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# The Influence of Pillow Material and Shape on Cervical Curvature Stability.

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## Abstract

**Objectives:** This study intends to provide basic materials for selecting an appropriate type of pillow that will maintain the cervical spine to be in a neutral position during sleeping time. **Methods/Statistical analysis:** Twenty-eight male and female adults agreed to participate in this study. 30 minutes to measure the amount of change in the coordinates. Towel were spread on a hard and flat floor and the pillows were horizontally placed parallel to the x-axis of the three-dimensional motion analyzer with one of their corners positioned at the origin of coordinates. The participants lied on their pillow with their head located right in the middle of their pillow and for those who lied on a Memory foam Pillow (MP) or a functional pillow, they located their neck on the neck-supporting part of their pillow. The participants were put to the test for 30 minutes for each type of pillow and during the experiment, they were prohibited from talking or moving. One way repeated ANOVA is used to compare the change in the coordinate in time of the three pillows. **Findings:** The descriptive statistics that show the location of the pillows and the participants' heads. Except for Lt 2 and Lt 3, all the markers showed a significant difference ($p<.05$). The descriptive statistics shows the height of the pillows and the participants' heads. All the markers showed a significant difference ($p<.05$). The average amount of change in the location of the pillows is shown. The markers on the left side of the pillows showed no significant difference in the average amount of change in their location. Among the markers on the right side of the pillows, the markers showed a significant difference between Feather Pillow (FP) group and MP group and between MP group and The Functional Pillow (TFP) group. Among the markers attached on the participants' face, there was a significant difference between FP group and MP group and between FP group and TFP group. The average amount of change in the location of the pillows is shown. Among the markers on the left side of the pillows, there was a significant difference in the average amount of change in the height of the pillows between FP group and MP group and between FP group and TFP group. Among the markers on the right side of the pillows, there was a significant difference in the average amount of change in the height of the pillows between FP group and MP group and between FP group and TFP group. Among the markers attached on the participants' face, there was a significant difference between FP group and MP group, between MP group and TFP group and between FP group and TFP group. **Application/Improvements:** This study revealed that the material and type of pillow were related to SC and found out that using TFP, compared to the other two types of pillows, the height of the participants' heads less significantly changed with the passage of time. Therefore, TFP can be recommended as an appropriate type of pillow with a proper level of SC for cervical spine .

**Keywords:** Cervical Support, Pillow Height, Sleep, Three-Dimensional Motion Analyzer

## 1. Introduction

Sleep occupies approximately one third of our life and activity so maintaining good health through good sleep is important. In addition, sleep is necessary to adjust the ability to cognize, judge and memorize required for the activity. The[1] quality of sleep is directly related to the standard of living as well as human health. The[2] quality of sleep is related to the thermal conductivity, height, flexibility, stability, moisture absorbing power, air permeability, temperature, physical mobility, and usefulness of the pillow used and among these elements,

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the height of pillow has the greatest influence. For[3] a good night's sleep both quantitative and qualitative factors of sleep should be satisfied. For sleeping time, a quantitative factor showing individual differences, about 7 hours is recommended and little or too much sleep can add to fatigue. Qualitative[4] factors include bedroom temperature, humidity, lighting, bedding, etc, and the bedroom environment for a good night's sleep requires the indoor temperature of 24 ± 2 ℃ and humidity of 60~70%[5].

As main elements required for good sleep, there are bed, blanket, pillow, etc. These bedding should maintain appropriate temperature during sleep, support our body to maintain natural postures and prevent accumulation of physical fatigue by the movements made during sleep[6]. The role of a pillow is to support the cervical spine during sleep to neutral position. The[7] height of a pillow is closely related to the cervical spine angle during sleep. A high pillow interferes with the cervical curvature with its increased cervical angle. Its use for a long period of time causes bending of the neck vein, risk of brain hemorrhage or stroke, and blood circulation disorder causes problems in the cervical spine and neck muscles. In[8] a research comparing the relationship between cervical pain and cervical lordosis, using Harrison posterior tangent method, found a statistically significant relationship between cervical pain and cervical lordosis less than 20 degrees and between cervical pain and a clinically normal range of cervical lordosis of 31-40 degrees. In[9] said keeping lordosis in the range of 31-40 degrees could be a clinical goal for treatment[9]. As one of the most common reasons that causes inconvenience to our daily life, spinal pains, such as back and neck pains, are greatly affected not only by the structural, biomechanical, functional and psychological problems of our body but by social factors such as urbanization and industrialization[10].

