Posture Support Equipment to Support Sitting for Lengthy Periods

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Posture Support Equipment to Support Sitting for Lengthy Periods

by

Teng Teng

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of Master
of Fine Art in Industrial Design

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College of Art and Design

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Abstract

Most people can't avoid sitting for long periods of time. Many people spend a lot of time in their chairs due to their work hours, medical issues, or sedentary lifestyle. The way a person sits, the time he or she sits, and the way he or she sits has a huge impact on the quality of a person's life. Many chronic diseases are caused by improper sitting postures. When working, studying or even resting, people like to spend a long time sitting in chairs without standing up or moving around. Staying in one position for long periods can lead to several potential spinal problems, or more musculoskeletal disorders that may eventually hurt your mental health. It is concerning that many people do not realize that sitting for long periods or in the wrong way can lead to serious health problems. According to research, users can ease or avoid back pain if they sit correctly and change their posture frequently, especially the people who sit in front of a computer for a long time because of work or study needs. In this project, I will introduce a body support device designed to encourage users to keep a healthy sitting posture and habit. This equipment is easy to learn how to use and convenient to use in their working place with the intention to improve their life quality and reduce and prevent the occurrence of spinal diseases.

Keywords

Back problem, correct posture, lower back pain, sedentary lifestyle
**Introduction**

Studies show that most Americans spend at least six hours a day sitting, and those in offices spend even more. Most Americans spend 70 percent of their lifetime sitting, except for their sleeping time. (Harshman, Marissa, 2016) Sitting for a long time means the body loses the benefits of exercise. Furthermore, sitting in bad postures can do more damage to your body, both mentally and physically. For example, sitting for long periods can lead to chronic headaches, Dr. French said (Harshman, Marissa, 2016), because muscles are tense, and a prolonged compression can also lead to disc problems and damage, which can cause radiating pain to spread down to the arms. Therefore, bad sitting posture can cause serious systemic pain.

**Review of Literature**

Sitting for a long time makes people relaxed, which is difficult for them to maintain correct posture in chairs and could lead to cervical spondylosis (Stephen Edmendston, 2006), neck-tongue syndrome (Jung Bin Kim et al., 2013), shoulder pain (Leanda Mckenna Ph.D. et al., 2016), abnormal respiration problems (Zafar et al., 2018) and other chronic diseases. At the same time, physical pain can also cause great mental stress and damage. (Linton, S J, 2000) Some people who feel back muscle discomfort, and have the heavy family burden, do not make any adjustments for the sake of their physical and mental health. This can eventually aggravate their disease and form a vicious circle. (Haitze J DE Vries et al., 2011) Low back pain affects the happy life of many Americans, which also affects social responsibilities such as work performance and family life. It has increasingly become a major factor in the rise of medical costs. According to a 2014 paper by Laxmaiha Manchikanti MD, the percentage prevalence of lumbago is about 12%, the one-month prevalence is 23%, the one-year prevalence is 38%, and the lifetime prevalence is about 40%. Besides, the number of people suffering from lower back pain is likely to increase significantly in the coming decades as the population ages. To solve this problem, there are a lot of products on the market to relieve the low back pain caused by a good sitting posture and the current market. They are generally divided into two categories: one is the chair that urges the user to keep moving while using, and the other one is the chair that urges the user to keep sitting correctly. However, most of this equipment is expensive or takes up too much room at their working place. The purpose of this paper is to provide posture support equipment that is affordable and portable with the function of preventing and reducing the back pain caused by long sitting periods and bad body postures so that users can gain the habit awareness of keeping good posture when sitting.
Increasing the angle between the trunk and thighs can help relieve back pain. According to Mamiko Noguchi's paper, chair designs aimed at reducing the lower limb demands within 115-170 ° trunk-thigh angle may improve the feasibility of sustaining the perched posture. However, keeping a wider trunk-thigh angle can improve lumbar posture at a cost of increased the lower limb demands, which suggests potential avenues for chair design for this thesis project. The research shows that when the trunk-thigh Angle is 135 °, the thigh muscles are in passive equilibrium (Keegan 1953). Similarly, tilting the back of the chair from 90° to 130° reduces the waist load by 60% (Rohlmann et al. 2011). Correct posture can help relieve pain by preventing overuse and tension in muscles that fight gravity, French says. Mamiko Noguchi also puts forward the future chair design should pay attention to three points: (1) seat interface should focus on pelvic alignment requirements for improving the lumbar spine Angle and unload some lower limb (2) the design of the support foot (if any) should pay attention to redirect force from sheer compression of lower limb joints at the same time reduce the user and the workstation encumbrance (3) adjust the Angle of the trunk - thigh from 115 to 170 °

