Experimental article – An experimental study to compare the interface pressure and experience of healthy participants when lying still for 20 minutes in a supine position on two different imaging surfaces

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ABSTRACT

Introduction: Pressure ulcers are a high cost, high volume issue for health and medical care providers, affecting patients' recovery and psychological wellbeing. The current research of support surfaces on pressure as a risk factor in the development of pressure ulcers is not relevant to the specialised, controlled environment of the radiological setting.

Method: 38 healthy participants aged 19-51 were placed supine on two different imaging surfaces. The XSENSOR pressure mapping system was used to measure the interface pressure. Data was acquired over a time of 20 minutes preceded by 6 minutes settling time to reduce measurement error. Qualitative information regarding participants' opinion on pain and comfort was recorded using a questionnaire. Data analysis was performed using SPSS 22.

Results: Data was collected from 30 participants aged 19 to 51 (mean 25.77, SD 7.72), BMI from 18.7 to 33.6 (mean 24.12, SD 3.29), for two surfaces, following eight participant exclusions due to technical faults. Total average pressure, average pressure for jeopardy areas (head, sacrum & heels) and peak pressure for jeopardy areas were calculated as interface pressure in mmHg. Qualitative data showed that a significant difference in experiences of comfort and pain was found in the jeopardy areas ($P<0.05$) between the two surfaces.

Conclusion: A significant difference is seen in average pressure between the two surfaces. Pain and comfort data also show a significant difference between the surfaces, both findings support the proposal for further investigation into the effects of radiological surfaces as a risk factor for the formation of pressure ulcers.

INTRODUCTION

Many medical imaging procedures, especially interventional procedures, can take up to 20 minutes or more[1]. During imaging, patients are required to lie completely still as movement during acquisition could make the resultant procedure diagnostically unacceptable. Whitley et al[2] argued that movement during X-ray procedures is a major contributor to loss of diagnostic value, leading to repeat examinations. Repeating an X-ray examination carries further risk, not just in terms of the patient experience but also because of the risk of the additional dose of radiation[2].

Studies have shown that sustained interface pressure for more than 20 minutes can cause tissue breakdown[2]. Lack of movement, as in the radiographical context, will increase the length of time the interface pressure between the patient and the imaging surface is maintained. Interface pressure is defined as the pressure exhibited between the body and a contact surface[3]. This could heighten the probability of developing Pressure Ulcers (PU)[2].

A search of the available literature reveals that there are currently no studies which investigate the relationship between radiological surfaces and interface pressure, and how these could affect the formation of PUs in at risk patients. Using healthy participants, this experimental study will therefore:

- Identify and compare the interface pressure of healthy participants on two imaging surfaces;
- Identify and compare the average and peak interface pressures of three areas of interest (head, sacrum and heels) of healthy participants on the two imaging surfaces;
- Compare the level of comfort of healthy participants on the two imaging surfaces;
- Explore the level of pain experienced by healthy participants on the two imaging surfaces.

Hypothesis

- The average interface pressure will be higher on the imaging surface without the mattress;
- The areas of interest (head, sacrum, heels) will have a higher interface pressure on the imaging surface without the mattress;
- The overall comfort will be higher on the mattress surface;
- The participants will experience higher pain when the interface pressure is higher in the three areas of interest.

METHODOLOGY

Ethical approval

This study was approved by the ethics committee of the College of Health and Social Care of the University of Salford, Manchester, UK.

Study design and setting

This study used pressure mapping equipment and software to measure interface pressures of 38 healthy participants whilst lying still on two medical imaging surfaces. The experiment was conducted in the medical imaging laboratory of the Escola Superior de Tecnologia da Saúde de Lisboa (ESTeSL) in Portugal during the Erasmus OPTIMAX 2014 Summer School.

Sample

A convenience sample of 38 healthy participants aged 19-51 was taken from a population of 65. These participants were from different countries in the European Union, with different academic backgrounds, attending the OPTIMAX summer school.

Inclusion criteria

- Healthy adults, 18 years or older were recruited to the study and therefore the findings of the study can be generalised to an adult population. Gelis et al[5] stated that adult populations constitute the majority of all PU cases and recommended that studies into measuring interface pressures should be targeted at this population group, so that the findings will be beneficial for clinical practice.

Exclusion criteria

- Participants with a height of 177cm or more were excluded from the study, due to the limitations of the pressure mat dimensions.
- Participants with any health condition, such as back pain, that prevents them from lying still for 20 minutes were excluded from the study. This was to ensure that participants can lie still during the acquisition of the interface pressure as excessive movement would render the data unusable in the study[4].
- Participants who could not participate on the grounds of religious beliefs.

