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ORIGINAL RESEARCH

Comparing the Efficacy of Long Spinal Board, Sked Stretcher, and Vacuum Mattress in Cervical Spine Immobilization; a Method-Oriented Experimental Study

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Abstract: **Introduction:** Inadequate spinal motion restriction in patients suffering from spinal injuries could lead to further neurological damage, ultimately worsening their prognosis. This study aimed to investigate the efficacy of long spinal boards (LSB), ske stretcher, and vacuum mattress for cervical spine immobilization during transportation of patients by measuring the angular motion of the cervical spine following lifting, transferring, and tilting. **Methods:** We conducted an experimental study using a box of three randomizations and crossover designs without a washout period effect for the long spinal board, sked stretcher, and vacuum mattress. We concealed the randomization with sequentially numbered, opaque, sealed envelopes (SNOSE). Kinematic data were collected using eight optoelectronic cameras at 200 Hz (BTS Bioengineering, Milan, Italy) in triangular planes (lateral bending, flexion-extension, and axial rotation) while performing all three motions (static lift-hold, transfer, and 90° tilt). **Results:** 12 cases (7 males and 5 females) with the mean age of 20 ± 3.03 (range: 18-28) years were studied. The three highest angular motions were observed in the axial rotation plane during patient's tilting under immobilization on all devices (Vacuum mattress having the highest value of 99.01±8.93, followed by the LSB at 89.89±34.35 and the sked stretcher at 86.30±7.73 degrees). During patient lifting, a higher angular motion was observed with vacuum mattress immobilization in flexion extension (Coefficient = 4.45; 95%CI: 0.46 – 8.45; p =0.029) and axial rotation (Coefficient = 3.70; 95%CI: 0.58 – 6.81; p =0.020) planes. During patient transfer, a higher angular motion was observed with sked stretcher in the flexion-extension plane (Coefficient = 2.98; 95%CI: 0.11 – 5.84; p = 0.042). During patient tilting to 90 degrees, a higher angular motion was observed with vacuum mattress immobilization in lateral bending (Coefficient = -4.08; 95%CI: -7.68 - -0.48; p = 0.026) for the vacuum mattress. **Conclusion:** Based on the finding of the present study, patients on the vacuum mattress experience significantly higher angular motion in flexion extension and axial rotation during lifting, as well as lateral bending during 90-degree tilting. In addition, patients on the Sked stretcher showed significantly higher angular motion in flexion-extension during the transferring. However, the predictive margins for immobilization across all devices did not demonstrate clinically significant differences among the three immobilization devices.

Keywords: Cervical vertebrae; motion; immobilization; stretcher; vacuum mattress

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1. Introduction

Approximately 55% of spinal injuries involve the cervical region, and improper management of patients with potential spinal injuries can result in additional neurological damage, worsening their prognosis (1, 2, 3). In emergency departments, a minimum of 5% of patients with spinal injuries exhibit the emergence of neurological symptoms or

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experience a decline in their condition. The determination to immobilize the spine is based on patient assessment and an evaluation of the trauma mechanics at the scene, while the decision to perform cervical imaging relies on clinical evaluation (2).

In a prehospital setting, spinal immobilization is indicated for cases involving a high mechanism of injury, which heightens the likelihood of head or spinal injuries (3). The indications for cervical immobilization are often based on guidelines such as those provided by the National Association of Emergency Medical Technicians (NAEMT) and the Prehospital Trauma Life Support (PHTLS) program. The indications for cervical immobilization generally include a high mechanism of injury with potential cervical spine involvement, altered mental status, neurological deficits, pain or tenderness in the cervical region, and inability to self-extricate or move without assistance (4, 5).

Nowadays, there are many patient transport equipment for patients with suspected cervical spine injury (6). Long spinal boards (LSB) have been a cornerstone of prehospital immobilization protocols for decades. LSB is typically rigid plastic, with straps and head immobilization devices to secure the patient during transportation.

Spinal boards have long served as a standard solution for prehospital patient immobilization (7). The findings of the studies indicate that implementing a spinal motion restriction (SMR) protocol without the use of a LSB does not lead to a higher occurrence of spinal cord injuries (SCI) (8, 9). However, there was no high-level evidence to support or refute the use of LSB in patients with suspected cervical spine injury (10).

The Sked stretcher comprises durable, high-density polyethylene plastic with multiple attachment points for securing patients and incorporating various configurations. It is compact, lightweight, and easily stored, making it an ideal solution for remote or challenging environments. The stretcher can be adapted for use in various emergency scenarios, including confined spaces, water and ice rescues, vertical or high-angle extractions, and hazardous materials incidents.

Vacuum mattresses consist of an air-impermeable cover filled with polystyrene beads, incorporated with straps and handles for secure patient immobilization and transportation. The beads conform to the patient's body by removing air from the mattress, providing a customized fit and immobilization. Vacuum mattresses effectively immobilize, reducing the risk of further injury during transportation. Studies have demonstrated their superiority in spinal immobilization compared to traditional backboards and distributing pressure evenly, reducing discomfort and the risk of pressure ulcers (11).

This study aimed to investigate the efficacy of LSB, ske stretcher, and vacuum mattress for cervical spine immobilization during transportation of patients by measuring the angular motion of the cervical spine following lifting, tranferring, and tilting.

