designs

MDPI

Article

Development of Self-Help Lifting Pads for Elderly People with Difficulty in Sitting Up

Manatee Jitanan [1], Kamphon Saeng-iam [2,*], Ekathai Wirojsakunchai [3], Kuanchai Kakaew [2] and Usanee Lalitpasan [4]

[1] Department of Physical Education, Faculty of Education, Kasetsart University, Bangkok 10900, Thailand; fedumtj@ku.ac.th
[2] Department of Architecture, Faculty of Architecture, Kasetsart University, Bangkok 10900, Thailand; kuanchai.k@ku.th
[3] Department of Mechanical Engineering, Faculty of Engineering, Kasetsart University, Bangkok 10900, Thailand; fengeka@ku.ac.th
[4] Center for Teacher Education Research, Faculty of Education, Beijing Normal University, Beijing 100875, China; yanni.usanee@gmail.com
* Correspondence: kamphon.s@ku.ac.th; Tel.: +66-99-1945935

Abstract: As individuals age, physiological changes can make it increasingly difficult to sit up unassisted. This study aimed to develop ergonomic self-help lifting pads to aid elderly individuals. The first phase involved constructing the pads and a needs assessment with elderly participants and caregivers to survey the physical dimensions and requirements for the design. The second phase focused on cost, engineering, and usage efficiency. Cost efficiency was analyzed using descriptive statistics, engineering efficiency was assessed through testing seat cushion, force reduction, and electrical safety, and usage efficiency was evaluated with participants aged 40 to 50 years. Results from the first phase indicated that the pads should be at least 53.15 cm wide and 153 cm long, with a need for relaxation and affordability. In the second phase, prototype pads were developed according to these specifications. A cost analysis showed that while the manual pad was more expensive than comparable products, the other variants were more cost-effective. Engineering tests confirmed that the cushions met ASTM D3574 standards and that the electrical components conformed to IEC 60335 standards. Usage efficiency ratings were the highest for the massage system pad. Participant feedback indicated longer pads, more convenient controls, and increased cushion comfort, guiding the development of the second version.

Keywords: lifting pad; ergonomics; elderly

Citation: Jitanan, M.; Saeng-iam, K.; Wirojsakunchai, E.; Kakaew, K.; Lalitpasan, U. Development of Self-Help Lifting Pads for Elderly People with Difficulty in Sitting Up. *Designs* **2024**, *8*, 108. https://doi.org/10.3390/designs8060108

Academic Editor: Subburaj Karupppasamy

Received: 5 September 2024
Revised: 14 October 2024
Accepted: 18 October 2024
Published: 24 October 2024

1. Introduction

The number of elderly people is projected to increase from 727 million in 2020 to 1.5 billion by 2050 [1]. As people age, they experience physical changes that affect their movement, primarily due to the deterioration of the musculoskeletal system, which includes brittle bones and a decrease in muscle fiber size [2]. Difficulties sitting up from lying down results from the state of muscle deterioration, which requires the equipment to help the elderly easily sit up. Experts have developed devices to solve this problem in two main groups. The first group involves devices that help with sitting or standing, such as a standing assistance device for the elderly [3] and a bed-adjustable device (BEN) that helps elders sit up and step up and down from the bed easily and safely [4]. The second group involves beds that help with sitting or standing, such as the JOEY electrical bed, which helps the user to sit up and get out of bed easily [5] and the Pantographe patient bed, which can be electrically adjusted in five ways: high-low, backrest, knees raised, head high-feet low, and head low-feet high, with a cost of THB 59,000 or approximately USD 1612 [6].

However, the production of various devices is still limited in terms of relatively high budgets. It causes high prices that generally, elderly can hardly afford. Including the size of the device being quite large, which makes it inconvenient for transport or storage. Moreover, some types of devices require the strength of the elderly to hold onto the device to sit up. This is not suitable for elderly people who do not have the strength to hold the device. The self-help lifting pads were created for helping the elderly to help easy sitting up. They were designed to solve these problems with easy to get up, a suitable price, and convenient transport. Their design is based on ergonomics to avoid injuries and the needs of elderly people. They consist of three types: manual pad (expected price THB 5000 or USD 136), electrical pad (expected price THB 10,000 or USD 272), and massage pad (expected price THB 15,000 or USD 408). Furthermore, the pads can be compared to similar studies as shown in Table 1.

Table 1. The comparison of similar studies and self-help lifting pads.

Study	Prototype	Outstand Function	Comparison
Smart nursing wheelchairs: a new trend in assisted care and the future of multifunctional integration [7]	Smart nursing wheelchairs	• Position changing • Transferring • Bathing • Toileting • Voice recognition • Touch screens • Remote controls	The pads and wheelchair assist disabled people to use their life as normal but smart nursing wheelchairs have advanced interactive technologies that should be realized to improve the pads.
Understanding the user experience of lumbar-support-assistive devices for lower-back pain patients: design recommendations [8]	Lumbar-support-assistive devices (LSADs) such as back support belts	• Additional lumbar support • Lumbar rehabilitation	The pads and LSAD support people to relieve backpain. However, LSAD are wearable and more portable devices that can be used in any place compared to the pads.
Assistive devices: technology development for the visually impaired [9]	Low-cost devices: a smart cane, smart cap, and smart glove	• Smart cane: obstacle detection, geolocation, navigation, and alert generation • Smart cap: falls control, obstacle detection, UV notification, and geolocation • Smart glove: interface and identification	Price of the pads is required to be low as these assistive devices are meant for easy accessibility for disabled people. However, the cost of the pads (USD 150–450) is higher than assistive devices (USD 50 per device).

