ORIGINAL ARTICLE / ÖZGÜN ARAŞTIRMA MAKALESİ

Supported Design Trauma Board: A Physiomechanical Study

Destekli Travma Tahtası: Fizyomekanik Bir Çalışma

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ABSTRACT

Introduction: The use of backboard is a widely-accepted practice for the stabilization of major trauma cases. Discomfort and pressure pain due to the use of backboard are common complications. In this study, we aimed to reduce the discomfort and pressure pain due to the use of backboard.

Materials and methods: The study was carried out with 20 healthy volunteers. In the first stage, the volunteers were placed in the supine position for 5 minutes on the standard backboard(STB) and on the supported backboard(SUB). The pressures in the occipital, scapular, and sacral regions were measured while lying on an STB and an SUB. In the second stage, the volunteers were placed in the supine position on an STB or an SUB as two episodes of 60 minutes. Visual Analog Scale(VAS) was used for evaluation of the pain at 10,15,30,45 and 60th minutes.

Results: When the VAS scores while lying on an STB and an SUB were compared in the volunteers, general pain and pain in the occipital, scapular, and sacral regions were found to be statistically significantly decreased at all minutes while lying on an SUB. When the pressures while lying on an STB and an SUB were compared in the volunteers, there was no statistically significant difference between the areas exposed to the pressure above the capillary filling pressure in the occipital and scapular regions. However, as a positive result, the area exposed to the pressure below the capillary filling pressure in the sacral region while lying on an SUB was found to be high at a statistically significant level.

Conclusion: Although it is needed to be slightly improved in terms of the pressure due to lengthened transport time and lengthened waiting time on a backboard, the SUB, which we used to reduce pressure pain, was demonstrated to provide significant benefits.

Key words: Backboard, pain, pressure, transport, trauma

ÖZET

Giriş: Travma tahtası kullanımı major travma olgularının stabilizasyonu için geniş ölçüde kabul edilmiş bir uygulamadır. Travma tahtası kullanımına bağlı oluşan rahatsızlık hissi ve bası ağrısı sık karşılaşılan komplikasyonlardandır. Bu çalışmamızdaki amacımız travma tahtası kullanımına bağlı oluşan rahatsızlık hissi ve bası ağrısının azaltılmasıdır.

Gereç ve Yöntem: Çalışma 20 adet gönüllü ile yapılmıştır. Birinci aşamada gönüllüler, standart travma tahtası (STT) ve bu çalışmada oluşturulan destekli travma tahtasına(DTT) 5 dakika süre ile supin pozisyonda yatırılmıştır. STT ve DTT üzerinde yatarken oksipital, skapular ve sakral bölgelerdeki oluşan basınçlar ölçülmüştür. İkinci aşamada ise 60'ar dakikalık iki bölüm halinde gönüllüler STT ve DTT üzerinde supin pozisyonda yatırılmıştır. Bu iki bölümün ilk 10 dakikası olay anındaki gibi ambulans içerisinde geçmiş olup, sonraki 50 dakika boyunca da kişiler supin pozisyonda STT ve DTT üzerinde acil serviste yatmaya devam etmiştir. Ağrının değerlendirilmesi için 10, 15, 30, 45 ve 60. dakikalarda Visual Analog Skala (VAS) kullanılmıştır.

Bulgular: Gönüllülerin DTT ve STT üzerinde VAS karşılaştırmasında tüm sorgulama dakikalarında genel ağrının ve oksipital bölge, skapular bölge ve sakral bölgelerdeki ağrının DTT üzerindeyken istatistiksel olarak anlamlı düzeyde azaldığı saptanmıştır. DTT ve STT üzerindeyken oluşan basınçlar karşılaştırıldığında; oksipital bölge ve skapular bölgelerde kapiller dolum basıncının üzerinde basıya uğrayan alanlar arasında istatistiksel fark bulunmamakla beraber, olumlu bir sonuç olarak DTT üzerindeyken sakral bölgede kapiller dolum basıncının altında basıya uğrayan alan oranının anlamlı düzeyde yüksek olduğu saptanmıştır.

