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Standing Inclination (posture) of Ergonomics and Design's Model Augment Comfort and Mitigate of Sedentary Influence

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Abstract. Since the 21st century, with the rapid development and advancement of science and technology, there is a significant increase in the employment and education rates of all people, more and more people are facing the problems caused by sedentary behavior. Sedentary behavior has some negative impacts on health, both of a physical, mental, and socio-economic nature. Though assuming traditional sitting postures is almost effective in reducing spinal pressure and muscle fatigue during long sitting, it normally does not help. This study mainly focuses on an innovative standing inclination posture designed to distribute body weight more evenly and reduce spinal stress. In this regard, the study uses conceptual factors' models of ergonomics, in conjunction with the Vink-Hallbeck comfort perception chart, to analyze the feasibility and comfort of such a new posture. The preliminary findings of this study already indicated a clear improvement in pressure distribution with an increase in comfort; thus, some sedentary subjects could benefit.

Keywords: Sedentary behavior, Spinal pressure, Standing inclination posture, conceptual model, industrial design postural confinement.

1. Introduction

Since the 21st century, with the rapid development and advancement of science and technology, and the significant increase in the employment and education rates of all people, more and more people are facing the problems caused by sedentary behavior. The effects of sedentary behavior are not limited to physiological effects, but also have far-reaching mental health and socio-economic impacts. In order to ensure overall physical health and promote public health, many health organizations are involved in interfering with the effects of sedentariness, e.g. providing sit-stand desks [1].

In addition to simply standing, good sitting habits can minimize the stress on muscles, spine, ligaments, and joints caused by prolonged sitting, thus reducing spinal injuries [2]. Even though people associate spinal injuries with heavy lifting and sports injuries, being sedentary puts pressure and deformity on the spine, excessive wear and tear on the muscles and ligaments, and insufficient blood nourishment, Anterior Pelvic Tilt (APT) etc. The main cause of APT is the lack of circulation in the cartilage of the spine, which prevents the supply of oxygen and nutrients through the blood [3]. There are many recommended postures claimed by modern science of as healthy that need to be maintained with great caution and it uses up a lot of energy. Many people fall into a state of "limitation", trying to maintain a movement that doesn't allow them to relax. One of the things that cannot be changed is the pressure on the spine and cartilage. The research concept of sitting presented in this article changes the

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need to maintain a healthy sedentary posture from one that is maintained by the person themselves, to one that uses the help of products to minimize the need to maintain a posture that requires constant attention during sedentary periods.

This research uses stance tilt (posture) base model and the new trend of Vink-Hallbeck comfort perception chart to demonstrate the feasibility of the new sitting culture and the reference level of user experience and comfort of three participants from different individual human condition (The models used are designed as ergonomic conceptual models) [4]. The objective of the study is to come up with a unique solution by increasing comfort and decreasing spinal stress, which aids in reducing sedentary behavior. This research shall add to the development of ergonomic solutions through the investigation of the standing inclination posture with respect to feasibility and effectiveness, leading to a better quality of life for so many people. These findings could also be useful for the future design of office furniture and work environments that support healthier, more sustainable sitting behavior.

2. Sedentary lifestyle

2.1. Significant increase in sedentary population

The population of sedentary people has increased significantly in recent years. In a multi-ethnic study in Singapore, researchers used the Physical Activity Global Questionnaire (PGAQ) to gather evidence to support the claim [5]. The PGAQ, a questionnaire developed by the World Health Organization, refers to a series of questions about the duration and frequency of vigorous and moderate-intensity activities during the week. The results showed that a high proportion of the sample had a sedentary frequency of ≥ 7 h/day. Sedentary behavior was particularly pronounced in the high-income and high-education groups. In addition, data from a U.S. study (NHANES) found that total daily sedentary time increased to 8.2 hours for adolescents and 6.4 hours for adults nationwide from 2007 to 2016 [6]. In a longitudinal study, adolescents showed a significant increase in average daily sedentary time in teenager and a 121% increase in continuous sedentary time (more than 30 minutes at a time) [7].

