

Cane Design: A Preliminary Research Concerning on Cane and Elderly Users

Yi Vonn Wong and Sungho Yang

Abstract—There are many canes in the market focusing on different specific group of users. This study aims to amass data to identify problems face by cane user (CU) and potential cane user (PCU) to determine the specific user group for the new cane design. A series of preliminary research (systematic review, online questionnaires, interview and direct observations) focusing on cane and user experience was conducted for this research. For systematic review, 26 cane-related-articles were chosen and finalized from 3 online databases (PubMed, Medscope and Science Direct). An online questionnaire was distributed to 46 Malaysians, age 40 and above, to understand their current health status and how they perceive the use of cane. 3 elders above 75 years old were interviewed to understand their current difficulties and health status in depth. Finally, 3 uniquely designed canes were distributed and tested among a group of Koreans aged 20s, 30s and 40s without cane experience for user interaction observation. Research shows that cane should be used correctly as misuse of canes could cause the increase of elderly's fall risk and thus affects the confidence of CU and PCU towards cane. First time users (FTU) of cane could be found among people in age group 50-59 years old. This research has suggested FTU as the specific user group of the new design as problems faced by CU and PCU are related to the lack of cane instruction in early stage. This study is conducted as a part of long-term project that ultimately designs a cane for the elderly.

Index Terms—Cane design, elderly, mobility aid, gait.

I. INTRODUCTION

Elderly who falls down should be treated seriously as it often results in other serious illness [1], thus mobility aid is needed as a support for elder's daily ambulation .Cane is considered as the basics of mobility aids and most frequently used by elders to assist in their daily mobility [2]. Unlike walker or crutch that are made to assist users that have difficulties in walking, cane assist users who require minimum balance support. There are many cane design in the market which has different functionality for different target user, for example: cane that allows support to user with difficulties in transition from sit to stand position and cane that has ergonomically designed handles dedicated to user with arthritis problems.

In order to design a cane that is unique from current cane design available in market, problems and needs faced by cane

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users (CU) and potential cane users (PCU) should be identified to grasp the design direction of the new cane design. A preliminary research consists of systematic review, online questionnaires, interview and direct observation was conducted in order to achieve the previous mentioned objective.

II. PRELIMINARY RESEARCH

A. Systematic Review

Search term was needed to conduct the initial database search for the systematic review. In order to amass as many information on cane as possible, key terms of this research and their related terms were identified and listed as shown in Table I below. These search terms were then applied to selected online database: Pubmed, Medscope and Science Direct.

TABLE I: SEARCH TERMS

Key Terms	Related Terms
Cane	Walking stick, assistive device, assistive tool, mobility aid, walking aid
Elder	Aged gait
Ergonomic Design	Ergonomic Cane Design

1) Inclusion and exclusion strategy

There are a total of 385,081 articles found using the search terms listed in Table 1. In order to obtain more related articles, article filtration was conducted according to the following list of inclusion and exclusion criteria:

- The paper has to be published in, or translated into the English language
- The paper had to be published between 2006 and 2016 (to ensure article findings are up-to-date)
- Studies that had involved older people (aged 65 and above) as part of the sample
- Studies that had involves walking stick/ cane as part of the sample
- The paper had to be an original study
- The paper is not a conference abstract
- Subject should be healthy aging adults with no severe sickness
- Elders with knee osteoarthritis and arthritis can be included

Four rounds of article filtration have been conducted as shown in Fig. 1, only 25 articles survived through the filtration.

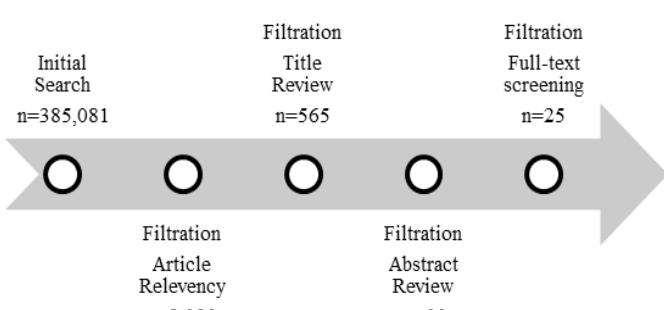


Fig. 1. Filtration process.

