Radiological perspective of the formation of pressure ulcers – A comparison of pressure and experience on two imaging surfaces

Conference Paper · March 2015

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Radiological perspective of the formation of pressure ulcers - A comparison of pressure and experience on two imaging surfaces.

Poster No.:	C-1282
Congress:	ECR 2015
Type:	Scientific Exhibit

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Keywords:	Soft tissues / Skin, Conventional radiography, Treatment effects, Biological effects
DOI:	10.1594/ecr2015/C-1282

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Aims and objectives

Many medical imaging procedures, especially interventional, can take up to 20 minutes or more (1). Patients are required to lie completely still during image acquisition, any movement could render resultant images 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, and can increase the prospect of the patient having a negative experience.

Studies have shown that sustained interface pressure, for more than 20 minutes, can cause tissue breakdown (5). This could heighten the probability of developing Pressure Ulcers (PUs) (3). PUs are a high cost problem for health care providers across Europe. The number of patients afflicted reaching over 18% (4).

In the radiographical context the interface pressure between the patient and the imaging surface is maintained for prolonged periods of time. A search of the available literature reveals that there are currently no studies which investigate the relationship between radiological surfaces and interface pressure, or how this could affect the formation of PUs in at risk patients.

The patient experience in the clinical setting is of paramount importance, and is an area where very little research has been undertaken. A number of studies and reviews recommend that further work should be done in this area to explore personal opinions (6)

Using healthy participants, this experimental study will therefore:

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

Methods and materials

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 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 (7) 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 177 cm or more were excluded from the study, due to the limitations of the pressure mat equipment.

Participants with any health condition, such as back pain, that would prevent them from lying still for 20 minutes were excluded from the study. This was to ensure that participants could lie still during the acquisition of the interface pressure, as excessive movement would render the data unusable in the study (8). Participants who could not participate on the grounds of religious beliefs were also excluded.

Surfaces

Two imaging surfaces were used for the study.

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

Measurement tools

Pressure Mat - This study used the XSENSOR PX100:48.144.02 pressure mat from Sumed International. Various clinical studies (9) and academic studies (10) used the XSENSOR to perform pressure mapping on humans. Fader et al (11) stated that XSENSOR appears to be the gold standard technology for pressure mapping. The mat was calibrated to manufacturers' specification. Manufacturer calibration and quality control data, confirm a high level of precision and reliability (12).

The pressure mat has an accuracy rate of ±10 percent of the calibrated values (9). The pressure mat was linked to XSENSOR X3 Medical v5.0 software, which according to Trewartha and Stiller (10) 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 designed to assess participants' level of comfort and pain. The Likert scale is the most widely used format for designing a questionnaire (14) suggested that scales ranging from 5-101 response categories show little difference in validity and reliability. Open-ended questions were also asked in order to explore the experience of the participants, providing responses in their own terms (15).

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.

Data Collection

Pressure - The pressure mat equipment was securely fixed onto the imaging surface to ensure that it remained in place during data acquisition. The pressure mat was not removed or repositioned until the full sample had been acquired. 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 and were asked to change into a pair of leggings and two t-shirts to standardise clothing as per

Fader et al (11). Participants were then positioned supine in the centre of the mat with their hands pronated.

A settling time of 6 minutes was used in this study, to reduce measurement error as recomended by Stinson et al (5) in a similar study which found that pressure values change significantly over the first 6 minutes.

Comfort and Pain - Following pressure data acquisition participants were asked to complete a questionnaire. In a cross-national setting, there is the potential for reliability error due to differences in knowledge, perceptions and familiarity with research instruments (16). Therefore two questions consisted of numerical descriptions with verbal anchors on a 5 point Likert scale, and the participants were escorted whilst completing the questionnaire by a member of the research team to assist with definitions and clarity.