2.2. Harmful effects of sedentary behavior

Until now, a number of papers have illustrated the harmful effects of sedentary behavior on the human organism. For example, APT is due to prolonged gults immobilization; poor blood circulation in the lower limbs. APT causes the pelvis to tilt forward at an angle, which weakens the abdomen and makes your belly bigger [2]; increased levels of inflammatory markers in the body. Lack of exercise can lead to stroke and cardiovascular disease; poor cartilage fluid flow can lead to arthritis; an increased risk of cancer and a number of skeletal muscle disorders. Some of these conditions have not only contributed to the sitting postures recommended by many modern scientific health guidelines, but have also served as a powerful reference for new sitting designs.

Prolonged sedentary behavior not only causes physiological damage to the body but also has psychological and socio-economic effects. In a literature, using data from NHANES 2017-2018, the study found that people who were sedentary for more than 600 minutes a day were more likely to experience depressive symptoms [8]. Similarly, sedentary behavior has a significant impact on the economy in terms of direct medical costs and indirect labor [9].

3. Innovative conceptual sitting postures: pioneering designs and assistive solutions

3.1. Recommended postures and principles for seated situations and flaw analysis

Researchers have come up with a number of sitting guidelines to help sedentary people alleviate disease and reduce stress. These articles can be found in more than 100 articles from a wide range of literature.

According to current medical guidelines, it is highly recommended to sit with your buttocks pressed against the back of the chair. Maintain the natural curvature of the spine in an "S" shape, including cervical lordosis, thoracic kyphosis and lumbar lordosis. This can be used to distribute pressure

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throughout the body. Also keep your feet flat on the floor and make sure knees are at a 90 degree angle to hips [10].

Even though the guidelines for proper sitting will substantially reduce the dangers of sedentary behavior and provide a great deal of help, there are still some shortcomings that need to be remedied. Some of the deficiencies that this paper seeks to remedy include no change in cartilage pressure, postural fatigue [11,12], reduced productivity in fixed postures [11,12], and insufficient dispersion of spinal pressure in seated postures.

3.2. The scientific concept of standing inclination posture and filling the gaps in standard sitting guidelines

3.2.1. Common posture analysis

The purpose of the new conceptual sitting is basically the same as the universal guideline sitting, but with some improvements and new ideas from the normal sitting. The biggest difference is the change from the normal sitting position to the kneeling, or half-standing, position. The traditional ergonomic definitions of standing and sitting are different. Sitting is physiologically defined and characterized as: weight and pressure are supported mainly by the thighs and buttocks, with the upper part of the body upright and slightly bent forward, the spine naturally maintains an S-curve. The main angle is defined as 90 degrees between the hip bone and the kneecap [13]. Contrasting Standing Stance Biology defines standing stance as having feet shoulder-width apart and weight supported by the front and back of the feet. The pelvis is in a neutral position, with anterior and posterior tilts of less than 10 degrees or less and ankles close to 90 degrees. The spine is in a natural S-shape [14]. In terms of observing their commonalities, the maintenance of the natural S-shape of the spine is commonly recognized. But both can cause skeletal muscle damage and disease when held for long periods of time. If unassisted, an incorrect stance can cause generalized pain, etc.

One of the problems not addressed by the original sitting recommendations is the pressure on the spine, which is approximately 140% of body weight in normal sitting (with the back against the back of the chair) and 150% of body weight in forward leaning sitting. It is worth noting that standing does put less pressure on the spine than sitting, mainly because the pressure is spread out, i.e. the pressure on the spine is 100% of the body weight in the correct standing position. The posture that minimizes stress and leads to the greatest mental relaxation and the least stress on the spine is the supine position, where the stress is received flat. The pressure on the spine is 25% of the body weight [15]. The new sitting posture is not the supine position, which is a good solution to the problem of spinal stress but causes relaxation and a lack of concentration, even the hands and arms can't do fine work in the supine position [16].