To ease back pain, postural adjustments can ease discomfort in a short time. Examples are alternate sitting (Gallagher, Campbell, and Callaghan 2014; Karakolis, Barrett, and Callaghan 2016), standing on a sloped surface (Nelson-wong and Callaghan 2010b; Gallagher, Wong, and Callaghan 2013; Gallagher and Callaghan, 2016). Paul Reed, a chiropractor at Bridge Chiropractic in Vancouver, said that "Our bodies were designed to move, so the more we sit, the less our bodies are doing what they're supposed to be doing." (Harshman, Marissa, 2016) Reed insisted that "Even a short walk around the office or to the water cooler every hour can help." Just being aware of your bad posture can go a long way toward breaking bad habits you've developed over the years. "It's really important to recognize your posture," he said. "Self-awareness is important."

What's the right way to sit? A good way is to align your ears, shoulders, and hips, Reed says. He says people who look at your body from the side should see a straight line, just like standing up. This can be uncomfortable for most people because they have been sitting in the wrong position for too long to correct. It's also important to keep the natural curve of your lower back while sitting. A lumbar support pillow or a rolled-up towel can help, French says. "Get up and move every hour," said Reed.

In summary, by increasing the angle between the thighs and torso, keeping the upper body upright, increasing self-awareness, and adjusting your posture regularly, you can reduce back pain caused by sitting.
Process

1. The problem area

Most Americans are at high risk for back problems from sitting for too long. Treatment for back pain is expensive. (Mafi, John N et al., 2013) Besides, the treatment cycle is long, which needs the assistance of a therapist and is closely related to long-term living habits. Severity is hard to detect in the early stages of the back disease so that most people ignore back pain, which can have serious consequences in the long run, including fever, neurological symptoms or cancer. (Mafi, John N et al., 2013) Instead of seeking help from medical staff, most people seek solutions by themselves, such as buying massage instruments, taking painkillers and using more comfortable office chairs. These operations can temporarily alleviate the symptoms of back pain but will benefit for a long period of life habits or fundamentally preventing and relieving the symptoms.

2. Research

The first step is to understand how people perceive the effects of proper sitting posture and sitting time on back pain and to develop any possible solutions to solve the problem. For this reason, I conducted an observation in a coffee shop and an online questionnaire survey. The advantage of field observation is to directly obtain the real habits of the observed person in an unconscious environment, while the disadvantage is that cognitive information cannot be acquired.

I went to a corner of RIT's JAVAS Cafe and spent a whole afternoon observing the behavior of the people in there. Eighteen people became the sample involved in the research. They range in age from 20 to 50. Ten took computers to study, eight didn't. (Chart 1) Seven came to the cafe to study on their own, and eleven came in groups. (Chart 2) Seventeen people sit and stay in a seat for more than an hour, one less than half an hour. Only five of the 17 got up and left their seats in the middle of their visit to the cafe (looking for a charging outlet, buying coffee, possibly going to the toilet, meeting someone they knew). (Chart 3) This means that 12 out of 18 people will sit for more than an hour straight, and 6 out of 18 will adjust their sitting position or change their position.