Long-term absenteeism due to chronic neck pain has become a social problem leading to economic losses[11]. The working environment and life habits of modern people, such as driving and working on the computer and desk, increase neck movements in a sitting position, causing reduction of normal lordosis of the cervical spine and abnormal movements between the cervical spine and body. When the deep muscles of neck cannot be properly adjusted due to the overuse of neck, a neck pain is caused[12]. The functional deterioration of the head-neck area caused by a wrong pillow occurs due to neck and shoulder pains and to their limited range of motion and 67~71% of adults experience this[13]. Due to the pains, it can lead to physical and mental problems in carrying out jobs or daily activities. Many people have complained of stiffness and muscle pain in the neck, unlike back pain, only a handful of therapists and researchers were trying to solve the problem of neck pain and as a solution, conservative treatment such as surface heat treatment, deep hyperthermia treatment and electric treatment has been used[14]. When treatment for the neck muscles is initiated, symptoms of depression are quickly mitigated and physical symptoms such as neck muscle tension are alleviated. In[15] this process, it is considered that the tension and chronic pain of neck muscle are closely related to mental depression[15]. Habitually protracted chin can result in adaptive shortening of occipitalis muscle. This can increase the stress applied to the facet joint of spine, can cause a change in the cervical spine arrangement due to the rear disc or other rear structures and can lead to weakening of the deep muscle of neck[16]. In [17] represented a neck bone through Upper Crossed Syndrome occurring due to the influence of a protracted chin.

Having this symptom weakens deep neck flexor, Rhomboids, Serratus anterior, and sometimes the lower trapezius, while pectoralis major, pectoralis minor; upper trapezius, levator scapulae, etc. get short and stiff[17]. Cyriax claimed that neck pain is aggravated due to incorrect posture during sleep, and presented ideal sleeping positions and pillow conditions. Ideal posture is the posture where cervical spine curvature is maintained and there is no muscle tension[18].

In the previous studies, pillows such as FP and MP were mostly used. They said roll-shaped TFP significantly increased cervical lordosis angles when compared to MP and regular FP. There was also a significant difference in comfortableness between different types of pillows. When we lie on a FP, out head is positioned higher than our neck, bending our cervical spine forward and thereby causing Cervical Kyphosis[5]. In[19] simulated a sleeping environment with which they could recommend proper pillows for people to buy and according to the result of a research done using eight combinations of four types of pillows, the type of pillow that supports our head and shoulders and our cervical spine at the same time turned out to be the most comfortable and optimal type[19].

Studies so far have investigated the physical characteristics of mattresses and pillows in relation to the external factors of a sleeping environment[20], while studies on the level of the neutral position of the cervical spine

maintained depending on the material and type of pillow are insufficient. The neutral position in according to the material and shape of the pillow is lacking. Therefore, in this study, to find out the influence the shape and filling material of a pillow has on the level of cervical spine curvature maintained, markers were attached on the participants' faces and on three different types of pillows including FP, MP and TFP. As the participants lied on a pillow, the amount of change in the coordinates of the markers were measured and compared using a three-dimensional motion analyzer. This study intends to provide basic materials for selecting an appropriate type of pillow that will maintain the cervical spine to be in a neutral position during sleeping time.

# 2. Methods

## 2.1 Subjects

This study aimed at healthy adult men and women enrolled in the S University in Asan, Chungcheongnam-do. Participant selection criteria were those who had not visited hospitals or received medical treatment for neck pain, those who had not undergone neck surgery and those who had not suffered from scoliosis, inflammatory or degenerative arthritis and connective tissue diseases. By putting the average and error values measured in the research into the sample size calculation program (G*Power, 3.1.9.2), the result of sample size was obtained and a total of 28 participants were selected. The ratio of males to females was one to one Table 1.

**Table 1.** General characteristics (n=28)

| Gender (male/ female) | male (n=14) | female (n=14) |
|---|---|---|
| Age (years) | 23.35±1.90 | 21.21±1.12 |
| Height (cm) | 176.08±4.87 | 163.88±4.75 |
| Weight (kg) | 70.7±6.05 | 54.66±4.70 |

Values indicate mean ± standard deviation

This study was conducted with the approval of Sun Moon University Institutional Review Board (SM-201506-013-1). Enough explanation was given through one-on-one interview about the purpose and method of study to all the participants prior to the experiment and the experiment was carried out for those who agreed to participate in the study.