3.2.2. Standing inclination posture

The analysis of the outputs resulting from the disadvantages of each posture allows to propose a new concept of posture, referring to the three most common postures and proposing the most intermediate sitting posture. This concept is defined as a standing inclination posture. It is worth stating that the stance needs to be accomplished with the use of product aids or equipment, and is not the same as purely standing up and lying down. The main definition of this posture is that the user's tailbone is tilted backward in a supported manner and held at 100-105 degrees to the floor, with the back vertebrae supported and held in an S-shape. The legs are free to bend or stand straight. In this way, the weight of the body is distributed to the knees, lumbar spine, spine, and tailbone.

The main definition of this posture is that the user's tailbone is tilted backward in a supported manner and held at 100-105 degrees to the floor, with the back vertebrae supported and held in an S-shape. The legs are free to bend or stand straight. In this way, the weight of the body is distributed to the knees, lumbar spine, spine, and tailbone. The neck is naturally flat, and the cervical spine is supported without any specific requirements. Keeping the arms at thoracic (especially lower thoracic) levels reduces stress on the shoulders and prevents shoulder and neck fatigue associated with long hours of work. This is above the L1-L5 area of the spine.

It has been calculated that when a person is leaning fully against a wall that is inclined at 110 degrees, the weight pressure is distributed to other parts of the body, instead of being directed to a single point. Stress reduction, i.e. different weight carry-over calculations, can be carried out using the following. Using 105 as the case angle, its most appropriate angle is in the final comparison:

This is the algebra used to calculate the formula above, and the formula below.

Total Force:

$$F_{total} = W_{total} * g \tag{1}$$

Upper Body Force:

$$F_{upper} = W_{upper} * g = 0.6 * W_{total} * g \tag{2}$$

Leg Force:

$$F_{legs} = W_{legs} * g = 0.4 * W_{total} * g \tag{3}$$

Since there is no additional support, the spine has to bear most of the upper body weight:

Force on the Spine

$$F_{spine} = F_{upper} \tag{4}$$

Calculate the Force Perpendicular to the Spine (at 105-degree angle:

$$\text{Angle} = 180° - \theta \tag{5}$$

$$F_{spine\ perpendicular} = F_{spine} * \cos(180° - \theta) \tag{6}$$

$$F_{spine\ perpendicular} = F_{spine} * \cos(75°) \tag{7}$$

Calculate the Percentage of Total Body Weight:

$$\text{Spine Pressure Percentage} = \frac{F_{spine\ perpendicular}}{F_{total}} * 100\% \tag{8}$$

These equations can be used to calculate the pressure on the spine for any given condition.

Next, the weight and height of a normal person are substituted. The pressure on the spine when leaning against a wall is still used. The variable is the angle between the body and the wall. The calculation can be visualized as follows (Figure 1):

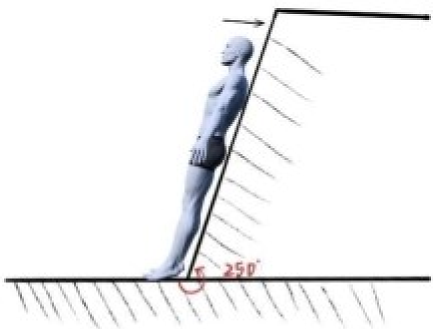

Figure 1. Unsupported Reclining Angle

Assuming an adult male with a total body weight of 70 kg, the upper body weight is 42 kg (60% of the total weight). The following conclusions have been calculated for various angles of inclination without any support:

At 100 Degrees:

$$F_{spine\ perpendicular} = 411.42 * \cos(180° - 100°) \tag{9}$$

$$F_{spine\ perpendicular} = 411.42 * \cos(80°) = 405.2N \tag{10}$$

At 105 Degrees:

$$\mathrm{F}_{\text{spine perpendicular}} = 411.42 * \cos(180° - 105°) \tag{11}$$

$$\mathrm{F}_{\text{spine perpendicular}} = 411.42 * \cos(75°) = 397.3\mathrm{N} \tag{12}$$

At 110 Degrees:

$$\mathrm{F}_{\text{spine perpendicular}} = 411.42 * \cos(180° - 110°) \tag{13}$$

$$\mathrm{F}_{\text{spine perpendicular}} = 411.42 * \cos(70°) = 386.5\mathrm{N} \tag{14}$$