This result suggests that most people, especially those who are concentrating on work and study, subconsciously do not adjust their sitting position but sit in one position for a long time until they are disturbed by external factors, such as a friend visiting, going to the bathroom, or the computer running out of power. They don't change their posture until they've finished their work or their studies.
Here are the result charts of the observation research:

**Chart1:** Whether people like to move around with their PC after sitting for one hour

- Moving around with PC
- Not moving without PC

**Chart2:** Whether people alone like to move around after sitting for one hour

- Moving around alone
- Not moving in group

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Chart2: Whether people alone like to move around after sitting for one hour
Since direct observation could not obtain subjective cognitive information from the observed, an online questionnaire was conducted as well. (Please see Appendix 4 Questionnaire A) The online questionnaire can make up for this defect in observation only, that is, the biggest advantage of an internet-based survey is that online survey can quickly interview the target population, thus helping researchers to have a more comprehensive understanding of target users.

My target population is divided into two groups: one is ordinary people who may have suffered from back pain or sit for a long time and have a risk for back pain), and two professionals (they may be therapists or medical experts). (Chart 4) The survey expectations are to get information about how people help themselves to alleviate back pain and how professional help brings benefits to prevent back pain by increasing proper behavior and cognition. The response rate of the questionnaire was 5 respondents out of 6. The reason for one responding not completing the questionnaire was that the doctor may have been too busy to respond in time. Among all the returned questionnaires, three were ordinary people, patients (students, office workers, spectrum store staff) and two were medical staff. (yoga instructor at RIT and the therapist at the rehabilitation center).
As can be seen from the Chart 5 below, 3 of the interviewees often spend a lot of time in the sitting position, and the proportion of them trying to ask a professional for help is very low---only 1 of them. (Chart 5) According to the results of the questionnaire, only one of the respondents changed their posture and posture at a 30-minute interval. (Chart 6) She has a history of asking medical staff for help and often goes to a physical therapy center. The interviewee was 45 years older and already had some symptoms of lower back pain, and she knew that switching between standing and sitting could help alleviate the pain. The other two, who were not asked for treatment, said they found it difficult to get up and exercise while concentrating on their work and did not develop the habit and subconscious of moving around regularly.

When it comes to sitting correctly, the answers from the three average people are incomplete in their awareness. They only answered that they should sit up straight and find a suitable seat, but they did not specify what kind of seat was suitable or what was considered to be a straight sitting posture. In order to get more professional information, I also asked two experts to answer another questionnaire which focuses on specific and medical questions. (Please see Appendix 4 Questionnaire B) The healthiest posture, according to the two experts, is one posture between sitting and standing, similar to squatting. A spine angle larger than 90 degrees from the recommended angle is good for the spine. Regular movement of body parts can also relieve stress on the body. Not sitting for hours can also help relieve pain. Get in the habit of exercising regularly to strengthen your muscles could protect your spine and joints. The right posture varies from person to person. Make sure your legs touch the ground naturally, with low handrails and adjustable back support equipment.

To sum up, the difficulty of this study is to find a relatively healthy and comfortable sitting posture as well as to improve people's understanding of the significance of a healthy lifestyle for the relief and improvement of back pain.

Chart 4: The percentage between experts and patients
3. Benchmarking

There are three types of chairs on the market that increase the angle between the torso and the thighs: one is the knee chair. (Figure 1) The advantage of this kind of chair is that it can help users develop the habit of sitting correctly, and the shape of the chair is elegant. The disadvantage is its large size, not flexible to use in the office. The other is a half standing support frame. (Figure 2) The advantage is that you can support your body in a half-sitting, half-standing position, which can help relieve pressure on your back. But the drawback is the agile degree is low, more dangerous, the requirement to the ground is too high, the exterior is too mechanical, resemble fitness apparatus very much. In addition to sitting properly, we can reduce the risks of sitting too much by exercising. There is a balance chair on the market. The chair has a variety of shapes and movement principles, allowing users to sit and wiggle. (Figures 3 and 4) But so far, there has been no evidence that this kind of movement reduces the pressure and damage to the spine.
caused by prolonged sitting. The third kind is a bar stool. The advantage of this chair is that it can guarantee a large
trunk elevation, but because the height is too high, it will not be able to adapt to the height of an ordinary desk, the
height of the adjustable table requirements is very high.