## 2.2 Experiment Procedures

This study is based on single-blind and randomly-controlled design and is a single-group repeated test. The participants were randomly assigned with a feather pillow, MP or TFP by lot and infoamation about pillows being used and test sequence were kept unknown to the participants.

Towel were spread on a hard and flat floor and the pillows were horizontally placed parallel to the x-axis of the three-dimensional motion analyzer with one of their corners positioned at the origin of coordinates. The participants lied on their pillow with their head located right in the middle of their pillow and for those who lied on a MPor a functional pillow, they located their neck on the neck-supporting part of their pillow. The participants were put to the test for 30 minutes for each type of pillow and during the experiment, they were prohibited from talking or moving.

### *2.2.1 Pillows*

A total of three types of pillows were used in the study. The FP (Doadream, Korea) was filled with goose down and the same shape as general pillows. Its size was 60cm in length, 45cm in width and 17cm in height. The MP (Sinomax, China) consisted of polyurethane foam and its size was 50cm in length, 38cm in width and 7~5cm in height. TFP (Venygood, Korea) was divided into shoulder support, cervical support and headrest and consisted of seven pieces. Its size was 45cm in length, 50cm in width and 8~4cm in height. It was filled with stuffing made of polypropylene. The amount of stuffing in the pillows remained unchanged during the experiment shown in Figure 1.

A. Feather pillow B. Memory foam pillow C. The functional pillow

**Figure 1.** Pillows.

### *2.2.2 Measurement Method*

A three-dimensional motion analyzer (Qualisys system - Qualisys Medical AB 41113, Goth en burg, Sweden) was used to measure Support Capacity for Cervical Spine (SC). Six cameras (Qualisys Oqus 300) were used for recording and infrared light reflected by spherical passive markers were used. Three markers were attached on the left and right side of the pillows at a regular interval (6 markers). And a marker was attached on the central forehead, glabellar and chin of the participants (3 markers). A total of 9 markers were attached on the face and pillows for each experiment. The markers attached on the left side of the pillows were named Lt 1, Lt 2 and Lt 3 in order starting from the one located closest to the participants' body when they lied on their pillow. The markers attached on the right side of the pillows were named Rt 1, Rt 2 and Rt 3 by applying the same rule. applied to the markers on the right side. The markers attached on the face were named Fa 1, Fa 2 and Fa 3 in the order of chin, glabellar and central forehead shown in Figure 2. Data were collected at the frequency of 100Hz using QTM (Qualisys Track Manager) ver 2.5. Three types of pillows were randomly assigned to the participants and they were made to lie down in a supine position for 30 minutes. The coordinates of the markers on the pillows right after they lied on their pillow and 30 minutes after were measured. To measure the location of their pillow and head and the height of their head that changed with time, the coordinates obtained right after the participants lied on their pillow and those obtained 30 minutes after were applied to the following foamula and the straight-line distance from the original coordinates to the changed ones was calculated the results shown in Figure 3. To calculate the changed location of the pillows and the participants' heads, the coordinates of all the markers on all the axes were used, while to calculate the changed height of the participants' heads, only the z-axis coordinates of the markers attached on their face were used.

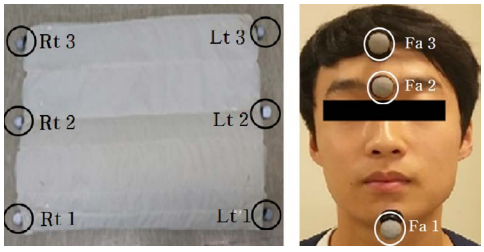


**Figure 2.** The name of the attached markers.

## 2.3 Measurement Time

In this study, sleep consists of four stages of Non-Rapid Eye Movement (NREM) sleep and rapid eye movement (REM) sleep. As the average sleeping time for ordinary people is 7.5 hours, NREM is conducted over four stages that last for a total of 90 minutes. Stage 1 of NREM is 20 to 30 minutes after sleep begins. In stage 1 of NREM, we can recognize a weak sound staying at the boundary between sleep and consciousness. In this stage, intervention is possible for the participants lying in a correct posture and considering intervention is difficult if they fall into deep sleep and toss and turn, 30 minutes of experiment time was applied to all the participants in this study.