Data Analysis

From the data acquired for each participant on both of the surfaces, the average pressure and the peak pressure in mmHg for the whole body and the areas of interest (head, sacrum & heel) 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 (17). Objective data analysis was achieved by selecting and averaging 30 frames per person on both surfaces in order to ensure the reliability of results in the presence of any data artefacts previously noted. The peak pressure measurements, of the sacrum, were collected by selecting an area of 3x3 cells with the highest pressure value in the centre (Fig 1), in order to calculate the mean peak value (18). 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.

Images for this section:

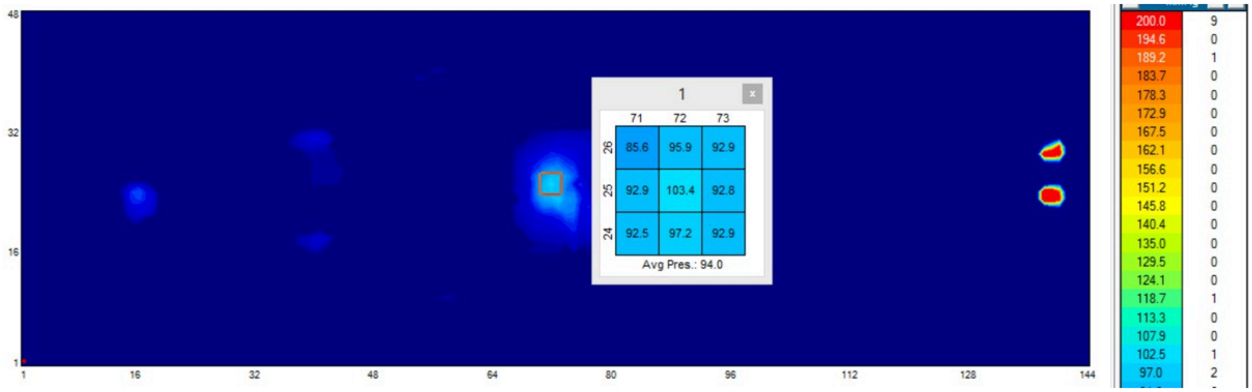


Fig. 1: Image depicting aquisition of mean peak value for the sacrum.

Results

Pressure -

The data sample of 30 healthy participants was analysed. 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 Figure 2.

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 (Fig 2).

In the measurements of average and peak pressures of the triple jeopardy areas (Fig 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 (Fig 4) and average pressure (Fig 3) measurements, it was found that the pressure was higher on the x-ray table than on the density scanner with a mattress. 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 ($r2 =0.029$).

Comfort and Pain -

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 table 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 was also higher for the hard surface.

Images for this section:

Total Average Pressure	43.04 ± 3.75	31.09 ± 2.34	<0.0001
Peak pressure measurements			
Peak Head	255.77 ± 1.18	159.72 ± 45.88	<0.0001
Peak Sacrum[a]	215.26 ± 54.6	97.65 ± 36.14	<0.0001
Peak Heels	246.87 ± 32.51	161.56 ± 63.02	<0.001
Average Pressure measurements			
Average Head	107.11 ± 19.29	53.92± 14.42	<0.0001
Average Sacrum	68.01 ± 10.09	48.83± 5.25	<0.0001
Average Heels	96.48 ± 26.28	58.36 ± 19.54	<0.0001

Fig. 2: Table showing total average bodu presure, and peak and average presure for head, sacrum and heels in mmGh.