Sonuç: Travma tahtası üzerinde transfer sırasında ve travma tahtası üzerinde bekleme süresinin uzaması nedeniyle oluşacak basınç açısında biraz daha geliştirilmeye ihtiyaç duyulmakla beraber bası ağrılarının azaltılmasında kullanmış olduğumuz DTT'nın önemli fayda sağladığı ortaya konmuştur.

Anahtar Kelimeler: Sırt tahtası, ağrı, basınç, transport, travma

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Introduction

The use of backboard is a widely-accepted practice for the stabilization of major trauma cases [1]. The main purpose of use of backboard is to improve pre-hospital transportation techniques and to reduce mortality and morbidity. One of these pathways is to provide to the stabilization during pre-hospital transportation of patients with spinal cord injury [2]. This stabilization prevents secondary injuries by immobilizing the head, neck and back of the patient.

In the literature, although no time has been mentioned to end immobilization with a backboard, general consensus is that backboard is removed from under the patient as soon as possible [3]. Lerner and Moscati reported that a trauma patient spent an average of 77 minutes on a backboard. It has been shown in the various studies that the duration of immobilization on a backboard differed between 30-80 minutes [4, 5]. Various adverse effects such as aspiration, pain, pressure ulcers, and impaired respiratory functions have been reported from the time when backboards began to be used routinely until today [6-9]. Pain related to backboard in patients lying on a backboard until arriving at the emergency service can lead to unnecessary radiographic examinations. It has been seen that patients who lied only 40 minutes on a backboard were suffering from unreal pain at first and therefore radiographic examinations were performed and no pathologies were found [10, 11]. Similarly, a well-known problem is that pressure ulcers are formed especially in patients who lay on a board for a long time. Many studies have shown that a potential source of discomfort and pressure ulcer in the patient is to lie on a backboard for a long time [4,12].

In this study, we aimed to investigate the effectiveness of the Supported Board (SUB), which was formed to reduce discomfort and pressure pain caused by the Standard Board (STB) and to enhance comfort.

Materials and Methods

This study is a prospective and comparative study using healthy volunteers. The study was approved by the Local Ethics Committee.

The STB used in the study is a patented model (EMS, ES-510). The SUB was formed by supporting the occipital, scapular, and sacral regions, where discomfort and pressure pain most frequently occur and there is a need for support while lying on an STB, with the visco-elastic sponge. The visco-elastic sponge takes the shape of the body within a few minutes at body temperature and is 100% permeable to X-Ray. The sponge was planned as self-adhesive and was adhered to a backboard. The points most exposed to the pressure in the supine position are the occiput, scapula, elbow, sacrum, and heel [13]. Therefore, the visco-elastic sponge used was designed to cover the occipital, scapular, and sacral regions.

In the first stage, the volunteers were placed in the supine position for 5 minutes on an STB and an SUB. At the end of this period, the pressures in the occipital, scapular, and sacral regions were measured with the XSensor device (XSENSOR Technology Corporation, Calgary, Alberta, Canada). The pads of the XSensor device were placed between the volunteer and the STB while lying on an STB and between the volunteer and the visco-elastic sponge while lying on an SUB. The pressures were measured in both cases (Figure 1). Each of the pads of the XSensor device has a dimension of 1.6 cm² and contains 36x36 pressure measurement sensors. These sensors can measure pressure values in a range of 5-232 mmHg. The 32-mmHg capillary filling pressure was used as a limit of the risk for pressure ulcer development due to the pressures measured from the occipital, scapular, and sacral regions and the values exceeding this pressure were considered as a risk indicator[14]. The values below the capillary filling pressure were considered as safe. The ratio of the area exposed to the pressure below the capillary filling pressure to the total surface area was used to determine the effectiveness of the SUB in reducing pressure. The ratios of the area exposed to the pressure below the capillary filling pressure to the total surface area while lying on an STB and an SUB were compared.

