BIOMECHANICAL TESTING OF MATTRESS COMFORT LAYERS

An Independent Report for Silentnight Group Ltd

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NOVEMBER 2017

REMIT OF THIS REPORT

This final independent report recognises the agreement established in the contract between Silentnight Group Ltd and the University of Central Lancashire (Allied Health Research Unit). This report discusses all the main outcome measures of this study including all data and meets the full contractual obligation between the parties.

INTRODUCTION

Humans spend around a third of a lifetime in bed (Gordon and Grimmer-somers, 2011), so in order to achieve improved quality of sleep it is vital to establish optimal sleeping conditions. Quality sleep is defined as when the human body is able to relax, recover and replenish itself most effectively. Research has demonstrated a direct relationship between the amount of quality sleep a person achieves, and their mood, behaviour, motor skills and overall performance in their everyday working and leisure activities (Brendel et al, 1990 & Smith and Maben, 1993 & Dotto, 1996 & Meney et al 1998 & Schlesinger et al, 1998). To allow for improved quality of sleep, sleep surfaces have several key roles, where the main function is to support the body in such a way that the muscles and intervertebral discs are able to recover from an almost continuous loaded force throughout the day (Gracovetsky, 1987). Combining gravity with the fact that humans spend a large proportion of their day in a vertical stance, whether it be standing or sitting, there is a constant load being applied to the soft tissues within the back, and as such it is important that a sleep system can alleviate this force at night. This reduction in load allows the pressure to be relieved from the intervertebral discs and surrounding musculature, therefore initiating recovery and rehydration as well as the regeneration of elasticity within soft tissues (Nachemson and Elfstrom, 1970 & Huysmans et al, 2004). Failure to achieve this state of recovery, however, can lead to the onset of back pain, and in particular simple mechanical Lower Back Pain (LBP).

In 1991, Frymoyer and Cats-Baril suggested that as much as 80% of the western population could suffer with at least one episode of disabling LBP at some stage in their lifetime. Now, LBP is said to affect two thirds of adults within the UK at some point in their lives, with as many as 2.5 million people suffering with such pain on a daily basis. A large prospective study by O'Donoghue and Fox (2009) found that there is a strongly significant relationship between sleep quality and LBP, with 55% of people reporting a restless night or very light state of sleep when experiencing an episode of LBP, compared to those that were pain free. There are however, a variety of mechanisms that are said to reduce LBP, and subsequently improve the quality of sleep including a decrease in spinal muscle activity, improved spinal alignment, and the reduction of pressure at main contact areas between the body and the sleep surface (Lahm and Iaizzo, 2002 & Verhaert et al, 2011 & Lee and Park, 2006). All of these factors can be accommodated for by varying mattress firmness, comfort layers and/or "zoning" within mattresses. A good quality sleep system will aim to adhere to as many of the aforementioned mechanisms as possible in order to provide improved comfort, and therefore improved sleep quality, to an individual.

AIMS

This study explores the effect of different comfort layers on biomechanical factors. The aims of the study are

- to explore differences in spinal alignment when lying on 4 zoned mattresses with differing comfort layers (Geltex, Latex, Memory Foam).
- to identify any changes in muscle activity when moving on the 4 different mattresses.
- to explore subjective feedback on support and comfort relative to the different comfort layers.

