

# Optimal Pillow Conditions for High-Quality Sleep: A Theoretical Review

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## Abstract

It is widely believed that using a pillow that allows appropriate neck support to maintain cervical lordosis during sleep can lead to better quality sleep. Conversely, use of the wrong type of pillow can compromise pain-sensitive structures and produce waking symptoms, such as cervical pain and stiffness, headaches, and arm pain; and this in turn results in reduced sleep quality. Therefore, the optimal pillow should have neutral cervical lordosis, prevent waking cervical symptoms, and increase sleep quality by optimizing the sleeping position. A factor critical to a suitable pillow is proper support for cervical lordosis. The main role of a pillow during sleep is to support the cervical spine in a neutral position, which prevents loss of cervical spine curvature and waking cervical symptoms by minimizing end-range positioning of the spinal segments. Another critical characteristic of a suitable pillow is reduction of the temperature of the head and core during nighttime sleep. Because, sympathetic nervous system innervation was less excited with a cool pillow, which is important for deep sleep. In addition to neck support and temperature control, the pillow comfort is another critical characteristic of a suitable pillow. However, no association between pillow comfort and waking symptoms has been reported, suggesting that the participants' perceptions of pillow comfort and their reports of waking symptoms are independent of one another.

In conclusion, a neck pillow with a firm support and low temperature may reduce neck pain and improve sleep quality. Therefore, a cool and not too hard pillow with enough support for cervical lordosis is considered optimal and is recommended for high quality sleep and cervical pain relief.

**Keywords:** Cervical Lordosis, Neck Pain, Pillow, Sleep, Temperature

## 1. Introduction

Sleep comprises one-third of a person's life, and thus occupies 24 years of the average life span of 72 years. Comfortable and sufficient sleeping helps relieve daily physical and mental tiredness, restore balance in our bodily metabolic functions, ease accumulated fatigue, and in nerve cell re-synthesis. For these reasons, sleeping is indispensable for humans<sup>1</sup>. For us, sleeping functions to relieve physical and mental fatigue from the day and helps us staying healthy, and sufficient amounts of quality sleep thus require a favorable environment. Conversely, in the case of insufficient sleeping, the tiredness cannot be resolved, which may in turn lead to reduced atten-

tion and concentration, poorer work performance, and in increased day-time sleeping and disruption to the individual's daily routine<sup>2</sup>. To ensure a regular sleeping pattern, an appropriate sleeping duration and environment are required. The appropriate amount of sleeping, considering slight differences among individuals, is recommended to be about 7 hours per night, and too long or too short sleeping hours can result in aggravated fatigue. The sleeping environment is affected by external factors such as bedroom temperature, humidity, lighting, and bedding. The quality of sleep is considered to affect not only the health of the individual, but also their quality of life<sup>3</sup>; and therefore, to ensure comfortable and sufficient sleep, an appropriate environment is required. Here, good

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bedding is of particular importance. Beddings include the bed, bedclothes, and pillows, which all help support the human body in terms of maintaining an appropriate body temperature and natural and comfortable postures during sleeping, while preventing possible in-sleep physical fatigue accumulation<sup>4</sup>. Pillows support the human body and head in a supine position naturally and stably for physically comfortable sleep. They also assist diverse in-sleep body movements, prevent noises or vibrations from the floor, and ease the pressure from the floor to the human head. In addition, they also reinforce the cervical vertebrae during movements while sleeping, thus allowing comfortable in-sleep postures. The optimal height and material of pillows have been researched actively for many years<sup>4</sup>, and it can be concluded that, as such, pillows are an indispensable daily necessity. For a good sleep, pillows also need to meet several conditions, including the sanitary aspect.

