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Influence of Sleeping Posture on Zoned Mattress for Wood-based Furniture

Qian Wei,[a,b,1] Jian-hao Peng,[a,1] Xiao-wen Wei,[b] Xiao-ci Hong,[a] Yan-ni Sun,[b] Xiu-zhen Lin,[a] Yuding Zhu,[a,*] and Wen-kai Zhu (iD) [a,*]

Zoned mattresses for wood-based furniture have been influenced by the sleeping posture of the human body. Due to the different weights of various parts of the human body, lying on the mattress for wood-based furniture with uniform elasticity for a long time can cause illness. Therefore, dividing the mattress into different zones provides an effective solution for improving sleep quality. Herein, this work examined the impact of division size on a five-zone mattress on subject posture in various sleeping positions. Compared with conventional wood-based furniture structures, which often lack flexibility in localized support, the zoned mattress demonstrated superior adaptability in accommodating body contours. The results of the subsidence test suggested that the elastic distribution of the selected mattress was appropriate. The spinal positioning point indicated minimal impact of the size of the zone on the spinal curve of a supine position. Furthermore, the results of the body pressure distribution test revealed a significant influence of the zoning dimensions of the zone on the overall maximum pressure exerted on the human body, reaching up to 12.2 KPa. These findings offer valuable theoretical insights into designing zoned mattresses for wood-based furniture that accommodate human sleep posture.

INTRODUCTION

Wood-based materials have long played a central role in furniture manufacturing due to their availability, mechanical performance, and sustainability (Zhang and Zhu 2025; Song *et al.* 2025). In mattress systems, wooden frames, and laminated composites are often used to provide structural stability and rigidity (Kulakovskaya *et al.* 2024; Bu *et al.* 2025). However, while wood-based materials offer strength and durability, they typically do not provide the same localized pressure distribution or ergonomic adaptability as modern composite or zoned mattress systems. This limitation has motivated research into integrating advanced partitioning designs and elastic materials that complement or surpass the supportive properties of wood-based substrates (Zhu *et al.* 2025). Thus, the comparison between wood-based structures and zoned elastic designs is particularly relevant for improving sleep quality and ergonomic performance.

A substantial portion of a typical person's life is spent on a mattress on a wood-based bed, which has an enduring and intimate relationship with individuals (Chao and Shen 2022; Fang and Shen 2023). With respect to wood-based furniture, there is nothing that stays as long and as close to people as the mattress (Ren *et al.* 2023). As an indispensable furniture item, the mattress that compliments a wood-based bed frame is not only related to the quality of sleep, but it also affects long-term physical well-being (Caggiari *et al.* 2021; Hong *et al.* 2022). Furthermore, high-quality mattresses can enhance sleep quality and promote proper sleeping posture, especially in today's fast-paced society where high-quality sleep is crucial (Moshayedi *et al.* 2023). Therefore, research on mattress-related performance to improve people's sleep quality is necessary.

At present, many types of multi-functional mattresses for wood-based furniture are common on the market, such as latex mattresses, negative ion mattresses, memory sponge mattresses, and zoned mattresses (Grandner 2022; Nelson *et al.* 2022). Among them, the zoned mattress has the advantages of providing customized support, improving sleep posture, avoiding disturbing partners, and durability (Ramar *et al.* 2021). Therefore, the zoned mattress for a wooden bed-frame is widely used. Furthermore, the zoned mattress is a uniquely designed mattress that provides different levels of support to various parts of the sleeper (Wei *et al.* 2023; Li *et al.* 2024). The independent partition support of the zoned mattress can significantly improve people's sleep quality and reduce movement transmission during sleep (Aijazi *et al.* 2024). Moreover, the zoned mattresses are usually categorized into three, five, and seven zones based on the number of zones. Generally speaking, the more zoning mattress zones, the more conducive will be the mattress to match the scale and biomechanical properties of various parts of the human body, and it will be more conducive to obtaining a comfortable sleep (Sejbuk *et al.* 2022). The five-zone mattress on the market divides the mattress into head, shoulder, lumbar, hip and leg, with each zone having a different spring stiffness (Altintaş *et al.* 2024). This design allows the mattress to more accurately correspond to and support these parts of the body. As a result, it can better maintain the normal curves of the spine and provide a more comfortable and healthy sleep. Therefore, five-zone mattresses have a large market share and have been widely researched (Oh *et al.* 2022). Recent research on the zoned mattresses for wood-based furniture has primarily focused on construction materials used in their production, structural aspects, geometric properties, spinal characteristics related to lying position as well as comfort level (Rockenfeller and Müller 2022; Yang *et al.* 2025; Zakharov *et al.* 2023). However, there have been fewer studies regarding the impact of zoning dimensions on human lying posture (Chao *et al.* 2023). Therefore, conducting comprehensive research into the zoned mattresses to understand their influence on human lying posture characteristics and comfort level will be necessary and meaningful.