METHOD

RECRUITMENT OF PARTICIPANTS

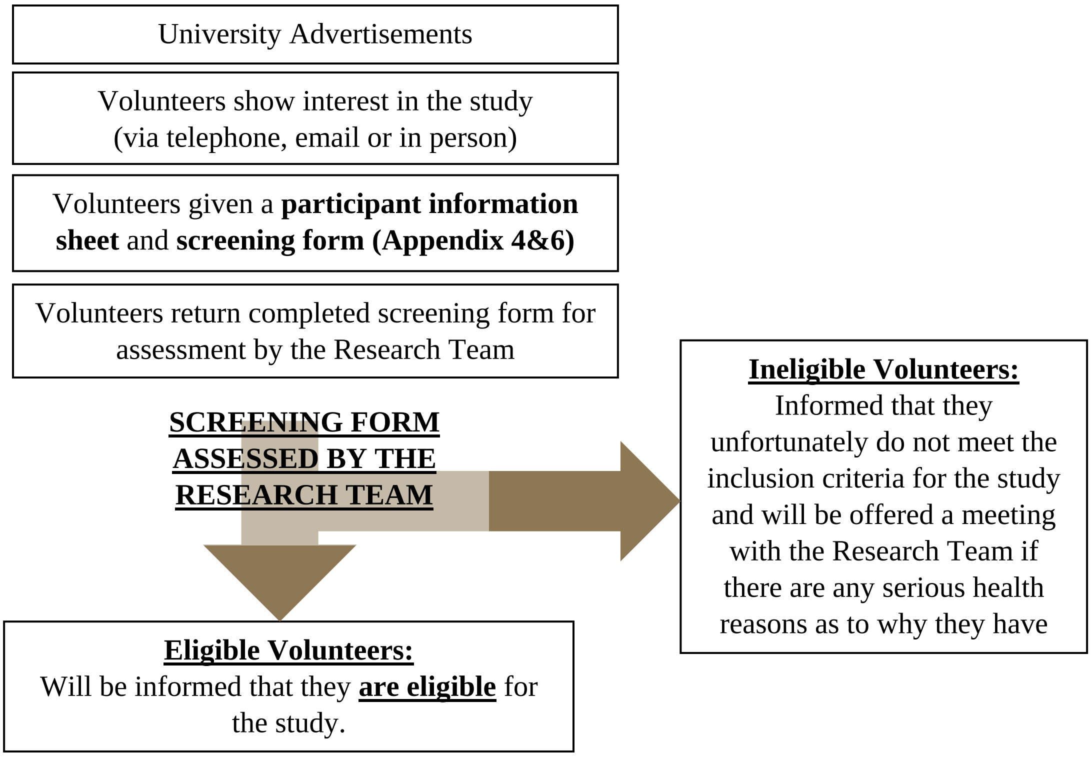

FIGURE 1. Schematic diagram representing the recruitment process

Participants were recruited (Figure 1) from within the University including UCLan staff and students through campus based advertisements and social media. Volunteers from outside the University who heard of the study through word of mouth (due the study's snowballing effects) were also included. Participants were required to actively volunteer for the study by contacting the researchers if they were interested in participating in the study using the contact information on the advertisements. Once a volunteer had shown interest in the study, they were given an information sheet to read and keep and a screening form (Greenhalgh & Selfe, 2010) to fill and securely return. Participants were provided with the opportunity to ask the research team any questions regarding the study. All participants were required to meet the inclusion criteria stipulated; to be free from any spinal red flags, free from spinal pain, with no history of any back surgery, not currently pregnant with comfortable mobility in the spine.

PROCEDURE

Participants were asked to visit the AHRu movement analysis laboratory (Figure 2 - left) at the UCLan campus at an arranged date and time. Upon arrival at the lab (Figure 2 - left) participants were reminded of what the testing protocol involves. Participants were required to wear a pair of shorts for the testing protocol. Additionally, during the testing participants were required to choose between either removing their upper body clothing or wearing an adapted t-shirt with a slit along the spine to allow appropriate analysis of spinal posture (see figure 2 - centre).

BASELINE DATA

Participants were asked to complete a consent form in line with the ethical guidance, before being asked some baseline questions relating to preferences in sleep system, current sleep surface and problems related to sleep. Body measurements were taken including height, weight, shoulder height and width, waist to hip ratio, waist height, and hip height.

FIGURE 2 (LEFT) The AHRu movement lab (Brook Building, UCLan) **(CENTRE)** Adapted t-shirt for marker placement and collection of spinal data. **(RIGHT)** Static model in software (Visual3D, CMotion, MD, (USA)).

BIOMECHANICAL DATA

Small retroreflective tracking markers (figure 2 – centre/right) were attached to each individual using a 5 segment spinal model (adapted from: Chohan et al. 2013; Preuss and Popovic 2010) and the Calibrated Anatomical System Technique (Capozzo, 1995) for the lower limbs and pelvis *(Further details in the results section)*. Data from the retroreflective markers was recorded using a 10 camera Oqus Qualisys motion capture system (Qualisys AB, Sweden). Participants were not identifiable in the recordings (Figure 2 RIGHT) and all recordings were coded to allow for anonymity. Movement data was collected using Qualisys Track Manager (QTM v.2.13; Qualisys AB, Sweden) and analysed using Visual 3D (C-Motion, MD, USA).

