



Ethnic Variation in preference of Sleep Surfaces including next-Generation AI-Smart-Beds and their association with Sleep Health Trends

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Abstract

Evolution of sleep surfaces, particularly introduction of next-generation AI smart beds could significantly influence global trends in sleep and health. This study was conducted in New Zealand, a multi-cultural nation with various ethnic communities to evaluate whether ethnicity influenced choice of static and dynamic sleep surfaces. Research involved 92 adults segmented into four major ethnic groups: New Zealand-European, New Zealand-Māori, New Zealand-Asian/Oriental, and New Zealand-Indian. Participants evaluated a conventional static mattress and the Smart-Tek AI Mattress scoring them based on Comfort, Firmness, Temperature, and Overall Satisfaction using the Boston Mattress Satisfaction Questionnaire from Harvard Medical School. The ethnic groups exhibited varied preferences for Static surfaces but collectively favored the Dynamic surface. Results revealed Dynamic surface significantly improved comfort feel, firmness support, and overall satisfaction, with effect sizes ranging from $\eta^2=.596$ to $.612$, while temperature regulation was not perceived. Comfort enhancements were most pronounced among NZ-European (+1.48) and NZ-Māori (+1.39) groups, whereas the NZ-Asian group experienced the greatest firmness preference increase (+1.70) followed by NZ-Indian participants (+1.39), and NZ-Māori participants (+1.00). Overall satisfaction increased across all groups, peaking in NZ-European participants (+1.74), followed by NZ-Māori (+1.04), NZ-Asian (+0.96), and NZ-Indian (+0.74). Such significant improvements indicate potential of adaptive sleep surfaces to personalize user experience, irrespective of backgrounds. This also suggests that next-Gen-AI Smart Beds may bridge ethnic disparities in sleep satisfaction and contribute to improved sleep medicine and health trend outcomes.

Keywords: Ethnicity, Next-Gen-AI Smart Bed, Chronobiology, Neurophysiology, Sleep Medicine

Introduction

The increasing interest in personalized sleep environments has emphasized the importance of accounting for individual heterogeneity in responses to sleep-related interventions and sleep-support technologies. Sleep-surface characteristics can influence subjective comfort, spinal support, pressure distribution and sleep quality, although the optimal characteristics of a mattress are not uniform across individuals (Radwan et al., 2015; Caggiari et al., 2021). Differences in body dimensions, body-mass distribution, habitual sleeping posture and spinal

geometry can alter the interaction between the sleeper and the mattress, with anthropometric characteristics influencing the degree of support required across different regions of the body (Verhaert et al., 2011, 2012). Thermal conditions are also important because environmental heat and cold can alter sleep continuity, sleep stages and thermoregulatory responses (Okamoto-Mizuno & Mizuno, 2012). Accordingly, the concept of an “ideal” sleep surface is increasingly understood as an individualized rather than universally fixed characteristic.

Biomechanical and ergonomic research indicates that mattress performance depends on the interaction between the physical characteristics of the sleep surface and characteristics of the sleeper. Personalized or adjustable sleep systems have been investigated in relation to spinal alignment, body contour and regional stiffness, with evidence suggesting that support customized to individual anthropometry and posture may improve aspects of sleep quality and comfort (Verhaert et al., 2011; Caggiari et al., 2021). Systematic reviews have similarly reported that medium-firm and customized mattress systems can provide favorable outcomes for comfort, sleep quality, spinal alignment and, in some populations, low-back-pain-related outcomes, although substantial heterogeneity remains among studies and individuals (Radwan et al., 2015; Caggiari et al., 2021). These findings provide a rationale for investigating adaptive systems capable of modifying support rather than assuming that a single static configuration is optimal for all users.

New Zealand provides a relevant setting for examining this question because of its ethnically diverse and increasingly multicultural population. The 2023 New Zealand Census identified European, Māori and Asian peoples as major population groups, with Māori constituting the Indigenous population of Aotearoa New Zealand and Asian populations encompassing multiple distinct ethnicities (Stats NZ, 2024; Ministry of Health, 2026). In the present study, the four major ethnic groups, New Zealand-European, New Zealand-Māori, New Zealand-Asian/Oriental, and New Zealand-Indian are therefore treated as study-defined population groups rather than as biologically homogeneous categories. This distinction is important because ethnicity represents a complex social and cultural construct that may interact with socioeconomic circumstances, migration history, occupation, living environment, health status and culturally patterned behaviors.

Sleep-health disparities across local ethnic population groups provide an additional rationale for investigating whether health trends exist in response to sleep environments. For example, in New Zealand, Māori adults have been reported to experience a greater prevalence of insomnia and sleep disturbances than non-Māori adults (Paine et al., 2005). In a nationally representative analysis, Māori participants had higher prevalence of difficulty initiating sleep,

frequent nocturnal awakenings and early-morning awakenings than European participants; importantly, socioeconomic position and experiences of racial discrimination accounted for a substantial proportion of the disparity in several sleep-disturbance measures (Rumball-Smith et al., 2016).

Contemporary New Zealand data further demonstrate substantial variation in health trends across population groups. In the 2024/25 New Zealand Health Survey, 27.0% of adults reported sleeping less than the recommended duration, with socioeconomic deprivation also associated with lower attainment of recommended sleep duration (Ministry of Health, 2025). Chronic pain was reported by 30.4% of European/Other adults, 30.2% of Māori adults and 14.6% of Asian adults; after adjustment for age and sex, Māori were 1.24 times as likely as non-Māori to report chronic pain, whereas Asian adults were less likely to report chronic pain than non-Asian adults (Ministry of Health, 2026). Diabetes prevalence also varies across population groups, with an age-standardized prevalence of 102.7 per 1,000 reported among Indian people compared with 33.1 per 1,000 among European/Other people in 2024 (Ministry of Health, 2026). Such population-level differences are relevant to sleep-health research because chronic pain, metabolic disease and sleep disturbances may interact bidirectionally.

Cultural practices may also influence the sleep environment. Bedding materials, bedroom organization, sleeping arrangements and preferred proximity to the floor have historically differed between populations. For example, floor-level sleeping and low bedding have longstanding cultural traditions in Japan and Korea, including the use of futons, mats and heated-floor systems, whereas raised beds have been more characteristic of many Western domestic environments (Wilson & Chu, 2005; Ikeda et al., 2014). A large epidemiological study of Japanese adolescents found that approximately one-third slept on futons placed on the floor or tatami, demonstrating that sleep-surface configuration can remain culturally patterned even within contemporary populations (Ikeda et al., 2014). Nevertheless, such observations cannot be generalized to all Asian populations or to Asian New Zealanders, whose sleep environments are heterogeneous and increasingly influenced by migration, urbanization and modern housing.