Herein, this study specifically focused on five-zone mattresses by investigating the human sleeping posture through examining subsidence, spinal positioning points, and body pressure distribution. The results can inform the design process for zoned mattresses leading to production suitable wood-based furniture that enhance people's sleep quality.

EXPERIMENTAL

Materials and Participants

The zoned mattress was provided by Xilinmen Furniture Co., Ltd. (Shaoxing, China). Eight healthy adult participants (2 males and 6 females, aged 20 to 30 years) were

recruited to provide typical body characteristics for comparative testing of mattress performance. Male participants had an average weight of 61.0 kg (SD 1.4) and an average height of 171.0 cm (SD 1.4), while female participants had an average weight of 53.0 kg (SD 5.6) and an average height of 160.7 cm (SD 5.5). The weight and height data were used to describe participant profiles only and are not intended to represent population-level statistics. All participants were in good health, and to minimize external influences during the experiments. Moreover, they wore loose clothing and refrained from wearing accessories such as belts or buttons. All experiments were performed in accordance with relevant guidelines and regulations.

Research Methodology

Subsidence test

A custom-made system was used to measure subsidence of zoned mattress and to evaluate its subsidence value in various areas under different sleeping positions, as shown in Fig. 1a. The procedure involved placing standard rods at regular intervals along the zoned mattress length, aligning the spinal line with these rods while lying down. Then, the localized mattress depression was calculated based on the difference between initial and post-sleep protrusions. This data made it possible to create a deformation curve for the mattress, representing human spinal morphology during supine positioning. Additionally, the lumbar support gap was assessed to gain further insight into spinal morphology during supine positioning. By calculating the low back clearance, it reflected the shape of the spine when the body is lying on its back. Spinal positioning points were identified by palpation of surface anatomical landmarks (*e.g.*, C7 spinous process, thoracic and lumbar protrusions). No imaging-based measurements of bone structure were taken. To ensure comparability among participants with different body sizes, an equal spacing of 65 mm between points was adopted, corresponding to the spring interval of the zoned mattress. This standardized approach allowed consistent analysis of spinal alignment across individuals.
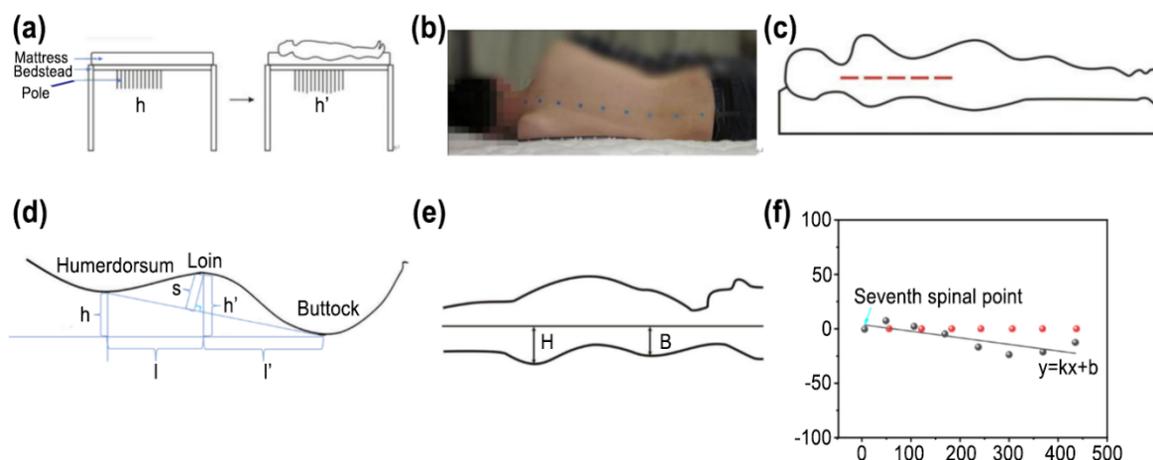

Fig. 1. (a) Schematic diagram of the measurement method for subsidence of zoned mattress; (b) Ideal spinal curvature in lateral recumbent position; (c) Localization of spinal landmarks; (d) Diagram illustrating lumbar intervertebral space; (e) Illustration of back and buttock depression levels; and (f) Slope of spinal curvature in lateral recumbent position

Digital measurement of spinal positioning points

When lying on the side, the spine should ideally maintain a neutral alignment in the coronal plane, appearing approximately straight from the front view. This posture minimizes lateral bending of the vertebral column and facilitates muscular relaxation, as supported by previous ergonomic studies on optimal sleep alignment (Zhang *et al.* 2023). Therefore, this study used the straight-line condition as a reference for assessing mattress conformity to natural spinal posture. The muscles are completely relaxed when the spine is a straight line from the front, as shown in Fig. 1b. This study identified spinal landmarks and used positioned photographs captured by a camera to analyze the spinal curvature of individuals lying on mattresses. The human spine consists of 24 vertebrae (7 cervical, 12 thoracic, and 5 lumbar), interconnected by ligaments, joints, and intervertebral discs along with one sacrum and coccyx bone. Due to challenges in precise localization of some spinous processes, specific methods for their identification were employed: identifying the highest protrusion at the neck area as C7 spinous process when observing or palpating. Subsequently, an equidistant approach was utilized, with each point set at intervals of 65 mm corresponding to mid-diameter of springs in zoned mattresses (Fig. 1c).