To sum up, there is a niche and a need for a device on the market for people who sit for a long time. The goal of this
project is to design posture support equipment that could help users keep good posture on it without taking a lot of
room and help them sit safely and comfortably without moving their body frequently.
4. Design goals, ideation, development of idea

The design goal is to help users keep a good posture habit safely and comfortably when they sit and the seating unit should take as little space as possible. The premier ideation for this project is to support people’s bodies to have multiple trunk-thigh angles when they are sitting.

The original concept is a huge block that could give users several opportunities to react within different ways, postures, and directions. (Figures 5, 6 and 7) However, after I finished the full-size mockup(Figures 9, 10), the new issues showed up. The volume is too huge—it takes much more room and weight than a regular chair and wastes too much material as well. Besides, the look of it seems similar to the general knee chair on the market so far. Therefore, here is a big challenge for me to break through the boundary and find something new to try. From then I focused on figuring out one angle that could meet most users’ needs and reduce the size of it which means that the design of the outline should be different. I did not find good references until I read the design concept form Kenya Hara, who is a famous industrial and visual art designer in Japan. His work is simple and neat without any useless details and focuses on “less is more”, which gives me a lot of inspiration. From then, I tried to start from the very beginning stage with the surface supporting people’s bodies (butts and shanks) just like the surfaces 1 and 2 in Figure 8 and see whether I could develop more concepts.

To reduce the volume of the product, I minimized all the surfaces into only these two practical surfaces (surfaces 1 and 2). The other needless structures are discarded, only leaving the structures to support these two surfaces. I tried
to take separate the whole piece into two parts and played with them to combine them again but in a different way. Then I figured out a new concept direction that I would like to make a further development (Figure 11). The outlook of the new concept is a stool in a classic minimalism style, which is composed of two parts. The upper parts could be taken off and put on the floor as a knee support point helping people sit with a much wider trunk-thigh angle. Besides, when the two parts go up and down, it looks like a regular stool with a horizontal plate surface, which could give people a regular nighty degree trunk-thigh angle to sit on. Therefore, the new body support equipment takes the smaller room, costs less material and is flexible enough providing users with two different postures when sitting on it.

5. Testing and validation of preliminary designs

Because the basic design needs to support the whole body to form a correct sitting posture, its height and angle need to be tested. Therefore, I made a device that can support multiple angled plane surfaces and a stool that can adjust the height. (Figure 12)

Four people were invited to take part in this test (convenience sample), which measures the comfort range of a sitting position and the critical angle at which people might fall down from the chair. (the angle mentioned here is angle ABC in figure 12). I took the average value of the critical angles which is 24 + - degree.

Table 1. The result of angle testing
To test the preliminary design, I conducted a questionnaire survey online with questions like “What is your experience when you look at it? Do you think this product could be helpful? Do you think it makes sense if the chair has two movable parts?” with some prototype and testing pictures attached (Please see Appendix 1 and 3). There are 15 questionnaires sent out and 13 of them are returned. The response rate is 87%. And the three patients and two experts who took part in the first questionnaire are also involved in this second online questionnaire. (please check the appendix questionnaire C) The questionnaire result is like the following charts:

<table>
<thead>
<tr>
<th>Tester</th>
<th>Range angle (Sin angle BAC)</th>
<th>Critical angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tester A</td>
<td>0-0.42</td>
<td>25+-</td>
</tr>
<tr>
<td>Tester B</td>
<td>0-0.5</td>
<td>30+-</td>
</tr>
<tr>
<td>Tester C</td>
<td>0-0.34</td>
<td>20+-</td>
</tr>
<tr>
<td>Tester D</td>
<td>0-0.34</td>
<td>20+-</td>
</tr>
</tbody>
</table>

Chart 7: How did people answer the question: “What is your experience when you look at it?”

Chart 8: How did people answer the question: “Do you think it is helpful for people who have sedentary lifestyle to sit in an appropriate posture?”

Chart 9: How did people answer the question: “Do you think it makes sense if the chair has two movable parts?”
Considering that, in the research, most people think that the design is cute, could make sense and the movable top part is acceptable, I developed this concept by adding more details and choosing the appropriate material for each part. Since many people were concerned about whether it is safe, I focused more on the safety element. As we can see from the Chart 9, there are more than a quarter of interviewees thought that they won’t move the upper part a lot, since every time when they want to change the position of the upper part, they need to raise the whole thing up over the ground and pull the feet of the bottom part out of/in to the hole of the upper part with both hands, which is really tough. Someone even said “I do not think many people will move it a lot after the first trial!” Therefore, I need to do some changes on the hole of the upper part to make it easier for everyone to move up and down.