The physical interaction between the sleeper and sleep surface provides a plausible mechanism through which individual and population characteristics may influence perceived comfort. Body dimensions, body-weight distribution and sleep posture affect the relationship between the human body and mattress stiffness, while inappropriate support may influence spinal alignment and pressure distribution (Verhaert et al., 2011, 2012). Experimental and review evidence also indicates that adjustable or customized support systems may provide advantages over fixed configurations for some users (Radwan et al., 2015; Caggiari et al., 2021). Similarly, thermal conditions are an important component of the sleep environment because excessive environmental heat can increase wakefulness and alter rapid-eye-movement and slow-wave sleep, whereas appropriate thermal conditions support sleep continuity (Okamoto-Mizuno & Mizuno, 2012). Thus, comfort, firmness and thermal perception should be regarded as multidimensional outcomes arising from interactions among the individual, the sleep surface and the surrounding sleep environment.

Conventional static mattresses provide a fixed mechanical response, whereas adaptive or dynamic

surfaces can modify regional support through adjustable zones, air chambers or variable-stiffness mechanisms. Such technologies have the potential to accommodate differences in body morphology and sleeping position, although evidence does not yet establish universal superiority over static mattresses (Caggiari et al., 2021). Recent smart-sleep technologies additionally incorporate pressure sensing, body-position detection and ballistocardiography to estimate physiological and sleep-related parameters, while AI-enabled systems may integrate these signals with automated mechanical adjustment. However, their measurement accuracy and clinical validity require further independent validation, and they should not be regarded as substitutes for polysomnography without appropriate evidence. Anthropometric inter-individual variability, including differences in body mass, body composition, stature, pelvic and shoulder dimensions, and spinal geometry influences pressure distribution, spinal alignment and gauges the support received from a sleep surface. Consequently, the same static mattress may produce different biomechanical and comfort responses among individuals (Bader & Engdal, 2000; De Vocht et al., 2006; Verhaert et al., 2011).

Table I: Use of Common Sleep Surfaces by different Ethnic Communities

Ethnic Community	Static Sleep Surface Preference	Common Mattress Types
New Zealand-European	Prefer plush/soft or medium mattresses emphasizing pressure relief, spinal support, and comfort.	Pocket Spring, Innerspring, Euro-Top, Hybrid (Posture pro-pocket Spring + Memory Foam), Latex, Wool, Tempur, Cool Gel, Adjustable Smart Bed-bases; Generally Medium to Soft/Plush beds
New Zealand-Māori	Traditionally accustomed to firmer sleeping surfaces; modern preference is medium-to-medium firm mattresses providing stability and adaptive support particularly for higher weight capacity.	Orthopedic Pocket Spring, High-Density Foam, Hybrid, Latex, Adjustable Smart Bed-bases; Double-spring mattresses ; generally Medium beds

Ethnic Community	Static Sleep Surface Preference	Common Mattress Types
NZ-Asian Orientals	Strong cultural preference for Firm and Xtra-firm sleeping surfaces. Less preference for highly undulating/soft/conforming mattresses.	Bamboo Mat, Firm Mattress, Firm Foam, High Density foam, High Tensile Spring, Latex, Coconut Coir, Firm Pocket Spring; generally Firm beds
NZ-Indian	Traditionally prefer medium to medium-firm sleep surfaces including coir, cotton and bamboo mattresses for support, ventilation, and heat dissipation.	Cotton (<i>Gaddi</i>), Rebounded Foam, Orthopedic, Hybrid (Pocket Spring + Memory Foam), Latex-Coir Hybrid; High rebound springs; generally Medium Firm beds

Despite rapid technological development, whether responses to dynamic sleep surfaces vary among ethnic or population groups remains largely unexplored. The aim of this scientific study was to analyse whether emerging adaptive mattress technologies achieve user satisfaction consistently across various cultural and physiological backgrounds, or are there significant ethnic disparities that remain?

Materials And Methods

This was a prospective, cross-sectional within-subject comparative, short-term user responsiveness study of a conventional static mattress compared with the recently commercialized Smart-Tek AI dynamic mattress following its launch in the New Zealand market (Satralkar, 2026). This study was conducted with visitors/shoppers who visited the New Zealand Bed Company showroom at Westgate Lifestyle Shopping Centre, Auckland, from 18 April to 18 June 2026. The showroom offered a private, temperature-controlled environment (21–23°C) designed to mimic a standard home bedroom; both mattresses were displayed under the same lighting, linens and noise conditions to control outside environmental variability. This study design reduced inter-individual variability, as each subject acted as their own control by evaluating both sleep surfaces under standardized conditions allowing for direct comparison of mattress performance.

A total of 92 adults aged between 30 to 70 years took part in the study. Participants were purely visitors and randomly recruited for the study depending on interest during their brief visit to the New Zealand Bed Company showroom. Data was then organized appropriately to represent four of New Zealand's largest ethnic populations: NZ European ($n = 23$), NZ Māori ($n = 23$), NZ Asian/Oriental ($n = 23$) and NZ Indian ($n = 23$). Ethnicity was self-reported and gender was not considered. Eligible participants were independently mobile, able to comfortably lie on both mattresses, able to understand the study procedures and verbally capable of giving informed consent. Exclusion criteria included acute musculoskeletal injuries, severe cognitive impairment and medical conditions interfering with participation in the study safely.

Demographic data was collected at the time of enrolment. Concurrent usability testing was conducted for both the conventional static mattress and the Smart-Tek AI dynamic mattress in one session with all participants. For the sake of potential order effects avoidance, mattress testing was balanced across the participants (i.e. Participants were instructed to lie on each mattress for about 30 min in their normal sleep posture, i.e., either supine, lateral, or prone postures if appropriate. The adaptive control system for the Smart-Tek AI mattress, which is constantly modulating support characteristics based on body

position and pressure distribution during sleep, was unaffected by the evaluator. Testing was conducted without too much verbal guidance regarding mattress performance or likely outcomes, to minimize observer effect or biases.

Immediately after evaluating each mattress participants filled out the Boston Mattress Satisfaction Questionnaire (BMSQ), a reliable tool for measuring subjective mattress evaluation. The four main domains were assessed for comfort, firmness, temperature, and perceived overall satisfaction. Each domain was scored on a 10-point Likert scale in which 1 was poor and 10 was excellent. After the quantitative scoring participants were asked to provide qualitative open-ended feedback on their experience with each mattress. Descriptive thematic analysis was then applied to summarize qualitative responses into common themes to support the quantitative findings.