Body pressure distribution test

The test employed the Body Pressure Measurement System (BPMS) from Tekscan, Inc. to evaluate body pressure distribution on zoned mattress in three sleeping positions (supine, lateral, and prone), as shown in Fig. 2. Various pressure distribution metrics such as maximum pressure, average pressure, and contact area were analyzed to understand the overall and localized pressure distribution of the human body on the zoned mattress across these sleeping positions.

Fig. 2. Schematic illustration of BPMS for evaluating body pressure distribution on zoned mattress

Test Indicators

Subsidence

In the subsidence test, evenly spaced measuring rods were placed beneath the mattress to monitor vertical displacement during loading. When a participant lay in the test position, the downward deformation of the mattress surface caused corresponding displacement of the rods, which was recorded to calculate localized subsidence based on the difference between unloaded and loaded positions. The experimental parameters for subsidence of zoned mattress include the lumbar indentation and the chest-hip subsidence ratio. The lumbar-back space (S) is the perpendicular distance from the highest point of the waist to a tangent line drawn between the shoulders and lower back, reflecting spinal curvature. An S-shaped spine typically exhibits a concave depth of 4 to 6 cm when standing; during comfortable sleep, muscle relaxation and reduced gravitational loading cause this depth to decrease to about 2 to 3 cm (Hong *et al.* 2022; Ren *et al.* 2023). By measuring

subsidence depth and horizontal distances at specific regions such as shoulder, waist, and hip areas, it becomes possible to compute lumbar indentation—a metric providing insights into body posture during sleep. S can be calculated from Eq. 1 as follows (Hong *et al.* 2022; Liu *et al.* 2022),

$$S = \frac{l(h' - \frac{h \times l'}{1+l'})}{\sqrt{l^2 + (h - \frac{h \times l'}{1+l'})^2}} \tag{1}$$

where *h* represents the difference in subsiding depth between the lowest point of the shoulders and hips; *h′* represents the difference in subsiding depth between the highest point of the waist and lowest point of the hips; *l* denotes the horizontal distance between the lowest point of shoulders and highest point of waist; *l′* signifies the horizontal distance between highest point of waist and lowest point of hips; and *S* indicates perpendicular distance depth from highest point of waist to a tangent line drawn between shoulders and lowest part of hips, known as lumbar-back space (Fig. 1d). Additionally, to quantitatively classify zoned mattress subsidence distribution across different sleeping postures, it is necessary to measure the chest-to-hip subsiding ratio. The calculation requires measuring maximum subsiding depths at back and hip regions, followed by using equation 2 to derive its value (Han *et al.* 2022),

$$X = B / H \tag{2}$$

where *B* denotes the maximum subsiding depth of the back and *H* represents the maximum subsiding depth of the hips (as illustrated in Fig. 1e). Furthermore, Yosuke classified supine sleeping postures into lumbar-dominant and hip-dominant based on their investigation of sleep comfort and sleeping positions. A posture is considered lumbar-dominant when *X* >1, while it is deemed hip-dominant when *X*<1.

Spinal alignment curve

When lying on the side, the ideal spine is expected to form a straight line when viewed from the front. However, the spinal alignment may tilt upwards or downwards while on the zoned mattress. Connecting and graphing the key points of the spine can yield the slope of the side-lying spinal curve (*k*), as shown in Fig. 1f.

Body pressure distribution

The body pressure distribution indicators include maximum pressure, average pressure, contact area, average pressure gradient, and maximum pressure gradient. This study focused on the maximum pressure and average pressure as the primary body pressure distribution indicators. From the perspective of the physical properties of the mattress, the maximum pressure (P_m, the maximum value among all the test points) reflected the stiffness of the mattress. A firmer cushion has a higher P_m, while a softer one has a lower P_m. Firmness is one of the most critical physical parameters of a zoned mattress. Therefore, P_m is crucial in indicating mattress comfort. Additionally, average pressure also holds significance as an indicator for expressing mattress comfort and can be calculated using Eq. 3 (Issa *et al.* 2023; Souslian and Patel 2024). This can be calculated to derive P_v:

$$P_v = \frac{1}{N_p} \sum_{i=1}^{N_p} P_i \tag{3}$$

where P_v represents the arithmetic mean of the pressure at all pressure points, N_p is the number of pressure points, and N indicates the number of measurement points.