This research had the following objectives: (1) To assess the needs of the elderly who have difficulty sitting up for developing self-help lifting pad version 1. (2) Evaluate efficiency with cost, engineering, and usage of version 1. (3) Develop self-help lifting pad version 2.

2. Materials and Methods

The research team used the principle of ergonomics or human factors engineering for designing self-standing up pads. This concept provides a reduction in the risk of injuries when body parts are moving. Ergonomics is a learning integration of environment and task requirements for ultimate efficiency, quality, and quantity of task while decreasing task-engaged musculoskeletal disorders, tiredness, and overwork. Modifying ergonomics can decrease the risk of injuries and illness [10]. Human studies are an important element of ergonomics studies for addressing the problem of suiting the products to user characteristics [11]. Additionally, cost efficiency was an important aspect to avoid cases of financial uncertainty. Cost and resource productivity were necessary to ensure the continuity of their development [12].

The construction of the pad prototypes (version 1) followed the design thinking principle [13] with (1) Empathy to understand the needs of the elderly to use the pads. The multifunctional approach of innovations was important for efficiently and effectively addressing the diverse needs of the aging people [7]. (2) Defined the problem or difficulty to get up in this research. (3) Ideated with brainstorming to produce the prototype to solve the problem. (4) Prototyped with sketching, modeling, and producing. (5) Tested and evaluated the prototype based on safety.

The pads were developed and tested for user safety. The main part of the pads was a cushion that hid the lifting mechanism and various electrical equipment. The engineering test was divided into mechanical and electrical tests. The mechanism of the pads was tested for the cushion's ability to withstand stress according to ASTM D3574 standards [14] with foam compression (method A). The relationship between compressive force and stretch was evaluated. To evaluate labor savings, the test was performed by using the Myometer, the instrument measuring muscle strength of a specific function. The electrical system was tested according to IEC 60335 standards [15] to prevent electrical leakage for household and electrical appliances.

The pads were designed to be placed on a bed or a floor. The platform of the pads was to help elderly people get up from a lying position by themselves. The contact material of the pad cushion was synthetic leather. As for the structure, which is made of steel, the pad was designed to fold up in an area where the user can raise their knees, causing the system to spread again. The lifting system can move slowly to prevent the user from straining the supplement.

An analytical rubric was used for evaluating the pad usage efficiency. This technique was chosen due to its relatively ease for the participants [16]. The questionnaire used a five-Likert scale, engaging the minds of participants to bring out the truth of the answer [17].

The study of the efficiency of self-help lifting pads was separated into two phases:

2.1. Phase 1: Constructing the Pads and Needs Assessment

This phase started from reviewing ergonomic design that involved the design of the pad version 1, or the prototype. Then, researchers designed the pads following ergonomic principles and constructed the pads. After finishing the prototype construction, needs assessment was begun. Researchers collected qualitative data by interviewing elderly people who have difficulty sitting up to obtain data on the proper characteristics of the pads, including necessary data for the development from the perspective of elderly caregivers.

2.1.1. Participants of Phase 1

The population was elderly people and caregivers from the elderly club of Din Daeng district and Phaya Thai district, with a total of 65 people [18]. The sample size was set to be not less than 30 percent of the population [19]. The strength limit was defined as people whose weight was higher than the average population or body mass index (BMI) was 30 and above due to the limit weightlifting function of the pad. Therefore, the sample group was 15 people from a population of 50 people. However, the researcher determined that the number of sample groups should be increased to more than 30 people to cover the loss of the target group. Therefore, the sample group was obtained through voluntary means, totaling 37 people from the elderly club of Din Daeng district. The sample group was 33 elderly people who have difficulty sitting up and 4 elderly caregivers.

2.1.2. Data Collection of Phase 1

The tools for collecting data were interview forms of self-help lifting pad development for the elderly, body measurement forms for the elderly, interview forms for caregivers of elderly who have difficulty sitting up, the prototype of self-help lifting pads, screening forms for elderly who have difficulty sitting up, and functional independence measure (FIM). The questionnaires were approved by seven experts considering index of item objective congruence (IOC) passing the criterion of 0.50. This research phase was created

following approval of the research ethics by the Institutional Review Board of Kasetsart University (COA 66/027).

The researchers collected data by:

(1) Asking permission to collect data from the coordinator of the elderly club in Din Daeng district. After receiving permission, researchers set a date to collect data, explained research details, and invited elderly people and caregivers to participate in a research project.
(2) Allowing elderly participants to come to the elderly club following the appointment date and time (9 June 2023). Researchers explained the details of the research, including background, objectives, responsibilities of research subjects, risks, benefits, potential dangers of participating in research, and responsibilities of the researcher/research sponsor.
(3) Announcing the recruitment of elderly volunteers. Researchers conducted the interview and evaluated preliminary data. This was to ensure that elderly volunteers could be the sample group. Considering (1) being 60 years of age or older (2) being able to read, listen, and write Thai. (3) being an elderly person identified based on their perception that they have difficulty sitting up from answering screening questions. (4) being an elderly person with a high level of ability to perform activities from medium level and more (36 points or more) from responses to FIM. (5) being assessed as having no serious illness that would impede participation in the research. There was no serious illness such as a herniated spinal disc, dislocated spine, abnormal spinal curve, and (6) consent to participate in the research. The interview took no more than 15 min per person.
(4) Allowing the volunteers to sign a consent form to participate in the research when elderly volunteers decided to participate in the research.
(5) Interviewing the elderly, such as physical characteristics of the elderly (height, weight), daily activities, characteristics and methods of sitting up for the elderly, points where muscle pain occurs when changing postures, characteristics of the desired equipment to assist in getting up. Researchers presented pad prototypes for participants to consider initially. The elderly specified the characteristics of additional equipment to assist while sitting up. This may be the same or different from the prototypes. By giving the elderly participants the freedom to express their opinions freely, as well as inquiring about budgets and satisfactions of purchasing the equipment to assist with sitting up, researchers used this information for developing the pads version 2. The interview took no more than 15 min per person.
(6) Interviewing caregivers about the needs of the elderly for developing the pads.
(7) Analyzing all information for developing the pads version 1 to meet the needs of elderly people who have difficulties sitting up.