In addition to the movement analysis, electromygraphic (EMG) sensors were placed bilaterally on the lumbar multifidus spinae and erector spinae longissimus muscles (Delsys, MA, USA; figure 4) in order monitor changes in muscle activity. EMG sensors were positioned in line with published guidelines (SENIAM, The Netherlands). All EMG data was collected simultaneous to the above movement data using QTM v2.13 and Visual3D.

FIGURE 3 (LEFT): Electromygraphic sensors (Delsys, MA (USA)) **(CENTRE)** Positioning of EMG sensors in accordance with SENIAM guidelines.

A pair of pressure distribution mats (Conformat, Tekscan, MA, (USA); Figure 4) were placed under the individuals' shoulder and hip, to monitor pressure differences between mattresses (Figure 4). The shoulder and hip were chosen based on their key role to support an individual on their sleep surface when in a side lying position. This data was collected using the Conformat Clinical software (F-scan research version 7) and exported for further analysis in MS Excel to allow peak pressures at the two main sites to be identified.

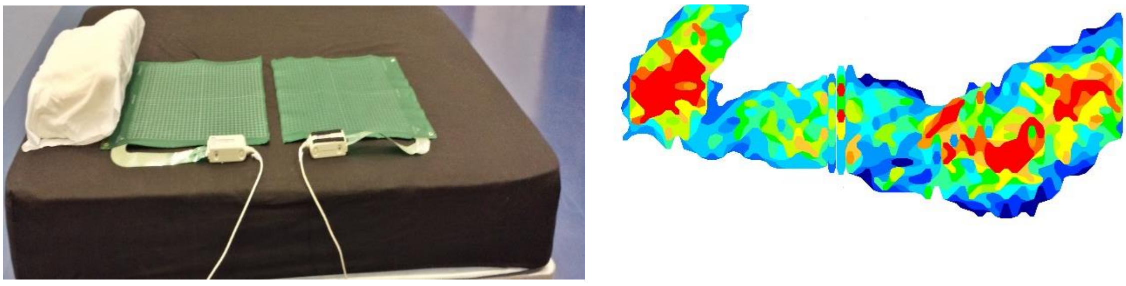

FIGURE 4 (LEFT): Conformat, Tekscan, MA, (USA) **(RIGHT):** Peak pressure data output (red indicating high pressure areas at the shoulder and hip.

Participants were positioned on a bed (standardised king-size divan base + one of the mattress options) in a predetermined position all (semi-foetal). Participants were required to remain in this side lying position for 10-minutes, during which recordings were made at 2.5 minute interval. At the end of this 10-minute period, participants were instructed to complete a standardized "roll" on the bed. This "roll" involved straightening the legs, before then bringing the top leg over to approximately 90 degrees. This was then repeated twice more on 2 different configurations of mattress. Mattresses were tested in a randomized order to which the participants will be blinded (www.randomisation.com). The mattress varied internally in terms of their comfort layers (Geltex, Memory Foam and Latex) however, the internal spring configuration was the same in each mattress (zoned) following on from the previous project. All mattresses appeared to be identical. Participants were effectively tested for 40 minutes in total. Figure 6 (page 7) summarises the full protocol for each testing session.

PARTICIPANT REPORTED OUTCOME MEASURES (PROMS)

Following each mattress trial, a series of short simple questions (See following section) related to each of the mattresses were asked. Participants were asked to mark locations on a body chart (Figure 5) where they perceived each of the mattresses offered the most support and where the mattress lacked support. The body chart is used widely within healthcare and has been shown to be a reliable method of collating and classifying location (Lacey et al., 2003, Schierhout and Myers, 1996).

In addition to this chart, individuals were asked to report on their perceived overall comfort and firmness of the mattress on a VAS scale marked between zero and ten. Key anchor words were used to describe each scale (e.g. very uncomfortable – very comfortable and soft – firm). Individuals then ranked the mattress in order of preference (1st, 2nd, 3rd and 4th).