The research work and survey were performed according to the ethical principles of the amended

Declaration of Helsinki on research involving human participants. All participation in this study was voluntary with informed oral consent for questionnaire study and photography. All responses were anonymized before any formal statistical analysis was performed on the dataset. The study presented minimal risk to participants since it was an observational evaluation of commercially available mattresses over the short duration exhibited in a high quality-retail showroom environment utilizing only non-invasive procedures and no clinical trial. This methodology allowed for the concurrent comparison of static and adaptive sleep surfaces, whilst exploring whether ethnicity (New Zealand European, Māori, Asian-oriental and Indian) impacted short term perceptions of comfort, firmness, temperature and satisfaction in different configurations to provide the first exploration of ethnic differences in responses to an AI-enabled adaptive sleep interface.

Figure 1 : Trialing a Static and Dynamic (Smart Tek AI Bed) at Auckland, New Zealand

Traditional Static mattress

Dynamic Smart Tek – AI (Smart-bed)



Figure 2 : Ethnic Communities comparing Static and Dynamic Surfaces at Auckland, New Zealand

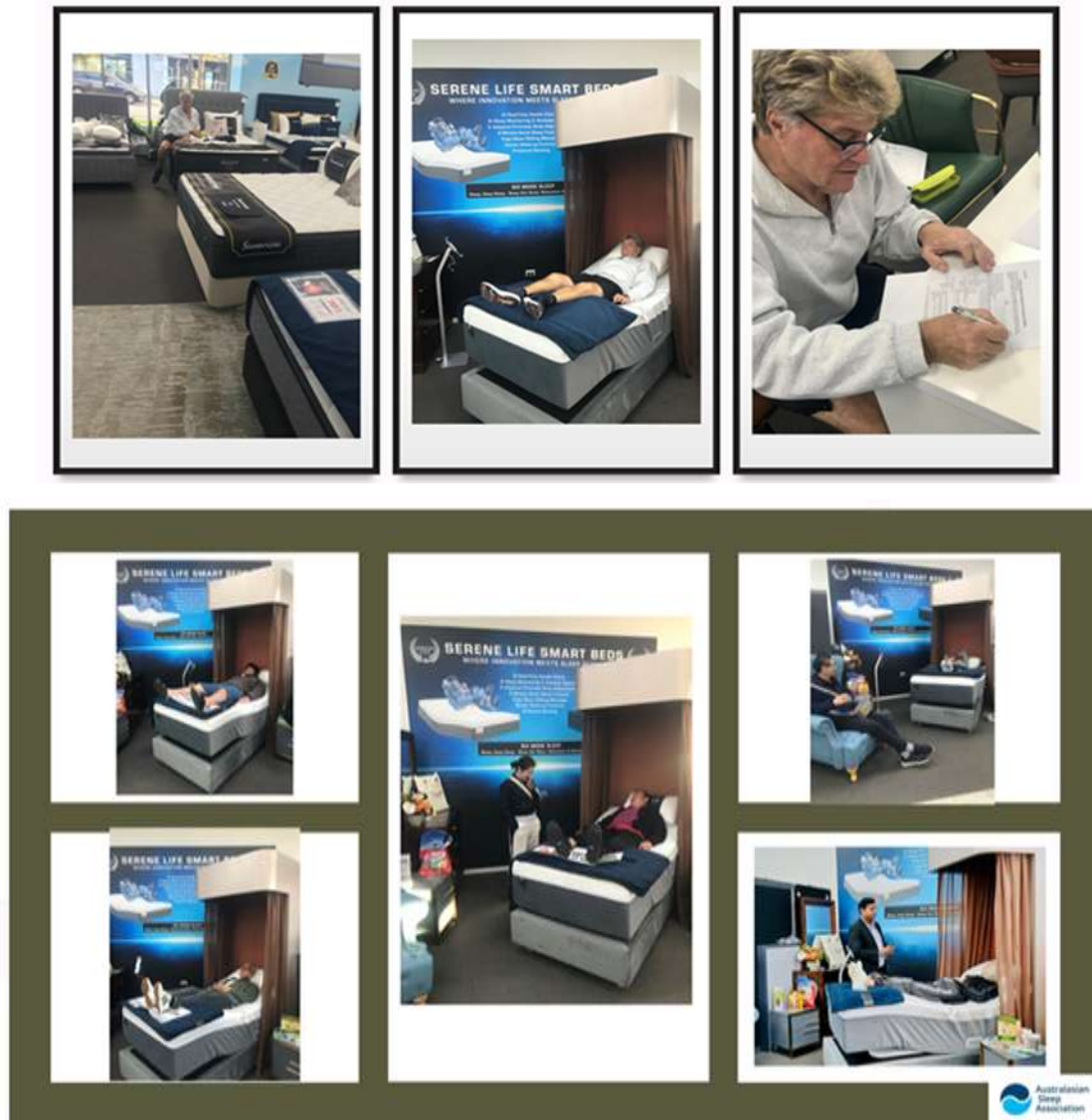
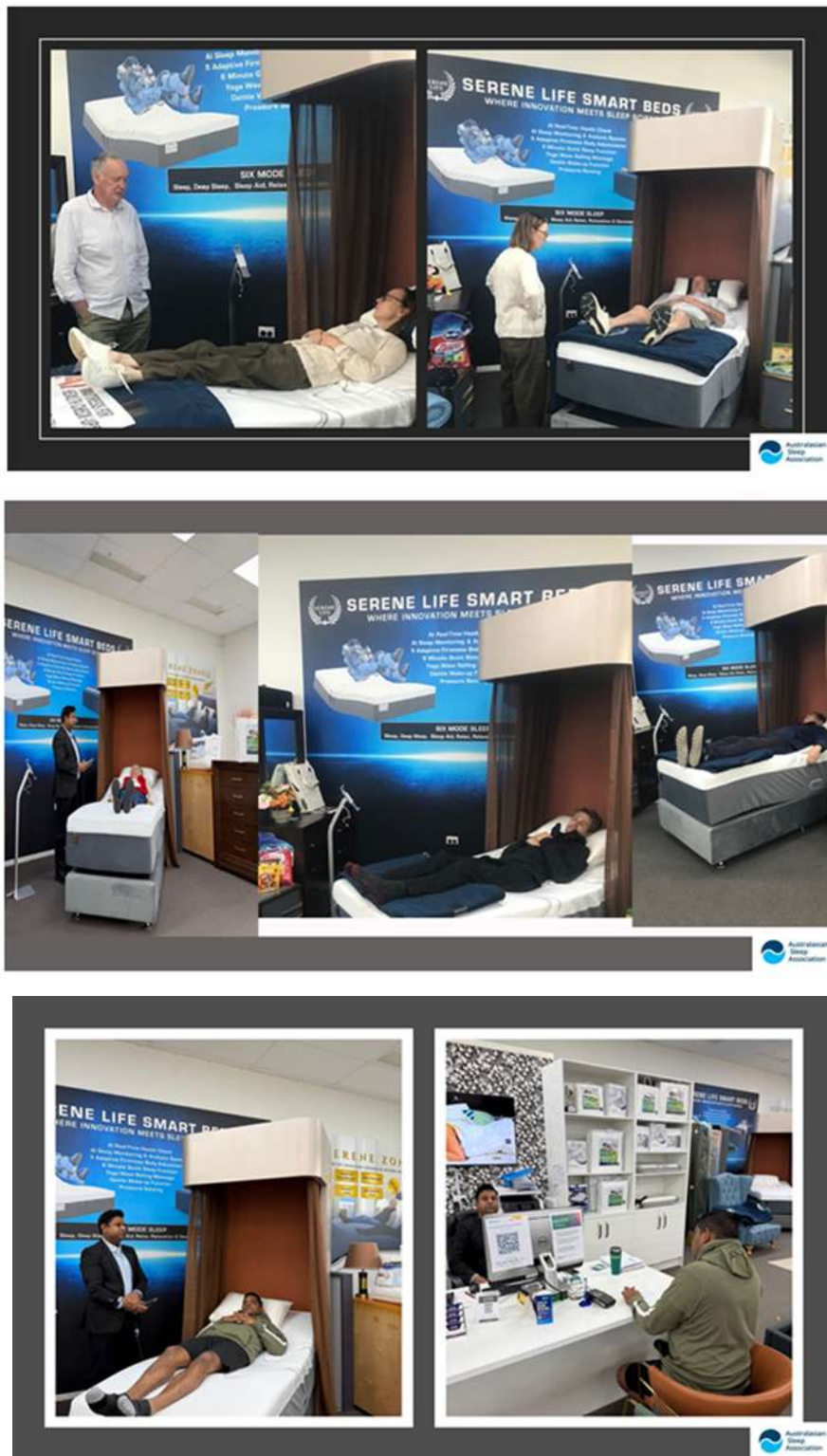