Qualitative data from the interviews were analyzed using content analysis by performing synthesis, classifying data types, comparing/categorizing interview words, counting frequencies, calculating percentages, and creating inductive conclusions.

2.2. Phase 2: Cost, Engineering, and Usage Efficiency

Cost efficiency was analyzed using descriptive statistics. Engineering efficiency was assessed through testing seat cushion, force reduction, and electrical safety. The seat cushion was tested with a Universal Testing Machine (UTM). Force reduction was examined by using the Macmesin Myometer. Electrical safety was tested with Chroma electrical safety analyzer model 19032.

2.2.1. Participants of Phase 2

Usage efficiency was evaluated with 40 participants aged from 40 to 50 years at Kasetsart University.

2.2.2. Data Collection of Phase 2

The tools for collecting usage efficiency data were the prototype of self-help lifting pads, manual with instructional video, self-help lifting pad efficiency assessment form, satisfaction interview form after using self-help lifting pad, and suggestions for developing self-help lifting pad. The questionnaires were approved by seven experts, considering IOC passing the criterion of 0.50. This research phase was created following approval of the research ethics by the Institutional Review Board of Kasetsart University (COA 66/067).

The researchers collected data by

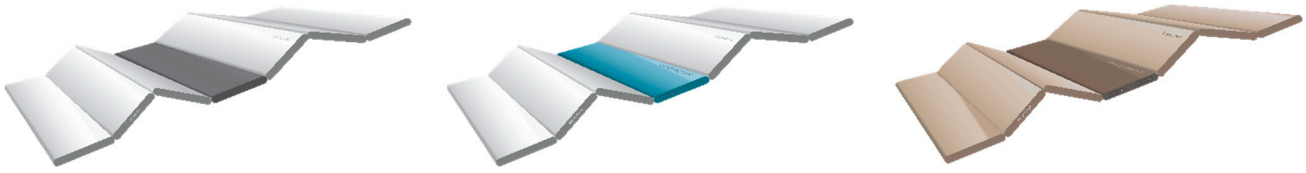
(1) Wrote a letter from the faculty of education to various departments in Kasetsart University requesting assistance from affiliated personnel recruiting volunteers aged 40–50 years.
(2) Invited volunteers who are interested in participating in the research project to make an appointment on a convenient date and time for participating in the research at the Faculty of Education, Kasetsart University.
(3) Recruited volunteers and checked qualifications according to the inclusion criteria.
(4) Allowed the volunteers to sign a letter expressing their consent to participate in the research.
(5) Explained the process of using the pads from the manual with the instructional video for volunteers to study before testing the pads.
(6) Allowed the volunteers to try out the pads. There was a physical therapist to examine the backs of volunteers and two nurses to ensure their safety. The duration of the trial was approximately 30 min, with 3 times per pad test, 2 min of rest for each test, for a total of 6 min of rest.
(7) Allowed volunteers to evaluate the pad efficiency by using the pads.
(8) Interviewed volunteers about their satisfaction while using the pads and discussed how to improve the pads and manual with instructional video. It took not over 15 min per person in each interview. Then, the researcher used the information obtained from the volunteers to develop the pads for version 2.

The analysis of the pad effectiveness used descriptive statistics (mean and standard deviation) and one-way ANOVA. The qualitative data obtained from the interviews was analyzed using content analysis, counting frequency percentages, and creating inductive conclusions.

3. Results

3.1. Phase 1

Researchers designed the pads based on ergonomics. The pads were produced in a factory as shown in Figures 1–3. We used different color for differentiating each function of the pad.



(**a**) (**b**) (**c**)

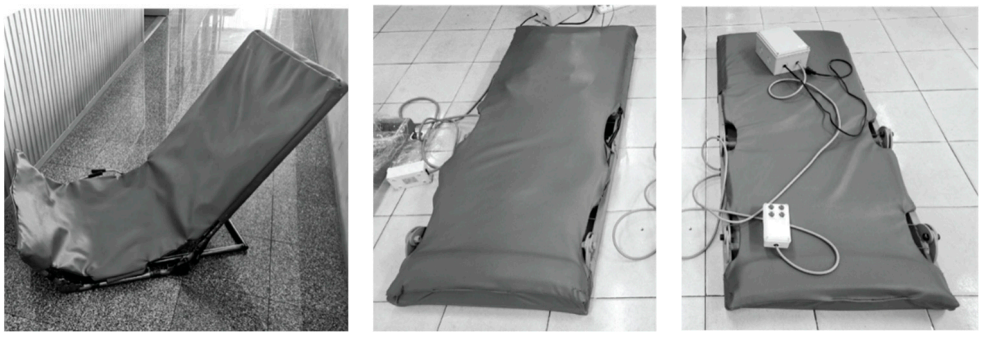
Figure 1. *Cont.*

(**d**)

Figure 1. Design of the pads: (**a**) Manual; Use one hand to pull up on the side lever for operating riser pad's tension mechanism for sitting up and kneeling; (**b**) Electrical; Use a finger to press the side button to adjust the plate up and down; (**c**) Electrical Massage system; Use a finger to press the side button to adjust the plate up and down. The pad has a massage system with 2 force levels; (**d**) Pad structure; Test the movement.

(**a**) (**b**) (**c**)

Figure 2. Pads production in a factory: (**a**) Structure; (**b**) Structure testing; (**c**) Cushion testing.