In the second stage, the volunteers were placed in the supine position on an STB or an SUB as two episodes of 60 minutes. They were allowed to lie in the supine position on a backboard in a moving ambulance in the first 10 minutes of the study protocol in order to simulate patients who are admitted to emergency services with an ambulance. Then, they were transferred to an emergency stretcher with the same backboard and continued to lie in the supine position on a backboard during the remaining 50 minutes. They evaluated their pain in the general body and in the occipital, scapular, and sacral regions at 10, 15, 30, 45 and 60th minutes with Visual Analog Scale (VAS) (0: no pain, 10: unbearable pain). They were allowed to rest for at least 3 hours after VAS assessment was done for one hour on the first backboard. Then, they were evaluated again on the other backboard with the same protocol.

Power analysis was done based on the study in which Edlich et al. compared the STB and the SUB with VAS in terms of pressures in the occipital, scapular, and sacral regions[2].If the significance level was accepted as 0.05 and a 3-unit difference in VAS was created by the SUB with 80% power, was considered to be clinically significant, it was concluded that a minimum of 15 individuals must be included in the study. Thus, 20 healthy volunteers aged 18-

65 years were included in the study. Written informed consent was obtained from all participants prior to the study. Individuals who had chronic pain, back or hip pain, dermal lesions behind the body, orthopedic deformities and who used analgesic drugs in the last 24 hours were excluded from the study.

Statistical analyzes were performed with Statistical Package for Social Sciences for Windows 11.5 (SPSS Inc, Chicago). VAS scores were expressed as mean value ±SD, minimum, maximum and median values. As a result of the pressures measured separately from the occipital, scapular, and sacral regions with the XSensor device, the ratio of the area exposed to the pressure below the capillary filling pressure to the total surface area was expressed as percentage, mean value ±SD, minimum, maximum and median value. The changes in VAS scores and pressure measurements were evaluated with the dependent sample t-test and the Wilcoxon test after it was checked that the data were normally distributed. The significance level was accepted as $p<0.05$.

Results

The study was carried out with 20 healthy volunteers. The demographic data, weight, height, and Body Mass Index (BMI) of the volunteers participating in the study are given in Table 1.

	Number (%)	Age; years (min-max)	Height; m (min-max)	Weight; kg (min-max)	BMI (min-max)
Female	5 (25%)	29 (24-36)	1.656(1.65-1.70)	53.2 (48-58)	19.438(17.63-22.65)
Male	15 (75%)	34.4 (25-49)	1.739(1.64-1.91)	73.33 (62-97)	24.181(19.35-28.34)
Total	20 (100%)	33.05 (24-49)	1.719(1.64-1.91)	68.3 (48-97)	22.996(17.63-28.34)

Table 1. The demographic data of the volunteers participating in the study

As a result of the pressures measured from the occipital, scapular, and sacral regions with the XSensor device, the ratios of the area exposed to the pressure below the capillary filling pressure to the total surface area were compared (Table 2). There was no significant difference between the means of the ratios of the area exposed to the pressure below the capillary filling pressure to the total surface area, which are considered as an indicator of a lower risk for pressure ulcer development in the occipital and scapular regions while lying on an STB and an SUB. The mean of the ratio of the area exposed to the pressure below the capillary filling pressure to the total surface area in the sacral region while lying on an SUB was found to be lower than the mean of the ratio of the area exposed to the pressure below the capillary filling pressure to the total surface area in the sacral region while lying on an STB. This difference was statistically significant ($p<0.05$). The distribution map of the pressure averages that occurred while lying on an STB and an SUB is shown in Figure 2.

	Standard backboard		Supported backboard		
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	p value
Occipital	74.68±12.20	74.56 (51.14-96.93)	69.59±6.47	69.57 (52.28-81.71)	0.086
Scapular	55.76±7.99	55.60 (39.03-70.88)	58.69±5.35	59.14 (50.58-68.85)	0.100
Sacral	45.93±5.11	44.33 (39.66-56.98)	54.63±3.12	54.01 (49.59-62.88)	<0.05

Table 2. The ratios of the area exposed to the pressure below the capillary filling pressure to the total surface area in the occipital, scapular, and sacral regions.