Figure 3 : Ethnic Communities using the Boston Mattress Satisfaction Questionnaire, New Zealand





A mixed-design comparative study was structured to evaluate user-reported responses to static and dynamically adaptive sleep surfaces. The dataset comprised 92 casual shoppers who visited the showroom. All were mature participants, equally distributed across four ethnically defined cohorts: NZ-European ($n = 23$), NZ-Māori ($n = 23$), NZ-

Asian/Oriental ($n = 23$), and NZ-Indian ($n = 23$). Ethnicity was treated as the between-subjects factor, while mattress condition was treated as the within-subjects repeated-measures factor. Each participant evaluated both mattress conditions, thereby providing paired observations under the Static and Dynamic sleep-surface conditions. This repeated-measures

design permitted each participant to serve as their own control when comparing mattress conditions while simultaneously examining whether responses differed between the four cohorts.

Statistical analysis was performed on scores and data collected from all 92 participants. Continuous variables were summarized using means and standard deviations (SD). Because each participant provided ratings for both mattress conditions, paired samples *t*-tests were used to compare Static and Dynamic mattress ratings across the complete sample. Separate paired-samples *t*-tests were also performed within each ethnicity-defined cohort to determine whether the direction and magnitude of the mattress-condition effect were consistent across groups.

To evaluate whether the magnitude of the Dynamic-minus-Static change differed among the four cohorts, one-way analysis of variance (ANOVA) was performed separately for each BMSQ outcome using the change score as the dependent variable and ethnicity as the between-subjects factor. Where appropriate, Tukey-adjusted post-hoc comparisons were used to examine pairwise cohort differences.

A two-way mixed-design ANOVA was subsequently performed for each outcome, with:

Mattress type: Static versus Dynamic — within-subject factor;

Ethnicity: Caucasian, Māori, Asian/Oriental, and Indian — between-subject factor;

Mattress Type × Ethnicity: interaction term.

The mixed ANOVA therefore tested three effects: the main effect of mattress type, the main effect of ethnicity, and the Mattress Type × Ethnicity interaction.

Effect sizes for paired comparisons were expressed as Cohen's *d*, calculated from the paired change scores. For ANOVA effects, partial eta squared (η^2) was reported. Statistical significance was evaluated at $\alpha = .05$, with two-tailed tests.

Results

The results depicted that almost all ethnicities preferred different types of static surfaces within the Showroom and were inclined traditionally to pick a surface they were used to sleeping on, the moment they experienced the dynamic surface they rated it higher. Details are elucidated below.

Descriptive and paired-samples analysis

Across the complete sample of 92 participants, the Dynamic surface produced higher mean ratings than the Static surface for comfort, firmness, and overall satisfaction, whereas the difference in temperature rating was very small. The results were both quantitative and qualitative and the former elucidated below.

Table 1. Descriptive statistics and paired samples *t*-tests for the complete sample (N = 92)

Outcome	Static, mean ± SD	Dynamic, mean ± SD	Mean change	95% CI for change	<i>t</i> (91)	<i>p</i>	Cohen's <i>d</i>
Comfort	5.72 ± 0.86	6.86 ± 0.84	+1.14	0.93–1.35	10.94	<.001	1.14
Firmness	5.49 ± 0.78	6.60 ± 0.74	+1.11	0.90–1.32	10.41	<.001	1.09
Temperature	6.12 ± 0.73	6.17 ± 0.74	+0.05	−0.14–0.24	0.51	.611	0.05
Overall satisfaction	5.56 ± 0.80	6.69 ± 0.86	+1.14	0.93–1.35	10.94	<.001	1.14

The paired analysis demonstrated statistically significant improvements in comfort, $t(91) = 10.94$, $p < .001$, $d = 1.14$; firmness, $t(91) = 10.41$, $p < .001$, $d = 1.09$; and overall satisfaction, $t(91) = 10.94$, $p < .001$, $d = 1.14$. In contrast, the Static-to-Dynamic difference in temperature was not statistically significant, $t(91) = 0.51$, $p = .611$, $d = 0.05$.

Thus, within the generated dataset, the Dynamic surface was associated with substantial improvements in perceived comfort, firmness and overall satisfaction, while temperature ratings remained statistically comparable between conditions.

Cohort-specific paired comparisons

The cohort-specific analysis demonstrated that the direction of change was generally positive across all four cohorts for comfort and overall satisfaction.