RESULTS AND DISCUSSION

Influence of Zoning Dimensions on Subsidence of Zoned Mattress

The study evaluated the subsiding depth of eight participants on three different zoned mattresses with five zones while lying supine. The data were used to calculate the mean and standard deviation of the maximum subsiding depth at the back, minimum subsiding depth at the waist, and maximum subsiding depth at the hips for each zoned mattress, as shown in Table 1. There was no significant difference in maximum subsiding depths across body regions among the five-zone mattresses in the supine position. Meanwhile, these results also indicated that zoning dimensions had minimal impact on subsidence of zoned mattress in this case.

Table 1. Subsiding Depths of the Back, Waist, and Hips in Supine Position with Zoned Mattress (unit: mm)

Mattress type	Maximum back sag		Minimum waist sag		Maximum hip sag	
	Average value	SD (N=8)	Average value	SD (N=8)	Average value	SD (N=8)
Mattress I	56.88	5.89	42.75	4.13	81.25	1.67
Mattress II	55.33	5.20	42.17	4.58	81.13	2.42
Mattress III	55.75	4.59	43.38	3.46	80.13	2.33

Furthermore, the mean and standard deviation of the chest-to-buttock depression ratio and lumbar-spine spacing were calculated for the mattresses, as shown in Table 2. Supine positioning results show chest-to-buttock depression ratios of approximately 70% across all three five-zone mattresses, with lumbar-spine spacing measuring 20 to 30 mm. These results suggest a reasonable elasticity distribution across these three five-zone mattresses.

Table 2. Chest-to-Buttock Depression Ratio and Lumbar-Spine Spacing of the Mattresses in Supine Position

Mattress Type	Dorsal-hip Subsidence Ratio (%)		Lumbar Back Clearance (mm)	
	Average Value	SD (N=8)	Average Value	SD (N=8)
Mattress I	67.3	7.7	25.55	1.22
Mattress II	68.3	6.8	25.40	2.38
Mattress III	69.6	6.5	23.98	1.57

Influence of Zoning Dimensions on Spinal Morphology

Based on the degree of spinal subsidence observed on three five-zone mattresses, the corresponding spinal curves were plotted (Fig. 3a). The results revealed that there were no significant differences in the spinal curves among these mattresses. Notably, mattress III exhibited a relatively flat spinal curve attributed to its larger back zoning dimensions, resulting in downward displacement of the hip and buttock areas (Jaenada-Carrilero *et al.* 2024). Consequently, individuals with shorter stature lying on mattress III may find their

waist located within the back zone and their sacrum positioned near the waist zone of the mattress. As a result, hip subsidence is slightly greater while buttock subsidence is slightly smaller on mattress III. These findings indicate that all three mattresses exhibit a 'buttock-shaped sleeping posture' curve with greater buttock subsidence than hip subsidence (Lopez-Garzon *et al.* 2022; Mihara *et al.* 2023). Additionally, observations from Fig. 3b and Table 3 show non-collinear alignment points in the side-lying position across all three mattresses. A noticeable upward curvature of the shoulder spine and a downward curvature of the lumbar spine are evident in each case. However, minimal slope values for all three mattresses suggest limited variation in spinal curvature and reasonable elastic distribution across partitioned zones. Overall, it can be inferred that zoning dimensions has minimal impact on human spinal curves.

Table 3. Spinal Curve Slopes on Three Zoned Mattresses in the Lateral Decubitus Position

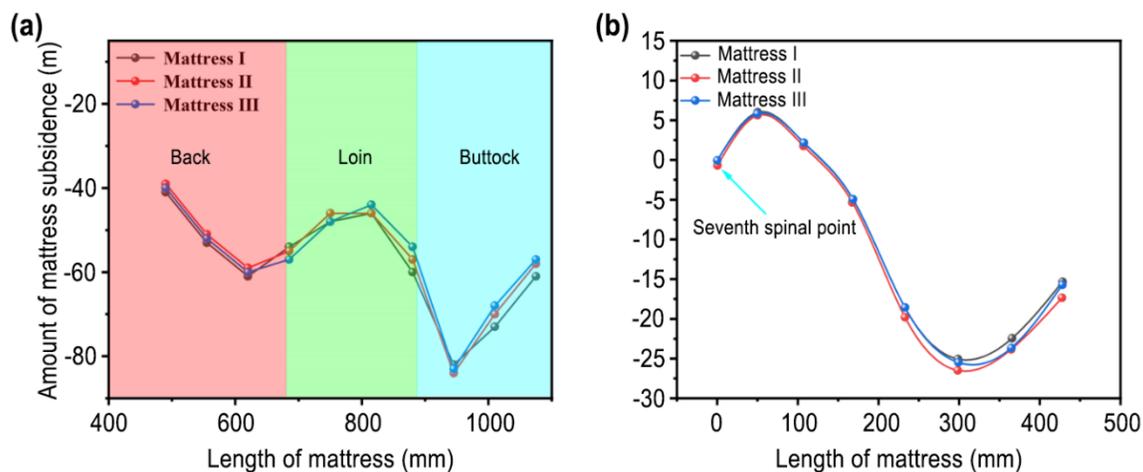|	Mattress I	Mattress II	Mattress III
Slope k	0.067	0.066	0.069
R^2	0.707	0.709	0.714