Conventionally shaped pillows are too soft and support only the head while failing to help maintain the cervical vertebral curvature properly, and hence, they tend to concentrate pressure only to the head. Moreover, as people's heads are buried deeper into these pillows, their head temperature is increased<sup>5</sup>. More recently, latex or memory foam pillows have been increasingly used. These are soft and cover the head and neck well to provide comfort. However, these materials may be too soft to support the neck sufficiently, causing cervical vertebral deformation. Furthermore, as they cover up large parts of the head and neck, their contact surface with the human skin is relatively wide, thus reducing ventilation and raising the head temperature while retaining sweat. For these reasons, pillows made of such materials may not be appropriate for a pleasant sleep. In addition, given the characteristics of the materials, these pillows are difficult to wash and may become unhygienic by retaining moisture or dusts particles etc., and these issues represent some of the main limitations of these pillows.

## 2. Theory

Neck pains are reportedly experienced by 35~80% of all people at least once in their life, and most of these people also complain of additional symptoms such as neck-chest or spine-related pain, stiffness, headaches, and scapular pain<sup>6</sup>. Neck pain is reported to often become worse when waking up in the morning after sleep and to get better

during the day. The reasons for such symptoms developing seem to include the individual's pillow failing to support the neck and head during sleep or neck movement<sup>7</sup>. Changing to a more appropriate pillow can result in significant improvements in terms of post-sleep neck stiffness, neck pain, headaches, and scapular pain, among other symptoms<sup>8</sup>. As such, the main function of a pillow is considered to be support of the neck in natural positions. People who cannot sleep easily tend to have a stiff neck and shoulder muscles, which in turn can result in chronic pain. Together with exercise, using a proper pillow supporting the neck has been reported to be one of the most effective ways to reduce this chronic neck pain. For good sleep, the conditions of pillows that need to be considered include its heat conduction properties, height, size, elasticity, morphostasis, hygroscopic properties, breathability, and temperature. In other words, the thermal characteristics, form, height, and texture of the pillow all need to be considered.

### 2.1 Cervical Lordosis

First, the height and size of an ideal pillow should be considered. The pillow height and size are closely related to the cervical vertebral angle during sleep. High pillows increase the cervical vertebral angle and disturb its curvature by bending the neck vein and disturbing blood circulation. If used in the long-term, such pillows may cause stroke and cervical vertebral problems, as well as tensing of the neck muscles<sup>8</sup>. Furthermore, if the neck is bent, the intervertebral nerves may become compressed, resulting in pain and disturbed sleep. If such a situation continues, it can cause chronic neck muscle pain, which, in particular, can negatively affect the skeletal development of growing children. In the case of sleeping in the wrong position, people may find it hard to turn the head the next day or may feel pain in their neck and shoulder. Especially, when sleeping in the prone or other "bad" positions, people tend to feel pain due to tensed neck muscles<sup>9</sup>. In the supine position, the normal cervical vertebral curvature needs to be maintained to reduce muscular tension. In the lateral position, the cervical and thoracic vertebrae should be in line, and the head should be lifted upward, away from the floor, to ease muscular tension<sup>10</sup>. Good pillows should be low to support the neck in the supine position rather than the head in order to allow for sufficient support of both the head and neck while effectively filling the space between the bottom of the head and neck. Additionally, depending

on the individual's shoulder width, the pillow size should be adjusted to support both the head and neck at the same time<sup>11,12</sup>. Therefore, in the supine position, the optimal pillow should have a higher neck support than head support in order to effectively support the neck to allow for normal neck curvature. In the lateral position, the neck and back should be in line and the pillow should be high enough to minimize the stress in the neck imposed in the supine and lateral positions, thereby elevating the overall satisfaction with the pillow<sup>13</sup>.

