greatest impact on the customer requirement factors. Besides, parameters should be meaningful, and measurable and the TRs must synchronize with the CRs. The relationship matrix determines the correlation or strength of CRs and TRs and can be depicted on a value scale that varies between 0 (no correlation), 1 (weak correlation), 3 (moderate correlation) and 9 (strong correlation). Data was further technically analyzed using specific equations (Equations 1, 2, and 3) to get importance value and Design Priority (DP) and Percent Priority (PP) values. The technical requirements that satisfy the majority of customer consequences are identified in this matrix. The values obtained are then displayed according to rank. To ensure a product or service that meets the stated customer expectations, the technical requirements that address the most customer consequences should be a top priority in the design process.

$$\text{Average CRs importance value} = \frac{\Sigma \text{ of all points from each CR given by respondent}}{\Sigma \text{ of maximum point value for each CR}} \quad [1]$$

$$\text{Design Priority (DP)} = \Sigma (\text{Correlation Value} \times \text{CRs Importance Value}) \quad [2]$$

$$\text{Percent Priority (PP)} = \frac{\Sigma (\text{Correlation Value} \times \text{CRs Importance Value}) \times 100}{\Sigma \text{ Design Priority}} \quad [3]$$

Ethical Approval

This study has obtained ethical approval from the Ethics Committee for Research Involving Human Subjects UPM (reference: JKEUPM-2018-122)

RESULTS

Focus Group Discussion (FGD)

There were some issues reported by respondents regarding walking frames/walkers based on discussions conducted. Hence, researchers have identified and categorized them into three themes issues, which were quality, design and cost.

Quality issue. Quality is defined as the degree of an object or entity (e.g., process, product, or service) satisfies a specified set of attributes or

requirements. The quality of something can be determined by comparing a set of inherent characteristics with a set of requirements. The statements below were some of the information shared by the respondents during the discussion.

Carer (M): The walking frame/walker is rusty, and the rubber caps at the bottom of the legs have come out and are broken.

Carer (M): We're going to change the walking frame/walker if we see it's potentially not strong enough and loose enough.

Elderly (M): My previous walking frame was a little bit heavy, but still alright.

Industry (F): In some areas like Damansara, outdoor is still accessible for walking frames/walkers, but if you're in Kajang, it's hard to use outdoor walking frames/walkers. So, our walking frame is better suited for indoor use.
Industry (F): If the material is thin, it is easy to break and become bent (aluminum).

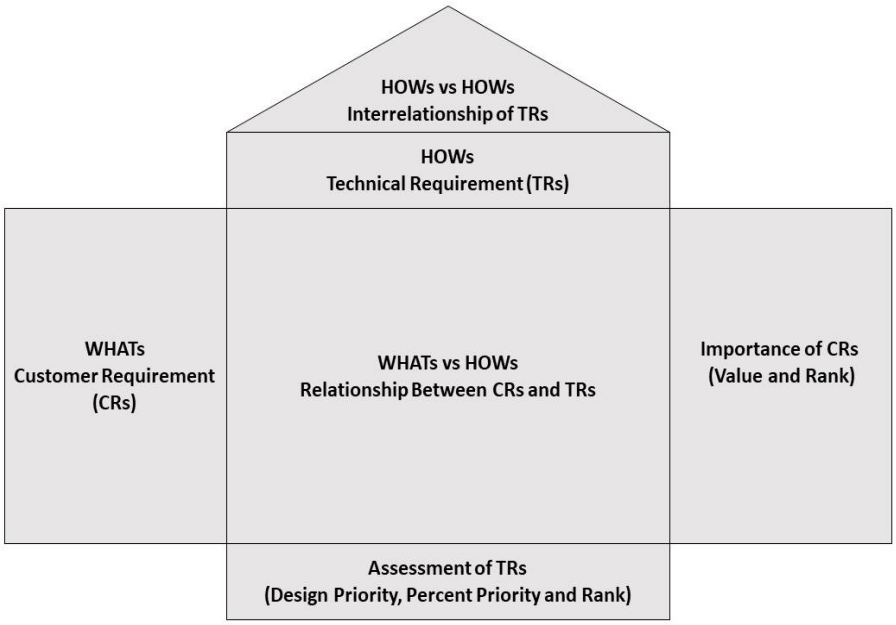

Figure 1: QFD House of Quality[41] (Cudney & Elrod, 2011)

Design issue. Design is also an important part of the product. In contrast to the actual materials, forms, processes and markets,' design' can express intention; it is often used to describe the driving force of the creative thought itself[42]. The results of the design-related interviews are shown below also found that there were some issues raised by the respondents.