Fig. 3. (a) Spinal curves on zoned mattresses of varying sizes in the supine position. (b) Spinal curves on zoned mattresses of varying sizes in the lateral decubitus position

Influence of Zoning Dimensions on the Distribution of Body Pressure

To study the impact of body pressure distribution on zoning dimensions of the mattresses, a test was conducted measuring contact area, maximum pressure, and average pressure (Seki *et al.* 2023). Eight subjects were positioned in supine, lateral, and prone postures on three different five-zone mattresses. Their contact areas, maximum pressures, and average pressures were measured for data analysis.

Contact Surface Area

The mean and standard deviation of the overall contact surface area for eight subjects in supine, lateral, and prone positions on the five-zone mattresses are detailed in Table 4 and Fig. 4d. The results reveals that mattress III exhibits the largest overall contact surface area for supine and prone positions, while mattress II demonstrates the greatest overall contact surface area for lateral position. In comparison to mattress II, mattress I

displays a smaller overall contact surface area across all positions due to its shorter hip zone length leading to an increased leg zone length. Conversely, mattress III's larger back zone length relative to mattress II results in decreased leg zone length. The hip zone exhibits the greatest elasticity, followed by the back zone with moderate elasticity, while the leg zone shows the least elasticity (Katsuura *et al.* 2022; Wan *et al.* 2023). Consequently, lying supine on a zoned mattress with low-elasticity zones such as mattress I leads to reduced contact surface area. Therefore, Mattress I exhibits a smaller overall contact area compared to each other, whereas Mattress III shows a larger one. The maximum overall contact area occurs in the supine position, followed by the prone position, while the lateral position yields the minimum contact area.

Table 4. Overall Contact Surface Area of Three Different Zoned Mattresses in Three Sleeping Positions (cm^2)

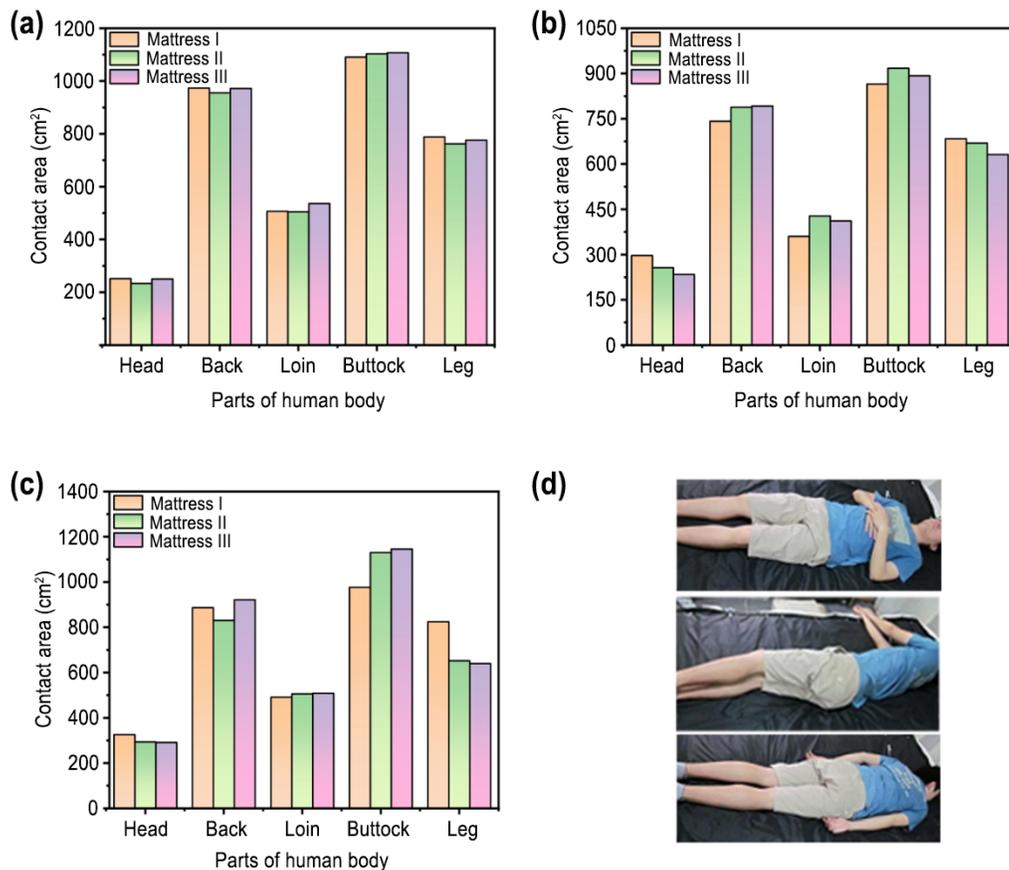| Mattress Type	Lie Supine		Lie on One's Side		Lie Prone	
	Average value	SD (N=8)	Average value	SD (N=8)	Average value	SD (N=8)
Mattress I	3610.29	421.03	2947.58	348.58	3448.50	377.21
Mattress II	3622.65	431.78	3059.29	287.53	3467.92	338.81
Mattress III	3641.10	448.14	2961.87	304.11	3506.28	355.36

