The Test of a Motor-powered Assistive Sofa for Elderly People

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Abstract: Sit-to-stand and stand-to-sit (STS) are considered to be one of the most challenging movements for elderly people in their daily life. Many fall accidents happened during STS maneuvers. An assistive chair may help elderly people sit down or stand up easily and prevent them from fall accidents. Sofa may be considered as one of the most common furniture in living rooms. However, the low seat height and soft padding may let elderly people reluctant to use it. As a result, it jeopardizes at least two universal design principles, equitable to use and low physical effort to use. There is a need to design an assistive sofa for elderly people. In a previous study, a motor-powered assistive sofa was designed by the author. This study aims to test the usability of the sofa. The test was conducted in within-subjects design. 10 subjects, aged over 65 years old, 5 males and 5 females, were recruited to test the sofa. Subjects tested two settings of sofa randomly, one with motor-powered seat (assistive), the other without motor-powered (non-assistive). Leaning trunk angles were monitored with BTS SMART-D 140 motion study system. At meantime the muscle electro-graph changes were monitored by an EMG module. Subjective satisfaction was also measured by a Likert Scale after the test. Results found that the differences between assistive and non-assistive sofa were found significant on the left leg for all subjects, whereas significant on both legs for males. The leaning trunk angles on assistive sofa were found significantly less than non-assistive one. This means the assistive sofa might be effective in helping subjects stand up and sit down, although the subjective satisfaction measure showed no difference.

Key words: elderly people, assistive technology, sofa, STS, universal design

1. Introduction

Sit-to-stand and stand-to-sit have been considered to be one of the most challenging movements older people encounter in their daily life [4]. Many fall accidents occur during these movements. Lehtola et al. [3] reported, after a two-year observation of 555 elders (the average age is 85), that 12% of falls occurred during the daily routines of standing up and sitting down. It has been observed that elderly subjects experienced difficulties in moving in and out of a chair [2], and therefore it is crucial to design a chair that can assist elderly people to safely stand up and sit down on a chair.

Huang [1] proposed a chair design that uses a gas spring installed underneath the seat to support part of the user's weight and to reduce the pressure on his/her lower limbs. The design was evaluated by 22 elderly subjects. It found the subjects using the chair had a smaller leaning angle than using a regular chair. This finding indicated that elderly people might be benefitted in using the design. 80% of subjects claimed that the design is easy to use.

However, the design did not fit for people in different weights, i.e., a heavier person needs a heavier support whereas a lighter one needs lighter support. An electric motor-powered assistive chair design which can support people in different weights was then proposed to solve this problem. Instead of chair, sofa was chosen because it may be considered as the most popular furniture in a living room nowadays. To fulfill the principles universal design, a sofa should fit for everyone in the house, including elderly adults.

The prototype of the design is shown in Figure 1. There is a motor installed underneath the seat which is controlled by a handheld controller. The user can control the seat up and down according to his need. The aim of this study is to test the prototype to see if powered seat works better than unpowered.

Figure 1. The prototype of motor-powered sofa (the seat was risen)

2. Methods

A within-subjects experiment design was adopted in this study. 10 elderly adults aged over 65 years old, five males and five females, were recruited to test the prototype according to the following procedures.

1. The aim and test procedures are explained to the subjects.
2. Filling up the data sheets. For those who are unable to fill up the sheets by themselves, alternatively, helps will be provided by the researchers.
3. Measuring the statue, weight and other anthropometric measurements, including shoulder height, trochanter height and knee height.
4. Marking the joints, including right shoulder, trochanter, knee, ankle and the first joint of little finger, with 5 reflective balls (Figure 2).
5. Sticking two electrode pads on the quadriceps of both thighs of the subject (Figure 3).
6. Testing two modes of the prototype, i.e. the powered and unpowered seat randomly to avoid learning effects.

Details of testing procedures are described as below.

