Barrier-free Design of Walking Vehicle for the Aged

Zhujun Jia\textsuperscript{a}, Liming Shen\textsuperscript{b}, Siegfried Lewark, Fei. Fang\textsuperscript{b}, Jin Wang\textsuperscript{a}, Weiji Zhu\textsuperscript{a}

\textsuperscript{a}College of Design and Art, Yancheng Institute of Technology, Yancheng, Jiangsu, China; \textsuperscript{b}College of Furniture and Industrial Design, Nanjing Forestry University, Nanjing, Jiangsu, China

Abstract: Due to the degradation of physiological function, the aged are liable to fall over and put themselves in danger. Therefore, improving the safety and quality conditions of transportation has attracted increasing attention. Walking vehicle can help the aged improve the comfort and safety of trip. The existing walking vehicles have inconvenience in folding and the overweight. Taking one hundred and twenty-four elderly people over the age of 65 as the research objects in five representative cities in China, via the Chinese Ministry of Civil Affairs and the local civil affairs bureaus, the questionnaires were sent to the target groups and feedbacks were collected. In Nanjing and Shanghai, with the help of the Civil Affairs Bureau, through the interviews with old people, the writer got buying factors and feedback of the elderly towards the walking vehicle. With scientific research methods, the author studied the behavioral and physical features of the aged. The study shows the results of activity and self-care of the aged by the method of observation and interview, and the results of change of the static body size and activity range by the method of measurement. The author applied the behavioral results to the optimizing the function of the walking vehicle, applied the physical results to the whole form structure and component size of the walking vehicle, based on the principles of safety, accessibility and comfort, therefore, the relationship between the aged and the walking vehicle is more harmonious and the product meets the demands of the aged.

Keywords: ergonomics, the aged, walking vehicle, barrier-free design

1. Introduction

According to the report which Chinese academy of social sciences has recently released, the aged population in China has increased. By the end of 2012, the aged population of over sixty has reached 193.9 million, counting of 14.3 percent of the total population and increasing by 0.59 percent. The incrementation of the aged population will reach 10 million a year in the future, to 400 million by 2033. Therefore, the demographic structure has stepped into the aged structure with large aged population in China. Due to the degradation of physiological function, the aged are liable to fall over and put themselves in danger. Therefore, improving the safety and quality conditions of transportation has attracted increasing attention. Through researches on walking vehicles for the aged and analysis of physiological characteristics of the aged and barrier-free design requirement of walking vehicle, safe and comfortable walking vehicles were designed in the paper.

2. Market research and analysis on walking vehicles
2.1 Analysis on the current products

The existing walking vehicles in current market can be divided into several types: manual and electric vehicles by the driving method, folding to carry and unfolding by the structure and portability, and storage capacity and non-storage capacity by the storage options. Obstacles in using the walking vehicles in current market can be listed as follows. First, with respect to the morphology, the function arrangement of the operating interface is not in accord with Ergonomics and is not convenient for the aged to use. For example, the hand brake is in the lateral of pistol grip which needs palm valgus when using. Also the color of function parts makes the aged dazzling. Second, in terms of the structure, the folded vehicle needs too much space to move and pile up. Third, on the material, the vehicle is too heavy that the aged cannot carry alone.

2.2 Research on product requirement

With the method of questionnaire survey, taking one hundred and twenty-four elderly people over the age of 65 as the research objects in Nanjing, Zhenjiang, Changzhou, Suzhou, Shanghai, Fuzhou, etc. via the Chinese Ministry of Civil Affairs and the local civil affairs bureaus, the questionnaires were sent to the target groups and feedbacks were collected.

Statistical analysis of the results of the survey, the motivational factors in buying walking vehicles include: (1) preventing falling over (37.9%); (2) hospitalization or assisted recovery after discharge (21%). (3) shopping (17%); (4) long-distance walking (14.5%); (5) buying food nearby (9.7%). Thus, the motivation of the aged to buy walking vehicles was due to physiological factors (poor legs and physical strength, unable to keep the balance of walking and longtime walking), accounting for 58.9%.