Table 2. Static versus Dynamic BMSQ ratings by cohort

Outcome	Cohort	Static mean	Dynamic mean	Mean change	t(22)	p	Cohen's d
Comfort	Caucasian	5.78	7.26	+1.48	7.13	<.001	1.49
	Māori	5.70	7.09	+1.39	7.96	<.001	1.66
	Asian/Oriental	5.70	6.43	+0.74	3.01	.006	0.63
	Indian	5.78	6.65	+0.87	6.01	<.001	1.25
Firmness	Caucasian	6.09	6.43	+0.35	1.62	.119	0.34
	Māori	5.48	6.48	+1.00	5.62	<.001	1.17
	Asian/Oriental	5.13	6.83	+1.70	8.78	<.001	1.83
	Indian	5.26	6.65	+1.39	8.53	<.001	1.78
Temperature	Caucasian	6.30	6.30	0.00	0.00	1.000	0.00
	Māori	6.13	6.09	-0.04	-0.21	.833	-0.05
	Asian/Oriental	5.83	6.22	+0.39	1.74	.095	0.36
	Indian	6.22	6.09	-0.13	-0.55	.589	-0.11
Overall satisfaction	Caucasian	5.74	7.48	+1.74	10.30	<.001	2.15
	Māori	5.52	6.57	+1.04	5.39	<.001	1.12
	Asian/Oriental	5.39	6.35	+0.96	6.50	<.001	1.36
	Indian	5.61	6.35	+0.74	3.01	.006	0.63

These results show that Asian/Oriental participants demonstrated the largest mean improvement in firmness (+1.70), followed by Indian (+1.39) and Māori (+1.00) participants. The Caucasian cohort showed only a small, non-significant firmness increase (+0.35).

For overall satisfaction, the largest increase was observed in the Caucasian cohort (+1.74). All four cohorts demonstrated statistically significant improvements in overall satisfaction.

Temperature responses were not statistically significant within any cohort.

Ethnicity Differences in Change Scores

One-way ANOVAs were conducted on Dynamic-minus-Static change scores as below.

Table 3. One-way ANOVA of ethnicity differences in mattress-condition change scores

Outcome	F(3,88)	p	Partial η^2	Interpretation
Comfort	3.53	.018	.108	Significant cohort difference
Firmness	9.57	<.001	.246	Significant cohort difference
Temperature	1.19	.319	.039	Not significant
Overall satisfaction	5.06	.003	.147	Significant cohort difference

There were statistically significant between-cohort differences in the magnitude of change for comfort, $F(3,88) = 3.53$, $p = .018$, $\eta^2 = .108$; firmness, $F(3,88) = 9.57$, $p < .001$, $\eta^2 = .246$; and overall satisfaction, $F(3,88) = 5.06$, $p = .003$, $\eta^2 = .147$.

The ethnicity effect for temperature was not statistically significant, $F(3,88) = 1.19$, $p = .319$, $\eta^2 = .039$.

Cohort	Comfort Δ	Firmness Δ	Temperature Δ	Overall satisfaction Δ
Caucasian	+1.48	+0.35	0.00	+1.74
Māori	+1.39	+1.00	-0.04	+1.04
Asian/Oriental	+0.74	+1.70	+0.39	+0.96
Indian	+0.87	+1.39	-0.13	+0.74

The largest cohort-level firmness response was observed among Asian-Oriental participants, whereas the largest overall-satisfaction response was observed among Caucasian participants. Māori participants demonstrated a comparatively large comfort improvement, while Indian participants demonstrated a relatively large firmness improvement.

The mixed-design ANOVA table only, combining the main effects of Mattress Type and Ethnicity and the Mattress Type $\times$ Ethnicity interaction is shown below in a table.

Table 3. Two-way mixed-design ANOVA for mattress type and ethnicity

Outcome	Effect	df	F	p-value	Partial η^2
Comfort	Mattress Type	1, 88	132.03	<.001	.596
	Ethnicity	3, 88	3.25	.026	.100
	Mattress Type $\times$ Ethnicity	3, 88	3.53	.018	.108
Firmness	Mattress Type	1, 88	150.65	<.001	.612
	Ethnicity	3, 88	2.00	.120	.064
	Mattress Type $\times$ Ethnicity	3, 88	9.57	<.001	.246

Outcome	Effect	df	F	p-value	Partial η^2
Temperature	Mattress Type	1, 88	0.26	.610	.003
	Ethnicity	3, 88	1.36	.260	.044
	Mattress Type $\times$ Ethnicity	3, 88	1.19	.319	.039
Overall satisfaction	Mattress Type	1, 88	135.00	<.001	.607
	Ethnicity	3, 88	11.76	<.001	.286
	Mattress Type $\times$ Ethnicity	3, 88	5.06	.003	.147

Mixed-ANOVA interpretation

The mixed-design analysis confirmed a significant **main effect of mattress type** for comfort, firmness, and overall satisfaction, indicating higher ratings under the Dynamic condition. No significant mattress-type effect was observed for temperature.

A significant **Mattress Type $\times$ Ethnicity interaction** was observed for:

- **Comfort:** $F(3,88) = 3.53, p = .018, \eta^2 = .108$
- **Firmness:** $F(3,88) = 9.57, p < .001, \eta^2 = .246$
- **Overall satisfaction:** $F(3,88) = 5.06, p = .003, \eta^2 = .147$

The interaction was not significant for temperature, $F(3,88) = 1.19, p = .319, \eta^2 = .039$.

Accordingly, the data generated support the conclusion that **the magnitude of response to the Dynamic versus Static surface differed across the four cohorts for comfort, firmness, and overall satisfaction, but not for temperature.**

Discussion

Ethnic heterogeneity in perceived response to adaptive sleep surfaces

The present study provides preliminary evidence that response to an adaptive sleep surface is higher but heterogeneous across ethnic groups. Across 92 participants, ratings for comfort, firmness and overall satisfaction were higher for the Dynamic than for the Static sleep surface, while the magnitude of these within-person-changes differed between the four cohorts. Comfort improved in all cohorts, with mean Dynamic-minus-Static changes of +1.48 points among

New Zealand European participants, +1.39 among Māori participants, +0.74 among NZ Asian participants and +0.87 among NZ Indian participants. Firmness showed a different pattern, with the largest improvement among NZ Asian participants (+1.70), followed by NZ Indian (+1.39) and Māori (+1.00) participants, whereas the New Zealand European cohort demonstrated a smaller and non-significant change (+0.35). Overall satisfaction increased significantly across all four cohorts, with the largest change observed among New Zealand European participants (+1.74). The significant Mattress Type $\times$ Ethnicity interactions for comfort, firmness and overall satisfaction therefore indicate that the magnitude of the subjective response to the Dynamic surface was not uniform across cohorts. In contrast, the absence of significant interaction for temperature suggests that the observed ethnic heterogeneity was more apparent for mechanical and perceptual attributes than for perceived thermal response.

