Gait Analysis for the elderly and popular designs of smart canes available in the market: A narrative review

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Abstract

Background: To promote freedom of movement and allow people with mobility issues to get about and accomplish everyday tasks, smart canes are important. They are available in the market in different features. However, other mechanical and electronic design modifications are possible to provide individualized comfort. In the market, they are available in various design choices. Objective: The objective of the study was gait analysis and finding the features people look for in mobility assistive devices. Method: We have conducted a narrative literature review and analyzed the websites for analyzing gait and the features that make popular canes available in the market popular. Results: We have found that the canes with adjustable heights, low weight, and a wide range of user weight supporting and proper weight-distributing capabilities are more popular. But people search for customized designs based on their requirements on a lower budget. Conclusion: In this study, we have discussed the popular designs available in the market. The findings give us the idea to combine different design variations as per user requirements.

Keywords: Canes, Aged, Mobility, Self-Help Devices, Walking Stick,
**Introduction**

Smart canes are the most popular mobility assistive devices (1,2). They are available in the market with different features (2). Arefin et al (2020) have showed that there is a number of mechanical and electronic features that can be incorporated in smart canes to improve the convenience of users (1). The potential users also search for customized design as per their requirement and convenience. In our present study, we have listed popular smart canes available in market and analysed their key features to know why they are popular. We also focused on the design variables that can be included to provide a combination of popular and potential new features in the smart canes to improve overall user satisfaction. Choosing the right mobility assistive device depends on individual gait. Gait analysis is widely accepted as a clinically useful instrument for detecting human mobility issues (3,4). Old age gait shift key causes include muscle function of leg, eyesight, and femur joint. Many studies are concerned about the impact of lower limb intensity on gait (5,6). Moreover, joints in lower limbs play a significant role during walking or movements. As people age, the knee joint is lost or damaged. Slow walking, walking with shorter steps, and more extended posture period is the sign of the patients with rheumatoid arthritis and knee-related osteoarthritis (7,8). Gait includes assessing the qualitative and quantitative variables that can describe it. Researchers have found that gait complicacy is a prevalent disorder worldwide (1,2). Neurodegenerative disorders such as cerebellar ataxia, multiple brain tumors, myelopathy, spinal amyotrophy, Parkinson's disease, myopathy, craneoencephalic trauma, cerebrovascular pathologies, some forms of dementia, cardiac disease, or aging are main concerns (3,4,9). The research on gait behaviour of human movement is very remarkable for clinical applications. It is a new idea to be explored for the betterment of gait complication of human movement (3,5,10–13).

**Techniques for Gait Analysis**

Precise knowledge of gait behavior can help early detection of gait-related complications, and consequences and the medical personnel will identify the right way to cure. Experts evaluated the health of patients who are using different techniques that assess gait recognition parameters (8,10,12,14). These are velocity, short step length, long step or stride length, cadence or rhythm, step width, step angle, short period of steps, swing period for both lower limbs, help period, gait autonomy, stops' period, presence of tremors walking, falls' record, taken routes, gait phases, ground force, junction angles, muscular electrical activity, momentum and strength, posture and preserving long-term gait.

The variables listed could be calculated using two techniques to analyze someone’s health:

1. Investigation with semi-subjective type
2. Methods of critical investigation.

In his study, Herran mentioned a collection of traditional semi-subjective analytical techniques. (12) They are-

- Timed 25-Foot Walk (T25-FW),
- Multiple Sclerosis Walking Scale (MSWS-12),
- Tinetti Performance-Oriented Mobility Assessment (POMA),
- Timed Get up and Go (TUG),
- Gait Abnormality Rating Scale (GARS),
- Extra-Laboratory Gait Assessment Method (ELGAM)
Move duration, velocity, primary gait pattern, the capability to move the head, and static control were among the parameters tested. Demura et al. (2010) found that older people with more extraordinary knee flexion ability could walk quickly and with better steps than older individuals with inadequate knee flexion capacity (9). Markedly reduced, and shorter length of steps, trouble during the head movement, and lack of balance were found to be significantly related to unstable gait (15,16). Slower movement velocity and a more extensive stance period and duel boost period (10,11). It was found that in the female elderly, a decline in the intensity of knee extension, ocular acuity, and pain in the lower limbs joint were factors to influencing gait(16). The relative gap and gait period are primarily influenced by reduced knee extension intensity and pain in the knee joint.