6. Further refinement and development

According to the research and testing above, I adjusted the height of the stool and the angle of the incline into about 24 degrees so that most people could sit on it comfortably. Due to the joint of the upper and lower parts of the product is not quick and convenient enough for users to operate, I changed the hole on the upper part into a gap. (figure 17) In order to prevent the sliding risk of the whole chair when the upper part is placed on the ground, I added rubber to cover both of the upper part nobs and the lower chair legs. (figure 18) The increased friction ensures that the upper and lower parts remain stable on the ground and everything will not be slid away by any accidents when people lean on it. To make people more comfortable putting their knee on the top part, I decided to use soft cotton to cover it and mix it with PP to protect the edges of it (figure 19). I also added a silicon bar below the upper part of the product in with the purpose of easily guiding users to slide the nobs of upper parting to the holes. (figure 19) Aware of the issue of packaging and transportation, I decided to use three 1/4-10in x 2in hanger bolts to connect the feet with the sitting surface of the bottom part. That means less packaging and a little bit of DIY requirement for
customers. The prototype I am going to do is make by maple, however, considering the further issue of manufacturing process and price I maybe change Maple (Please see Appendix 2) into Wood-plastic composites (WPCs). The material is characterized by high surface hardness, good elasticity and good compressive and mechanical property which is higher than wood. WPCs are also considered durable, and good pigmentation, UV stability, water resistance, corrosion resistance, antibacterial. The life cycle of WPCs could reach more than 50 years. The quality of it is lighter and convenient for transportation and assembly. It is also very environmental-friendly produced by mixing ground wood particles and heated thermoplastic resin. In other words, the waste utilization rate of this material is as high as 90%. That is the reason why I will choose WPCs for further manufacture of this product.

7. Summary
The final design is a wooden three-legged stool with two parts at the top. One is the level that you can sit on, and one is the part that you take off and wrap in fabric. The two parts are connected by three knobs and a prominent hook. When the upper part is taken down and placed on the ground, the leg of the stool is inserted into the hole in the upper part. The user can sit on the device at a large trunk-width Angle, but also at the same height as in the 90-degree sitting position, allowing for normal desk height for work and study.

Conclusions
The next steps should be to test the ergonomics by asking people who prefer to sit for long period of time, and ask about a better choice of materials for better benefit on the market. All these steps could be done by experts or companies, which have robust research labs and may be more efficient.

Until now, few people have the knowledge of sitting for long periods leading to a variety of diseases, especially back problems. Few people are health-conscious and exercise to help support their back. In order to improve the well-being of sedentary people, the practice of designing seats to improve the way people sit is just the beginning leading people to a much healthier and more comfortable life. The ultimate goal of designers is to raise people's awareness of healthy living by developing healthy living habits. A simple project or a single design is not going to solve this problem completely, however, the design of posture support equipment could draw significant attention to healthy living habits for all.
Appendix

1. Full size prototype

2. Making process and full-size sketches
3. Testing
4. Questionnaire A

This is the first questionnaire for both experts and ordinary people. I sent the questionnaire as an email and the interviewer sent back to me so that I could collect the information.

Hi there

The purpose of this questionnaire is to learn from experts. This is a questionnaire related to my thesis which is about redesigning equipment that people use in their daily life to improve the experience for people who have or are trying to prevent back problems. The survey is being conducted by Jingjing, a student who is doing her thesis at RMIT. I would very much appreciate your assistance in answering the questions below.