Table 1. 100-109 pressure calculation data

Inclination Degree (θ)	100	101	102	103	104	105	106	107	108	109
Stress as a Percentage of weight (%)	59.0	58.8	58.6	58.4	57.1	57.9	57.6	57.3	57.0	56.7

According to Table 1, as the angle increases, the pressure decreases. Up to 100 degrees is infinitely close to 100%. Therefore, an angle within 100-110 degrees is used as the tilt angle. According to the data, 110 degrees should be taken as the minimum pressure value. One study noted that when a seat is reclined at an angle of more than 105 degrees, subjects are more likely to feel sleepy and relaxed, which is detrimental to a work environment that requires high levels of concentration and productivity. While the body may feel more comfortable at this angle, concentration and reaction time may suffer [17, 18].

So, in terms of tilt-back, seated recipients maintain a tilt-back angle of 100-105 degrees, which is the least stressful and has the widest dispersion area.

Total Weight: $\mathrm{W}_{\text{total}}$

$$\text{Upper Body Weight: } \mathrm{W}_{\text{upper}} = 0.6 * \mathrm{W}_{\text{total}} \tag{15}$$

$$\text{Leg Weight: } \mathrm{W}_{\text{leg}} = 0.4 * \mathrm{W}_{\text{total}} \tag{16}$$

$$Inclination\ Angle: \theta = 100° to\ 105° \tag{17}$$

$$\text{Gravitational Acceleration: } \mathrm{g} = 9.81/\mathrm{s}^2 \tag{18}$$

Support distribution: Assume the cushion supports 35% of the weight on the tailbone [21].

Strong lumbar and coccygeal support can better distribute the pressure when it is at its lowest at an inclination angle of 100-105. Strong lumbar and coccygeal support can better distribute the pressure when it is at its lowest at an inclination angle of 100-105. In one study, pressure distribution in the spine and tailbone was measured by using pressure sensors in different positions. It was found that proper support of the coccyx and lumbar spine can significantly reduce localized pressure, spreading it over a larger area and thus reducing pressure concentrations at a single point. This assumes that one-half of the tailbone is supported, reducing the pressure on the tailbone by 50% [19,20]. That is, the pressure in each part can be written as the following formula:

Total Force:

$$\mathrm{F}_{\text{total}} = \mathrm{W}_{\text{total}} * \mathrm{g} \tag{19}$$

Upper Body Force:

$$\mathrm{F}_{\text{upper}} = \mathrm{W}_{\text{upper}} * \mathrm{g} = 0.6 * \mathrm{W}_{\text{total}} * \mathrm{g} \tag{20}$$

Leg Force:

$$\mathrm{F}_{\text{legs}} = \mathrm{W}_{\text{legs}} * \mathrm{g} = 0.4 * \mathrm{W}_{\text{total}} * \mathrm{g} \tag{21}$$

Assuming the spine supports 35% of the upper body weight directly:

$$\mathrm{F}_{\text{spine}} = 0.35 * \mathrm{F}_{\text{upper}} \tag{22}$$

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Assuming the legs support 0% of the leg weight:

$$F_{\text{leg support}} = 0.35 * F_{\text{leg}} \tag{23}$$

Assuming the back (including the cushion) supports the other 35% of the upper body weight:

$$F_{\text{back}} = 0.35 * F_{\text{upper}} \tag{24}$$

Based on this formula, it can be deduced that the tailbone support in a semi-sitting position can be very helpful in distributing the pressure. When assumed into the formula, the back, spine, and leg pressures as a percentage of body weight are calculated as follows. The assumptions are: 100 degree inclination, caudal spine supporting 35% of the pressure, adult male 140kg:

$$\text{Spine Pressure Percentage} = \frac{F_{\text{spine perpendicular}}}{F_{\text{total}}} * 100\% = \frac{92.89\text{N}}{1373.4} * 100\% \approx 6.76\% \tag{25}$$

$$\text{Spine Pressure Percentage} = \frac{F_{\text{spine perpendicular}}}{F_{\text{total}}} * 100\% = \frac{288.20\text{N}}{1373.4} * 100\% \approx 21.00\% \tag{26}$$

$$\text{Spine Pressure Percentage} = \frac{F_{\text{spine perpendicular}}}{F_{\text{total}}} * 100\% = \frac{274.68\text{N}}{1373.4} * 100\% \approx 20.00\% \tag{27}$$