The mean VAS scores which evaluated the pain levels of the participants at 10, 15, 30, 45 and 60th minutes in the general body and in the occipital, scapular, and sacral regions while lying on an STB and an SUB are given in Table 3 and Figure 3. In all regions and at all evaluation times, the mean VAS scores of the pain felt while lying on an SUB were lower at a statistically significant level than the mean VAS scores of the pain felt while lying on an STB ($p<0.05$).

Discussion

Backboards have been primarily designed to provide rigid support during the transport of patients with suspected spinal or extremity injuries [15]. Backboards are mainly used for the proper handling and transport of individuals with spinal injuries in cases where the injury mechanism and spinal injury cannot be ruled out [3]. The use of backboards is recommended to immobilize individuals who have trauma-induced mental status change, pain and tenderness in the spine, muscle weakness due to motor nerve damage and undergo trauma due to drug and alcohol intoxication [3].The use of backboards can lead to undesirable effects such as pain, pressure ulcers, and impaired respiratory functions in trauma patients and also can increase the cost per patient [6-9].

Pressure ulcers are the wounds that occur as a result of ischemia and necrosis in any part of the body due to the effect of prolonged pressure. The causes of the formation of these wounds can include pressure, shear force, and increased surface heat and humidity [16]. Many studies show that the primary reason leading to ischaemia is pressure [16]. Pressure ulcers are characterized respectively by reduced perfusion, ischemia, and necrosis especially in areas where there are bone protrusions [17]. Low grade pressure ulcers occur in about 2 hours [17]. There is an inverse proportion between duration and pressure [18, 19]. Although the visco-elastic support reduces it by seriously distributing the

pressure, which is the main cause of pressure ulcer, it also has negative aspects such as increased heat and humidity because it reduces the airflow secondary to increased surface area of the material.

	Standard backboard		Supported backboard		
	Mean±SD	Median (minimum-maximum)	Mean±SD	Median (minimum-maximum)	P value
General VAS					
VAS 10 min	2.60±1.09	3 (0-5)	0.05±0.22	0 (0-1)	<0.05
VAS 15 min	3.55±1.39	3 (0-6)	0.25±0.55	0 (0-2)	<0.05
VAS 30 min	4.90±1.71	5 (0-7)	0.60±0.59	1 (0-2)	<0.05
VAS 45 min	5.95±1.79	6 (2-8)	1.50±1.19	1 (0-3)	<0.05
VAS 60 min	7.20±2.09	7 (2-10)	1.95±1.27	2 (0-4)	<0.05
Occipital VAS					
VAS 10 min	3.05±1.43	3 (0-6)	0.10±0.30	0 (0-1)	<0.05
VAS 15 min	4.00±1.55	4 (1-7)	0.30±0.47	0 (0-1)	<0.05
VAS 30 min	5.50±1.93	5 (2-10)	0.85±0.81	1 (0-2)	<0.05
VAS 45 min	7.10±1.74	7 (4-10)	1.40±1.35	1 (0-4)	<0.05
VAS 60 min	8.05±1.57	8 (6-10)	1.85±1.46	1.50 (0-4)	<0.05
Scapular VAS					
VAS 10 min	1.85±1.49	2 (0-5)	0.35±0.67	0 (0-2)	<0.05
VAS 15 min	2.70±1.55	3 (0-6)	0.65±0.74	0.50 (0-2)	<0.05
VAS 30 min	4.25±2.14	4 (0-8)	0.80±0.83	1 (0-2)	<0.05
VAS 45 min	5.05±2.16	5 (2-10)	1.35±1.30	1 (0-4)	<0.05
VAS 60 min	5.85±2.08	6 (2-9)	1.60±1.39	1.50 (0-5)	<0.05
Sacral VAS					
VAS 10 min	2.00±1.29	2 (0-4)	0.25±0.55	0 (0-2)	<0.05
VAS 15 min	2.85±1.34	3 (0-5)	0.50±0.68	0 (0-2)	<0.05
VAS 30 min	5.05±1.43	4 (0-8)	0.75±0.78	1 (0-2)	<0.05
VAS 45 min	6.45±2.01	6.5 (3-10)	1.65±1.13	2 (0-3)	<0.05
VAS 60 min	7.55±2.11	8 (4-10)	2.65±1.38	3 (0-5)	<0.05

Table 3. The evaluation of pain level with VAS in the general body and in the occipital, scapular, and sacral regions.