Fig. 4. Contact area of different body segments in the supine position (a), lateral position (b), prone position (c). (d) Optical images depicting the three lying positions.

The contact area on the zoned mattresses decreases in the following order: hips, back, legs, waist, and head in the supine position as depicted in Figs. 4a-c. The differences in contact areas of different body parts on the three zoned mattresses are not statistically significant. The waist contact area is relatively larger on mattress III while it is relatively smaller on mattress II. In the lateral position, the contact area decreases in the following order: hips, back, legs, waist and head. The back and hip contact areas are relatively larger on mattress II while the waist, back and hip contact areas are relatively smaller on mattress I. In prone position, the sequence of decreasing contact area for different body parts is: hips, back, legs, waist, and head. The contact surface area of the back, waist, and hip are in the order of mattress Ⅰ, mattress Ⅱ, and mattress Ⅲ, respectively.

Maximum Pressure

The mean and standard deviation of the overall maximum pressure were measured on three different five-zone mattresses in supine, lateral, and prone positions for 8 subjects, as presented in Table 5. The results reveal that mattress II exhibits lower overall maximum pressure compared to both mattress I and mattress III in both supine and prone positions. In the lateral position, the overall maximum pressure on mattress I is lower than that on mattress II and mattress III. Across all three lying positions, it is observed that the overall maximum pressure on mattress III surpasses that of both mattress I and mattress II. The highest overall maximum pressure occurs during lateral lying position followed by prone position with supine exhibiting the lowest overall maximum pressure.

Table 5. Presents the Overall Maximum Pressure (kPa) of Three Different Zoned Mattresses in Supine, Lateral, and Prone Positions

Mattress type	Lie Supine		Lie on One's Side		Lie Prone	
	Average value	SD (N=8)	Average value	SD (N=8)	Average value	SD (N=8)
Mattress Ⅰ	9.77	3.57	12.38	4.78	10.19	3.12
Mattress II	8.86	2.22	12.61	5.40	10.16	3.45
Mattress III	10.23	2.56	13.15	4.29	10.36	4.91

When the human body is in a supine position, the primary load-bearing areas include the occipital bone, shoulder blades, elbows, sacrum and coccyx, and heels (Radwan *et al.* 2021; Weng *et al.* 2022). Consequently, these areas experience greater pressure. In a lateral position, the main load-bearing areas are the ears, shoulders, ribs, pelvis, greater trochanters and outer ankles (Fig. 5d), resulting in increased pressure on these regions. Meanwhile, the results illustrate varying pressures experienced in these three positions. Additionally, Figs. 5a-c reveals that maximum pressure is greatest at the head and legs during supine positioning while being lowest at the waist. Maximum pressure across all sections of Mattress II is lower than that of Mattress I and Mattress III. However, maximum pressure on Mattress III's buttocks exceeds that of both Mattress I and Mattress II. This phenomenon arises from the longer back area of Mattress III compared to those of Mattresses I and II which causes displacement downwards of its waist and buttocks regions. When individuals with shorter backs lie on this mattress type their buttocks rest within its waist region where elasticity is minimal leading to relatively higher maximum pressures. In lateral positioning order for maximum pressures across all zoned mattresses follows: buttocks > back > head > waist > legs.