Figure 1. The statistical results of the survey on factors of choosing a walking vehicle

Figure 2. The statistical results of the usage feedback on walking vehicles
The feedback of the aged when using walking vehicles includes: (1) poor after-sale services (45.2%). For example, domestic entities shops (rehabilitation center and pharmacy) are selling walking vehicle with relatively more brands and specifications, but seldom provide accessories. The vehicles cannot be repaired after damaged, maintained or updated, so the aged have to buy a new one. The walking vehicle parts are not general and do not form a unified standard, causing great waste of social resources; (2) too expensive (25%); (3) unsuitable product size (17.7%). According to the age segmentation and regional differences in China, the differences in body size of the aged is big. However, the size of the product is relatively single and it is difficult for many elderly people to choose products suitable to their body sizes; (4) unreasonable design (12.1%). Therefore, walking vehicle usage feedback is mainly due to poor after-sales services, accounting for 45.2%. Manufacturers not only "sell" products, also need to be concerned with the users who know how to "use". Relevant national industry departments should pay attention to that and related standards and specifications should be formulated.

3. Barrier-free Design principles of walking vehicles

The design of walking vehicles should center on convenient use for people with disabilities, the aged and disabled, and must accord with human engineering.

(1) Security principles. Due to muscle atrophy, osteoporosis, declining sports function and poor legs, the aged are easy to fall over. After squat and standing up, it is also easy to lose balance, dizzy and fall over. Security should be the prime factor as far as the walking vehicles are concerned.

(2) Easy use principle. According to the survey, most of the aged in different degrees suffer "science and technology phobia", for example, they cannot use mobile phones, the Internet or even turn on TV. It is a very common phenomenon that the aged can't learn and use hi-tech products skillfully in life just like the youth. Due to the vision degradation in the aged, concise visual design and clear color are better used; simplified function design and simple steps should be applied because of the amnesia [6]. It is suitable to use subtraction method in the design for the aged.

(3) Comfort principle. The detail processing of walking vehicle must embody comfort and humanity, with reasonable structure, beautiful form and comfortable materials, making the elderly feel comfortable.

4. Design examples and Ergonomics analysis of walking vehicles

In the premise of walking vehicle research, on the basis of ergonomics, walking vehicles were analyzed from "human-machine (object)-environment" systematical view, a student majoring in industrial design, was guided to design and make a walking vehicle.

4.1 Human factor

Sports function. Due to physiological changes the sports function of the aged could be shown as follows: (1) declining physical coordination function and balance ability, more difficult to balance for a long time and prone
to fall; (2) lower position control ability, resulting in lower physiological posture control ability and increasing pose obliquity \[^{6,7}\]; (3) muscle recession, limb strength weakening and lower accuracy of the hand movements.

**Human dimensions.** According to "Chinese adult body size" GB10000-88, as shown in table 1, The height, cubits height, legs and feet height, hip breadth and sitting depth were selected as the dimension design basis of walking vehicle designed for the aged. The body size was shrinking in the aged as the growth of the age, the most obvious was in height. Scientific research results showed that the people at the age of 28 ~ 30 have peak height, but gradually decreased after the age of 35 ~ 40.

<table>
<thead>
<tr>
<th>Measurement Items</th>
<th>Age Group</th>
<th>36~60（Male）</th>
<th>36~55（Female）</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentile</td>
<td>10 50 90</td>
<td>10 50 90</td>
</tr>
<tr>
<td>Height</td>
<td></td>
<td>1596 1667 1739</td>
<td>1494 1560 1627</td>
</tr>
<tr>
<td>Cubits height</td>
<td></td>
<td>963 1019 1072</td>
<td>908 956 1004</td>
</tr>
<tr>
<td>Legs and feet height</td>
<td></td>
<td>386 409 435</td>
<td>344 379 396</td>
</tr>
<tr>
<td>Hip width</td>
<td></td>
<td>304 327 354</td>
<td>325 353 382</td>
</tr>
<tr>
<td>Sitting depth</td>
<td></td>
<td>428 457 486</td>
<td>406 432 461</td>
</tr>
</tbody>
</table>

Generally the height at the age of 70 will be reduced by 2.5% ~ 3%, women sometimes by 6% in maximum \[^{8-9}\]. The maximum height in youth and the values of the aged after shrinking were listed, as shown in figure 3.