In a previous study using lateral radiographs of the cervical spine in patients exposed to regular or roll-shaped pillows, the roll-shaped pillow was found to restore cervical lordosis and to decrease neck pain and discomfort while sleeping<sup>14</sup>. In another study, Hagino et al. evaluated the effectiveness of the Align-Right Cylindrical cervical pillow in reducing chronic neck pain severity. The authors found that there were clinically and statistically significant reductions in neck pain severity upon waking and at bedtime in this sample of chronic neck pain subjects, and suggested that the Align-Right Cylindrical cervical pillow may represent an effective therapy for a target population resembling their sample population of 25-45 year old subjects. Some subjects reportedly found the pillow very uncomfortable at the start, but experienced positive results when they persevered<sup>15</sup>. In conclusion, a neck pillow with a good shape and graded consistency may reduce neck pain and improve night rest. Therefore, a soft and not too high pillow with firm support for cervical lordosis appears to be the optimal type of pillow, and prescribing a good cervical support pillow is an important adjunctive therapy in the management of neck pain.

## 2.2 Pillow Temperature

Second, it has been reported that for an ideal sleep, people generally need to keep their head cooler and feet warmer. In other words, pillows need to maintain a lower temperature to allow for a pleasant sleep<sup>16</sup>. Pillows show different effectiveness depending upon their temperature characteristics, and cooling materials can help lower the overall body temperature, including that measured rectally and on the forehead, to slow the heartbeat<sup>16</sup>. As a result, this temperature decrease is helpful to ensure a good sleep. Especially, the under-pillow temperature increase time varies according to the pillow-and-head contact surface area, pillow filler thermal conduction, and the breathability of the pillow. Taking this into consideration, a new

filling material that can effectively support the neck while presenting lower thermal conduction, high breathability, and, in particular, minimum head contact needs to be developed<sup>12,17</sup>. Conventional pillows, especially those made of cotton, latex, or memory foam, comfortably covers the head and neck; however, their skin contact area is wide and they tend to reduce ventilation, resulting in raised head temperature, while retaining sweat<sup>12,16</sup>. A previous study showed that a cool material pillow could lower the rectal, forehead, and whole body temperatures, resulting in all subjects falling asleep more easily and sleeping better. Moreover, this pillow clearly slowed the heart rate of the subjects, suggesting that the sympathetic nervous system was less excited<sup>16</sup>. Taken together, these results suggest that a cool material pillow can reduce the body temperature and may improve the quality of sleep. Furthermore, a study by Okamoto et al. also showed that the cool pillow design could reduce sweating and whole body temperature, and indirectly improve the quality of sleep. These findings suggest that the thermal characteristic of pillows may be related to the type of materials used<sup>18</sup>. Regarding the type of materials, Jeon, et al. evaluated the temperature of 3 different types of pillows after 30 minutes of lying down, and showed that the degree of temperature increase was significantly lower for orthopedic pillows than for the memory foam and feather pillows. It is likely that this finding is because the capsules in each segment of the orthopedic pillow are open-ended, which helps to evenly distribute the heat of the pillow as well as to promote air circulation. Consequently, this prevents an increase in temperature and may improve sleep quality. In contrast, the memory foam pillow is more dense and molds to the neck and head closely; therefore, while it gives a feeling of comfort and stability, it decreases the air circulation and prevents thermal dissipation to the surroundings, ultimately increasing the temperature of the pillow. Duck or goose feathers are good at retaining heat, and accordingly, the feather pillow showed the highest temperature among the 3 pillows. Moreover, these pillows can emit an unpleasant odor due to the poor air circulation. Taken together, these findings indicate that the orthopedic pillow might be more effective in preventing an increase in neck and head temperatures, which may improve the sleep quality and result in improved sanitary conditions compared with the other 2 pillows<sup>12</sup>. The China pillow, also known as 'Tochin', and the stone pillow have traditionally been used in China and Japan. Presumably, the China and stone pillows can conduct heat from the

head to the pillow effectively, resulting in reduced brain temperature and increased extremity skin temperatures, and hence, deep sleep<sup>16</sup>. People have known for a long that that cooling the head is important to ensure deep sleep. Thus, it can be concluded that the moderate cooling of the head by the pillow during night sleep is of physiological significance for deep sleep.