However, considering that EPUAP (European Pressure Ulcer Advisory Panel) has defined pressure ulcer as damage area localized in the skin and subcutaneous tissues caused by tension, friction, compression, or any combination of these, these effects have been considered negligible because the duration is not too long [20]. In comparison of general pain levels with VAS while lying on an STB and an SUB, the feelings of discomfort in all their bodies except for pressure pain were measured in the volunteers within the scope of said general pain. It was used to evaluate the feelings of discomfort such as nausea, fatigue, headache, and tension in the skin due to ambulance transportation. In this evaluation, it was found that the visco elasticated backboard was statistically significantly more comfortable.

In comparison of VAS scores for the occipital region while lying on an STB and an SUB, pressure pain that the participants felt only in the occipital region was evaluated. It was found that especially the participants with a small occipital lobe surface area experienced more unbearable pain in a shorter time while lying on an STB. In this evaluation, it was found that the SUB was statistically significantly more comfortable ($p<0.05$).

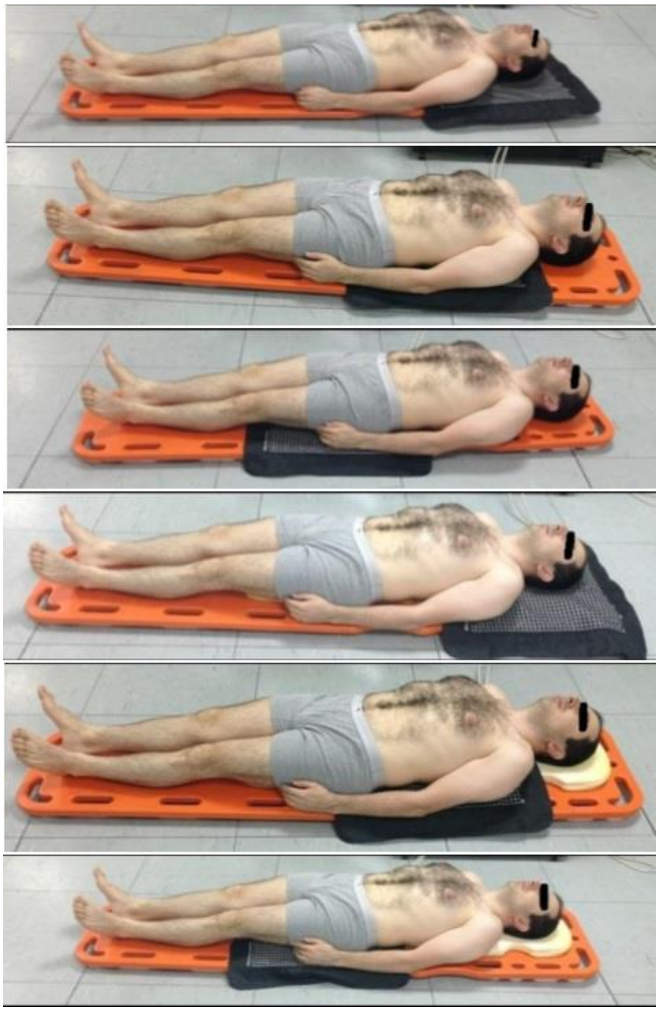

Figure 1. Pressure measurements using the XSensor device from the occipital, scapular, and sacral regions while lying on an STB and an SUB.