Ethnicity is a socially and culturally constructed population characteristic that may capture the combined influence of socioeconomic circumstances, health status, environment, cultural practices, previous experiences, body morphology and other factors. Sleep-disparity research similarly accentuates that ethnic differences in sleep cannot generally be attributed to a single biological mechanism and are influenced by interacting social, environmental and socioeconomic pathways (Grandner et al., 2016; Paine et al., 2016). The present findings therefore support the more cautious interpretation that ethnic-group membership was associated with different patterns of “perceived response” to adaptive sleep-surface

conditions, rather than demonstrating an intrinsic ethnic sensitivity to mattresses.

The result extends predominantly biomechanical literature on mattress evaluation. Previous research has concentrated on firmness, pressure distribution, spinal alignment, comfort, pain and sleep quality, while comparatively little work has examined whether responses to the same sleep surface differ systematically across population groups. A biomechanical review concluded that although pressure distribution and spinal alignment are important considerations in mattress evaluation, sufficiently validated universal target values have not yet been established (Lin & Powell-Roach, 2019). Recent evidence further demonstrates that pressure distribution can vary according to anatomical characteristics, sleeping position and sex, reinforcing the importance of considering inter-individual variability when designing sleep-support systems (Mohamadi et al., 2026).

Mattress characteristics, body morphology and mechanical interaction

The interaction between the human body and the sleep surface is inherently mechanical. Body mass, body dimensions, body composition, spinal curvature, shoulder and pelvic geometry, sleeping position and movement determine how load is distributed over the mattress. Consequently, a mattress with fixed mechanical characteristics necessarily represents a compromise across individuals. Experimental and modelling studies have demonstrated relationships between body morphology and mattress contact area and interface pressure, although the magnitude and clinical relevance of these relationships vary between individuals (Gefen et al., 2012). Automated approaches combining body morphology and pressure distribution have consequently been proposed for individualized sleep-surface selection (Carrer et al., 2017). This framework provides a plausible biomechanical explanation for why a dynamically adjustable surface could produce such a heterogeneous response. Rather than requiring the entire body to accommodate one fixed mechanical configuration, an adaptive surface can theoretically modify support according to pressure distribution, body position and individual preference.

The existing mattress literature supports the general importance of appropriate surface characteristics but

does not establish a universally optimal firmness. In the landmark randomized trial by Kovacs et al. (2003), involving 313 adults with chronic non-specific low-back pain, medium-firm mattresses produced better outcomes for pain and disability than firm mattresses. A systematic review of controlled mattress trials subsequently reported that medium-firm and self-adjusted surfaces generally showed favorable effects on comfort, sleep quality and spinal alignment, although methodological heterogeneity remained substantial (Caggiari et al., 2019). A more recent 25-year review similarly concluded that the evidence most consistently favors medium-firm rather than very firm or very soft surfaces, while identifying zoned, air-adjustable and customized systems as promising approaches requiring further investigation.

The significance of the present findings is therefore not that a Dynamic mattress is universally superior to a Static mattress as it a medium firm sleeping surface, nor that a particular ethnicity requires a particular firmness, rather, the findings suggest that ‘adaptability of the mattress’ itself may be an important design characteristic of the Dynamic surface that benefits everyone.

NZ-European participants: comfort and adaptive support

The relatively large improvement in comfort (+1.48) and overall satisfaction (+1.74) among New Zealand European participants may indicate greater physical responsiveness to the combination of pressure redistribution and individualized support provided by the Dynamic surface. A more practical interpretation is that the observed response may reflect differences in the combination of individual biomechanical characteristics and prior sleep-surface experience. Age-related changes in musculoskeletal function and the increasing prevalence of chronic musculoskeletal conditions may alter the importance of pressure distribution and support, but these mechanisms cannot be established from the present subjective data alone. Future studies should therefore determine whether the larger comfort response observed in this cohort is associated with age, body mass index, musculoskeletal symptoms, body-pressure maps, spinal alignment or previous mattress characteristics.

NZ-Māori participants, health status and sleep inequity

The response among Māori participants is particularly relevant within the Aotearoa New Zealand context. The present data demonstrated a substantial improvement in comfort (+1.39) and overall satisfaction following exposure to the Dynamic surface. This observation is encouraging as there are several documented ethnic inequities in sleep health of Maori's. Population research has identified ethnic differences in sleep disturbance and sleep duration, with socioeconomic position, health status and experiences of discrimination contributing to these disparities (Paine et al., 2016). More broadly, reviews of sleep disparities emphasize that differences between ethnic populations arise through interacting social, environmental, socioeconomic and health pathways rather than ethnicity functioning as an isolated biological determinant (Grandner et al., 2016).

Contemporary New Zealand health surveillance also documents substantial health inequities affecting Māori, including higher burdens of several chronic conditions. The Ministry of Health reports higher rates of diabetes, cardiovascular disease and other chronic conditions among Māori compared with non-Māori populations. The 2022/23 New Zealand Health Survey also reported a substantially higher prevalence of obesity among Māori adults than among European/other adults, although obesity itself should not be used as a proxy for an individual's sleep-surface requirements.

The relationship between pain and sleep provides another potentially relevant pathway. Sleep disturbance and pain are reciprocally associated, with experimental and longitudinal evidence indicating that inadequate sleep can increase pain sensitivity and that persistent pain can disrupt sleep (Finan et al., 2013). More recent systematic evidence continues to support an association between sleep disturbance and impaired endogenous pain modulation, although the underlying mechanisms remain incompletely resolved. Thus, if adaptive pressure redistribution reduces mechanically uncomfortable loading during sleep, it could theoretically influence sleep-related discomfort in people with musculoskeletal symptoms. The current study, however, measured perceived sleep-surface characteristics rather than pain, sleep continuity or clinical outcomes; consequently, this interpretation requires prospective clinical testing.

The Māori response should also be considered within Indigenous models of wellbeing. Te Whare Tapa Whā conceptualizes health through interconnected physical, mental, spiritual and whānau dimensions (Durie, 1994). Contemporary New Zealand health and rehabilitation literature continues to use this framework to emphasize holistic and culturally responsive approaches to health and wellbeing. Importantly, the present study did not measure Te Whare Tapa Whā domains, cultural beliefs, whānau influences or Māori concepts of sleep and wellbeing. It would therefore be inappropriate to attribute the observed mattress response directly to Māori cultural values. Rather, the finding provides a rationale for future research using culturally appropriate co-design and Māori-led methodologies to investigate whether adaptive sleep technologies can be developed in ways that are acceptable, relevant and equitable.