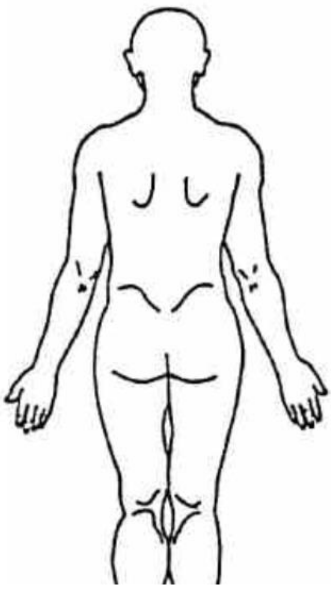

FIGURE 5 The Body Chart used to mark mattress support location.

PRE-ASSESSMENT:

Volunteer asked to read participant information sheet, and complete screening form

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ARRIVAL TO MOVEMENT LABORATORY

- ✓ Participant Initial Consent taken (Appendix 3)
- ✓ Participant completes pre-testing questionnaire (Mattress type, current mattress properties, sleep issues)
- ✓ Participant's body measurements are taken by researcher.
- ✓ Participant assigned a code and randomisation order for the study
- ✓ Participant is fitted with markers, and muscle activity sensors

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DATA COLLECTION – 1st Mattress (Randomised)

- ✓ Participant positioned on the bed with a pressure mat in a standardised position beneath shoulder and hip
- ✓ Once in position, the trial begins and the participant lays still for 10 minutes
- ✓ 4 Data collections are taken at 2.5 minute intervals
- ✓ After 20 minutes, the participant completes a "roll" on the mattress
- ✓ 4 Data collections are taken at 5 minute intervals
- ✓ After 20 minutes, the participant completes a "roll" on the mattress

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The mattress is exchanged for a different configuration (Randomised)

PROMS for Mattress 1 are completed

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DATA COLLECTION –2nd & 3rd Mattresses (Randomised)

- ✓ "Data collection-1st mattress" is repeated for mattresses 2 and 3.
- ✓ PROMS are completed for each mattress as the mattress exchanged for the next one

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After the final mattress participants are requested to list the three mattresses in order of preference.

FIGURE 6: PROTOCOL SUMMARY.

DATA ANALYSIS

A preliminary analysis was first performed to check whether there was any significant change over time during the 10-minute recording period on each mattress. A repeated measures ANOVA test was performed with post-hoc pairwise comparisons with LSD correction on pelvic and spinal angles, EMG and peak pressures, to analyse differences between the 3 sleep surfaces. All data was entered into IBM SPSS statistics v23 for and Microsoft Office Excel 2010 for analysis. Data from questionnaires was analysed using a repeated measures ANOVA test with post-hoc pairwise comparison with LSD correction for applicable scores.

RESULTS

This study has seen that 26 individuals have contact the research team for information about the study, four were excluded immediately as they did not meet the inclusion criteria for the study. Of the remaining participants 22 completed the screening form (30%) to assess eligibility. Two of these were then classified as ineligible, and 20 participants have been included. All data collection conformed to the declaration of Helsinki and volunteers gave written informed consent prior to participation. The study was approved by the University's ethics committee (STEMH 551).

BASELINE MEASUREMENTS

A total of (n=20) participants (mean age: 29.75 +/- 8.08 years; BMI: 25.88 +/- 6.07 kg/m2) were eligible for inclusion within this independent report. The demographic and anthropometric data of these participants are presented below (table 1).