Mattress III exhibits consistent maximum pressure points at its buttocks as when lying supine but surpasses those found in both mattresses I and II. Furthermore, the mattress' waist also experiences higher maximum pressures compared to other two mattresses. Maximum pressure point at back section is smallest for Mattress I whereas it's largest for back section but smallest for waist section for Mattress II. The sequence from lowest to highest maximum pressure points observed at buttock region are: Mattress II < Mattress I < Mattress III when lying laterally. During prone positioning, maximum pressures occur first at leg followed by head then back, waist, and finally hip. The minimum value occurs at Mattress II's back and Mattress I's buttock. Maximum pressure point in waist section is identical for all three mattresses.
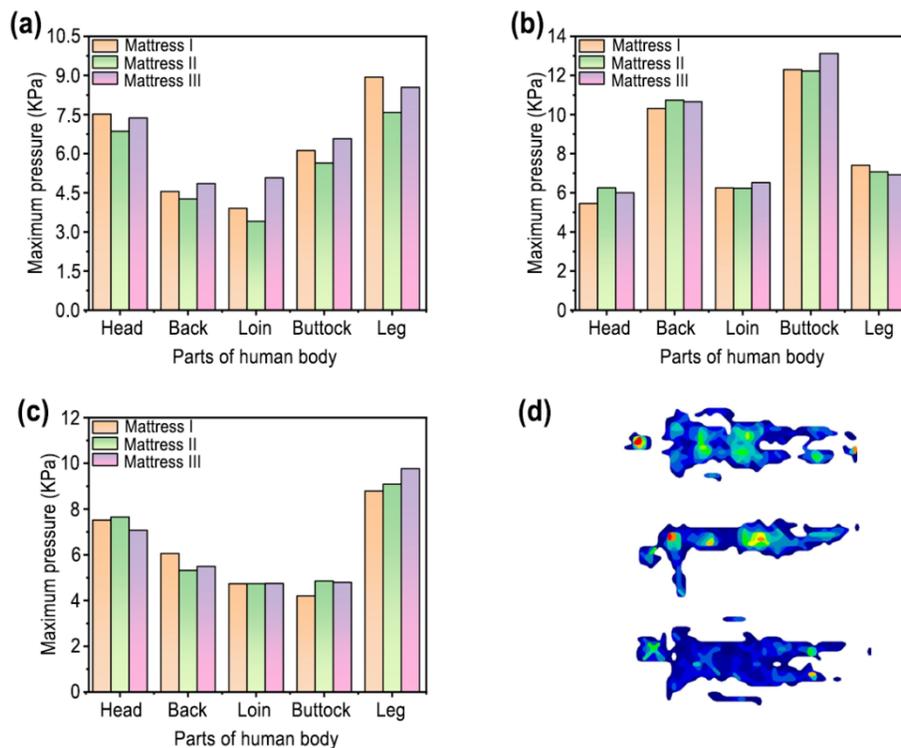

Fig. 5. Maximum pressure of different body parts in supine position (a), lateral position (b), and prone position (c). (d) Pressure distribution of the human body in supine, lateral, and prone positions.

Average Pressure

The average and standard deviation of the overall pressure on the three five-zone mattresses were tested with subjects in supine, lateral, and prone positions, as shown in Table 6. Table 6 shows that in supine, lateral, and prone positions, Mattress II consistently exhibits the lowest overall average pressure, while Mattress I shows the highest. This is due to the relatively larger overall contact area on Mattress III leading to higher maximum pressures and subsequently higher average pressures.

Table 6. Overall Average Pressure of the Three Different Zoned Mattresses in Supine, Lateral, And Prone Positions (KPa)

Mattress type	Lie supine		Lie on one's side		Lie prone	
	Average value	SD (N=8)	Average value	SD (N=8)	Average value	SD (N=8)
Mattress I	1.37	0.19	2.08	0.36	1.387	0.24
Mattress II	1.32	0.15	2.03	0.36	1.382	0.20
Mattress III	1.35	0.17	2.07	0.33	1.384	0.20

Additionally, the slightly larger overall contact area and lower maximum pressure distribution on Mattress II result in a more uniform pressure distribution leading to a lower average pressure. Furthermore, the overall average pressure is highest in the lateral position, followed by the prone position, and lowest in the supine position (Xiao *et al.* 2023).