(**a**) (**b**) (**c**)

Figure 3. Pads version 1: (**a**) Manual pad; (**b**) Electrical pad; (**c**) Massage system pad.

The results of the study of the needs assessment were divided into two sections as follows.

(1) Proportions of Elderly People

The samples were male elderly 15.15% and female elderly 84.85%; average age was 72.18 years (SD = 6.30, Max = 86 years, Min = 60 years). The overall elderly proportion of 33 elderly samples followed Table 2.

Table 2. The 29 anthropometry dimensions of elderly proportion (n = 33).

Items	M	SD	Min	Max	P_5	P_{50}	P_{95}
Weight (kilogram)	60.05	11.14	43	86.6	44.33	59.90	84.08
Height	152.73	10.04	141	196.5	142.40	152.00	175.85
Eyes height	136.74	23.39	13.3	158	93.24	140.50	156.60
Shoulder height	124.26	6.99	111.5	137.5	113.25	124.00	136.10
Elbow height	97.17	10.16	87	143.5	87.70	95.00	118.30
Waist height	94.45	4.22	87.5	105.5	87.50	95.50	103.05
Knuckle height	68.12	4.65	59	81.5	59.35	68.00	78.35
Fingertip height	59.08	4.52	50.5	70.5	50.85	58.00	68.75
Both arms while extended	152.64	12.87	132	199	134.10	151.00	183.60
Elbow length when raising at chest level	82.55	6.06	70	94	71.40	82.00	93.30
Height when the arm is raised into a fist	169.64	22.02	60	193	126.50	172.00	190.90
Forward grip reach	55.73	3.29	49	62	49.70	56.00	61.30
Forward fingertip reach	68.45	18.22	59	168	59.70	66.00	100.80
Range from a bottom to a tip of a head when sitting	77.94	7.21	46	87	62.80	78.00	86.30
Range from the bottom to eyes when sitting	70.73	4.27	63	77	63.70	70.00	77.00
Range from the bottom to shoulder when sitting	52.79	4.31	46	63	46.70	53.00	61.60
Height from the bottom to elbow when sitting	21.76	2.77	15	26	15.70	22.00	26.00
Range from toe to knee when sitting	44.61	2.00	39	49	41.10	44.00	48.30
Range from hip to knee when sitting	51.55	2.82	44	57	46.10	52.00	55.60
Range from hip to knee joint when sitting	41.12	3.19	34	50	35.40	41.00	47.90
Back to side chest	36.18	8.29	19	54	21.10	38.00	51.20
shoulder breadth	53.15	7.31	40	71	41.40	54.00	68.90
Back of hips	46.94	6.23	37	62	37.70	46.00	59.90
Upper arm length	31.45	2.09	27	36	27.70	32.00	35.30
Bottom arm length to finger	41.48	2.29	38	47	38.00	42.00	46.30
Hand length at fingertip	13.30	1.10	10.6	15.4	11.02	13.40	14.91
Hand width above thumb	6.48	0.76	4.6	8	4.60	6.50	7.86
Inner diameter when the thumb and a middle finger are joined together	1.29	0.61	0.4	2.5	0.47	1.10	2.43

From the average measurement of shoulder breadth and height, the size of the self-help lifting pad should be not less than 53.15 cm wide and not less than 153 cm long.

(2) Interview results

Elderly samples required the self-help lifting pad as follows: (1) comfortable to use as resting (2) easy getting up (3) no back pain causing (4) no knee causing (5) convenient to use (6) suitable price (THB 5000 for manual pad, THB 10,000 for electrical pad, and THB 12,000 for massage system pad) (7) easy support to get up slowly (8) force saving. The electrical pad was the most preferred because most elderly people thought that it was convenient to use, followed by the manual pad and massage system pad. Caregivers reflected that difficulty in sitting up for the elderly was health problems that cause them to lack energy.

Most caregivers of the elderly agreed that the right device for easy getting up from sitting was a self-help lifting pad.

3.2. Phase 2

The results were divided into three sections as follows.

3.2.1. Cost Efficiency

The cost of the pads can be presented as shown in Table 3.

Table 3. Cost of the pads (THB).

Item	Pad Type		
	Manual	Electrical	Massage System
Raw material (steel, artificial leather upholstery)	833.33	1733.33	1733.33
Production (welding, Assy, upholstery costs, paint costs)	2316.67	2716.67	2916.67
Other supplements - Manual (gas choke, Koyo, KX gear lever type) - Electrical (Motor, power supply, push button set) - Massage system (Motor, Power Supply, push button set, massage cushion set)	1792	7098	11,678
Company overhead	247.10	577.40	697.40
Profit margin (20%)	1037.82	2425.08	2929.08
Total *	* 6226.92	14,550.48	19,954.48
Selling price (20%)	7500	17,500	24,000

* The costs did not include design costs and marginal production costs because this step was a pilot study.

Researchers compared the price of all pads with benchmarking products as shown in Table 4.

Table 4. Comparisons of the price of all pads and benchmarking products.

Type	Selling Price * (THB)	Benchmarking	Selling Price * (THB)	Price Difference
Manual	7500	Bed rail	1050	+6450
Electrical	17,500	Patient bed with 3 gears	19,600	−2100
Massage system	24,000	Pantographe electric patient bed	59,000	−35,000

* The price comparison used selling prices because the production costs of comparable companies were disclosed information.

The electrical pad and massage system pad had a lower selling price than benchmarking products. While the manual pad had a higher selling price than the benchmarking product. This was due to the developed mechanism of manual using a gas choke and KX Gear Lever Type, which was more complicated than the structure of the bed rail.