In comparison of VAS scores for the scapular region while lying on an STB and an SUB, pressure pain that the participants felt only in the scapular region was evaluated. It was found that the pain was felt least in this region during follow-up. In this evaluation, it was found that the SUB was statistically significantly more comfortable ($p<0.05$). In comparison of VAS scores for the sacral region while lying on an STB and an SUB, pressure pain that the participants felt only in the sacral region was evaluated. It was noticed that the pain increased significantly especially between 15 and 30 minutes during follow-up. In this evaluation, it was found that the SUB was statistically significantly more comfortable ($p<0.05$).

In comparison of the pressures in the occipital and scapular regions while lying on an STB and an SUB, the pressures were measured separately in the participants. In this measurement, the ratios of the area exposed to the pressure below the capillary filling pressure to the total surface area in the occipital and scapular regions on a backboard were compared. When the surface areas were

compared while lying on an STB and an SUB in this evaluation, it was found that the STB was more advantageous in terms of the ratio of the area exposed to the pressure below the capillary filling pressure to the total surface area. Despite the fact that the SUB can distribute the pressure, it can be considered that such a result has occurred because this pressure did not fall below the capillary filling pressure. Therefore, it was found that the SUB did not have a statistically significant positive effect on reducing the pressure below the capillary filling pressure.

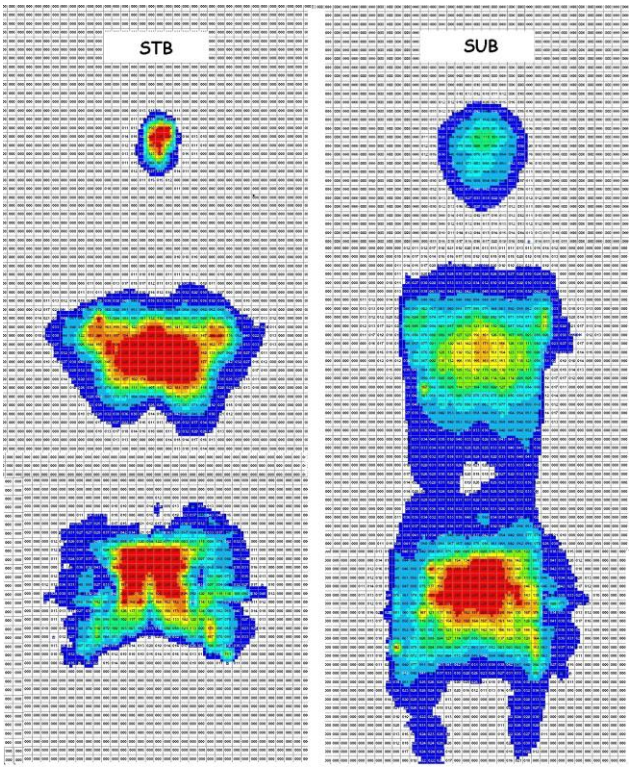

Figure 2. The distribution map of the pressure averages that occurred while lying on an STB and an SUB.

In comparison of the pressures in the sacral region while lying on an STB and an SUB, the pressures were measured separately in the participants. In this measurement, the ratios of the area exposed to the pressure below the capillary filling pressure to the total surface area in the sacral region on a backboard were compared. When the surface areas were compared while lying on an STB and an SUB in this evaluation, it was found that the SUB was more advantageous in terms of the ratio of the area exposed to the pressure below the capillary filling pressure to the total surface area. The reason why it was advantageous in this measurement is due to the fact that the pressure is distributed over a wider surface.

There are two different products in the literature as the Back Raft System and the soft-layered spine board. It has been shown that both products were more comfortable than the STB by participants [21, 22]. In addition, it was found that both products had statistically significantly lower pressure than the STB in terms of average pressure distribution [21, 22] . Our study differs from these studies. These differences are that the evaluation period of VAS was longer and the capillary filling pressure (circulation limit) was based for the comparison of pressure measurements in our study. The measurements obtained from three different regions with the XSENSOR® pressure measurement device while lying on a backboard were combined with the excel program. When their averages were taken, the STB and the SUB could be compared. In this comparison, although the sacral and scapular distributions can be seen clearly, the measurement made in the occipital region while lying on an SUB was seen to have a higher pressure. The reason for this is that the pressure at a single point was divided into 20 because the device is unable to measure the pressures more than 232 mmHg. Moreover, when the measurements, which we made with the XSENSOR® pressure measurement device, are handled individually, we see that pressure distribution for each region has appeared very effectively. When we individually analyzed the pressure distribution map for each volunteer, it has been shown that the reason why VAS assessment was so meaningful was an effective distribution.