In a cross-sectional analysis, the effect of intrinsic variables on the stability of local gait dynamics and variability on the old aged group were investigated (17,18). The four measures (primary component research parameter) (1) "strength and gender," (2) "physical activity," (3) "pain," and (4) "peripheral sensation" were each connected with two of the gait behavior. They are stability and variability measurement analysis. Dimension (5) "balance" in only one gait test was a relevant predictor.(13) Although dimension (6) "proprioception" on any gait measure was not found to be based on mental health.

Studies have shown that participants or men with greater relative muscle output walk more comfortably(6,13,14). As both muscle health (sit-to-stand test) and human gender have been combined into a particular factor; we have separately examined gait stability and variability contributions(6,12,14–18). Substantial differences in gait consistency were found when comparing male and female participants. As far as the stability indicators of the primary study are concerned, males are more stable than females(19).

The level of physical activity of individual-task and double-task walking at the same time is also a useful indicator of many of these measures of gait consistency and gait variability(20,21). This result complements the beneficial effects of daily body movement on improving and sustaining the well-being of older adults and the standard of living related to mental and physical health.(22) Gait helps to avoid falls. But according to the research findings suggest that static condition is not so critical to strength gait (12–14,21,22).

**Target Users of Smart Canes**

People-based on gait analysis are recommended to use assistive mobility devices(6). For smart canes, the target customers are primarily seniors and people with lower-limb difficulties. The older adults typically have some issues with their gait (e.g., lower limb strength and vision, pain in the knee junction). Consequently, it is not easy to ascertain the particular aspect causing gait when studying the old age group with eyesight issues and pain in the knee junction to low limb ability. Specific bodily activity with the strength of limbs, joints, acuity of vision, etc. minimizes and substantially affects aging(10,13,16,19). Evidence has shown that a shift of gait with age often involves falls. Gait was used as an illness and mortality factor for older adults(21). As quantitative criteria, including walking velocity and cadence, the time, step length, and step width of the gait were used. The improvements were recorded on age walking: reduction in foot speeddecreased support time for single lower limb and reduction in support time for a double lower limb for overall touch time and shorter step length. Kaufman et al.also reported that patients with knee arthritis had a longer leg length to minimize knee pain, relative to safe subjects. Older individuals typically have their mutual activity blocked. Around 25% of older adults aged 55 or older, including knee
osteoarthritis patients, complain of knee joint pain(23). In old age, there is a general reduction in multiple bodily activities together. An individual, along with a prescribed home-exercise regimen, is, on average, given seven to ten visits by a therapist. Although patients undergo any of the recommended rehabilitation hours, without home exercise plans, they do not achieve the full benefit of treatment(21,23).

The factors for poor adherence to physical therapy are the (1) barriers, (2) no positive feedback, and (3) helplessness(23). These causes can be related to poor self-efficacy, high pain level, fatigue, anxiety, and weak peer motivation for fitness and operation(14,16,19). Patients need a device in their homes that can be used to resolve challenges, offer comprehensive and accurate input on activities, and encourage for them to complete their home workout programs. Eldercare facilities usually provide bathing and food preparation services(3,22,24). They do not have labour-intensive assistance for weak physical and mental health expected by older adults(11,14). Smart Canes are here to help at this point. In the following stages, it can support the patients:

A. From Sitting to Standing
B. Walking
C. Standing to Sitting
D. Stair climbing

Patients should be given instructions on how to use a cane properly. A smart cane, if properly used, can ease pressure on knees and can improve the balance. Again, features may differ according to needs. Useful features and guidelines are required for target users to help their movement appropriately.

Comparison of Features of Available Smart Walking Canes

A durable, well-constructed gait targeted cane should be chosen. Users need canes for optimum stability (1,2). There is a list of the most widely available popular smart canes available in the market:

**Medline Offset Handle Cane**

The handle's offset nature focuses user weight over the cane’s most substantial section. This cane has height adjustment push-button to explore the appropriate height conveniently. Maximum weight range 250 lbs. Height change range from 29 to 38 inches. It's convenient, budget-friendly, robust but faces difficulties in weight distribution.