Surfaces

Two imaging surfaces available at the Escola Superior de Tecnologia da Saúde de Lisboa were used for the study.

- Norland XR-36 bone density scanner with a mattress;
- Siemens MULTIX Pro X-ray table without a mattress.

The Siemens X-ray table is typical of many systems available in radiographical departments throughout Europe. The Norland density scanner is not in regular use, but the mattress was designed for radiographic practice, as such the findings of this study should be representative of available equipment.

Measurement tools

Pressure Mat – This study used the XSENSOR PX100:48.144.02 pressure mat from Sumed International. Various clinical studies[5] and academic studies[6] used the XSENSOR to perform pressure mapping on humans. Fader et al[7] stated that XSENSOR appears to be the gold standard technology for pressure mapping. Manufacturer calibration and quality control data, prior to sales, confirm a high level of precision and reliability[8].

The pressure mat is flexible, has a 61cm x 183cm sensing area, 12.7mm resolution, 6,912 sensing points, and 5-50mmHg and 10-200mmHg pressure ranges[8], and an accuracy rate of ± 10 percent of the calibrated values[5]. The XSENSOR has been calibrated to manufactures specification. The pressure mat transmits individual pressure measurement from each sensor to a computer for analysis[5].

The pressure mat was linked to XSENSOR X3 Medical v5.0 software, which according to Trewartha and Stiller[6] has excellent calibration stability leading to consistent data collection with high reliability, high accuracy and low creep, defined as the increase in pressure with constant force.

Questionnaire – A 5-point Likert scale questionnaire was used to assess participants' level of comfort and pain. The Likert scale is the most widely used format for designing a questionnaire9. The questionnaire was checked for validity and unethical questions. Preston and Colman[10] suggested that scales ranging from 5-101 response categories show little difference in validity and reliability. Open-ended questions were asked in order to explore the experience of the participants, providing responses in their own terms[7]. This qualitative questionnaire was filled out after each pressure measurement to provide subjective information in a standardised design[11]. Brace[11] discussed that by using a questionnaire one can assure all participants are asked the appropriate questions and that they are always asked in the same way, thus standardising the acquisition. Furthermore time constraints made it impractical to conduct verbal interviews with the participants; therefore a questionnaire was desirable.

Pilot

A pilot study was performed with a participant representative of the target population to assess the validity and reliability of the equipment and method. The height limitation of the XSENSOR mat was discovered and exclusion criteria were implemented. During acquisition in the pilot the participants feet were immobilised to prevent movement. However this was not carried forward in to the main study so participants' feet were in their natural position. This was to better assess their level of comfort, and get a true baseline reading.

Data collection

Quantitative – The XSENSOR equipment was securely fixed onto the imaging surface with tape to ensure that it remained in place during data acquisition. Once secure, the pressure mat was not removed or repositioned until the full sample had been acquired. The pressure mat was checked to ensure that it worked to the manufacturer's specifications, at this time some artefacts in the data were noted and recorded for further evaluation. Participants signed up at a mutually convenient time to participate in the study. The participants were given the opportunity to read the information sheet, and to ask questions or seek clarification. Subsequently, participants were asked to sign a consent form.

Participants were asked to change into a pair of leggings and two t-shirts. This was to respect participants' privacy and standardise clothing. Fader et al[12] established that different clothing has different impacts on interface pressure and advised that studies involving interface pressure measurements should have standardised clothing. The height and weight of the participants were measured and recorded prior to acquisition. Participants were then asked to lie supine on the pressure mat with their hands pronated. Positioning of participants was checked to ensure they were lying straight, in the centre of the mat.

A similar study by Stinson et al[3] measured interface pressure over a 20 minute sitting period and established that the pressure values change significantly over the first 6 minutes, this increase in pressure values may be due to creep. Six minutes were anticipated by Stinson et al to be an optimal settling time prior to interface pressure measurement. A settling time of 6 minutes was used in this study, to reduce measurement error.

A supervisor from the research team was present at each acquisition to monitor participants and equipment.

Qualitative – The patient experience in the clinical setting is of paramount importance, and a number of studies and reviews recommend that further work should be done in this area to explore personal opinions[13]. Following pressure data acquisition participants were asked to complete a questionnaire devised by the research team, it included five questions, two of which were on a five-point Likert scale. These two questions consisted of numerical descriptions with verbal anchors. In a cross-national setting, there is the potential for reliability error due to differences in knowledge, perceptions and familiarity with research instruments[14]. In this study the participants were assisted in completing the questionnaire by a member of the research team to assist in definitions and clarity.