2) Systematic review results

Different aspect of cane has been researched in the 25 finalist articles, but most findings were interrelated to one another. Findings that are deem helpful to determine the new cane design concept were summarized and listed in the followings:

- Majority CU were not educated on the correct way of using the cane (ex: height/ holding the cane in the wrong hand) [3]-[5]
- Misuse of cane would increase fall rate thus causing more injuries to elderly users. [3], [4], [6]
- Cane would decrease the walking speed of CU [2], [7]-[10], pros and cons of slow walking speed are shown in the following Table II.

TABLE II: PROS AND CONS OF SLOW WALKING SPEED

Slow Speed	
Pros	Cons
Enhanced bio-mechanic stabilization and decreased limb pain.	Problematic in situation where speed is needed. Ex: difficulty crossing the street with traffic lights in a timely manner.

- Different cane height adjustments have different impact to CU [4], [9] as shown in Table 3. Cane height that requires the least energy expenditure is suggested to be the measurement from ground to wrist joint line when the hands are place comfortably at both sides [4], [10].

TABLE III: EFFECTS OF DIFFERENT CANE HEIGHT

Cane Height			
Short		Long	
Pros	Cons	Pros	Cons
Enable CU to perceive ground touch more accurately which is safer for those with visual impairment.	Causes the CU to lean forward while standing or walking which increase rate of falls. CU has to stoop, which can cause back problem.	To be held in front of the body if 2 sticks is needed.	May skid, reducing support.

- CU may not always need their cane in daily mobility, especially at home [2]. It depends on the distance that they expect to walk [3].
- Application of arm muscle force could reduce weights on the limb muscle thus improves CU's balance [11]
- Using the cane is a sign of frailty [3] which will cause PCU denial of accepting the cane.
- Using a cane in the opposite hand to the weaker leg could reduce knee load [4],[5], [10], but [7] stated that there were no significant difference
- Holding the cane with elbows bent to 20–30 °could help offset body weight [11]

B. Online Questionnaires

A total of 10 questions were posted through a survey website name Survey Monkey and were distributed online to Malaysians aged 40 and above. 46 Malaysians have responded to the questionnaires, majority are female from the age group 50-59. Table 4 shows the gender of the respondents and the number of CU in each age group.

TABLE IV: GENDER AND NUMBER OF CU SORT BY AGE GROUP

Age Group	Gender		Total Num.	Total CU	CU %
	F	M			
40-49	2	0	2	0	0.00
50-59	20	14	34	6	17.65
60-69	2	1	3	1	33.33
70-79	1	0	1	1	100.00
80-89	4	1	5	4	80.00
90 or older	1	0	1	0	0.00
Total	30	16	46	12	26.09

This questionnaire aims to understand the current health status of people aged 40 and above and how they perceive cane. Question includes:

- 1) Age and gender
- 2) Have you ever used a cane?
- 3) From your experience using the cane, is there anything that needs improving?
- 4) In your opinion, how important is walking devices (walker, crutch, wheel chair) to Elderly?
- 5) In your opinion, how important is cane to Elderly?
- 6) Have you been hospitalized in the past 10 years?
- 7) Do you have difficulties with activities listed in the following? (Eating, Bathing, Dressing, Toilet use, Walking inside and outside the house, meal preparation, ordinary housework, shopping)
- 8) Do you habitually hold onto furniture/railings for balance while walking at home?
- 9) What influence you when purchasing a cane?
- 10) Under what circumstance will (did) you start using a walking stick/cane?

1) Online questionnaires results

As stated in Table IV, a total of 12 CUs were found among the 46 respondents. 6 used quad canes, 5 used adjustable single point cane and only 1 used a wooden single point cane. Due to the limited number of respondent, preference between a quad cane and a single point cane could not be identify. Reference [6] states that CU are commonly found in elderly aged 75 and above, however this study has found CU in age 50-59. Majority young CUs have a common point which is people who have suffered from severe physical injuries such

as hip injuries or people who have undergone minor surgeries. In addition, not all CUs are frail and weak. 41.67% CUs stated that they are capable in keeping up their daily activities. 58.33% CUs also do not need the support from holding onto railings and furniture while walking at home.