### 2.3 Pillow Comfort

Lastly, in addition to neck support and temperature, pillow comfort is another critical characteristic of the optimal pillow. The stability of the pillow form is achieved using an optimal shape based on a dynamic structure and an appropriate filler for maintaining this shape. Pillow stability is essential for evenly distributing the pressure of the parts of the head and neck touching the pillow. If such pressure is not evenly distributed and instead concentrated on a specific part, local pressure is generated. If continued, such local pressure can cause pain in the corresponding pressure point, disturbing the sleep<sup>19</sup>. According to previous studies on the topic, regular or memory foam pillows use high compressibility materials, which concentrate the pressure to a single point. Conversely, pillows with relatively hard materials generally maintain an appropriate shape for supporting the head and neck, thus distributing the pressure evenly. Using harder materials as fillers has been demonstrated to show an initial effect on sleep quality, whereas no long-term effects have been found<sup>17</sup>. The study by Shields et al. showed that some subjects may initially find cervical pillows uncomfortable. However, these subjects tend to accept them after an extended period of use<sup>20</sup>. Carskadon performed a similar study with mattresses and found that the mattress material affected the quality of sleep in subjects who could not adapt to a new bed, namely that the material affected the sleep quality in the early stages. However, after a period of adaptation, the mattress material no longer had an effect on the sleep quality<sup>21</sup>. Furthermore, hard Chinese pillows, such as those made of jade or ceramic, were widely accepted in ancient China. Thus, these studies indicate that the time required for adaptation is an important factor for determining the comfort provided by the pillows. In addition, Ambrogio et al. used 3 types of neck support pillow designs on 35 fibromyalgia patients. Their research showed that the primary factor of a good pillow design was the comfort level, even though the most comfortable pillow did not directly improve the patients' symptoms.

A strong significant association was observed between reported poor-quality sleep and waking with cervical stiffness and scapula pain, whereas no association was noted between pillow comfort and waking symptoms, suggesting that people's perceptions of pillow comfort and their reports of waking symptoms are independent from one another.

Many patients complain of symptoms related to the cervical spine such as pain, stiffness, headaches, and scapular pain<sup>22,23</sup>; and many people appear to make poor pillow choices, as low sleep quality, low pillow comfort, and waking cervico-thoracic symptoms are commonly reported<sup>4</sup>. Especially, the nighttime sleeping posture should be taken into consideration, as any long-lasting inappropriate posture of the spine can irritate the capsular ligaments of the motor segments<sup>24</sup>. These patients' complaints revolve mostly around pain sensations that appear primarily during the night and in the morning, and which frequently cause sleep disturbances. It is difficult to alleviate such symptoms by physical therapy and postural exercises alone, and therefore, the night-time sleeping position must be changed to achieve physiological positioning of the spine by using a suitable pillow with appropriate support of the head in order to maintain a natural curvature of the spine during the sleep, consequently resulting in a higher quality sleep<sup>19,24</sup>.

## 3. Conclusion

There is still considerable controversy over the optimal design, material, and contents of pillows, with little published research supporting any particular type of pillow in terms of cervical lordosis, pillow temperature, and pillow comfort. Therefore, many people still make poor pillow choices, and low sleep quality, low pillow comfort, and waking cervical pain are commonly reported. Based on the previous studies on the topic, we here reached the conclusions that a soft, not too high pillow with firm support for cervical lordosis is the optimal type of pillow, and that prescribing a good cervical support pillow represents an important adjunctive therapy in the management of neck pain. Moreover, the moderate cooling of the head by the pillow during night sleep is of physiological significance to allow for deep sleep.

In conclusion, a neck pillow with a firm support and low temperature may reduce neck pain and improve sleep quality. Therefore, a cool and not too hard pillow

with enough support for cervical lordosis is considered optimal and is recommended for high quality sleep and cervical pain relief.

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