Data analysis

From the data acquired for participants on each of the surfaces the average pressure and the peak pressure in mmHg of the whole body and the areas of interest (head, sacrum and heels) were calculated. When taking the average readings, of the sacrum, the lower limit of the pressure was set to 32mmHg, as this represents the value from which the pressure may influence the formation of Pus[15]. Objective data analysis was achieved by selecting and averaging 30 frames per person on both surfaces in order to ensure the reliability of results therefore verifying the non-existence of data changes obtained due to the performance of the equipment. The peak pressure measurements, of the sacrum, were collected by selecting an area of 3x3 cells with the highest pressure value in the centre, in order to calculate the mean peak value[16]. SPSS version 22 was used to assess normal distribution of data using histograms and Shapiro-Wilk tests. In the second phase, the average pressures of both the mattress and the X-ray table were compared using a paired t-test. Measures of the average and peak pressures were taken at the triple jeopardy areas and a comparison between the three individual areas on both surfaces were made using a paired t-test. Finally, a qualitative analysis was made in order to verify the relationship between the pain experience in the triple jeopardy areas during the experiment and the average pressure obtained in those areas. A Wilcoxon test was used to compare the level of pain in each of the triple jeopardy areas and the overall comfort of the participants.

RESULTS

Quantitative -

The data sample of 30 healthy participants was analyzed. The sample included 24 females (80%) and 6 males (20%) with an age range from 19 to 51 (mean=25.77; SD=7.72) and a BMI range from 18.7 to 33.6 (mean 24.12; SD=3.29). The average pressure of both surfaces is presented in Table 1. The results indicate a significant difference (P<0.001) in average IP between the different imaging surfaces showing a higher average pressure on the X-ray table with a mean difference of 11.95mmHg (Figure 1). In the measurements of average and peak pressures of the triple jeopardy areas (Table 1, Graphic 1 and 2) the pressure reduction was found to be statistically significant in all three areas for the different surfaces (P<0.001). In both the peak and average pressure measurements, it was found that the pressure is higher on the X-ray table than in the density scanner with a mattress (Figure 2). For peak pressure the mean differences achieved for each area were 96.06mmHg (head), 117.61mmHg (sacrum) and 85.30mmHg (heels) and the differences obtained for the average pressures were 53.19mmHg, 19.18mmHg and 38.11mmHg respectively. There was no correlation between BMI and average pressure (r^2 =0.029).

Table 1: Interface pressure measurements on the whole body, average and peak values for the triple jeopardy areas

	Siemens MULTIX Pro X-ray table without a mattress	Norland XR-36 bone density scanner with a mattress	P value
Total Average Pressure	43.04 ± 3.75	31.09 ± 2.34	<0.0001
Peak pressure measurements			
Peak Head	159.72 ± 45.88	255.77 ± 1.18	<0.0001
Peak Sacruma	97.65 ± 36.14	215.26 ± 54.6	<0.0001
Peak Heels	161.56 ± 63.02	246.87 ± 32.51	<0.001
Average Pressure measurements			
Average Head	53.92± 14.42	107.11 ± 19.29	<0.0001
Average Sacrum	48.83± 5.25	68.01 ± 10.09	<0.0001
Average Heels	58.36 ± 19.54	96.48 ± 26.28	<0.0001

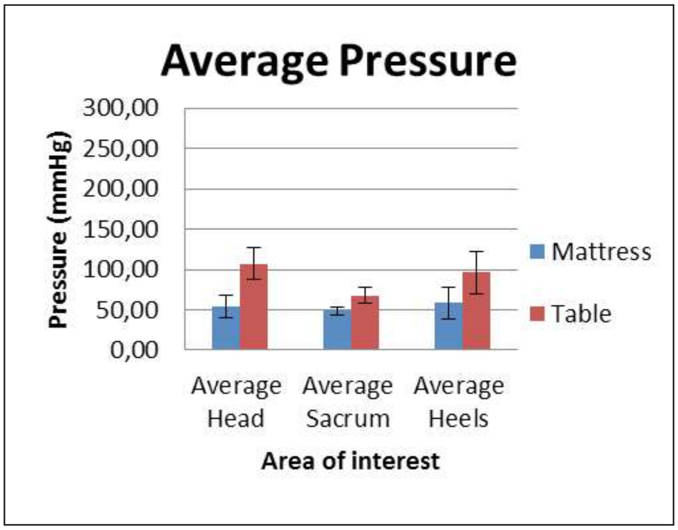

Figure 1: Graph comparing average pressure in mmHg for each of the jeopardy areas for both the mattress and the x-ray table. Inc standard deviation.