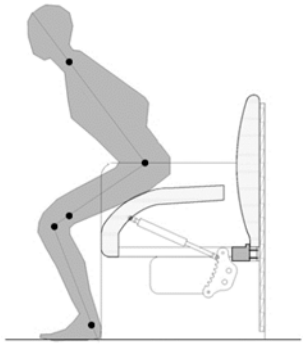

Figure 2.　Positions of reflective balls for motion-capture system

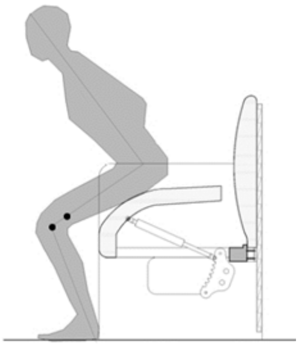

Figure 3. Sticking position for EMG electrode pads

2.1 Test of unpowered mode

2.1.1 standing up

Subjects were asked to sit down on the sofa at the beginning.　After a 5-seconds rest, the subjects were asked to stand up from the unpowered seat.　Movements were monitored with a motion-capture system and Free EMG (Figure 4).　An enquiry about how he/she was satisfied in safety and easiness respectively was followed.

2.1.2 sitting down

Subjects were asked to sit down on the sofa.　The movement was monitored with a motion-capture system and Free EMG.　A questionnaire n Likert Scale about easiness and safety in use was followed.

2. 2 Test of powered mode

Before the test, how to operate the motor-powered sofa was explained to the subject.　Subjects were allowed practice it until they were comfortable with the operation.　Both the standing up and sitting down were repeated three times according to the same process of the unpowered mode.　Average values were calculated.

Figure 4.　Motion-capture system for the test

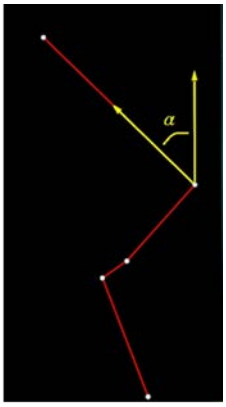

Figure 5.　A sample of leaning angle obtained form the motion capture system

3. Results and discussion

The leaning angle of the subjects during the test was captured by a motion capture system for further analysis (Figure 5).　At mean time, Free-EMG was used to monitor the EMG changes on the quadriceps of the subjects. These data was collected and analyzed by Smart-D Analyzer to see the differences between the performances of the powered and unpowered sofas.　The subjective satisfaction ratings on easiness and safety were also compared to justify the results.　The results are discussed below.

3.1 descriptive statistics

10 subjects aged over 65, 5 males and 5 females, who is able to walk freely were recruited to do the test. Their average age, stature, weight, shoulder height, trochanter height, knee height are listed on Table 1.

Table 1 Descriptive data of subjects (N=10)

Variables	Mean(SD)	Min.	Max.
Age (years)	71.2(5.25)	65	83
Stature (cm)	159.6(7.67)	150	170
Weight (kg)	64.9(15.95)	45	95
Shoulder height (cm)	129.5(5.00)	117	141
Trochanter height (cm)	91.7(6.59)	84	105
Knee height (cm)	46.2(5.81)	39	60

3.2 Leaning angles

The trunk leaning angles (Figure 5) of the subjects rising up and sitting down on motor-powered and unpowered sofas are listed on Table 2. The leaning angles of the subjects when using motor-powered sofa are significantly lesser than using unpowered sofa on rising up ($p<0.05$). This means the motor-powered sofa may help subjects stand up more easily than the unpowered one. However, there are no differences when sitting down.