3.2.2. Engineering Efficiency

(1) Seat cushion: The test started by taking two samples (specimen 1 and specimen 2) with the same dimensions of 100 × 100 mm. Then the cushions are pressed using a Universal Testing Machine (UTM). The results showed the values in the form of force (Load, N) and compressive strain (%) by pressing the cushion twice of all specimens. They were derived from the calculation of the distance from pressing/height of the cushion. Values obtained from pressing at the range of 25% and 65% of the cushion thickness using a force of 30–50 N. These results were in accordance with ASTM D3574 (The standard used to examine the collapse of car seats, sofa cushions, and various furniture cushions).

(2) Force reduction: The manual pad was tested for force using the Mecmesin Myometer to measure the stress of the stomach muscles when sitting up (Figure 4). The testing samples included subjects A (male: 81 kg, 173 cm), B (male: 114 kg, 180 cm), and C (female: 52 kg, 154 cm).

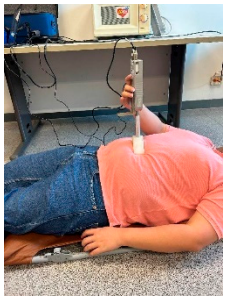


Figure 4. Position for measuring force from abdominal muscles in sitting up.

The results showed that a manual pad can reduce force in each subject for three testing times. However, the percentage of force reduction varies according to the physiology of each subject, as shown in Figure 4. This is because the spring mechanism has been designed to help while sitting up by considering the average weight of the Thai population, which tends towards subjects A and C as shown in Figure 5.

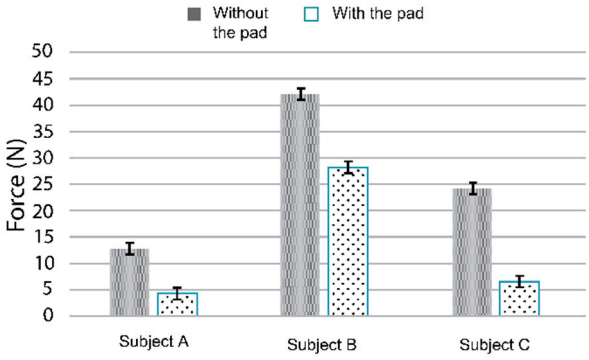


Figure 5. Samples comparing muscle exertion without the pad and with the pad.

3.2.3. Electrical Safety

Standard testing of residential electronic appliances was performed by testing the leakage current of the electrical/massage system pad with an electrical safety analysis set (Chroma Electrical Safety Analyzer Model 19032). The results showed that electrical leakage testing met IEC 60335 standards (Electrical safety standards for household equipment), as shown in Table 5.

Table 5. Electrical test.

Test Format	Pad Type	Result (mA)	IEC 60335
Leakage test without turning on electrical appliances	Massage system	2.26	Passed
Leakage test without turning on electrical appliances	Electrical	2.62	Passed
LC leakage test (Normal type)	Massage system	0.074	Passed
LC leakage test (Normal type)	Electrical	0.074	Passed
LC leakage test (Reverse type)	Massage system	0.076	Passed
LC leakage test (Reverse type)	Electrical	0.074	Passed

3.2.4. Usage Efficiency

The analysis for usage efficiency was considered based on functionality and quality, useful life, strength and safety ease of use, beautiful appearance and value for price, and the use of force by volunteers to lift themselves (according to perception). The results showed that all three pad types had a high efficiency. The massage system pad had the highest mean efficiency score (M = 4.41, SD = 0.60) as shown in Table 6.

Table 6. Efficiency evaluation results (n = 40).

Issue	Manual		Electrical		Massage System	
	M (SD)	Efficiency	M (SD)	Efficiency	M (SD)	Efficiency
Functionality and quality	3.68 (1.07)	High	4.28 (0.60)	High	4.60 (0.59)	Very high
Strength	4.00 (0.85)	High	4.18 (0.64)	High	4.48 (0.72)	High
Safety	3.95 (0.96)	High	4.25 (0.59)	High	4.53 (0.64)	Very high
Ease of use	3.58 (1.08)	High	4.38 (0.59)	High	4.60 (0.63)	Very high
Beautiful appearance	3.48 (0.88)	Medium	3.95 (0.68)	High	High	High
Value for price	3.40 (1.15)	Medium	3.83 (0.75)	High	High	High
Use of force	3.45 (1.11)	Medium	4.03 (0.80)	High	High	High
Total	3.68 (0.82)	High	4.12 (0.53)	High	4.41 (0.60)	High

Note: 1.00–1.49 = Very low efficiency, 1.50–2.49 = Low efficiency, 2.50–3.49 = Moderate efficiency, 3.50–4.49 = High efficiency, and 4.50–5.00 = Very high efficiency.

Furthermore, researchers evaluated the satisfaction after 40 samples using all 3 pad types. The satisfaction with the massage system pad was at the highest level (M = 4.45, SD = 0.78). An electrical pad had satisfaction at the high level (M = 4.03, SD = 0.62). The least satisfied pad was a manual pad with a moderate level (M = 3.30, SD = 0.97).

The samples recommended to develop the pads as shown in Table 7.

Table 7. Opinions and development guidelines of the pads and instructions.