Elderly (F): It's quite difficult. If I use this, my body is going to be painful.
Elderly (F): the noise is generated when the walking frames/walkers slide on the floor surface.
Elderly (F): Walking frames/walkers previously used to can't be folded.
Carer (M): The previous walking frames/walkers can't be folded. Difficult to get in the car for outdoor activities.
Carer (M): For those who use walking frames/walkers, their movements are slower.
Carer (M): We also have problems helping elderly people who use walking frames/walkers when entering the toilet.
Carer (F): Walking frames/walkers get up front when the elderly wants to stand up after sitting down.
Carer (F): The walking frames/walkers can still enter the toilet, but the space will be narrower.
Industry (M): Some walking frame are dark colour such as black.

Cost issue. Cost is the number of inputs gained in producing a product[43]. Costs are often used to determine the price of a product. It will be calculated based on the product's profit. With an industry that produces only one type of cost calculation product, it is simple, while with an industry that produces different products, cost calculation is complex. Thus, cost calculation is very important. The following is some of the feedback provided by the respondents in the cost-related discussion.

Industry (F): Walking frames/walkers prices are slightly higher.
Industry (F): Less awareness and education on the walking frames/walkers among professionals and the user.
Industry (F): No subsidies for the user/patient to purchase the walking frames/walkers.
Carer (M): Price? I'm not sure. Because it is managed by nurse. She purchased this equipment.

Elderly (F): Price? I don't know because I didn't purchase it. I believe the cost is more than hundreds. But for me it's bit expensive

QFD House of Quality

As shown in Figure 2, CRs were classified into three namely quality, design and cost based on feedback from respondents during the FGD session. Under (Quality) the list of customers' requirements can be classified into lightweight, durable, good material and suitable for outdoor use. Under (Design), the list of customers' requirements can be classified into the stable, user-friendly, faster movement of the walking frames/walkers, safety, noise insulation, comfort design, easy to fold, suitable folding size even in the toilet, flexible size, and nice design. Lastly for (cost), affordable price is the list of CRs.

For TRs, the requirement is obtained according to the list of CRs. Some list of TRs that were identified was the use of aluminum alloy materials, increase thickness of the aluminum alloy, increasing thickness of the walking frames/walkers' body, conducting strength analysis of the walking frames/walkers, and redesigning the shape of the frame of the walking frames/walkers. The example detailed calculation for (TR 1) is shown in Table 1. Finally, the rank for the TRs was determined accordingly based on the value of PP starting from the highest (Rank No.1) to the lowest (Rank No. 17).

As illustrated in Figure 2, the top five most important criteria based on CRs for a new walking frame/walker design is safety (rank 1), stability (rank 2), suitability for outdoor use (rank 3), user-friendly (rank 4), and comfort design (rank 5). Meanwhile, the top five highest ranked TRs is adjustable height and width (rank 1), designed two-level handle walking frames/walkers and designed 'R' shape walking frames/walkers (rank 2 & 3), design with ABS castor wheel (rank 4), and provide functional accessories such as seat, bucket, and pocket (rank 5).

Table 1: The detailed calculation of Percent Priority (PP) for TR 1

(CR)	TR 1: Use Aluminum Alloy Materials	CRs Importance Value (IV)
CR 1	Strong correlation = 9	0.11
CR 2	Strong correlation = 9	0.29
CR 3	Strong correlation = 9	0.12
CR 4	Strong correlation = 9	0.71
CR 5	Strong correlation = 9	0.73
CR 8	Strong correlation = 9	0.84
CR 15	Medium correlation = 3	0.18
	DP = (9 x 0.11) + (9 x 0.29) + (9 x 0.12) + (9 x 0.71) + (9 x 0.73) + (9 x 0.84) + (3 x 0.18) = 25.71	
	PP $= \frac{\text{Design Priority}}{\Sigma \text{ Design Priority}} \; x\,100$ $= \frac{25.71}{389.18} \; x100$ = 6.61	