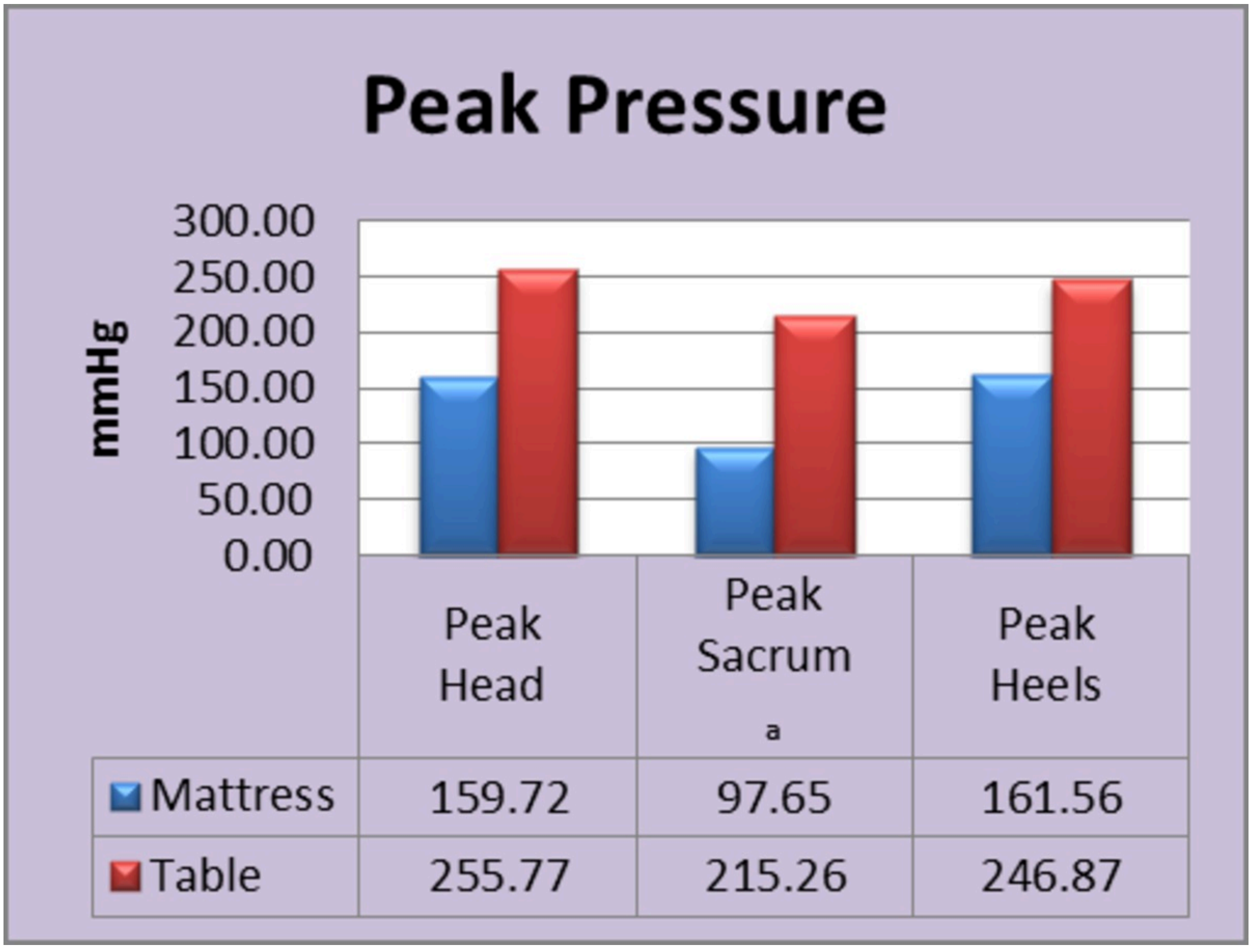
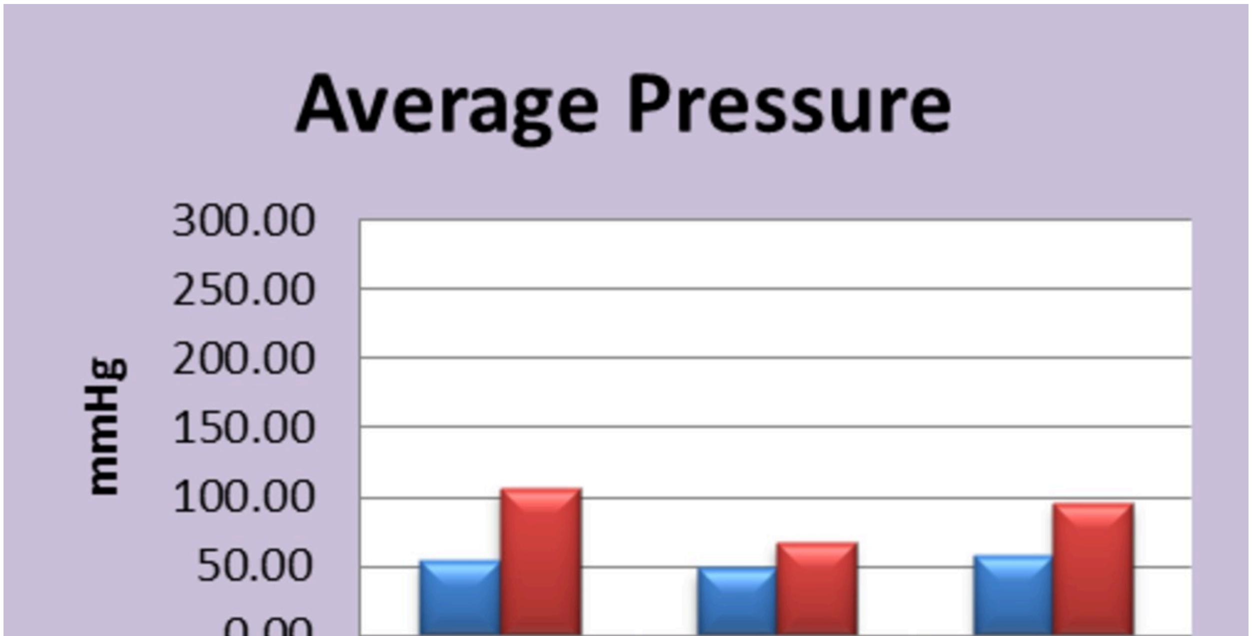