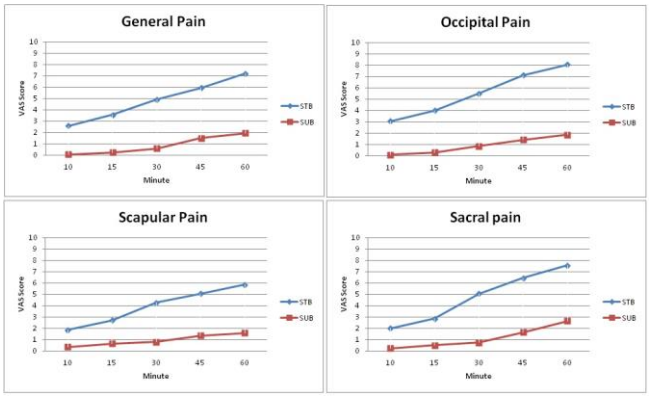

Figure 3. Line graph of VAS assessment of the pain in the general body and in the occipital, scapular, and sacral regions while lying on an STB and an SUB.

The limitations of our study; the visco-elastic support, which we used, was used on entirely healthy volunteers. It also needs to be used on patients. Although the visco-elastic support reduces it by seriously distributing the pressure, which is the main cause of pressure ulcer, it also has negative aspects such as increased heat and humidity because it reduces the airflow secondary to increased surface area of the material. Because the XSENSOR® pressure measurement device, which we used for measurement, measures up to 232 mmHg, there was no significant difference in the occipital and scapular regions while lying on an STB and an SUB when comparing the pressure measurements obtained from the volunteers.

The visco-elastic support used in our study can make this change even more difficult due to its non-slip feature. The

elasticity of the visco-elastic support is reduced at temperatures below zero. Therefore, it is thought that the visco-elastic supports should be maintained in the closed area and should be kept in an ambulance before use. Since our study was performed in adult volunteers, there is a need for studies on the use of the SUB in pediatric trauma patients.

Conclusion

Consequently, the SUB, which we used, was demonstrated to provide significant benefits in order to reduce pressure pains in the occipital, scapular, and sacral regions due to both lengthened transport time on a backboard and prolonged imaging time. It is thought that it is possible to increase the comfort level of the patients with low costs and to reduce pressure pain that may occur in the patient and so to prevent additional imaging costs. It is thought that studies, where pediatric backboard is supported by the visco-elastic support, can be performed in the future. Although multiple studies are needed in order to achieve a more useful backboard with some supports, it is important that the SUB provides the benefits in terms of reducing pressure pain and the risk for pressure ulcer development.