NZ-Asian participants: firmness response and the importance of avoiding cultural overinterpretation

The largest improvement in perceived firmness occurred among NZ Asian participants (+1.70). This finding is potentially important because firmness is not a simple physical property from the user's perspective; it represents an interaction between objective mechanical surface, physiological behavior, body morphology, pressure distribution, expectation and prior experience. The ability to withstand firm surface seems to be ingrained due to cultural-traditional use of firm surfaces in the past.

However, the term "Asian" encompasses highly heterogeneous populations. Majority, Chinese, Korean, Japanese and other minority Asian populations such as Vietnamese, Indonesians, Burmese, Nepali, etc. who differ substantially in cultural practices, socioeconomic circumstances, body morphology and sleep behaviors co-exist in New Zealand. Consequently, the present sample cannot establish a generalized "Asian preference" for firm mattresses only. Cross-cultural sleep research demonstrates substantial differences in sleep practices and sleep characteristics between Asian populations and between individual Asian countries (Mindell et al., 2010; Huang et al., 2018). Few readings indicated preferences for medium or soft mattresses also.

The observed firmness response may nevertheless be consistent with the broader concept of learned or experience-dependent comfort. A person accustomed

to a particular mechanical sleeping environment may evaluate a novel surface relative to an internal reference developed through repeated exposure. This possibility should be investigated directly rather than inferred from ethnicity. Future studies should therefore record previous mattress firmness, mattress material, floor- or platform-based sleeping experience, preferred firmness and years of exposure to different sleep surfaces.

The present findings are particularly interesting because the Dynamic system permits adjustment real-time without requiring the user to select a single fixed firmness for the entire body. This concept is consistent with previous research showing potential advantages of self-adjusted or custom-inflated mattress systems for lifestyle of comfort and sleep-related outcomes (Caggiari et al., 2019).

NZ-Indian participants: firmness, body composition and sleep health

NZ Indian participants also demonstrated a substantial improvement in perceived firmness (+1.39) and overall satisfaction. As with the NZ Asian cohort, this should not be interpreted as evidence of a universal Indian preference for firm bedding, this ethnic group does prefer medium or medium soft surface also on a case-by-case basis. The Dynamic mattress make itself was medium firm hence the satisfaction levels were high across this community. Yet traditional bedding practices vary considerably across India according to region, socioeconomic position, household structure and individual preference, and the present study did not measure these variables as these were ethnically migrant populations residing long term in New Zealand.

A potentially relevant health consideration is that South Asian populations can experience cardiometabolic risk at lower BMI thresholds than European populations. Earlier epidemiological work demonstrated increased cardiometabolic risk among Indian populations even in individuals who would not be classified as obese according to conventional BMI thresholds (Vikram et al., 2003). Similarly, obstructive sleep apnea in Asian populations may occur at lower BMI than in many Western populations, with craniofacial morphology identified as one potential contributing factor in addition to obesity (Lam et al., 2007). These observations provide a rationale for investigating sleep technologies capable of

unobtrusive physiological monitoring, but they do not establish that the Indian participants in the present study had increased cardiometabolic or sleep-disordered breathing risk. This distinction is important as the present investigation evaluated preferred sleep-surface characteristics, not physiological sleep outcomes. Therefore, the potential value of Smart-Tek AI for monitoring respiratory or cardiovascular signals should be regarded as a future research direction rather than a clinical conclusion.

Transition from Passive and Static Sleep Surfaces to Next-Gen-AI Smart beds.

The conceptual significance of the Dynamic mattress lies in the transition from a passive mechanical interface to a potentially responsive sleep environment. Conventional mattresses provide relatively fixed mechanical characteristics and can take a fixed load, whereas adaptive systems can theoretically modify support in response to more weight capacity, wider sleep positions, can orchestrate pressure distribution all of which were preferred unanimously by all the ethnic cohorts participating in the study. Earlier, different ethnic groups showed preference for different static surfaces, however, now different ethnic groups show preference for the same dynamic surface. This was because the next Gen AI Smart bed was able to personalize according to everyone's needs.

These developments are relevant to the Smart-Tek AI concept because a future adaptive sleep platform could potentially integrate three levels of personalization: mechanical adaptation, neurophysiological sensing, and algorithmic decision support (Satralkar, 2026). Such a dynamic platform should ultimately use Neurotechnology, machine learning, AI and deep learning to investigate modulation of sleep ecosystems tailor made to each person irrespective of ethnicity, gender, age, weight etc. to optimize the circadian sleep cycle and promote deeper sleep (Satralkar 2026).

A Multidimensional Model of Ethnic Variation in Sleep-Surface Response

The findings support a multidimensional framework in which perceived response to sleep surfaces may emerge from interacting pathways rather than from ethnicity alone. Five domains appear particularly relevant:

1. **Prior sleep-surface experience and cultural practices** — previous exposure may shape expectations of firmness, stability and comfort.
2. **Anthropometry and body composition** — body dimensions and mass distribution influence mattress-body contact and pressure distribution.
3. **Biomechanics** — spinal alignment, joint loading, body position and interface pressure influence mechanical comfort.
4. **Health and physiology** — age, musculoskeletal symptoms, pain, obesity and existing cardiometabolic or respiratory conditions may alter sleep-surface requirements.
5. **Sleep characteristics** — sleep posture, sleep hygiene, prevalence of disorders, symptoms, sleep fragmentation may modify the importance of comfort and support.

This framework is compatible with contemporary sleep-disparity models in which ethnic differences are understood through interactions between social position, environment, behavior, health and biological processes rather than through ethnicity as an isolated causal variable (Grandner et al., 2016). It also aligns with evidence that sleep-surface effects are influenced by individual characteristics, including body morphology and sex-related differences in pressure distribution (Gefen et al., 2012; Mohamadi et al., 2026).

The present study therefore suggests a shift from the traditional question, “Which mattress firmness is optimal?”, toward the more individualized question, “Which sleep-surface characteristics are optimal for this individual, under these mechanical and physiological conditions?” This distinction is particularly relevant in ethnically diverse populations, but it should ultimately be tested on the AI-smart bed using individual-level predictors rather than ethnicity alone.

Implications for ‘Personalized’ Sleep Medicine

The potential clinical significance of adaptive sleep technology lies not in assigning different mattress types to different ethnic groups, but in identifying individual characteristics that predict response. Ethnicity may initially appear as a population-level marker of heterogeneity, but future models should determine whether the observed differences are better explained by measurable variables such as age, sex, BMI, waist-to-hip ratio, shoulder and pelvic dimensions, previous mattress characteristics, preferred firmness, musculoskeletal pain, osteoarthritis, sleep-disordered breathing, sleep duration and socioeconomic circumstances.