Opinion	Development Guidelines
1. Manual pad (given opinions from 34 samples: 85%)	
• There was difficulty in using it because it needed to use force for lifting. It probably would be impossible to lift if a person had much weight.	• Improve mechanism for easier lifting.
• The handle was too stiff. It took a lot of force to pull the lever.	• Adjust the softness with the handle and less force to pull the lever.
• The seat cushion was rigid, thin, and has separate sections.	• Adjust the seat cushion to thicker and softer and improve the seat to have continuous cushion.
• The color looked too dark.	• Change the seat color to softer.
• The leg cushion was short.	• Extend the cushion to reach the length of feet.
• The design should be more beautiful.	• Adjust the design to be modern and beautiful.
2. Electrical pad (given opinions from 24 samples: 60%))	
• The control buttons were too big that made them difficult to press.	• Make smaller buttons for easier use, low force pressing button, and provide a remote control with a large description.
• The seat cushion was uncomfortable to sit on and too small. It should be adjustable according to the user's condition. The seat cushion style should increase the concavity. The cushion was too rigid.	• Adjust the seat cushion to softer and comfortable and a bit bigger.
• The leg cushion was short.	• Extend the cushion to reach the length of feet.
• The design should be more beautiful.	• Adjust the design to be modern and beautiful.

Table 7. *Cont.*

Opinion	Development Guidelines
3. Massage system pad (given opinions from 23 samples: 57.50%)	
• The control buttons were difficult to press.	• Make smaller buttons for easier use, low force pressing button, and provide a remote control with a large description.
• The seat cushion was uncomfortable and too small.	• Adjust the seat cushion to softer and comfortable and a bit bigger
• It has no waist massage. I would like to add massage to the waist area and a more powerful massage system. There should be a hip massage.	• May add waist massage and more massage force for the next project due to limited budget.
• the length of the leg cushion should be increased. The appearance should be more beautiful and interesting. It may be made into a bed.	• Adjust the design to be modern and beautiful. Extend the cushion to reach the length of feet.
• Steel parts should be covered with a cushion to keep the steel from sticking out because it might be dangerous.	• Cover the protruding steel parts for safety.
• All 3 pad types should be considered to produce for differ size of users.	• The pad sizes may be produced as small, medium, and large for further project implementation due to limited production time.
4. Manual with instructional video (given opinions from 11 samples: 27.50%)	
• The paper manual was not consistent with actual use. The design of instruction should be readable and have large letters including illustrations to explain the poses.	• Increase clarity in displaying usage, more readable, clear illustrations, and larger text.
• The instructional video should be more modern and interesting. Instructor should dress brightly with smiling face.	• Make explanatory video more interesting. Researcher may allow undergraduate students to present the pads with a bright smile.

Researchers used all data from phase 1 and phase 2 to develop the pads version 2 as shown in Figures 6–9.

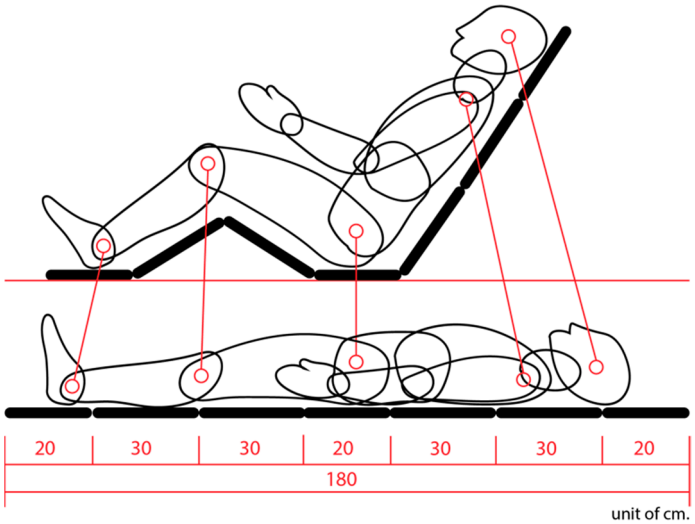


Figure 6. Application of anthropometric data in pads.