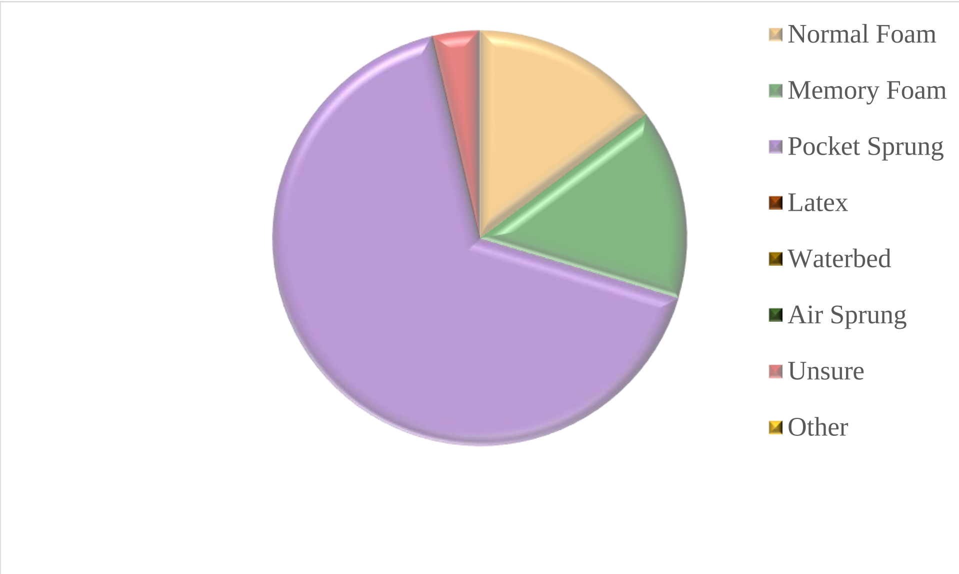
DEMOGRAPHICS	MEAN	RANGE
Age (years)	29.75 (8.07)	22 - 50
Height (m)	1.74 (0.09)	1.64 – 1.88
Weight (kg)	78.64 (20.19)	61.8 – 128.9
BMI (kg/m^2)	25.88 (6.07)	19.78 – 41.52
Shoulder Height (cm)	146.63 (6.66)	135 – 159.1
Shoulder Width (cm)	39.64 (4.51)	34 – 49.2
Waist Height (cm)	112.88 (4.62)	104.9 – 117.9
Waist Circumference (cm)	86.71 (15.46)	69.5 – 119.9
Hip Height (cm)	90.86 (13.33)	81.3 – 100.3
Hip Circumference (cm)	103.90 (9.81)	92.6 – 126.4

TABLE 1: DEMOGRAPHICS AND ANTHROPOMETRICS OF PARTICIPANTS.

BIOMECHANICAL TESTING OF MATTRESS COMFORT LAYERS

Participants reported their usual sleep surface properties (Figure 7), with the majority usually sleeping on a Pocket Sprung and/or Memory Foam or other foam mattress. Other options were given however aside from a single individual reporting they were unsure of what mattress they used, results unanimously supported the use of the most commonly available mattress types. Though average mattress firmness and ideal mattress firmness is reported in figure 7, this only shows an indication that on average 80% (70% wanted more, 10% wanted less) of individuals were not satisfied with the support their existing mattress provided.

Though previous research has discussed in detail the basis of sleep zoning and relative support, participants were asked about their perceptions on where their sleep surface provided support and how their ideal sleep surface would support them. Results indicated that participants' current sleep surfaces faired best in supporting the shoulder (70%) and hip (35%). However, when describing their ideal sleep surface support the 50% of individuals selected the hip, 55% selected the shoulder and 60% selected the back as key areas that they required support.



CURRENT SLEEP SYSTEM	MEAN	STANDARD DEVIATION
Current Mattress Firmness	4.65	2.01
Ideal Mattress Firmness	3.20	1.61

FIGURE 7: BASELINE SLEEP SURFACE ATTRIBUTES

BIOMECHANICAL MEASURES

ANGLE (°)	MATTRESS		
	GELTEX	LATEX	MEMORY FOAM
SAGITTAL PLANE			
UT-MT	10.61 (9.13)	11.99 (9.83)	10.98 (10.09)
MT-LT	0.63 (5.18)	0.61 (5.16)	-0.00 (4.60)
LT-UL	-3.76 (5.83)	-4.35 (6.61)	-4.38 (5.97)
UL-LL	-12.18 (10.96)	-11.03 (13.63)	-11.48 (9.19)
LL-PEL	-0.398 (7.48)	-2.579 (9.71)	-1.342 (6.68)
CORONAL PLANE			
UT-MT	-3.70 (5.41)	-3.00 (5.68)	-2.85 (4.77)
MT-LT	1.54 (3.26)	1.73 (3.44)	2.06 (2.98)
LT-UL	2.23 (1.83)	2.48 (1.67)	2.35 (1.82)
UL-LL	3.08 (2.87)	2.52 (3.51)	1.89 (3.59)
LL-PEL	1.22 (4.98)	1.39 (3.46)	2.31 (4.27)
TRANSVERSE PLANE			
UT-MT	4.90 (5.37)	6.46 (5.49)	6.12 (4.58)
MT-LT	4.49 (4.16)	4.04 (3.69)	4.63 (4.80)
LT-UL	0.54 (2.92)	0.61 (3.47)	0.25 (3.28)
UL-LL	-2.00 (4.10)	-1.86 (4.10)	-2.02 (3.98)
LL-PEL	2.72 (3.89)	1.95 (2.89)	1.10 (3.89)