Fig. 4: Graph comparing peak pressure in mmHg for each of the jeopardy areas for both the mattress and the x-ray table. Inc standard deviation. a Mean peak of the 3x3 area.



	Average Head	Average Sacrum	Average Heels
Mattress	53.92	48.83	58.36
Table	107.11	68.01	96.48

Fig. 3: Graph comparing average pressure in mmHg for each of the jeopardy areas for both the mattress and the x-ray table. Inc standard deviation.

Conclusion

The results obtained confirm that the average IP for whole body and average IP of the triple jeopardy areas were higher on the hard surface. All of the IP values recorded for the mattress surface showed an improvement when compared to the hard surface (Fig 5 & Fig 6).

It is therfore suggested that the inclusion of radiolucent mattresses could reduce average pressure on the jeopardy areas to below the accepted PU formation benchmark of 90mmHg. Bony prominences may need a thicker or higher specification mattress (5).

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 reduce the incidence of PUs (19). Although more work would need to be done as most jeopardy area values recorded from both surfaces still exceed the standard for a hospital mattress (60mmHg).

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 could moved during the 20 minutes. This could have a negative impact on image quality, suggesting the need for further work on the impact of movement on image acquisition and dose. 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 (20, 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 & Bridges (5).

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.

Limitations

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

Acknowledgements

The authors would like to thank, Erasmus for funding, The Nuffield Foundation, and Sumed International. Thanks are also extended to all participants who gave their time.

Images for this section:

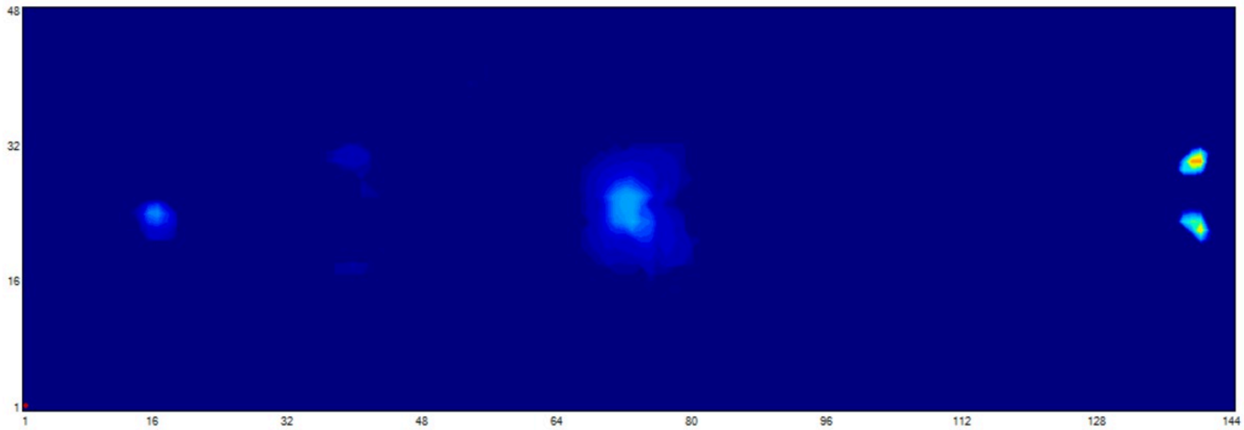


Fig. 5: Image representing total pressures exherted on the pressure mat during a 20 minitue session on the Norland XR-36 bone density scanner with a mattress.

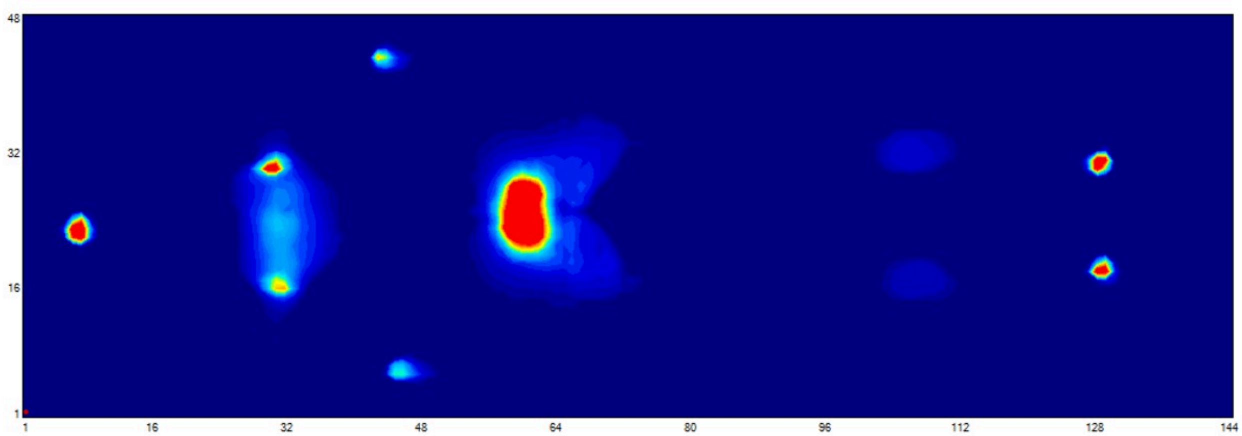


Fig. 6: Image representing total pressures exherted on the pressure mat during a 20 minitue session on the Siemens MULTIX Pro x-ray table without a mattress.

References

1. Westbrook C, Kaut Roth C. MRI in practice. 4th ed. John Wiley & sons; 2011.

2. Whitley S, Sloane C, Hoadley G, Moore AD, Alsop C. 12th ed. (2005) Clark's positioning in radiography. Hodder Arnold:London

3. Dharmarajan TS, T UJ. Pressure Ulcers; clinical features and management. Clin Rehabil. 2003;17:504-11.

4. Vanderwee K, Clark M, Dealey C, Gunningberg L, Defloor T. Pressure ulcer prevalence in Europe; a pilot study. J Eval Clin Pract [Internet]. 2005;13:227-35. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2753.2006.00684.x/abstract