Cane improvements suggested by CUs in this study are:

- 1) Quad cane base need to be strengthened
- 2) Cane should be light and foldable
- 3) Single pointed cane should have wider base- increase stability and support

Comparing between question 4 and 5, 26.09% respondent thinks that other walking devices are more important than cane while majority 65.22% thinks that both are equally important. This shows that 26.09% of respondent have the possibility of denying the use of cane when the time they have become PCUs.

Question 9, allows respondent to vote not more than 3 cane purchase influence criteria. Details are listed in the following Table V.

TABLE V: PURCHASE INFLUENCE SORT BY GENDER

Purchase Influence	Gender		Total	
	F	M	Num.	%
Cheap Price	2	3	5	4.17
More Durable	12	6	18	15.00
Multi-Functional	12	7	19	15.83
Light Weighted	18	9	27	22.50
Easy Storage	13	4	17	14.17
Stability	20	9	29	24.17
Appearance/ Design	4	1	5	4.17

The 2 most important criteria of cane agreed by both gender is the stability and weight of the cane. The third most important purchase influence criterion was differed between genders. Female respondent prefers the convenience of mobility and easy storage, while male respondent prefers multi-functional cane.

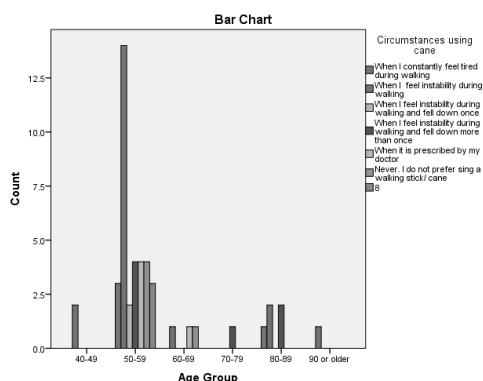


Fig. 2. Circumstances initiates the use of cane.

Fig. 2 has portrayed a clearer picture from the result of question 10. Majority of 43.48% respondent has stated that they will (have) started using the cane when they felt instability during walking.

C. Interview

In contrast with the online questionnaire survey, this interview was made to understand the problems and difficulties face by elderly age 75 and above. 3 elderly (2 Korean, 1 Malaysian) - hereafter known as subjects A, B and

C - have helped out in this interview session. The Canadian Study of Health and Aging (CSHA) Clinical Frailty Scale was constantly referred in order to understand the frailty stage of the interviewed subject.

The interview was taken place in year 2016. Details of the interview could be referred from Table VI and Fig. 3.

TABLE VI: INTERVIEW NOTES

Subject	A	B	C
Age	89	80	77
Gender	F	F	F
Nationality	Malaysian	Korean	Korean
Mobility aid used	None	Single Point Cane	Crutch
Gait without mobility aid	Rest after 10-15 mins walking	Rest after 8-12 mins walking	Can't walk without crutches
IADL & ADL	IADL Dependent	IADL & ADL Dependent	Independent (Living alone)
Daily (vigorous) physical activity	Minimal engage in sports daily, 1 shopping trip weekly	Do not engage, usually spends time at home or church	Everyday (House chores), upper body only
Daily activities limitation	Limited in the time of walk	Very Limited to physical activities	Limited to all leg-required activities
Mobility in Bed	o	o	o
Transfers	o	x	o
Locomotion indoors and outdoors	o	x	x
Dressing	o	o	o
Eating	o	o	o
Toilet use	o	o	o
Personal hygiene	o	x	o
Preferred Cane	none	Single Point Cane	Crutch and wheel chair only
Reason of picking preferred cane	Troublesome of carrying cane when not needed	Gift from family, thinks that other designs are troublesome	Underwent waist bone surgery, needs mobility aid that could support most of her weight

IADL: Instrumental activities of daily living

ADL Activities of daily living



Fig. 3. Interviewed subject.

D. Interview Results

All 3 subjects are old and shows sign of frailty. However due to different lifestyle and practices, the stage of frailty were not the same. This proves that constant physical activity could prevent the human body to deteriorate quickly.