## 2.4 Statistical Analysis

Statistical analysis was perfoamed using SPSS version 22.0 for Window (SPSS Inc., Chicago, IL, USA). The mean and standard deviation of the variables were calculated by descriptive statistics and Oneway repeated ANOVA was used to compare the coordinates of the three types of pillows that changed with time. The Shapiro-Wilk test was conducted for normality test and Bonferroni method was used for post hoc test. The level of statistical significance was set at $p < .05$.

# 3. Result

All the markers showed a significant difference ($p<.05$). The markers on the left side of the pillows showed no

$$\text{Distance of pillow and head in all axis} = \sqrt{(x_n - x_1)^2 + (y_n - y_1)^2 + (z_n - z_1)^2}$$

$$\text{Distance of pillow and head in z axis} = \sqrt{(z_n - z_1)^2}$$

**Figure 3.** Distance formula.

significant difference in the average amount of change in their location. Among the markers on the right side of the pillows, the markers showed a significant difference between FP group and MP group and between MP group and TFP group. Among the markers attached on the participants' face, there was a significant difference between FP group and MP group and between FP group and TFP group. The average amount of change in the location of the pillows and the participants' heads that changed with time is shown in Figure 4 and Figure 5. Among the markers on the left side of the pillows, there was a significant difference in the average amount of change in the height of the pillows between FP group and MP group and between FP group and TFP group. Among the markers on the right side of the pillows, there was a significant difference in the average amount of change in the height of the pillows between FP group and MP group and between FP group and TFP group. Among the markers attached on the participants' face, there was a significant difference between FP group and MP group, between MP group and TFP group and between FP group and TFP group.

## 4. Discussion

In this study, three types of pillows were randomly assigned to the participants and the level of SC that changed with the passage of time was measured and compared. According to the result, MP group showed the least amount of change in the coordinates of the location of the pillows and the participants' heads, while TFP group showed the least amount of change in the coordinates of the height of the pillows and the participants' heads.

When comparing the amount of change in height between Lt and Rt, there are no significant difference between MP group and TFP group. However, in all the Fa coordinates, TFP group had a significant difference compared to FP and MP group. This is considered to indicate that if the amount of change in the coordinates of Fa 1, Fa 2 and Fa 3 attached on the participants' face differs, the level of SC differs. When considering only the coordinates of the markers attached on the pillows, since they include coordinate movements in all directions (x-, y- and z-axis), the location and height of the pillows obtained from the markers determined depending on the pillow material change on all the axes.

In addition, it is not possible to measure the restoring ability which depends on the material of the pillow and the amount of change in the location and height varies depending on the respiration pattern of the participants. Therefore, it cannot be necessarily said that analyzing the amount of change in the coordinates of the markers attached on the pillows means verifying the level of SC.

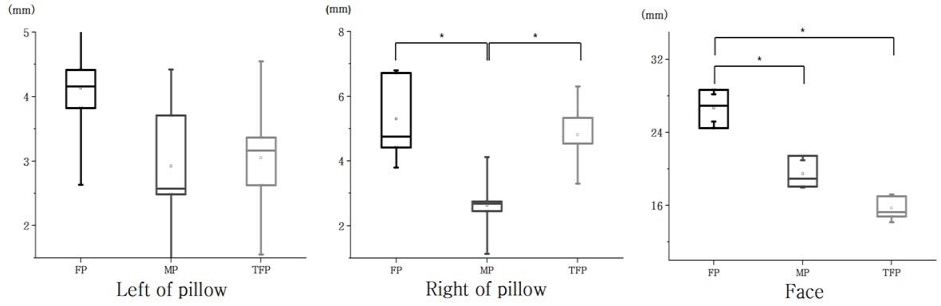


**Figure 4.** Changes of head and pillow height with the time lapses.

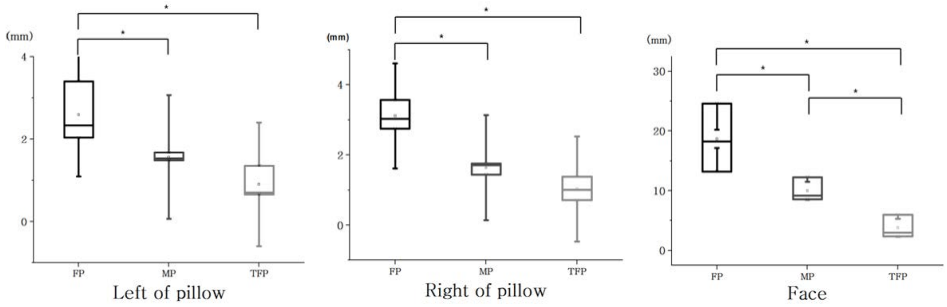


**Figure 5.** Changes of head and pillow position with the time lapses.

In previous studies as well, they mentioned a change in the location of the pillows on the z-axis because Cobb's angle for the participants changed before and right after they used the three types of pillows (FP, MP and TFP). Changing of Z-axis position of Cobb's Angle changed the subjects after using three kinds of pillow[21]. According to the above result as well, what effectively determines SC is the amount of change in the height of Fa and as a result, MP group has better SC than TFP Group.