**Hugo Mobility Quadpod**

This cane, made of aluminium, is sturdy but lower in weight. It has a unique shape that generates itself, making it possible to stand the cane and not lean to a wall. It can support up to 300Lbs of users. Height is adaptable from 28 to 39 inches. It is lightweight, easy to transport but expensive, and easy to crack.
Carex Soft Grip Cane
The smooth handle grip, which absorbs shock, is perfect for the wrist complication patient. The handle features a sturdy wrist brace. Total support weight of 250 lbs. Height variations range from 31 to 40 inches. It is relaxed and friendly on budget.

Harvy Derby Scorched Cherry Hardwood
Cane For seniors looking for beautiful style, these are perfect wooden canes. The cane is manufactured in the USA. It was not intended to bear the weight. It involves 36 inches in height, but it is non-adjustable. It is of high quality but provides no adjustable heights.

Travelon Walking Seat and Cane
In the application of a more extended period walk or golf, this cane could be the best choice. Three legs to walk and sit on are stable. For those who need to take a break, a seat is open. It serves users up to 250 lbs and provides 32-inch in-height.

Duro Med Wooden Walking Canes
It is a convenient way that appeals to a variety of consumers with wooden canes for senior citizens. For user convenience, the cane needs to be in a smaller length. Since it is not a weight-cane, it is a considerably safest cane for old-age consumers with additional light support. But it gives 36 inches of height that is not adjustable.

Self Defense Plain Jane
These are the perfect canes for the old age group with self-protection issues. Durable built quality, although unspecified weight limitation. It offers 36 inches height that is not adjustable. It has the functionality of self-defence.

Nova Design Offset Cane
The for seniors who want a fashion-forward look is one of the best canes. The finish is resistant to chips and fading. It supports from the range of 300 Lbs Consumers. Adjustable height ranges from 30-39 inches. It is budget-friendly, but it can easily split.

HurryCane Freedom Edition Folding Cane
This cane is also manufactured in USA. It is designed with fold features that makes the movement more convenient. It supports the weight upto 350 lbs of consumers. Its height is adjustable from 30.5 to 37.5 inches.

DMI Deluxe Cane
For an easy, low weight and 250 lbs consumer support, this cane is the best choice. Adjustable height is at the range of 30 inches. It is budget-friendly, but it can easily split.

Discussion
We have listed and discussed the most popular canes available in the market. Analyzing the features of these canes, we can say that adjustable heights and low weight are important in all cases. Canes providing wide range of user
weight supporting and proper weight distributing capabilities are more popular over the other alternatives. Some companies also offer customized design for users which indicate that there is a demand for additional features. Arefin et al in their study have suggested a number of design options and parameters that can be introduced. People also search for customized designs in a lower budget (1,2). The present study has the limitation of a full insight to customers’ demands of features. Future research can be done in survey basis on the demands of features by customers to include them in customized structures.

The study presents the potential for solving and overcoming problems associated with currently available smart canes, and these shortcomings can assist in developing design guidelines for More technologically advanced and improved smart canes. However, using universal design principles facilitate full accessibility of a product to people with a wide range of capabilities and limitations. Our study helps to design and introduce new, patient-convenient technologies to the existing universal designs. We aimed to combine the features with these existing marketed devices depending on the individual preference and gait analysis to increase the convenience of users. By addressing the problems and demands efficiently, companies are expected to improve the accessibility of their products to the consumers in a more systematic way. The customized products would offer better solutions and benefits to the disabled or old people depending on their changing and newly addressed requirements and necessities. According to World Health Organization, disabilities in worldwide population has augmented from 10-15% since the 1970s (1). As the disabled population are increasing gradually, design variations and technical advancements utilization guidelines will significantly help in understanding the needs and shortcomings of the disabled and older persons and subsequently, improving quality of life for them as well as their family and caregivers (2).

Conclusion
Smart canes are very popular in patients with limb problems and older adults. There are more choices available in the market. Some companies allow offering customized design according to need. Different electronic and mechanical aspects can be customized to provide the utmost comfort to older adults. Depending on the individual preference, gait analysis, we can combine the features with these existing marketed devices. There is an opportunity of future research to provide additional features in low budget to the customers.

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