TABLE 2: ALL SPINAL DATA (UT = Upper Thoracic; MT=Mid Thoracic; LT=Lower Thoracic; UL=Upper Lumbar; LL=Lower Lumbar; Pel=Pelvis.

SPINAL ANALYSIS

The spine was divided into 5 segments for analysis (upper thoracic to mid-thoracic, mid-thoracic to lower thoracic, lower thoracic to upper lumbar, upper lumbar to lower lumbar and lower lumbar to pelvis). Movement data was then processed between these segments using Visual 3D v.6 (C-Motion, USA). The influence of each mattress on spinal posture was assessed by initially placing each participant in their natural neutral standing posture, and classing this stance as “zero”. The change in angle between each of the spinal segments away from their neutral posture was determined in order to depict which mattress had the most adverse effect on spinal alignment. In summary, the closer the degree of change was to zero, the closer the participants were to neutral alignment.

This model was then then used to measure the six degrees of freedom, the sagittal (Anterior-Posterior flexion and extension), coronal (mediolateral-flexion and extension), and transverse (rotational) planes of movement were analysed. Data for each segment and in each plane of movement is reported in Table 2.

CORONAL PLANE (MEDIO-LATERAL FLEXION)

During the testing procedure all participants were laying on their left side, therefore a positive increase in flexion of the segment would represent either the subject raising their head and feet, or, more realistically, the increase in flexion would be caused due to a less supportive sleep surface. Conversely, a negative change from neutral would suggest that the head and feet are further sunken into the mattress than the middle of the torso.

In the Coronal plane there was no statistically significant difference between mattresses for the UT-MT, MT-LT and LT-UL segments (Table 2). There was however a statistical significant difference between the mattresses at the UL-LL segment ($p=0.015$) and LL-PEL segment ($p=0.046$). Pairwise comparisons showed that for the UL-LL segment there was statistical significant differences between Geltex and Latex ($p=0.011$), Geltex and Memory Foam ($p=0.000$) and Latex and Memory Foam ($p=0.002$). This indicates that all mattresses were significantly different to memory foam, with the biggest change being seen in the Geltex mattress (from static), and the smallest lumbar spine change seen in this plane in on the Memory Foam mattress. There were also statistically significant differences between the mattresses for the LL-PEL segment when comparing both Geltex and Latex against Memory foam ($p \leq 0.046$). Here the smallest change occurred on the Geltex mattress and the largest on the memory foam mattress. This shows that in the hip region the Geltex and Latex mattresses perform superior to the memory foam mattress in terms of support.

TRANSVERSE PLANE (ROTATION)

In the transverse plane there was no statistically significant difference between mattresses for the any of the spinal segments (Table 2). As the spring unit structure was the same (zoned) for all mattresses and only the comfort layer changed, this suggests that all comfort layers performed similarly in stabilising the body and preventing rotation during side lying.

SAGITTAL PLANE (ANTERIO-POSTERIOR FLEXION – EXTENSION)

In the sagittal plane, of the 5 sections of the spine analysed, only the LT-UL segment showed statistical differences between mattresses (p=0.042). Pairwise comparisons showed that there was a significant difference between Geltex and Latex (p=0.012) and Geltex and Memory foam (p=0.005). This showed that the Geltex mattress showed significantly less deviation from neutral posture compared to the Latex and Memory foam mattresses (p≤0.01).

When analysing the spinal posture there was no significant change over the 10 minute period for any of the mattresses at any of the segments.