Spinal pressure: 92.89N, Spinal stress/approx. 6.76% of total body weight
Leg Pressure: 274.68N, Approx. 20.00% of total body weight
Back pressure: 288.20, 21.00% of total body weight

These calculations show the pressure on each part and its percentage relative to body weight in a half-sitting, half-standing situation (Figure 2).

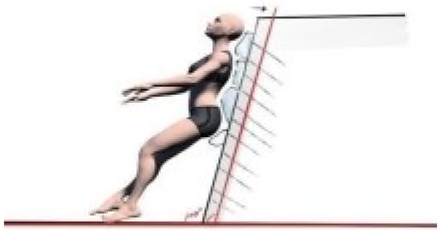

Figure 2. Conceptual Pose Schematic

3.3. Pose-assisted modeling and material selection

3.3.1. Postural stress dispersion problem

The concept of sitting addresses the issue of excessive pressure on the spine, while more information about the changes in muscle fatigue and spinal pressure that result from holding a posture for a long period of time needs to be accomplished with the aid of modeling.

The first part that can be solved by modeling is that holding the same pose for a long time leads to inefficiency. Because the shape of the model's outer contour is already a good complement to the posture, i.e. you can relax the pressure on your muscles and completely rely on the model, you can break free from the so-called "medical shackles". Cases of loss of efficiency in order to maintain a posture are very common. Although proper sitting posture is recommended to prevent back problems and improve overall health, forcing the body to maintain this unaccustomed sitting position can have negative results. Healthy sitting requires the use of specific muscles, however, over-exertion of specific muscles can force people to keep their back straight and their hips back, which can lead to overuse of the back and core muscles. This leads to muscle fatigue and causes discomfort and pain [21]. Similarly, maintaining a uniform posture can lead to prolonged periods of static sitting, resulting in muscle stiffness and a lack of blood circulation [22]. In a butterfly effect, small discomforts respond to inefficiencies and decreased concentration. Maintaining an uncomfortable sitting position can lead to distraction and decreased productivity, as shown in a US study. Physical discomfort has a direct impact on cognitive function and productivity. Therefore, in order to remove the shackles imposed by the standardized sitting posture, a number of methods and aids are required. For example, the spinal S-modeling aid and the 110-degree

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recline and coccyx support. In terms of product appearance, it directly assists and maintains the sitting posture. This gives the body more room to move, thus reducing muscle fatigue.

The cushion for assisted posture is set to the following sets of data, and is raised above the spine, excluding the tailbone, at an angle that is opposite to the natural curvature of the S-shape. The cushion is designed to provide strong support. The main spinal positions of the back cushion are: neck, chest, and lumbar vertebrae. Let's start with the neck cushion, which is dominated by the bulge. The most important and highest point is C4. The length of the female neck is different from the length of the male neck, which is between 21 and 22 centimeters. It is possible to use a softer material and ignore it. The highest point, C4, is different for men and women, with men's neck lengths ranging from 70-76 centimeters from the bottom to the top and women's neck lengths ranging from 66-70 centimeters from the bottom to the top. According to Borden's measurement of cervical curvature, the vertical line from C2 to C7 spine is line A, and the most prominent point of C4 is line C of line A, forming an angle of 90 degrees. The optimal length of the C-section is 7-17mm, which can be adjusted with a cushion or device. The curvature is such that a person can rest on it when tilted at 110 degrees, and there is enough support for the neck to rest the head.