1. Are you an expert for back problem?
   - [ ] Yes
   - [x] No

2. What is your job?

3. How old are you?

4. Do you need to sit for a long time during the day?
   - [ ] Yes
   - [x] No

5. Do you have a long-term back problem?
   - [ ] Yes
   - [x] No

6. Have you ever asked others for help because of your back pain?
   - [ ] Yes
   - [x] No

7. Do you have a habit to move around after sitting for about 30 minutes?
   - [ ] Yes
   - [x] No

8. Do you think that sitting in a good posture could help release the pain and reduce the risk of having other health problems?
   - [ ] Yes
   - [x] No

9. Do you know what kind of posture is a good posture for sitting? Can you describe it?
   - [ ] Yes
   - [x] No
Questionnaire B

This is one of the questionnaires from the experts team. Andriy is a therapist at Lattimore of Rush Henrietta Physical Therapy, Rochester, NY.

Hi Andriy,

I am TT. The purpose of this questionnaire is to learn from experts. This is a questionnaire related to my thesis which is about redesigning the equipment that people use in their daily life to improve the experience for people who have or are trying to prevent back problems. The survey is being conducted by Teng Teng, a student who is doing his thesis at RIT. I would very much appreciate your assistance in answering the questions below.

1. What are the positions where people feel pain very easily or very common?
   - Most people feel back pain if they are sitting for longer periods of time with a poor posture. The prolonged poor posture puts their low back into a flexed position, and this causes strain on the low back and produces pain. People also often experience low back pain if they bend down to pick something up because this further taxes their spine.

2. Why do people have back problems?
   - X sitting for a long time
   - X standing for a long time
   - X bad posture bad habits
   - X lack of exercise
   - X bearing too much weight
   - X injury
   - X having surgery
   - X other special reasons:________________________

3. Which reason do you think is the most common one? And why?
   - All of those reasons are seen here in the clinic. However, the most somewhat during the day. Additionally, most people don’t have perfect posture when they do sit, so this causes low back pain.

4. Are there any popular and common daily things (careers) that healthy people do in their daily life that could lead to a back problem?
   - X wearing their heads to look inside
   - X using the computer for a long time (programmers, students)
   - X standing for a long time to serve people (waiters, teachers)
   - X carrying too many heavy cases and boxes (workers, deliverymen)
   - X sitting on a wrong bed or with a wrong pillow
   - X riding professional bicycle (athletes)
   - X reaching high spots (cleaner)
   - X other things and careers:________________________

5. What is the age trend of patients with back pain problems?
   - X younger
   - X older
   - X NA

6. If people have back problems, what do you recommend them to do before asking a doctor for help?
   - X buy heating blanket
   - X go to pharmacy looking for help from over the counter medications
   - X ignore it
   - X do some simple exercise
   - X do some research on line
   - X do some specific sports
   - X buy a more comfortable chair, mouse, cushion or any equipment
   - X posture plays a key role in low back pain. Having a poor posture problem can go a long way in fixing the back pain. Buying something like a lumbar roll is something I would recommend to anyone:________________________

7. How could people recognize their problem before they have severe back pain?
   - X reassess their posture when they are sitting for longer periods of time or sitting at workstation. Sitting up straight:

8. Is there any simple but useful exercise that could help people who have to sit or stand for a long time during the day line?
   - For upper back:________________________
   - For lower back:________________________
   - For neck:________________________
   - For shoulders:________________________

9. Is there any good product that you recommend for patients who have back problems to keep a good sitting or standing position?
   - Out of those options with pictures, I put an “x” at what I think are the most important. The most important thing to think about is using something that helps fix your posture. Having a good supported chair and using a back cushion (or lumbar roll) will help promote good posture both in the low back and upper back. Additionally, people now a days have their workplace get them standing desks, which help individuals stand up occasionally throughout the day, in order to avoid sitting for these long periods of time.

10. Have these items helped?
    - Yes, items that fix posture and help people sit up better for longer periods of time are very beneficial in preventing back pain from occurring:

11. Are there any papers, books or doctors that you think is helpful for me to learn something more in this area?
    - Two books that I would recommend for anyone who has back pain are called “Treat your own neck” and “Treat your own back.” Both of the books are by Rubin McKenzie.

THANK YOU VERY MUCH HAVE A NICE DAY!

Sincerely,
TT
Questionnaire C

This is the third questionnaire about how people think about the design concept of this posture support product.

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