ELECTROMYOGRAPHY (EMG)

EMG (μV)	MATTRESS		
	GELTEX	LATEX	MEMORY FOAM
	MEAN (SD)	MEAN (SD)	MEAN (SD)
RECTIFIED LEFT ERECTOR SPINAE	0.00005 (0.00005)	0.00004 (0.00003)	0.00004 (0.00003)
RECTIFIED RIGHT ERECTOR SPINAE	0.00003 (0.00002)	0.00004 (0.00005)	0.00004 (0.00004)
RECTIFIED LEFT MULTIFIDUS	0.00083 (0.00157)	0.00047 (0.00090)	0.00088 (0.00139)
RECTIFIED RIGHT MULTIFIDUS	0.00090 (0.00186)	0.00103 (0.00192)	0.00062 (0.00145)
INTEGRATED LEFT ERECTOR SPINAE	0.00009 (0.00004)	0.00008 (0.00003)	0.00007 (0.00003)
INTEGRATED RIGHT ERECTOR SPINAE	0.00008 (0.00005)	0.00009 (0.00007)	0.00009 (0.00005)
INTEGRATED LEFT MULTIFIDUS	0.00080 (0.00135)	0.00041 (0.00059)	0.00086 (0.00147)
INTEGRATED RIGHT MULTIFIDUS	0.00081 (0.00186)	0.00128 (0.00394)	0.00134 (0.00470)

TABLE 3: ALL MEAN EMG DATA (SD-STANDARD DEVIATION)

Electromyography (EMG) data was analysed using both rectified (converts all negative EMG signals to positive) and integrated EMG (the area under the curve of the rectified EMG, or in other words, the total muscle activity for a given period). Results are presented in Table 3. There were no statistically significant differences in EMG activity between any of the mattresses. It is suggested that future studies carried out on the mattresses should involve multiple extended periods of data collection and may also include analysis of muscle activity when getting on and off the mattress.

PEAK CONTACT PRESSURE

All data for peak contact pressure calculated at the shoulder and hip on each of the three sleep surfaces is reported in Table 4.

Peak Pressure (kPa)	**MATTRESS**		
	GELTEX	**LATEX**	**MEMORY FOAM**
Shoulder Peak Pressure			
0mins	1.86 (0.74)	2.24 (0.86)	2.32 (0.99)
2.5mins	1.94 (0.86)	2.30 (0.86)	2.42 (0.95)
5mins	1.94 (0.70)	2.38 (0.86)	2.44 (0.88)
7mins	1.97 (0.77)	2.41 (0.96)	2.42 (0.79)
10mins	2.07 (0.90)	2.48 (0.95)	2.48 (0.81)
Mean difference	0.211[A]	0.236[A]	0.166
Average	1.96* (0.78)	2.36* (0.88)	2.41* (0.87)
Hip Peak Pressure			
0mins	2.05 (0.60)	2.23 (0.61)	2.43 (0.56)
2.5mins	2.20 (0.67)	2.31 (0.57)	2.48 (0.51)
5mins	2.17 (0.60)	2.40 (0.60)	2.48 (0.56)
7mins	2.22 (0.57)	2.38 (0.61)	2.56 (0.55)
10mins	2.19 (0.57)	2.61 (0.68)	2.63 (0.54)
Mean difference	0.132	0.376[A]	0.198[A]
Average	2.17 (0.59)	2.39 (0.62)	2.51 (0.54)

TABLE 4: ALL PEAK CONTACT PRESSURES

[A]denoting significance within mattress between time points of $p \leq 0.05$.

SHOULDER

A strong statistical significance in peak pressure of the shoulder was seen between mattresses ($p<0.000$). This suggests that there is a measurable difference between the different comfort layers. The mean difference (between zero and 10 minutes) and average peak pressure over the is noted in table 4. Pairwise comparisons showed a statistically significant difference between all mattresses and the Geltex mattress ($p = 0.000$), with Geltex mattress having the lowest peak pressure at the shoulder over the 10-minute period this demonstrates the ability of the Geltex mattress to dispose pressure more effectively ahead of the other three mattresses (latex =2.36 kPa, memory foam= 2.41 kPa). Within mattress peak pressure at the shoulder also changes significantly ($p\leq 0.000$) over time (start to end of 10-minute data collection period) for the Geltex and latex mattresses (table 4, mean difference denoted with [A]). However the peak pressure of the shoulder did not significantly change over time for the Memory Foam mattress ($p=0.707$).