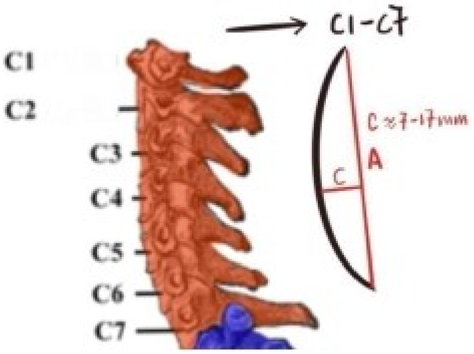

Figure 3. Cervical Spine and Spinal Curvature Measurement

In Figure 3, the thoracic cushion is recessed to the rear, and the thoracic spine is located in the center of the body and consists of 12 bones. Its main direction of curvature is posterior. In order to maintain the natural S-shaped spine, the modeling aid must be bent backward. The length of the thoracic vertebrae is different for males and females, i.e. the length of the male thoracic vertebrae is different, so the model is subjected to a different median length. That is, the length of the thoracic spine is 70-76 centimeters in males and 66-70 centimeters in females. That is, the length of the thoracic spine is 70-76 centimeters in males and 66-70 centimeters in females. The angle of the cushion is the tangent line at both ends, the angle is 45 degrees, and the center is the apex of the inner concave.

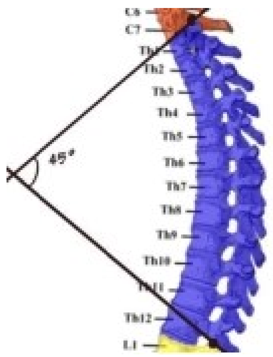

Figure 4. Thoracic Spine Curvature Measurement

In Figure 4, the lowermost, lumbar portion of the spine is supported by a lumbar cushion that protrudes outward. The bones at the very end of the body's lumbar spine form a 45-degree angle of external curvature. Of the L1-L5, L4 is the most apical. The model L4 protrudes outward. It can be used to elongate the length of the spine. It can support the spine. Model L5 extends downward. Because of their proximity to the caudal vertebrae, the caudal vertebrae are posteriorly curved. Model L5-L1 will form a slope. At the same time, it protrudes outward about 4-5 centimeters, which is the most comfortable height for spinal support. It can be lifted up and down as well as side to side [4]. At the same time, it protrudes outward about 4-5 centimeters, which is the most comfortable height for spinal support. It can be lifted up and down as well as side to side.

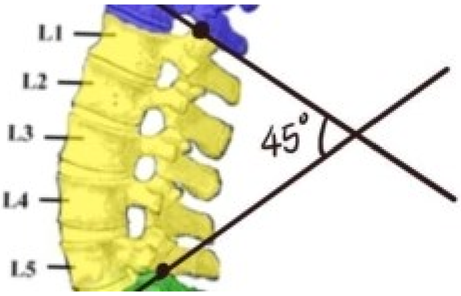

Figure 5. Lumbar Spine Curvature Measurement

In Figure 5, the coccyx is the last part of the model and is the main pressure point in the sitting position. The tailbone is mainly supported by a soft cushion with a downward sloping wedge design. It forms an angle of 94 degrees with the lumbar spine. The tailbone is mainly supported by a soft cushion with a downward sloping wedge design. It forms an angle of 94 degrees with the lumbar spine. This allows for a better support of the knees. The wedge-shaped cushion allows a slight forward tilt of your hips, which helps the back of the body maintain its natural curve. This design is particularly effective in reducing pressure on the tailbone [23]. However, the cushions are not designed to fully cover the thighs or buttocks, but rather to provide a small amount of support. The cushion design does not fully cover the thighs, i.e. the buttocks, but only provides a small amount of support. The tailbone is fully covered and the thighs are only supported by 4-5 centimeters. This is due to the fact that prolonged and extensive support can lead to the development of many diseases.