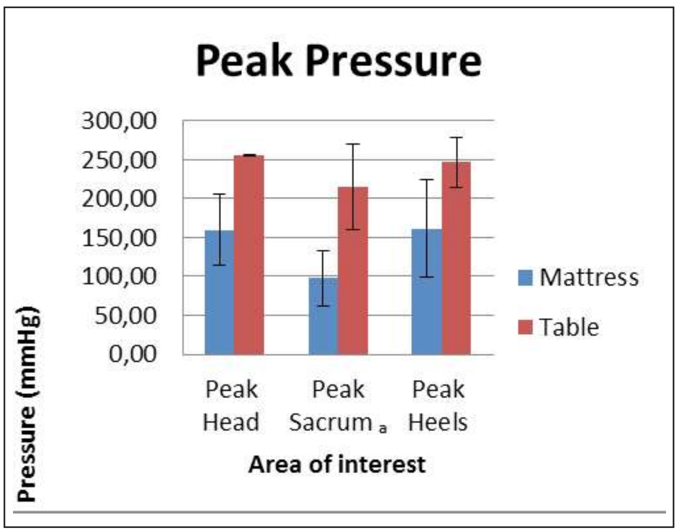

Figure 2: Graph comparing peak pressure in mmHg for each of the jeopardy areas for both the mattress and the x-ray table. Inc standard deviation. [a] Mean peak of the 3x3 area.

Qualitative -

The comfort levels between the mattress and the X-ray table varied, 50% of the participants found the surface with a mattress was comfortable or very comfortable, compared to the X-ray table where only 23% found the mattress comfortable or very comfortable. 10% of participants described the X-ray table as very uncomfortable, whereas none of the participants scored the mattress as very uncomfortable.

There is a significant difference in the pain experienced in the sacrum and head (P<0.001) between the two surfaces. The participants experienced more pain in the head when lying on the X-ray table compared to the other areas of interest. For the other jeopardy areas the pain experienced by the participants was higher for the hard surface as well.

DISCUSSION

The results obtained in our study confirm that the average IP for whole body and average of the triple jeopardy areas were higher in the hard surface. All of the IP values recorded for the mattress surface showed an improvement when compared to the hard surface. From this we can say that with the inclusion of radiolucent mattresses average pressure of the jeopardy areas can be reduced below the accepted benchmark of 90mmHg, the bony prominences may need a thicker or higher specification mattress[13]. Although most jeopardy area values recorded from both surfaces still exceed the standard for a hospital mattress (60mmHg). The mattress surface provides a more even distribution of pressure in the jeopardy regions; this is comparable to a previous study that found greater distribution to be in agreement with the conclusion, that higher specification surfaces reduce the incidence of PUs, proposed in a recent Cochrane analysis (Moysidis).

The open-ended questions revealed themes of movement and loss of sensation, a number of the participants highlighted that they had ´twitched´ or were ´shocked´, suggesting that they had moved during the 20 minutes which in practice may have a negative impact on image quality. More participants had a sensation of 'numbness' on the mattress surface, this is an issue that needs further work as loss of sensation is another risk factor for the formation of PUs (NICE CG 179, Cochrane review).

The participants found the mattress surface to be overall more comfortable (P=0.015) and less painful in the head and sacrum, this is comparable with the findings of King and Bridges. When asked if the participants felt like moving 22 said yes on the mattress surface, whereas only 19 said yes on the hard surface, implying that although the mattress appears to reduce discomfort and interface pressure participants where more inclined to move. More research needs to be done to look at the movement of patients, on various surfaces, during radiography image acquisition.

Limitations

This study included only healthy participants; it is recommended that further work be undertaken with samples including at risk patients.

The Norland XR-36 bone densitometry scanner is outdated equipment and may not be found in most radiology departments. Nevertheless the findings of this study are likely to be comparable to imaging surfaces with thin radiolucent mattresses. Further research exploring interface pressure on other surfaces often used in radiology is recommended.

CONCLUSION

A significant difference in average interface pressure is demonstrated between imaging surfaces, justifying the need for further investigation into pressure reducing surfaces and overlays in the radiographic context. A mattress surface reduces both average and peak interface pressures on the whole body and the three jeopardy areas. Therefore it can be assumed that the use of a mattress will reduce the probability of developing pressure ulcers. There is a significant difference in pain and comfort assessment between the two surfaces, which also supports the findings in favour of using radiolucent mattresses or supports (pillows, props, foam pads) where possible.

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