HIP

A strong statistical significance in peak pressure at the hip ($p=0.000$) was seen between mattresses suggesting there was a measurable difference between each of the comfort layers. Pairwise comparisons further supported this, as there was a strong significant difference between Geltex and the other two surfaces (Latex $p=0.013$, Memory Foam $p=0.000$), with Geltex having the lowest peak pressure at the hip. The peak pressure of the hip also changes significantly over time in Latex ($p=0.000$) and Memory Foam ($p=0.004$). Geltex, however did not significantly alter peak pressure at the hip over a ten-minute period in contrast to Latex which changed the most. In agreement with the above data on peak pressure at the shoulder, the Memory foam mattress displayed the highest peak pressures at the hip. A significant difference was also seen between the latex and memory foam mattress ($p = 0.014$), where the latex mattress showed the lowest contact pressure at the hip however it also showed the greatest increase over the 10 minute period.

PARTICIPANT REPORTED OUTCOME MEASURES

MATTRESS PROPERTIES

As mentioned earlier, following each mattress trial all participants were asked to complete a VAS scale on mattress firmness and comfort. No significant difference was seen between the mattresses when considering mattress comfort. There was a significant difference between the firmness of comfort layers (p=0.002) with Memory Foam being significantly softer than both other comfort layers (Geltex p=0.004, Latex p=0.005).

All participants were asked to rank the three sleep surfaces in order of preference (See table 5). Of the participants, 40% ranked the Geltex Comfort layer as their most preferred, followed by the Latex and Memory Foam comfort layers.

VAS (0-10)	MATTRESS		
	GELTEX	LATEX	MEMORY FOAM
Mattress Comfort (0=not comfortable, 10=extremely comfortable)	7.5 (1.99)	7.03 (1.85)	7.05 (1.61)
Mattress Firmness (0=Firm, 10=Soft)	6.6 (1.8)*	6.55 (1.90)	5.25 (2.10)**
Mattress Preference	1st	3rd	2nd

TABLE 5: MATTRESS PROPERTIES AND PREFERENCE

MATTRESS		
GELTEX	LATEX	MEMORY FOAM
Slightly firmer Did not sink as much Comfortable	Very comfortable mattress	Very comfortable, good support all over
Nice Comfortable	Not enough hip support, better than micro springs mattress	Good comfy mattress
Comfortable More support needed on legs	Pressure in the shoulder and numbness in hip	Uncomfortable especially around legs
Felt wobbly/floaty	Initially comfortable became uncomfortable	All felt the same
Supportive	Lacked support at the shoulder	Too soft
Very comfortable at shoulder	It shouldn't hurt	Shoulder ached
Firmer	Firm Very comfortable	Sunk into it very easily
Hip needed to sink in more	Firm, lay on top of it instead of in it	
Very comfortable fell asleep	Started comfortable but soon got very uncomfortable	

TABLE 6: ALL MATTRESS FEEDBACK: Key: Positive (green), neutral (black), negative (red)

Additional feedback was provided on each mattress by the individuals which is transcribed in Table 6. Whilst the majority of feedback was positive for the Geltex mattress, feedback regarding the latex and memory foam mattresses varied somewhat with a number of individuals complaining of ineffective support around the shoulder area causing pain.

SUMMARY MATTRESS RATING SYSTEM

All mattress variables have been ranked using a points based system (3 realising the vision is table at the end of the website you to 1) in order to give an overall score per mattress. Higher scores indicate the best performance. With the Geltex mattress performing the best in all areas when compared to the other three comfort layers. The Memory foam mattress displayed poor performance in all areas except perceived comfort.

VARIABLE	GELTEX	LATEX	MEMORY FOAM
Mattress Firmness	3	2	1
Mattress Comfort	3	1	2
Mattress Preference	3	1	2
Spinal posture (Mid-spine)	3	2	1
Spinal posture (Hip)	3	2	1
Peak Pressure (SHOULDER)	3	2	1
Peak Pressure (HIP)	3	2	1
TOTAL	**21**	**12**	**9**

TABLE 7: MATTRESS SCORING

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