**Behavior characteristics.** (1) Physiological effects of psychology and behavior. Behavior characteristics of the aged will change in accord with the change of the physiological characteristics. The simulating behaviors in use of a walking vehicle were hand hold handrail and standing, sitting on the walking vehicle and walking by pushing the walking vehicle. The main characteristics were unbalanced walking postures, slow pace, decreasing walking step, uneven body pressure distribution between the two legs, affecting balance; (2) the action reaction, slow reaction and motion; (3) in the design the relationship between the center of gravity and total weight should be coordinated.
4.2 Factors of walking vehicle

(1) **Function.** Based on the decreasing balance ability in the aged, more difficult to keep longtime balance and easy to fall over, walking vehicles need to help the aged keep body posture balanced. The aged can hold handles to keep walking balance and when encountered obstacles, the aged can use the brake to stop the walking vehicle, as shown in figure 4. Based on the physiological characteristics of the weakened limb strength, the walking vehicle should be designed to promote energy saving. Due to the weakened physical strength, the seat of the walking vehicle should provide the aged with a place to take a rest. Considering the aged cannot carry heavy things for a long time, a storage basket under the seating cushion can be very convenient. Additional features can be realized, such as GPS positioning function in the handles (yellow part in figure 6), convenient real-time positioning helping family know the position, and the fluorescent pigment on the rear wheel, can be a reminder to others to give way to the aged in the dark.

(2) **Size and shape.** The size design was based on the size of the aged (atrophy) and spine (curved) form, as shown in figure 4. The design basis of functional size, selection principle, percentile, measured value and application value were shown in table 2.

![Figure 4](image-url) Human dimensions as the design principles of the walking vehicle

The shape was designed by the behavior characteristics and needs of the aged (pushing in standing position and rest in sitting position) combined with human body size as the design basis, as shown in figure 4. The relationship between human body size and standing and sitting postures was shown in the figure. The size of the walking vehicle parts corresponded to the human body size, more in accord with human body engineering; on the interface, the hand brake should be placed in the lower part, as shown in figure 6, accord with people's habits and ergonomics. The handbrake grips shall use soft and elastic material to make it more comfortable and the handbrake shall use flat and stainless steel to make it more secure.

<table>
<thead>
<tr>
<th>Size</th>
<th>Design principle</th>
<th>Selection principle</th>
<th>Percentile</th>
<th>Measured value</th>
<th>Application value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armrest height</td>
<td>Cubits height</td>
<td>Reachable</td>
<td>Female 10</td>
<td>908</td>
<td>770</td>
</tr>
<tr>
<td>Sitting height</td>
<td>Legs and feet height</td>
<td>Reachable</td>
<td>Female 10</td>
<td>344</td>
<td>430</td>
</tr>
<tr>
<td>Sitting depth</td>
<td>Sitting depth</td>
<td>Minimum</td>
<td>Female 10</td>
<td>406</td>
<td>420</td>
</tr>
<tr>
<td>Sitting width</td>
<td>Hip breadth</td>
<td>Be hold</td>
<td>Female 90</td>
<td>382</td>
<td>450</td>
</tr>
</tbody>
</table>

Table 2. The design principle of the walking vehicle size (mm)
(3) **Material and Weight.** In view of the characteristics of weakened limb strength in the aged, and the fact that now most urban residents live in buildings, overall material should be light. Through the questionnaires, the single mobile force of 65 ~ 70-year-old man (city) was under 12.6 kg (burden not felt in 5 minutes). Strong and professional exercisers (farming workers) could bear heavier weight. The walking vehicle designed in the paper was 5.9 kg in net weight. Aluminum alloy profiles with light weight and high strength could be chosen.

(4) **Structure.** Considering that the walking vehicle sometimes might be taken to public transport (subways and buses, etc.) and private cars, the vehicle should be designed to be folded and easy to carry. The folding structure was shown in figure 5 and after folding the vehicle was in small volume and energy conserved when carrying.

![Figure 5. The folding structure of the walking vehicle](image)

The figure 6 showed the prototype of the walking vehicle rendering into 1:1 prototype. In the production of prototype, the size and structural mechanics were fully considered, trying to achieve the safety, comfort and beauty.

![Figure 6. The design rendering and proto of the walking vehicle](image)

5. **Conclusion**

Based on the research on walking vehicles status for the aged and user needs, combined with the barrier-free design principles, with the physical function, body size and behavior features of the aged, the function, shape, material and structure of a walking vehicle were specifically analyzed, a kind of walking vehicle was designed and the design renderings and the prototype were provided as the reference for related
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References