Note. CR = Customer's Requirement, TR = Technical Requirement, IV = Importance Value, DP = Design Priority and PP = Percent Priority

CUSTOMER REQUIREMENT (CRs)	TECHNICAL REQUIREMENT (TRs)																	CRs Importance value	Rank
	Use Aluminium alloy material	Increase thickness of the aluminium alloy materials	Increase thickness of the walker body	Conduct strength analysis of the walker	Redesign the shape of the frame of the walker	Provide changeable castor wheel (optional)	Design with ABS castor wheel	Design two level handle walker	Design 'R' shape walker	Provide LED light	Provide breaking system	Design triangle base walker for stability	Foldable design	Adjustable height & width	Ergonomi chandle design and materials	Provide accessories to enhance design aesthetic	Provide functional accessories e.g. seat, bucket, pocket		
Quality																			
Lightweight	9	3	1	3														0.56	12
Durable	9	9	9	9	9												1	1.47	6
Good material	9														9			0.59	11
Suitable for outdoor use	9	9	9			9	9	9	9		9		9	9		9	9	3.53	3
Design																			
Stable	9	9	9	9	9	3	3	9	9		9	9	3	9	3	9		3.63	2
User firendly						9	9	9	9	9	3	9	9	9	9		9	3.04	4
Fast		3	1			9	9								1		3	0.85	9
Safety	9	9	9	9	9	3	9	9	9	9	9	9		9	9		9	4.22	1
Noise insulation						9	9					3						0.69	10
Comfort					3	1	9	9	9			9		9	9		9	2.19	5
Easy to fold													9				3	0.39	14
Suitable folding size even in the toilet													9	3			3	0.49	13
Flexible size														9			3	0.39	14
Nice design					1										9	9	9	0.92	7
Cost																			
Affordable price	3	1	1			3	1	3	3	3	3	1			3	1	1	0.88	8
TRs Importance value																			
Design priority	128.5	120.7	117.9	85.49	91.31	101.3	142.4	152.1	152.1	67.94	114.1	120.6	77.94	154.4	112.9	73.53	132.8		
Percent Priority	6.61	6.20	6.06	4.39	4.69	5.21	7.32	7.81	7.81	3.49	5.86	6.20	4.01	7.94	5.80	3.78	6.83		
Rank	6	7	9	14	13	12	4	2	2	17	10	8	15	1	11	16	5		

Figure 2: QFD House of Quality (HoQ) for new walking frames/walkers design requirement

DISCUSSION

Feedback from respondents during FGD regarding issues or challenges related to the quality issue of their current walking frames/walkers such as their walking frames/walkers become slightly heavy, become loose when it has been used for long periods and easy to break (using soft materials) was found in line with earlier studies. Using common assistive walking aid may increase the risk of falling and injuries[44] such as heavy and making movement difficult[45]. Although some respondents stated that the walking frame is not appropriate for outdoor use, it can be used outdoors as well[46]. Probably this perception is caused by the uneven condition of the road surface outside compared to the floor surface inside the house.

Some earlier research findings were found similar to issues and challenges related to the design issue of current walking frames/walkers such as need more energy/force to move the device, lack of stability and brake control (particularly in rollers), the possibility of obstacle collisions and the difficulty maneuvering the device through doorways and congested areas[47], which require the user to lift and move the device forward during walking, which may result uncomfortable and unnatural[48], slower gait[49] and become tired quickly[50]. This situation is relevant because as individuals age, physiological and psychological changes will cause in difficulty when interacting within their environment due to functional impairment or decline in these aspects[51].

When dealing with a product or service, the price is a vital aspect need to give consideration. Some of elderly customer may left behind with an unfortunate situation reinforced by pressure from the changed demographic situation on old-age pensions and public goods[52]. Previous study shows most of the elderly could not afford to purchase certain goods due to their low-income status[53] or no income at all. Thus, their ability to purchase goods or services will be affected, particularly at an affordable price. As we know, majority of Malaysians elderly are financially dependent on their children[54,55] and some of them received no income, whereas in terms of financial independence they must rely on others to meet their needs[56]. Although the respondents in this study stated that they could still purchase a walking frame, they felt the price was a bit higher. Thus, the higher priced product should be carefully considered based on scientific support or feedback from the user before being produced or marketed[57].

