Design of Backpack to Aid Elderly for the Mazu Touring Procession in Taiwan

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Abstract. The Dajia Mazu Touring Procession is a 9-day long religious event held annually. However, for the elderly participants, it is a big burden especially in regards to physical strength. The goal of designing a backpack is to reduce the physiological stress of elderly during the procession. Firstly, physical parameters were measured to explore the dimension parameters by testing. The height of the chair is different from that of the kneeling pad; a smooth curve was chosen to coordinate the two as the main outline of the backpack. Secondly, material selections based on following limits were considered: (1) acceptable weight and size, (2) intermediate price and (3) a design that is fitting to the Dajia event. The material and structural strength were evaluated for wood, bamboo, stainless steel. Two design concept were proposed, wood is selected for construction and testing by users. The texture of the backpack is Rush grass, it was built successfully to cover the backpack’s external surface to meet local culture features.

1. Introduction
The annual eight-day Mazu Holy Pilgrimage, which usually takes place in April, is a religious festival that begins at Zhenlan Temple (zhènlángōng) in Dajia (dàjià), Taichung County to Fengtian Temple (fèngtiāngōng) in Xingang (xīngǎng), Chiayi County [1]. It perhaps is one of the most bizarre of all Taiwan’s religious festivals. The pilgrimage traces its roots to the early nineteenth century, when Taiwanese pilgrims would cross the Taiwan Strait to the Mazu “mother temple” in Meizhou in Fujian every twelve years. The core procession comprises a series of palanquins that ferry Mazu and other senior Taoist deities 200 kilometers through rice fields and small villages. Stops are made at smaller “branch” temples to enhance the power of local deities. The statue remains in Xingang for a day of celebrations for Mazu’s birthday before embarking on its four-day journey back to Dajia.

Pilgrims usually participate in the full trip by walking. For the elderly pilgrims, the burden of physical strength is especially consequential. Relying only on perseverance in the long journey, the elderly occasionally need to kneel in prayer for blessing of their families. To comply with formalities and tradition, one will have to kneel with the head touching the ground, which is an especially difficult task for the elderly.

Supporting of the core muscles group is required in order to go from kneeling to standing position. The abdominal muscles need a strong contraction of the organs within the abdomen to produce some
pressure to help evenly distribute the force to the entire spine. Usually people train muscle endurance and core muscle groups under stable circumstances. If the abdominal muscles do not have enough contraction force, muscles on the lower back may easily become fatigued or sore. By kneeling, the knee joint may also be damaged. Sports knee-pads are commonly used by football goalkeepers, volleyball players, as well as male and female hip-hop dancers. Thickened sponge knee pads are fabricated with highly elastic knitted fabric (which will not shift in position during the bending), with sponge lining added to provide protection for the knee. One of the shortcomings of sponge filling knee pads is that it causes pressure around joint during walking. The kneeling stool can be used in temples, and usually consists of soft material wrapped with leather. High-density foam is often used as the soft material to reduce the impact as the knee touches the pad. Through the sloped surface and the foot support bar, the stool height is increased to 17 cm to reduce the joint pressure (figure 1). Apple News has reported [2] the launch of a newly designed “cool bench” for the Dajia Mazu Touring Procession, which allows the believers/pilgrims to sit down and rest at any time (figure 2). The bench is designed to be similar to a drum that can be tied to the waist. It is light weight and has an elastic surface for one to sit on. Because the stool is usually tied to the waist, and pilgrims walk most of the time during the procession, pilgrims will have to walk with the attached stool shaking behind their buttocks, which may not be aesthetically pleasing.

![Figure 1. Kneeling stool.](image1)

![Figure 2. Cool bench [2] for the touring procession.](image2)

2. Design parameters estimation

2.1. Previous study

Many scholars have studied the design of the seat to reduce the body load while getting up. In designing household chairs for the elderly to sit, the scholars discovered that (1) the elderly often have to rely on other objects to assist them in standing up, (2) low seat surface will make it more difficult for elders to stand up, (3) sometimes elderly people fall onto chair during standing. The study developed solution by means of a pneumatic bar mechanism to assist the elderly in standing up, which was found to require less effort for the elderly [3]. In the study of the dynamic needs for the elderly of...
the seat; the researchers found that the key parameters are the seat height and armrest height. They also study the chair armrest design, and found out that as the age of an elderly increase, the degradation of muscle strength makes it difficult for them to sit and move [4]. The best armrest position and height ranges are between 65 to 70 centimetres.