Subject A is 89 years old and she is the eldest among 3 subjects. Subject A is also the only one who walks without a walking device nor support from people beside her. She is very strict on maintaining her healthy lifestyle. She doesn't eat oily or high cholesterol food, never sleep after 10pm and she does 30mins of light exercise such as stretching and slow walking every day. But in the past year, she noted that she starts developing difficulties in long distance walking and standing. She mentioned that now she needs to take rest if she walks approximately 10-15mins continuously. When subject A was being asked if she would consider of using a cane, she expressed her fear being treated as a weak person. She will only consider using the cane if her gait becomes unstable and constantly needs support. She prefers a cane that is convenient to store or carry along when it is unused.

Subject B is 80 years old and she owns a height adjustable single point cane. Her cane was a present from her family and she used it whenever she goes. Unlike subject A, subject B is very dependent on her cane and grandson in daily activities. She express that she is old and needed constant support from her grandson. Due to lack of education on the use of cane, subject B's cane was set lower than the required height found in the systematic review, causing subject B to hunch while walking. When 3 uniquely design cane was presented to subject B, refer to table 8, she expressed that the new cane designs were hard to adapt and she prefers her old cane. This shows the lack of ability to adapt to new design among elderlies.

Subject C is 77 years old and she is the youngest among all. She had suffered from waist bone surgery thus requires her to use mobility aids that could support most of her body. Subject C uses her crutches for indoor mobility while using a wheel chair for outdoor mobility. It is impossible for subject C to use a cane for cane could not support much body weight. Although subject C might be limited to most activity which requires lower body, her upper body remains strong as she has to do her house chore daily.

As a summary, the following listed the difficulties or fear faced by subject A, B and C:

- A – incapable of long duration walking and standing
- A – fear of being treated as a weak person (social pressure)
- B – incapability of accepting new design
- B – Not properly educated on usage of cane
- C – lower extremities are too weak for cane

E. Direct Observation

TABLE VII: SUBJECTS FOR DIRECT OBSERVATION

Age group	Gender		Total Num.
	F	M	
20 - 29	4	2	6
30 - 39	1	0	1
40 - 49	1	0	1
Total	6	2	8

The direct observation study aims to understand the

interaction of non-CU with cane. In this section, 8 Koreans aged 20s, 30s and 40s – hereafter known as subjects- were randomly picked among Inje University students. All of these subjects have no experience in using the cane. Details of the observed subject could be found in Table VIII:

3 uniquely designed canes were selected for this experiment. Each of these canes has a different approach and was designed to aid in particular circumstances. Description of each chosen cane is listed in Table VIII.

TABLE VIII: CANE USED FOR DIRECT OBSERVATION

		
Sit-to-stand Quad Cane	Flexyfoot Walking Stick	Forearm Cane
Quad Cane/ Multi-purpose	Single Point Cane	Single Point Cane
S-shaped body designed to support users in sit-to-stand positioning	An oval handle with write band, award winning cane tip with spring design that enables shock absorbing	A built-in forearm cradle that decrease stress on wrist by increasing area of interaction between arm and cane.

When the cane was presented to the subjects, the subjects were not given any direction on the correct way of using the cane. They were told to use whichever way that feels the most comfortable.

F. Direct Observation Results

Among the 3 canes, the correct way of using forearm cane and sit-to-stand quad cane was the most received question. Questions from subjects on the correct way of using the cane were not answered directly but were told to discover themselves. The forearm cane design was clearer, as subjects slowly starts to figure out the correct way of using. However none of the subjects notices the intention behind the unique S-shaped design of the sit-to-stand quad cane. The intention behind the quad cane was demonstrated to the subject after they give up guessing. This observation shows the importancy of user manual.

User manual as shown in figure 4 was provided during the purchase of cane. Although it might not be a language all CUs understand, the image on the user manual is sufficient to provide a rough idea on how the cane works.

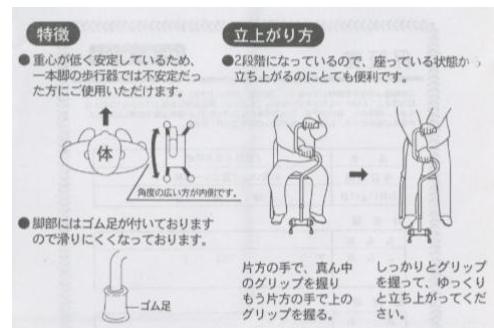


Fig. 4. User manual.