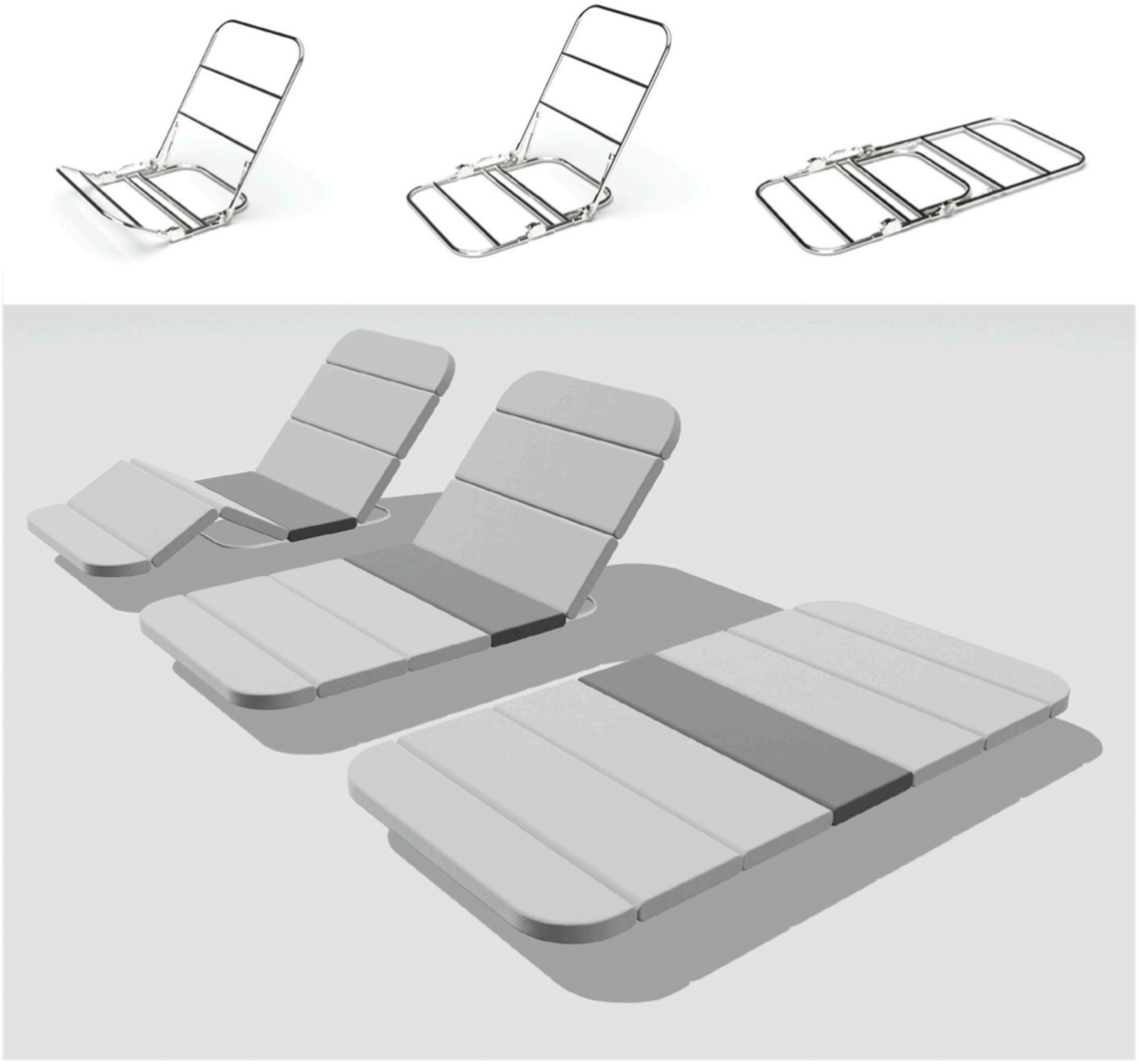


Figure 7. Design of pads version 2.

(**a**) (**b**) (**c**)

Figure 8. Finished products of pads version 2: (**a**) Manual pad; (**b**) Electrical pad; (**c**) Electrical massage system pad.

(**a**) (**b**)

Figure 9. Remote control of pads version 2: (**a**) Electrical pad; (**b**) Electrical massage system pad.

4. Discussions

The key findings revealed that the elderly participants required relaxation, a slow sit-up mechanism, and affordable equipment to help them get up easier. This information is associated with the review about understanding the care and support needs of older people. It pointed out that elderly people had a range of physical, social, and psychological challenges because living with chronic status needed care and support. However, they lack professional suggestions on self-care methods and care support services [20].

To support health care for the elderly, assistive equipment had an important role to play because it provided functional performance of activities, decreased disabilities to perform activities, and led to a better quality of life [21]. Furthermore, the study about knowledge and attitude of the elderly recommended that the elderly should be educated to improve their positive knowledge and attitude regarding assistive equipment [22]. Cost efficiency is necessary for economic viability. The lower price of the pads opens higher accessibility of the pads for the elderly population. However, the pad production may require a low cost of electronic components to decrease the price of the pads. However, it can lead to low accuracy, potentially compromising the final product's function accuracy [9]. Therefore, self-help care equipment with positive knowledge and attitude with cost efficiency was necessary to support them.

The efficiency of the pads showed that the massage system was mostly required among all pad types. The study of massage therapy showed positive effects from people who had experienced massage. It was because massage therapy provided more stimulation of pressure receptors, which, in turn, increased vagal activity and decreased cortisol levels [23]. Additionally, women with poor health-related quality of life were found to use more massage therapy in the treatment of their chronic illness [24].

5. Conclusions

Self-help lifting pads were developed from ergonomic design and design thinking concepts to construct the pad prototypes (version 1). After finishing the prototype, researchers collected the needs of elderly people with difficulty sitting up data and evaluated cost, engineering, and usage efficiency to develop the pads version 2. The research limitations included a limited 45 to 50 kg weight of user who can efficiently use a manual pad, a delay of importing motors from another country to assemble in the pads, and a delay of asking research ethics. Researchers recommend that it needs to be planned if a time delay happens for any research that engages the anatomy of elderly people. The manual pad should be further developed for any weight user. The size of the pads can be manufactured as small,

medium, and large for the future project. The material of the pad cushion can be changed to a natural latex mattress for more comfort.

6. Patents

Researchers asked for the patents of the pads. It is on a progression.

Author Contributions: Conceptualization, M.J.; methodology, U.L.; validation, E.W., K.S.-i. and K.K.; formal analysis, U.L.; investigation, E.W. and K.K.; resources, E.W. and K.K.; data curation, U.L.; writing—original draft preparation, M.J.; writing—review and editing, K.S.-i. and E.W.; visualization, K.S.-i. and K.K.; supervision, K.S.-i.; project administration, M.J.; funding acquisition, M.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Research Council of Thailand, grant number N34A650687.

Data Availability Statement: Where data are unavailable due to.