It can be seen from Figs. 6a-c that the longitudinal pressure distribution curves of the human body on the three different zoned mattresses in the supine, lateral, and prone positions are consistent, and the differences are not significant. These results indicating that the zoning dimensions has little effect on the longitudinal pressure distribution curves of the zoned mattresses (Yasser *et al.* 2022). The longitudinal pressure distribution curve of the supine position is consistent with the pressure distribution of the human body in the supine position, with the greatest pressure on the occipital bone, shoulder blades, sacrum, and coccyx, and the heel. In the lateral position, the pressure distribution of the human body is on the ear, shoulder, ribs, greater trochanter, and ankle. The longitudinal pressure distribution curve of the lateral position shows that the pressure on the ear, shoulder, ribs, greater trochanter, and ankle is greater. When the human body lies prone on the zoned mattress, the chin, sternum, kneecap, and toes are subjected to greater compression, and the longitudinal pressure distribution curve shows that the pressure on the chin, sternum, knees, and toes is greater. It is evident that in the supine position, the head and buttocks experience the highest average pressure, while the back, waist, and buttocks exhibit similar pressure values (Fig. 6d–f).
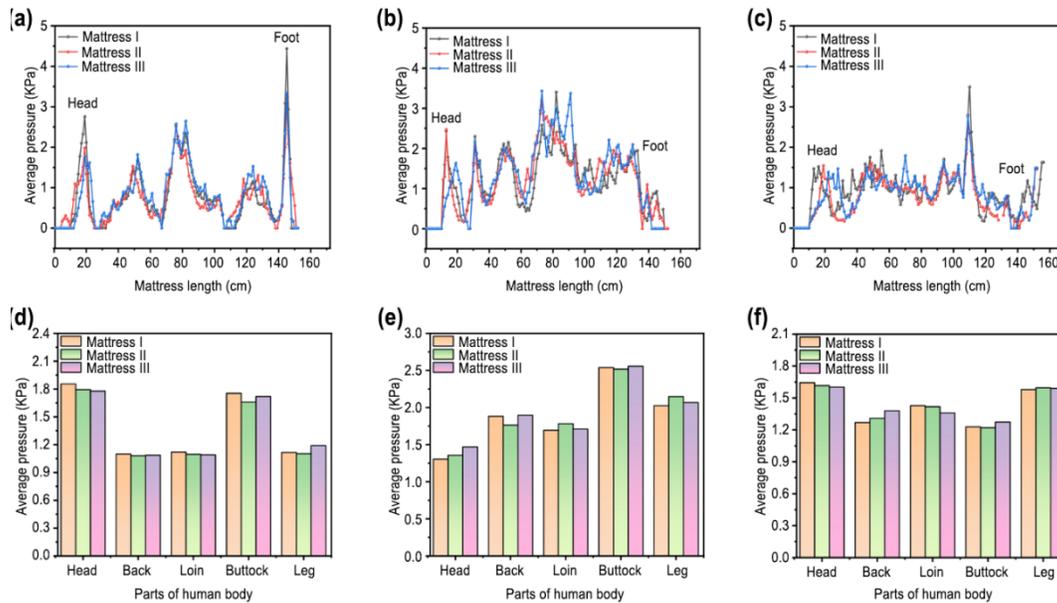
Fig. 6. The longitudinal pressure distribution curve in the supine position (a), the lateral position (b), and the prone position (c). Average pressure on different body parts of an individual lying supine (d), lying laterally (e), and lying prone (f)

Mattress I exhibits the highest average pressure on the buttocks. This is due to its shorter buttock zone and longer leg zone, which result in a softer buttock region and a firmer leg region. The reduced contact area in the buttock zone increases the average pressure in that area. In the lateral position, the average pressure on the buttocks is the greatest, followed by the legs, back, and waist, and the average pressure on the head is the smallest. The average pressure on the back and buttocks of Mattress II is smaller than that of Mattress I and Mattress III, while the average pressure on the waist of Mattress II is relatively the largest. The average pressure on the buttocks in descending order is Mattress I, Mattress II, and Mattress III when lying on the stomach. When lying on the stomach, the average pressure on the head, back, waist, buttocks, and legs of the three zoned mattresses is not significantly different, and the average pressure on the buttocks is relatively the smallest. When lying on the stomach, the average pressure on the waist increases compared to lying on the back or side, while the average pressure on the buttocks decreases. This occurs because body weight shifts from the buttocks to the kneecaps, altering the load-bearing area and subsequently redistributing pressure. It is expected that users with higher body weight would exhibit increased subsidence and contact pressures, especially in the hip and lumbar zones. Nevertheless, the zoned elastic design can mitigate such effects by redistributing body load across regions with varying stiffness. Future studies should expand the sample size and include participants with a wider range of body weights to further validate the adaptability of zoned mattresses.

CONCLUSIONS

In this study, the five-zone mattresses that affects subjects' posture in different sleeping positions were investigated. Although this study used a flat wooden base to isolate the mattress effect, the observed variation in pressure distribution across body regions suggests

that future designs could integrate contoured or zoned wooden bases to better match human body morphology and further improve ergonomic comfort.

1. Subsidence value, spinal alignment points, and body pressure distribution to understand the impact of zoning dimensions on human sleeping posture were analyzed. Results indicated that the back and buttock depression ratio was around 70% in the supine position, with a waist-back gap of 20 to 30 mm, suggesting reasonable elastic distribution across the three five-zone mattresses.

2. The analysis also found minimal influence of zoning dimensions on human spine posture and insignificant differences in spine curvature slope among different zones. Additionally, results showed a significant effect of zoning dimensions on overall maximum body pressure, reaching up to 12.15 KPa.

3. The results of this work can guide the design of zoned mattresses for wood-based furniture, producing sleep systems that conform to human posture and enhance sleep quality. Unlike conventional wood-based furniture elements that primarily provide structural support without adapting to individual body pressure distributions, zoned elastic mattresses offer dynamic support tailored to human biomechanics. This comparison highlights the potential for zoned mattress technologies to complement or even surpass traditional wood-based solutions in promoting ergonomic comfort and long-term health benefits.

ACKNOWLEDGMENTS

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