The items that a Pilgrim will need during Mazu touring procession include simple carry-on items such as cutlery, toiletries, clothing, medicine, water and food, most likely packed in a backpack. Since people will carry these things as they walk, the backpack weight should be light. When the item are placed in the backpack, the backpack can be converted into a temporary chair or kneeling pad. The size of the chair and kneeling pad needs to be optimized both in terms of convenience and supportiveness. To avoid interfering with walking, handrails should best be able to be collapsed. The location where the backpack and item can be opened and closed should be chosen carefully to provide convenience of access.

2.2. Chair and kneeling pad experiment

The experiments were planned according to the individual needs of the seat and the size of the kneeling pad. If the subject’s height is 160 cm, with sitting height of 28 cm, kneeling height of 13 cm, handrail height of 14 cm, then the total relative height is 42 cm [5].

The height of the chair and the height of the kneeling pad are different. Thus we take both height and use smooth curves to harmonize between the two parameters, to use as the main contour of the backpack. By sitting, one has his or her buttocks contact the chair surface; however, in kneeling, one has his or her knee in point contact with the knee pad, and will have to use the feet as a fulcrum to remain in balance. Thus the kneeling pad is designed to be lower than the chair. The height of the seat is also limited by the environmental constraints that occur as the user is walking. The handle is set at the levelled area at the top of the seat. The handler height is changed at the chosen position in order to determine suitable handle height. The height of the handle bar, relative to ground level, was changed to the thickness. The handle bar height relative to the ground level is 42 centimetres, and that of the handle bars height relative to the top of the chair is 13 centimeters [5].

From the experiment, it was discovered that, for subjects from different age groups, the change in joint angle over time from kneeling to standing is clearly different. The response change corresponds to elderly people is slow and there are slight shakings present (mild slope). This indicates either a lack of muscular strength or loss of flexibility in the ligaments, thus leading to a bit of struggle in standing up [6].

3. Concept design procedure

The proposed backpack auxiliary object can be used to carry items, and can be used to sit. The parameters that were researched can be applied on the design of the auxiliary object; the backpack needs to be made with lightweight materials, and auxiliary parts should be added so that the elderly can have support while squatting down or standing up, reducing the load on the knee. The combination of the seat, the objects for support, and the backpack makes the item convenient to use for the user. The curved appearance and the height difference of the item allows kneeling for prayer, and sitting for rest. Handle bars are added on the two sides of the item, so that the elderly have support while kneeling down or standing up. Thus, the physiological load can be reduced in the procession.

Material selections based on following limits were considered: (1) acceptable weight and size, (2) intermediate price. The material processing and structure strength were analyzed for wood, bamboo, stainless steel and plastic (table 1). Wood strength is not high, easy processing, the use of reinforcing ribs can maintain sufficient strength, but will also increase the weight. Curved wood technology can maintain sufficient tension; it requires tooling template and molding tool in manufacturing.

Bamboo is inherently lightweight and resilient, and can withstand pressure or force in a particular direction, but the strength is rapidly reduced when the joint is poorly handled. It also requires special techniques for bending and using tension to provide support. Plastic, for example Acrylic, can form continuous curved surface structure under specific temperature and pressure conditions and providing
sufficient strength. The forming cost is high; costs can not be shared in a small amount of production. The use of lightweight steel pipe structures with canvas tension property can provide durable support. The initial processing costs can also be controlled in a reasonable range. Owing to the initial prototyping cost, the wood and stainless steel were selected during brainstorming process.

| Table 1. Material selection considerations. |
|---------------------------------------------|
| Material | Weight | Strength | Processing | Cost |
|----------|--------|----------|------------|------|
| Wood     | ++     | +        | +          | ++   |
| Bamboo   | ++     | ++       | -          | -    |
| Plastic  | +      | +        | -          | -    |
| Steel    | ++     | ++       | +          | ++   |

4. Design A: stainless steel
Backpack topical material functions require waterproof, anti-wear. It can be divided into two categories, nylon or man-made fibres, each with different characteristics. Suggested fibres are more than 1000 denier for durability. The benefits of canvas are contact and comfortable. For waterproof consideration, it can be added another inner surface with waterproof protective material. Although the canvas is heavier but more suitable materials, it can fulfill the need of outdoor activities and durable in pressure.