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References

1. White CC, Domeier RM, Millin MG; Standards and Clinical Practice Committee, National Association of EMS Physicians. EMS spinal precautions and the use of the long backboard – resource document to the position statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma. Prehosp Emerg Care. 2014 Apr-Jun;18(2):306-14. doi: 10.3109/10903127.2014.884197. Epub 2014 Feb 21.
2. Rimel R., Winn R., Rice P., Butler A., Edlich R., Buck R., Jane J.. Prehospital treatment of the patient with spinal cord injuries. EMT J 1979:51-4.
3. National Association of EMS Physicians and American College of Surgeons Committee on Trauma. January 15, 2013 Position Statement: EMS Spinal Precautions and the Use of the Long Backboard
4. Lerner B, Moscati R. Duration of patient immobilization in the ED. Am J Emerg Med 2000;18 (1):28-30.
5. March J, Ausband S, Brown L. Changes in physical examination caused by use of spinal immobilization. Prehosp Emerg Care. 2002;6:421–4.
6. Cordell WH, Hollingsworth JC, Olinger ML, Stroman SJ, Nelson DR. Pain and tissue-interface pressure during spine-board immobilization. Ann Emerg Med 1995;26:31–6
7. Kwan I, Bunn F. Effects of prehospital spinal immobilization: a systematic review of randomized trials on healthy subject. Prehospital Disaster Med 2005;20:47–53.
8. Bauer D, Kowalski R. Effect of spinal immobilization devices on pulmonary function in the healthy, nonsmoking man. Ann Emerg Med 1988;17: 915–8.
9. Berg G, Nyberg S, Harrison P, Baumchen J, Gurss E, Hennes E. Near-infrared spectroscopy measurement of sacral tissue oxygen saturation in healthy volun- teers immobilized on rigid spine boards. Prehosp Emerg Care 2010;14: 419–24.
10. Ay D, Aktaş C, Yeşilyurt S, Sarıkaya S, Cetin A, Ozdoğan ES. Effects of spinal immobilization devices on pulmonary function in healthy volunteer individuals.Ulus Travma Acil Cerrahi Derg. 2011 Mar;17(2):103-7.
11. Lerner EB, Billittier AJ, Moscati RM. The effects of neutral positioning with and without padding on spinal immobilization of healthy subjects. Prehosp Emerg Care. 1998;2:112–6.
12. Sheerin F, de Frein R. The occipital and sacral pressures experienced by healthy volunteers under spinal immobilization: a trial of three surfaces. J Emerg Nurs 2007;33(5):447-50.
13. Uysal, A.: Bası Yaraları, Editör: Ali Haydar Şahinoğlu; Özel Yoğun Bakım Sorunları ve Tedavileri, Türkiye Klinikleri Yayınevi, Ankara, 1992, s.827-32.
14. Lyder C. H. Pressure ulcer prevention and management. *JAMA*, 2003; *289*(2), 223-6.
15. Ahn H.,Singh J., Nathens, MacDonald R.D., Travers A., Tallon J., Fehlings M.G., Yee A.. Pre-hospital care management of a potential spinal cord injured patient: a systematic review of the literature and evidence-based guidelines. *Journal of neurotrauma*, 2011; *28*(8), 1341-1361.
16. Jonsson A, Lindén M, Lindgren M, Malmqvist LA, Bäcklund Y. Evaluation of antidecubitus mattresses. Med Biol Eng Comput 2005; 43(5): 541-7
17. Dini V, Bertone M, Romanelli M. Prevention and management of pressure ulcers. Dermatol Ther 2006; 19 (6):356-64.
18. Çizmeci O, Emekli U. Bası Yaraları. Türkiye Fiziksel Tıp ve Rehabilitasyon Dergisi. Cilt: 45, Sayı: 4,1999.
19. Beğer T. Yoğun Bakımda Dekübit Ülserleri: Risk Faktörleri ve Önlenmesi, Yoğun Bakım Dergisi, Cilt: 4, Sayı:4, Ankara, 2004, s.244-53.
20. European Pressure Ulcer Advisory Panel. Guidelines on treatment of pressure ulcers. *EPUAP Review* 1999; 1 (2), 31–3.
21. Edlich R. F., Mason S. S., Vissers R. J., Gubler K. D., Thacker J. G., Pharr P., Anderson M., Long III W.B. Revolutionary advances in enhancing patient comfort on patients transported on a backboard. *The American journal of emergency medicine* 2011; *29*(2), 181-6.
22. Hemmes B, Poeze M, Brink P. R. Reduced tissue-interface pressure and increased comfort on a newly developed soft-layered long spineboard. *Journal of Trauma and Acute Care Surgery* 2010; *68*(3), 593-8.
23. Sharifi M, Bay C, Skrocki L, Rahimi F, Mehdipour M. Moderate Pulmonary Embolism Treated With Thrombolysis (from the "MOPETT" Trial). Am J Cardiol. 2013 Jan 15;111(2):273-7.