Table 2 Leaning angles

Movements		**Motor-powered(SD)**	**Unpowered (SD)**
Stand up	Mean (n=10)	49.97(10.20)*	64.18(11.13) *
	Male (n=5)	51.88(10.96)*	66.95(13.13) *
	Female (n=5)	48.07(10.24)*	61.40(9.33) *
Sit down	Mean (n=10)	60.70 (9.07)	56.80 (13.30)
	Male (n=5)	66.91 (8.73)	62.32 (17.43)
	Female (n=5)	54.49 (3.51)	51.29 (4.26)

*$p<0.05$

3.3 Free-EMG

The average EMG values on left and right thigh quadriceps during standing up and sitting down by powered and unpowered modes are listed on Table 3. In standing up, the average EMG value on left thigh quadriceps for powered mode is significantly lesser than unpowered mode, whereas no significant difference on right thigh quadriceps between powered and unpowered. This means that the subjects may exert less mussel power when use the powered sofa than unpowered did. This confirms the findings of leaning angles analysis.

Table 3 EMG values on thigh quadriceps (mv)

Movements		**Powered**		**Unpowered**	
		Left (SD)	Right (SD)	Left (SD)	Right (SD)
Stand up	Mean (n=10)	0.14(0.05)*	0.19(0.07)	0.21(0.09) *	0.23(0.08)
	Male (n=5)	0.11(0.02)*	0.17 (0.07)*	0.25(0.10) *	0.28(0.08) *
	Female (n=5)	0.16(0.05)	0.21(0.08)	0.16(0.05)	0.19(0.06)
Sit down	Mean (n=10)	0.21(0.12)	0.25(0.14)	0.14(0.05)	0.17(0.07)
	Male (n=5)	0.25(0.16)	0.31(0.18)	0.15(0.06)	0.19(0.08)
	Female (n=5)	0.17(0.06)	0.19(0.06)	0.13(0.05)	0.14(0.05)

*$p<0.05$

3.4 Subjective satisfaction analysis

Table 4 shows the subjective satisfaction on easiness and safety of powered and unpowered sofa in rising up and sitting down. It shows powered sofa are slightly easier to use than the unpowered one. However the difference is insignificant. On the contrast, the subjects may think the powered sofa is less safe than the unpowered one. Again, the difference is also insignificant. In sitting down, both the easiness and safety of powered sofa are slightly less than the unpowered one, but insignificant. Overall, there are no significant differences found between powered and unpowered sofa on easiness and safety in both rising up and sitting down.

Table 4 Subjective satisfaction

Movements		**easiness**		**safety**	
		Powered (SD)	Unpowered (SD)	Powered (SD)	**Unpowered (SD)**
Stand up	Mean (n=10)	4.05(1.54)	3.80(0.63)	4.05(1.54)	**4.15(0.75)**
	Male (n=5)	4.40(1.52)	3.80(0.67)	4.40(1.52)	**4.20(0.76)**
	Female (n=5)	3.70(1.64)	3.80(0.67)	3.70(1.64)	**4.10(0.82)**
Sit down	Mean (n=10)	3.90(1.51)	3.95(0.72)	3.60(1.61)	**4.15(0.75)**
	Male (n=5)	4.10(1.52)	3.80(0.67)	3.80(1.89)	**4.20(0.76)**
	Female (n=5)	3.70(1.64)	4.10(0.82)	3.40(1.47)	**4.10(0.82)**

$*p<0.05$

4. Discussions and Conclusions

This study tested powered and un-powered sofas to see the effects on both standing up and sitting down movements of the subjects. The result shows that, the average trunk leaning angle of the subjects in using powered sofa was smaller than using unpowered one. Correspondently, the average EMG value on the quadriceps of the subjects in using powered sofa is also smaller than the unpowered one. This may means the powered sofa can help elderly people to stand up more easily than the unpowered one. However, the result also shows that there is no significant difference between powered and unpowered sofa in sitting down on both the leaning angles and EMG values. Moreover, on the subjective satisfaction measures, the differences between powered and unpowered sofa, both easiness and safety, are not significant. This may conclude that the prototye may be helpful for elderly people but not good enough. Further improvements on the speed and power of the assistive mechanism are needed.

5. Acknowledgement

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6. References

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