Considering the balance of the spine, the left side of the spine will bend to the left, and ultimately will oppress to the lumbar spine. The shoulder strap of backpack is easy to fall, the user often unconsciously raise the shoulder to stabilize the shoulder strap. So that the shoulder muscles stay in a state of contraction, which lead to shoulder pain and joint muscle strain and causes shoulder and back problems. Carrying heavy items, it is appropriate to use double shoulder strap. By utilize good back plate (figure 3), the body can in line with the body’s three-dimensional structure, to strengthen the protection of the lower back and shock absorption. The guide grooves with air convection channel that made by heat conducted material also can improve heat dissipation ability.

The proposed concept design has dual shoulder straps (figure 4). Through the reinforced material within the backplane, it can support sitting or kneeling posture. The 2D computer product sketch is presented in Figure 5, kneeling posture schematic diagram is also shown. In the future, through part modularize it can provide required sitting and kneeling support.

![Figure 3. Guide grooves with air convection channel.](image3)

![Figure 4. Design A: inner structure is stainless steel, outer surface is canvas.](image4)
5. Design B: wood

5.1. Support handle
As the backpack is placed on the ground, by changing the direction the backpack may become a seat or a kneeling pad. On the two sides of the backpack there are handles that can assist in standing up. As the user wants to stand up, the auxiliary handle can be extended outwards (figure 6), and after it is stabilized it can be held as a handle to assist the elderly in standing up. In order to avoid interfering others during the march, the handle have features that allow folding, and can be opened during use (figure 7).

Figure 5. Kneeling posture schematic.

Figure 6. Handle usage and the kneeling pad.

Figure 7. Combination of the seat, support, and the backpack
5.2. Surface texture of Rush grass
To incorporate spatial capacity, appearance in sitting and kneeling, and to assist in standing, two design concepts were selected for model construction and user testing. The texture of the backpack is Rush grass (*Cyperus malaccensis*) [7]. Historically, local people use wild ridge grass with sub-root transplanted to paddy fields, and after harvested treatment, transform grass into thin strips, and wove them into beautiful straw mattresses. Triangular cross sections of grass were utilized in hand-woven weaving, producing a soft texture that exudes a touch of fragrance and cool feeling in summer [8]. In the final design process, rush grass is successfully used to cover the backpack’s external surface (see figure 8) to express local cultural features.

![Figure 8. Rush grass surface texture by hand-woven weaving (Mrs. Y J Sun).](image)

6. Conclusions
The backpack combines a seat and a kneeling pad, with auxiliary handles to assist in standing up, allowing the elderly to have support while kneeling down or rising up, thus reducing the physiological load for elderly during the Mazu Touring Procession. The curved appearance and use of lightweight materials does not increase the weight by too much; the item will have affordable weight, size, and price, and is designed with an appearance that is compatible with the local image, and thus can be accepted by consumers, which is the goal that the designer pursuing.

References
[1] Http://travel.cnn.com/taiwan-mazu-religious-festival-pilgrimage-226351/
[2] Apple Daily April 2016 http://www.appledaily.com.tw/realtimenews/article/new/20160408/834412/.
[3] Doorenbosch C A, Harlaar J, Roebroeck M E and Lankhorst G J 1994 Two strategies of transferring from sit-to-stand: the activation of monoarticular and biarticular muscles *Journal of Biomechanics* 27 1299-1307
[4] Dubost V, Beauchet O, Manckoundia P, Herrmann F and Mourey F 2005 Decreased trunk angular displacement during sitting down; an early feature of ageing *Physical Therapy* 85 804-81
[5] Chao F L 2017 Parameter estimation of assisting objects to aid elderly for Mazu touring procession *Ergonomics Society of Taiwan conference* Quemoy R.O.C 100-105
[6] Khemlan M M, Carr J H and Crosbie W J 1999 Muscle Synergies and joint linkages in sit-to-stand under two initial foot positions *Clinical Biomechanics* 14 236-246
[7] Http://tropical.theferns.info/viewtropical.php?id=Cyperus+malaccensis
[8] Http://www.mdnkids.com/taiwan_library/index2.asp