Acknowledgments: We are grateful to Kasetsart University and the National Research Council of Thailand, as well as the elderly club of Din Daeng district, Thailand, for their support in conducting this research.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. United Nations Department of Economic and Social Affairs. *World Population Ageing 2020 Highlights: Living Arrangements of Older Persons*; United Nations Department of Economic and Social Affairs; Population Division: New York, NY, USA, 2020; pp. 3–5. ISBN 9789211483475.
2. Nakphu, T.; Songthap, A. Self-care behavior of the elderly. *EAU Herit. J. Sci. Technol.* **2019**, *3*, 48–54. (In Thai)
3. Atcharit, S.; Srinoi, S.; Inthanon, N.; Thimata, M. Stand-up aid equipment for elders. *SAU J. Sci. Technol.* **2017**, *3*, 10–17.
4. BEN, a Device to Help Get In and Out of Bed and Adjustable for Sitting. Available online: https://www.mtec.or.th/ben/ (accessed on 20 June 2024).
5. Joey-Active Bed: The Mechanical Bed that Helps Bodily Movement for the Elderly and Patients. Available online: https://www.mtec.or.th/annual-report2020/en/joey-bed_en/index.html (accessed on 23 June 2024).
6. Pantographe Electric Bed. Available online: https://allwellhealthcare.com/product/pantographe34/ (accessed on 23 June 2024).
7. Zhang, Z.; Xu, P.; Wu, C.; Yu, H. Smart Nursing Wheelchairs: A New Trend in Assisted Care and the Future of Multifunctional Integration. *Biomimetics* **2024**, *9*, 492. [CrossRef] [PubMed]
8. Chen, Z.; Zhang, M.; Zhang, X.; Liu, C.; Wang, H. Understanding the User Experience of Lumbar-Support-Assistive Devices in Lower-Back Pain Patients: Design Recommendations. *Appl. Sci.* **2024**, *14*, 7495. [CrossRef]
9. Beingolea, J.R.; Zea-Vargas, M.A.; Huallpa, R.; Vilca, X.; Bolivar, R.; Rendulich, J. Assistive Devices: Technology Development for the Visually Impaired. *Designs* **2021**, *5*, 75. [CrossRef]
10. Ergonomics. Available online: https://www.ncbi.nlm.nih.gov/books/NBK580551/ (accessed on 24 June 2024).
11. Dianat, I.; Molenbroek, J.; Castellucci, H.I. A review of the methodology and applications of anthropometry in ergonomics and product design. *Ergonomics* **2018**, *61*, 1696–1720. [CrossRef] [PubMed]
12. Narawish, C.; Sharma, D.; Rajest, S.; Rajan, R. Importance of Cost Efficiency in Critical Aspect of Influences the Decision-Making Process in Banks. *Türk Fiz. Ve Rehabil. Derg./Turk. J. Physiother. Rehabil.* **2022**, *32*, 47184–47212.
13. An Introduction to Design Thinking: Precess Guide. Available online: https://web.stanford.edu/~mshanks/MichaelShanks/files/509554.pdf (accessed on 27 June 2024).
14. Natika, N.; Sangkapong, N.; Promma, N. Evaluation of Material Parameters PE Foam Using Hyperelastic Model. *Eng. J. Chiangmai Univ.* **2021**, *28*, 1–11.
15. Vorapojpisut, S. A V-model framework for the certification against the Annex R of IEC 60335-1: Class B appliances. In Proceedings of the IEEE International Conference on Industrial Technology (ICIT), Taipei, Taiwan, 14–17 March 2016.
16. Beyrelï, L.; An, G. The use of analytic rubric in the assessment of writing performance -inter-rater concordance study. *Kuram Ve Uygulamada Egit. Bilim.* **2009**, *9*, 105–125.
17. Joshi, A.; Kale, S.; Chandel, S.; Pal, D. Likert Scale: Explored and Explained. *Br. J. Appl. Sci. Technol.* **2015**, *7*, 396–403. [CrossRef]
18. Information on Senior Citizens' Clubs in the Bangkok Area, Fiscal Year 2023. Available online: https://webportal.bangkok.go.th/public/user_files_editor/103/3Sor/Chomrom2566.pdf (accessed on 20 February 2024). (In Thai).

19. Identifying Population and Sample. Available online: https://www.ict.up.ac.th/surinthips/ResearchMethodology_2554/%E0%B9%80%E0%B8%AD%E0%B8%81%E0%B8%AA%E0%B8%B2%E0%B8%A3%E0%B9%80%E0%B8%9E%E0%B8%B4%E0%B9%88%E0%B8%A1%E0%B9%80%E0%B8%95%E0%B8%B4%E0%B8%A1/%E0%B8%81%E0%B8%B2%E0%B8%A3%E0%B8%81%E0%B8%B3%E0%B8%AB%E0%B8%99%E0%B8%94%E0%B8%9B%E0%B8%A3%E0%B8%B0%E0%B8%8A%E0%B8%B2%E0%B8%81%E0%B8%A3%E0%B9%81%E0%B8%A5%E0%B8%B0%E0%B8%81%E0%B8%A5%E0%B8%B8%E0%B9%88%E0%B8%A1%E0%B8%95%E0%B8%B1%E0%B8%A7%E0%B8%AD%E0%B8%A2%E0%B9%88%E0%B8%B2%E0%B8%87.PDF (accessed on 2 February 2024). (In Thai)
20. Abdi, S.; Spann, A.; Borilovic, J.; Witte, L.; Hawley, M. Understanding the care and support needs of older people: A scoping review and categorisation using the WHO international classification of functioning, disability and health framework (ICF). *BMC Geriatr.* **2019**, *19*, 195. [CrossRef] [PubMed]
21. Prajapati, G.; Sharmila, K. Role of Assistive Devices in Wellbeing of Elderly: A Review. *Indian J. Gerontol.* **2020**, *34*, 394–402.
22. Mohamed, A.; Hassanen, S.; Elsheriny, A.E.H.; El-sherbieny, E. Knowledge and Attitude of Elderly regarding Assistive Devices; Explore Barriers. *NILES J. Geriatr. Gerontol.* **2022**, *5*, 206–233. [CrossRef]
23. Field, T. Massage therapy research review. *Complement. Ther. Clin. Pract.* **2014**, *20*, 224–229. [CrossRef] [PubMed]
24. Ladanyi, S.; Adams, J.; Sibbritt, D. Use of massage therapy by mid-aged and older Australian women. *BMC Complement. Med. Ther.* **2022**, *22*, 148. [CrossRef] [PubMed]