5. Stinson MD, Porter-Armstrong a P, Eakin P a. Pressure mapping systems: reliability of pressure map interpretation. Clin Rehabil [Internet]. 2003 Aug;17(5):504-11. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12952156

6. King C a., Bridges E. Comparison of Pressure Relief Properties of Operating Room Surfaces. Perioper Nurs Clin [Internet]. 2006 Sep [cited 2014 Aug 12];1(3):261-5. Available from: http://linkinghub.elsevier.com/retrieve/pii/S1556793106000507

7. Gélis A, Dupeyron A, Legros P, Benaïm C, Pelissier J, Fattal C. Pressure ulcer risk factors in persons with SCI: Part I: Acute and rehabilitation stages. Spinal Cord. 2009;47(2): 99-107

8. Gil-Agudo a, De la Peña-González a, Del Ama-Espinosa a, Pérez-Rizo E, Díaz-Domínguez E, Sánchez-Ramos a. Comparative study of pressure distribution at the user-cushion interface with different cushions in a population with spinal cord injury. Clin Biomech (Bristol, Avon) [Internet]. Elsevier Ltd; 2009 Aug [cited 2014 Aug 20];24(7):558-63. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19447532

9. Peterson MJ, Gravenstein N, Schwab WK, van Oostrom JH, Caruso LJ. Patient repositioning and pressure ulcer risk - Monitoring interface pressures of at-risk patients. J Rehabil Res Dev [Internet]. 2013;50(4):477-88. Available from: http://www.rehab.research.va.gov/jour/2013/504/page477.html

10. Trewartha M, Stiller K. Comparison of the pressure redistribution qualities of two air-filled wheelchair cushions for people with spinal cord injuries. Aust Occup Ther J [Internet]. 2011 Aug [cited 2014 Aug 20];58(4):287-92. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21770964

11. Fader M, Bain D, Cottenden A. Effects of absorbent incontinence pads on pressure management mattresses. J Adv Nurs [Internet]. 2004 Dec;48(6):569-74. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15548247

12. Lewis-Beck M. Encyclopedia of social Science research methods. Encyclopedia of Social Science Research Methods.; 2013.

13. Wakita T, Ueshima N, Noguchi H. Psychological Distance Between Categories in the Likert Scale: Comparing Different Numbers of Options. Educ Psychol Meas [Internet]. 2012 Jan 12 [cited 2014 Aug 3];72(4):533-46. Available from: http://epm.sagepub.com/cgi/doi/10.1177/0013164411431162

14. Preston CC, Colman a M. Optimal number of response categories in rating scales: reliability, validity, discriminating power, and respondent preferences. Acta Psychol (Amst). 2000;104(1):1-15.

15. Brace I. Questionnaire design. Barr D, Birn RJ, editors. London: Kogan page; 2004.

16. Parameswaran R, Yaprak A. A cross-national comparison of consumer measures. J Int Bus Stud [Internet]. 1987;18:35-49. Available from: http://www.palgrave-journals.com/jibs/journal/v18/n1/abs/8490398a.html

17. Kosiak M. Etiology of decubitus ulcers. Arch Phys Med Rehabil [Internet]. 1961 [cited 2014 Aug 20]; Available from: http://europepmc.org/abstract/MED/13753341

18. Hemmes B, Brink PRG, Poeze M. Effects of unconsciousness during spinal immobilization on tissue-interface pressures: A randomized controlled trial comparing a standard rigid spineboard with a newly developed soft-layered long spineboard. Injury [Internet]. Elsevier Ltd; 2014 Jun 17 [cited 2014 Aug 12];(june). Available from: http://www.ncbi.nlm.nih.gov/pubmed/24998039

19. Moysidis T, Niebel W, Bartsch K, Maier I, Lehmann N, Nonnemacher M, Kroeger K. Prevention of pressure ulcer: interaction of body characteristics and different mattresses. Int Wound J. 2011;8(6):578-84.

20. NICE. Pressure ulcers: prevention and management of pressure ulcers. 2014