Such an approach would also reduce the risk of stereotyping populations and channelize the efforts to personalize the sleep surface. For example, the present findings should not be interpreted as indicating that Māori or New Zealand European individuals generally require greater cushioning, or that Asian or Indian individuals generally require firmer mattresses. Instead, the results indicate that the same adaptive intervention produced different patterns of perceived change across the sampled cohorts, providing a signal that independent individualization deserves more investigation on dynamic surfaces.

This distinction has relevance for health equity. New Zealand health surveillance continues to document substantial disparities in health outcomes and social determinants especially those affecting the Māori, while the national policy highlights culturally responsive and equitable health services. If future research demonstrates that adaptive sleep environments can reduce mechanically mediated discomfort or improve objectively measured sleep among populations experiencing disproportionate sleep or musculoskeletal burdens, personalized sleep-surface technology could potentially become one component of a broader sleep-health strategy. That possibility remains hypothetical and requires clinical evidence.

Table II: Potential Health Benefits of next Gen AI-Smart Beds for different communities

New Zealand–European	New Zealand–Māori	New Zealand–Asian	New Zealand–Indian
Sleep problems: Sleep disturbance, insomnia symptoms, insufficient sleep, nocturnal awakening and sleep-disordered breathing may occur. National NZ data indicate that 27.0% of adults slept less than recommended in 2024/25, although the national figure is not specific to Europeans (Ministry of Health, 2025).	Sleep problems: Māori have reported higher levels of insomnia symptoms and sleep disturbances than non-Māori/European adults, including difficulty initiating sleep and nocturnal awakening (Paine et al., 2004; Rumball-Smith et al., 2016).	Sleep problems: Asian populations are heterogeneous, and evidence should not be generalized across all Asian ethnicities. NZ population data show substantial variation in sleep duration by demographic and socioeconomic characteristics; therefore, Chinese-specific sleep problems should be interpreted cautiously (Ministry of Health, 2025).	Sleep problems: Robust NZ population-level evidence specifically describing Indian sleep phenotypes is comparatively limited. Sleep duration, insomnia symptoms and sleep-disordered breathing may be influenced by obesity, diabetes, occupational schedules, socioeconomic factors and migration-related circumstances; these factors should not be interpreted as characteristics of ethnicity itself.
General health: In 2024/25, 30.4% of European/Other adults reported chronic pain. European/Other adults had 87.1% good/very-good/excellent self-rated health (Ministry of Health, 2026).	General health: Māori adults reported lower good self-rated health than European/Other adults (79.1% vs 87.1%) in 2024/25. Chronic pain was reported by 30.2% of Māori adults; after age/sex adjustment, Māori were 1.24 times as likely as non-Māori to report chronic pain (Ministry of Health, 2026).	General health: Asian adults had the highest reported good self-rated health among the major ethnic categories in 2024/25 (91.1%). Chronic pain was reported by 14.6% of Asian adults, although the Asian category combines diverse populations and should not be treated as representative of Chinese people specifically (Ministry of Health, 2026).	General health: Diabetes is particularly relevant at a population level. In 2024, age-standardized diabetes prevalence was 102.7 per 1,000 among Indian people compared with 33.1 per 1,000 in the European/Other category (Ministry of Health, 2026). This is a population-level association and does not imply that individual Indian participants have diabetes.
Potential AI-smart-bed contribution: Dynamic adjustment of firmness and pressure distribution, adjustable positioning, thermal regulation and individualized settings could potentially improve	Potential AI-smart-bed contribution: Adaptive pressure redistribution and individualized firmness could potentially improve sleep-surface comfort for individuals experiencing musculoskeletal discomfort	Potential AI-smart-bed contribution: Individualized firmness, pressure redistribution, temperature regulation and automated adjustment may accommodate individual differences	Potential AI-smart-bed contribution: Individualized pressure support, firmness adjustment, temperature management and sleep monitoring may provide supportive sleep-

New Zealand–European	New Zealand–Māori	New Zealand–Asian	New Zealand–Indian
comfort and sleep-surface compatibility. These should be presented as potential supportive functions rather than established clinical treatments.	or chronic pain. Adjustable positioning may also provide individualized positional support. It should not be described as treating Māori health inequities or sleep disorders.	without assuming a culturally predetermined mattress preference. Sleep-monitoring functions could additionally provide longitudinal information about sleep patterns, subject to clinical validation and privacy safeguards.	environment personalization. Given the higher population-level diabetes prevalence among Indian New Zealanders, however, an AI bed should be described as a sleep-support technology, not as a diabetes diagnostic or treatment device.

Conclusion

In this balanced sample of 92 participants, the Smart-Tek AI Dynamic sleep surface produced higher perceived comfort, firmness and overall satisfaction than the Static surface, with significant Mattress Type $\times$ Ethnicity interactions for comfort, firmness and overall satisfaction but not temperature. The pattern of response varied across cohorts, with substantial comfort improvements among New Zealand European and Māori participants and particularly pronounced firmness improvements among NZ Asian and NZ Indian participants. These findings provide preliminary evidence of heterogeneity in perceived responses to adaptive sleep-surface technology. What is clear is that the Dynamic surface was better accepted overall rather than Static surface by all the cohorts, hence, they support a personalized sleep-surface framework in which individual anthropometry, biomechanics, health, prior bedding experience, sleep characteristics and cultural or environmental factors may all interact on next-Gen AI Smart Beds. The possibilities of measuring, modulating and documenting such evidence could enable precision health.

Limitations

Few key limitations should be considered. The sample comprised 92 participants (23 per ethnic cohort), limiting statistical power and generalizability to the wider New Zealand population, while the broad ethnic categories do not capture within-group variation in

culture, socioeconomic circumstances, lifestyle, body composition or previous bedding experience. The study assessed subjective perceptions after a brief 30-minute exposure rather than longer-term sleep outcomes, and adaptation to a new sleep surface may require several nights or weeks. Objective measures of sleep physiology and biomechanics, including polysomnography, sleep architecture, sleep efficiency, pressure distribution, spinal alignment, anthropometry, nocturnal movement and validated physiological monitoring, were not obtained. Future longitudinal, adequately powered multiethnic studies combining subjective assessments with pressure mapping, anthropometry, polysomnography and validated physiological measures are needed to establish whether adaptive sleep-surface personalization produces sustained and clinically meaningful improvements in individual sleep and health.

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