3.3.2. Changes in cartilage pressure

The third heading of the article mentioned cartilage joints. Cartilage is located in every part of the spine. Sitting for long periods of time causes the cartilage to be under constant pressure. This is known as unchanged cartilage pressure. The lack of cartilage compression has a direct impact on the availability of nutrients. Cartilage contracts and expands under pressure. This pressure change helps to squeeze joint fluid (synovial fluid) into the matrix of the cartilage, thus providing the necessary nutrients and oxygen to the chondrocytes [24]. The periodic pressure changes that occur during joint movement help in the production and circulation of joint fluid. This variation ensures that the joint fluid can fully penetrate the cartilage and expel waste products when the joints are at rest. It is therefore necessary to maintain some degree of spinal motion during long periods of sedentary activity [25]. Therefore, in addition to getting up and moving on a regular basis, the choice of modeling materials is also very important. For example, it is important to use a soft material such as silicone. Not only does it provide comfortable support, but it also promotes small movements, helps to maintain the circulation of joint fluids and supports the health of the cartilage, also uses cushions with airbags or gel. This can turn the cushion into a dynamic cushion. This encourages the user to make small adjustments and movements, thus relieving a portion of the cartilage from stress-free changes [26, 27].

4. Model use and experimenter feedback

The model and the seating position of the man-machine, modeled according to the previous design

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concept, is the following finished product.

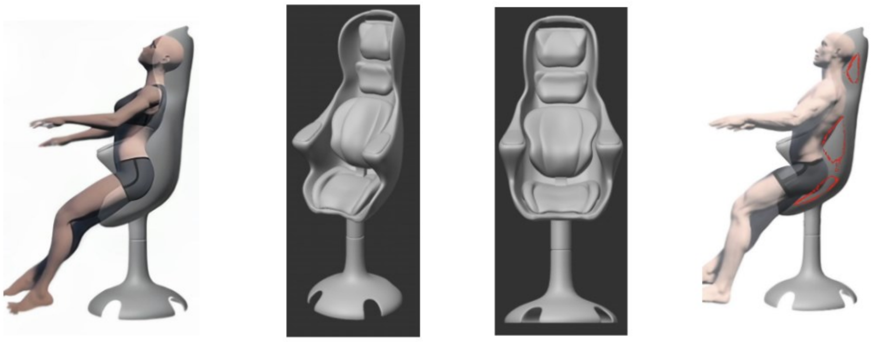

Figure 6. Ergonomic Chair Design and User Positioning

After 3D printing and simple airbag filling, three sedentary people of different ages were invited for a simple sitting assessment. A modified version of the Vink-Hallbeck comfort perception chart was used to demonstrate the feasibility of the new sitting culture and the reference level of user experience and comfort of three participants from different individual human conditions.

5. Conclusion

In a sedentary society, many people are trapped in a sedentary cycle. Many people acquire spinal disorders at a young age. Even obesity is due to anterior pelvic tilt, according to many studies. Poor sitting habits and a sedentary lifestyle can lead to depression. Therefore, many medical and health reports have ergonomically designed different sitting postures. So to ensure good sitting posture. Many people fall into a new type of shackle, staying in the same position all the time, which reduces efficiency, and so on. The new concept of sitting culture is therefore called standing inclination (posture). It is calculated that a backward inclination of between 100 and 105 degrees reduces the pressure on a single part of the body. With strong lumbar and coccygeal support, the pressure is reduced to 20% of the total weight of each part of the body. The model cushion is designed according to the concept of the natural S-shape of the spine. The cushion is free from medical shackles. Strong lumbar support and semi-caudal support distribute the pressure. The use of soft silicone and airbags provides better relief of cartilage pressure without changes. The experience of all three subjects was well received.

The research significance of the new conceptual posture is to move away from the traditional sitting culture by using intermediate pressure values between standing and reclining. Distribute the pressure to every part of the body. In addition, the spine is strongly supported with the aid of modeling. To break free from the shackles of conventional medicine.

The study still leaves much to be desired, such as more accurate data on spinal pressure and the angle at which pressure is dispersed most evenly and comfortably. There are no STANDARDIZED standards. Because the most important part of the experience lies with the user. The user's own comfort level is generated from both objective and non-objective perspectives. Precise calculations require the user's own experience. Therefore, some accurate angle data and backward curvature are lost.

In the future, it hopes to standardize the user experience data and the ergonomics of the backward curvature and the cushion angle of the model. And calculate the actual knee pressure and more comfortable modeling assistance. Thus, people can minimize the pressure on the spine in the case of the most healthy sitting posture for the spine to reflect.

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