In addition, the base of the quad cane also was specifically design for its users. This quad cane has a base that one side was shorter than the other so that the user wont get tripped while walking with the quad cane. However, few only realize about the design.



Fig. 5. Forearm cane observation.

2 male subjects prefer the forearm cane out of the 3 canes as they said that it gives support to the whole arm thus decreases the pressure of the palm while gaining more stability. However 3 female subjects express that the forearm cane was uncomfortable. Referring to Fig. 5 above, female subject on the left pointed out that the length of the upper portion of the cane was too high, causing sore in the elbow during mobility. On the other hand, male subject on the right of Fig. 5 was in a comfortable position. Observation shows that as the forearm cane is not customizable, it could not fulfill every users comfort. Customizability is important for cane as CU doesn't come in the same size.

When subjects were asked to adjust the cane's height according to the correct measurement, observation shows that all subjects had stand up straight, eyes facing down while adjusting their cane height with both hands, refer to figure 6. Standing up straight could help CU adjust the cane to the accurate height, however this is also observed as a potential increase in risk of fall.



Fig. 6. Cane height adjustment observation.

During cane height adjustment, female subjects complained the difficulty of pressing the button as it was very tight. Two female subjects has requested for help in the height adjustment test. Observation shows that the current button type height adjustment should be improved.



Fig. 7. Cane storage observation.

For cane storage, cane could be place in an umbrella rack or store horizontally. But majority CU prefers to just place the cane standing near to them so that they are in hand reachable distance as shown in Fig. 7. Unlike quad cane single point cane needs to lean on a wall for balance. From experience, these canes will slide and fall and might cause someone to accidentally trip over it. Thus new idea is needed to improve the convenience of cane storage.

III. PRELIMINARY STUDIES SUMMARY

Massive data regarding on cane and CU were gathered throughout the preliminary studies. Some results were similar to previous articles proven that CU's physical and mental needs are similar throughout the globe. Data collected was summarize and categorized as listed below for easy reference:

PCU characteristics:

- Not necessarily above age 75
- Able to walk independently but need support for insurance
- Weak lower extremities
- Could be people age 50s that gone through minor surgery operation or have any physical injuries

Problem faced by CU:

- Afraid of being categorize as the old and weak

CU characteristics:

- Possible to walk independently
- May not always need their cane in daily mobility, especially at home. It depends on the distance that they expect to walk

Older CU characteristics:

- Rely heavily on cane
- Might not be able to accept any new cane design apart from own cane.

Problem faced by CU:

- Not educated on the correct way of using the cane (ex: height/ holding the cane in the wrong hand) Leading to the misuse of cane which increases fall rate thus causing more injuries.
- Lean forward or lean sideward gait posture might be caused by misuse of cane.

Cane Design Reference Notes:

- Implement one-handed cane height adjustment to decrease fall-risk and increase convenience

- Holding the cane with elbows bent to 20–30 °could help offset body weight
- Stability / Independency to stand alone
- Light cane weight
- User manual with diagram is necessary
- Customizability

Apart from the above listed finding, there are also data that are left questionable. According to online questionnaire, design of the cane was not an important factor for purchase influence. Findings have shown that PCU have a hard time accepting the cane as it symbolize old and weak. However in South Korea, hiking sticks are commonly found everywhere. If cane were designed to be more sporty and stylish, PCU might find it easier to accept.

Educating CU on the correct way of using the cane or introducing a new cane design should be in an early stage. This study has suggested that first time users of cane to be the specific user group of the upcoming new cane design.

IV. CONCLUSION

Many problems faced by CU were caused by lack of cane training from the first point of interaction with cane. Many PCU has refuse using the cane due to stereotype and social pressure. Thus there is a need to develop a cane design that is capable to attract PCU's attention, gaining their trust and turning their status into cane first time users (FTU). The new cane design should not only be physically helpful but also be able to overcome the stereotype mentality of PCU.

This study has a limited numbers of interviewee. Due to the small amount of interviewee, the results found could not represent the whole PCU and FTU society. However, this study has summarized extensive literature around the world regarding to cane. It will be a good reference to researchers who will be researching on cane in the future.

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