On the other part, CRs for improvements are consistent with some of the previous study's findings. Several previous studies have suggested that assistive walking devices/aids including walking frames/walkers must be lightweight for easy mobility[58,59], durable[60,61], high-quality materials[62], and support outdoor mobility[63]. In addition, current guidance and device design also should be reviewed and expanded[64], to purpose new recommendation for properly use and better design. Since walking frames/walkers provide the best weight support and mobility for frail people, safety is critical[65]. Consideration of user-friendly and fast-response mobility devices is also important for a smooth and enjoyable user experience during walking[66]. Further, folded function and appropriate size are also recommended are the best options for the user[67-69] and for storage to save space[70].

The results of the Technical Requirements (TRs) analysis were also compared to some previous research suggestions. Two options needed to be considered for the mobility aids material: carbon fiber and aluminum. Carbon fiber has advantages in terms of load resistance, lighter weight, and strength, but it is more expensive than aluminium[71]. Walking aids including waking frames/walkers are designed to improve user safety and prevent falls during walking. Therefore, coordination with the user also should not be ignore[72]. This is because incorrect use was associated to reduce stability, which was linked to environmental constraints and a specific frame design feature[22]. Walking frames/walkers must be used in a stably and current guidance needs to be improved to prevent falls.

On the usage aspect, the walking frames/walkers should translate into mobility and versatility requirements to be used indoors but outdoors as well[33] for promoting participation in community life and social events[73]. While in the user-friendly aspect, participatory design approaches can be viewed as attempts to better understand and involve real users, and important in creating user-friendly products or services[74]. One of the most important factors determining the walker's usefulness is the handgrip height. This is because the walker's use varied depending on the physical characteristics of the users. If some users have strong physical characteristics, they should use a walker with a higher handgrip to maintain their current physical characteristics, where same as normal walking[27]. For width, narrow frames should be prescribed and used with caution because they reduce stability when walking compared to a standard-width frame[64]. Furthermore, the user is made up of a variety of different body sizes. Thus, the walker with an adjustable width function is more appropriate.

Currently, there are 2 types of walking frame shapes in the market; N and R-shaped. The differences between these two types of walking frames/walkers are the number of handgrips and the height level of the handgrip that supports the user while sitting, standing or walking. The number of handgrips on an N-shaped walking frame is one, and it is located at the top level of the frame height. While the number of handgrips on the walking frame with an R-shaped frame is two and located at the top level and middle level of the frame height. For the elderly and overweight, the transition from sitting to standing is one of the most physically demanding maneuvers. It can also be challenging due to a traumatic injury, such as a spinal cord injury, or due to lower extremity muscle weakness[75]. Sit-to-stand movement with a low handgrip level resulted in increased hip flexion angle, ankle dorsiflexion angle, trunk forward tilt angle, greater forward center-of-gravity shift and decrease in backward force on the floor. As a result, the handrail height level position should be chosen to match the functional status and impairment of older persons[76].

As we know, a brake is a mechanical device that uses friction to absorb the energy of a moving system or mechanism. The brake's primary function is to slow or completely stop the emotion of a moving system such as a rotating drum, machine or vehicle[77]. Anti-lock Braking System (ABS) is a safety system that prevents the wheels from protecting up while braking[78]. It is thought to have the potential to be used as a support system related to the safety of walking frame users.

CONCLUSION

In summary, it has been discovered that there are issues and challenges in the use of walking frames/walkers among the elderly in Malaysia, which have been classified into three categories: quality, design and cost. By using HoQ, the design team can prioritize the TRs for a new walking frames/walkers design, which may meet the CRs, especially on the ergonomic aspects for the elderly. Thus, it is hoped that the information gained would be useful as a reference for future studies on walking frames/walkers that can offer more safety features, be stable and be more user-friendly for the elderly.

ACKNOWLEDGEMENTS

Many special thanks to all respondents that took part in this study. We also wish thanks to any person or organization who was involved directly or indirectly in this study. This study was supported by the Putra Research Grant Scheme (GP/2018/9625600), Universiti Putra Malaysia, Malaysia

Conflict of interest
There is no conflict of interest in this study.

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