In[22] results of this study as well as previous research showed that SC for cervical spine was good in the order of TFP, MP and FP and this is considered to be affected by both the material and structure of the pillow. Z-axis movement in the order shown smaller SC came out, the results are good, The amount of change of the Z-axis from which variables were removed to measure heights, in other words through the result of difference in the amount of change in the height, the substantial amount of change in SC was smallest for TFP. It is believed that there is affected the material and structure of the pillow. Between FP and MP and between FP and TFP, both the material and structure were different, while between FP and TFP, the material was different but they both had an ergonomic structure. Since TFP was filled with polypropylene capsule stuffing, it was sturdy and definitely comfortable and by reducing the space between the stuffing materials, it helped to maintain the cervical spine curvature. In addition, in previous studies, the time taken for TFP to reach Slow-Wave Sleep (SWS) turned out to be longer than other types of pillows, while concerning the percentage of SWS which is the basis for assessing deep sleep; TFP was higher than other types of pillows[23].

Through this, it is considered that the amount of change in the height decreases depending on the hardness of material. TFP not only supports our cervical spine but it also supports our head and since each of them is supported by a different rate of stuffing depending on the distribution of the pressure they apply on the pillow, the quality of sleep improves. It can be said that the harder the material of pillow is, the higher the level of SC is, while a pillow made of a soft material not only requires that more of our muscles be involved in tossing and turning but also requires more effort in maintaining a sleeping posture, preventing our body from taking a rest and causing us to have a light sleep[24].

In[25] the case of FP, it is not recommended, because it promotes waking symptoms and in the case of MP, like TFP, it provides SC for lordotic curve of cervical spine but in hardness of material, it is inferior than TFP. As a result, during sleep, cervical and head are not sufficiently supported or unconscious cervical movement occurs and due to the inappropriate cervical position during sleep, waking symptoms occur. According to other studies as well, the fact that increased quality of sleep increased the ability to lead a better daily life indirectly proves the importance of the quality of sleep in patients with pains[12]. If we use a proper pillow that fits each of us, the naturally-foamed cervical curvature angle minimizes the pressure applied to our cervical disc by even distributing it. However, if we use a FP or a MP which does not provide sufficient SC, the cervical lordosis does not provide sufficient SC, the cervical lordosis angle increases and according to a comparison conducted by[26] between an asymptomatic group and patients with acute and chronic cervical pains, the symptoms of cervical lordosis decreased significantly in the patients with chronic cervical pains[26].

As a limitation to this study, the experiment was conducted with an estimated total sleeping time so the amount of change in the height of the pillows and the participants' heads was not measured during actual sleeping time. As the participants toss and turn during sleep, their sleeping posture can change, causing even more amount of change. So far, there are many studies that compare pillows with a different structure, while studies that assess the structure and material at the same time are a few. Therefore, more study has to be conducted in addition to our study.

As a result of this study, FP and MP, commonly used by the public, aim for convenience to users by simply using softness of material. However, they are not suitable for each individual's cervical spine condition and if used thoughtlessly, even though FP and MP may not immediately cause musculoskeletal diseases, they decrease the quality of sleep and aggravate the condition of neck diseases so attention is required.

In selecting a pillow, rather than simply considering its softness to touch and comfortableness, it is important to make a choice by taking into account both the structure and material of pillow that is suitable for each individual's neck condition[27]. Securing sleeping time by selecting a suitable pillow in this way will prevent or prevent aggravation of musculoskeletal diseases involving cervical and shoulders in a modern society.

## 5. Conclusions

This study revealed that the material and type of pillow were related to SC and found out that using TFP, compared to the other two types of pillows, the height of the participants' heads less significantly changed with the passage of time. Therefore, TFP can be recommended as an appropriate type of pillow with a proper level of SC for cervical spine.

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