2. Methods

2.1. Study design and setting

This study was a method-oriented experimental study with a cross-over design, conducted from April 6, 2022, to May 25, 2022, at the Department of Emergency Medicine, Ramathibodi hospital, Mahidol University, to compare the angular motion of cervical spine (flexion extension, axial rotation, and lateral bending) during lifting, transferring, and 90-degree tilting of patients.

Mahidol University, a public institution in Thailand, is situated in the Salaya sub-district of Phutthamonthon District, Nakhon Pathom Province. The testing was conducted in a randomized crossover, with each participant assigned a random sequence using the LSB, sked stretcher, and vacuum mattress, without a washout period between each sequence. The study was designed such that there were 4 participants for each sequence. Volunteer recruitment was facilitated by posting invitation posters within the university premises and scheduling appointments for interested individuals to participate in the study. None of the data used in this study revealed the volunteer' identities. We replaced the volunteers' names with their research ID numbers. The study was approved by the Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA. MURA2021/725).

2.2. Participants

The eligibility criteria of this study included adult volunteers aged 18-60, with a height range of 150-190 cm. Exclusion criteria for the study were pre-existing spine deformities such as scoliosis, kyphosis, flatback syndrome, chin-on-chest syndrome, prior spine injury, and obesity with BMI of 30 kg/m^2 or above. All eligible volunteers were stabilized with a cervical collar and head immobilization before being randomized to be studied using any of the three devices.

2.3. Data gathering

For all eligible study participants, various variables were recorded, including baseline characteristics such as age, gender, body mass index (BMI), height, and weight, as well as medical comorbidities and prior medical histories, such as diabetes mellitus, dyslipidemia, asthma, and allergic rhinitis, prior history of surgery, and prior history of trauma. Additionally, the angular motion (lateral bending, flexion-extension, and axial rotation) during lifting, transferring, and tilting with LSB, sked stretcher, and vacuum mattress was recorded.

2.4. Angular motion analysis

We used a 3-dimensional (3D) motion analysis system (BTS bioengineering (Smart DX 5000, Italy)) to capture and analyze human body movement in three dimensions (figure 1). The BTS Smart DX 5000 system consisted of infrared cameras, reflective markers, and synchronized data capture. The Smart DX camera uses infrared light to track reflective markers strategically placed on the subject's body. Reflective markers were attached to the mid-forehead, mid-upper anterior chest (sternal notch), and middle-of-the-lowest rib (Figure 1). These markers help the infrared cameras track the movement of the subject's body. The software system used complex algorithms to reconstruct the 3D coordinates of the reflective markers, creating a digital representation of the subject's body movement.

The participants were assigned to lift, transfer, and tilt in a box of three randomizations and crossover designs. We used only one volunteer in all procedures for each of the three devices including LSB, sked stretcher, and vacuum mattress (Figure 2). Each participant underwent three procedures, including liftings, transferring, and tilting. We concealed the randomized sequence with sequentially numbered, opaque, sealed envelopes (SNOSE). Angular displacements were measured at the cervical spine motion in three planes (lateral bending, flexion-extension, rotation) by a 3D motion analysis system while performing all three movements.

Four participants assumed positions at each corner of the transportation equipment, facing it with their feet shoulder-width apart. They bent their knees and maintained a straight back to ensure proper lifting posture. Each participant grasped the equipment using a power grip with both hands. A designated team leader coordinated the lift, ensuring everyone moves in unison. The team leader provided a verbal countdown to synchronize the lift. All participants lifted the equipment simultaneously, utilizing their legs to generate power while keeping their backs straight (Lifting procedure). Upon lifting the transportation equipment, the participants moved together in a coordinated manner, covering a distance of 2 meters while maintaining the equipment's stability and level position (Transfer procedure). The team then executed another verbal countdown to synchronize the lowering of the equipment to the floor. All participants bent their knees and lowered the equipment smoothly and in unison. Lastly, two individuals grasped the equipment and jointly tilted it to a 90-degree angle (Tilting procedure).

2.5. Outcome measures

The outcome of interest was angular motion of cervical spine in three planes (lateral bending, flexion extension, rotation) by a 3D motion analysis system while performing all three movements.

Figure 1: DX camera (left) and the reflective markers attached on the volunteer's body (right).

2.6. Statistical analysis

Statistical analyses were performed with STATA version 16.0. We used numbers, mean, and standard deviation for the descriptive variables. For the analytic statistics, chi-square was applied when calculating the P-values of the cervical angle in three planes. A P-value ≤ 0.05 was considered significant. The coefficient mixed-effects multilevel regression was applied to compare the angle of motion between the vacuum mattress, sked, and LSB, and the LSB was the standard reference (the coefficient was 1).

The sample size estimation was determined based on the study by Etier BE Jr. et al. (12), which compared cervical spine motion following immobilization using a long spine board and a vacuum mattress. In their findings, the mean peak motion ranged from 12.5° to 14.0° for the LSB and from 11.4° to 15.4° for the vacuum mattress. With a significance level (alpha) of 0.10 and a power (1- beta) of 95% for a one-sided test, the estimated sample size was 32.

Currently, no evidence supports a universally acceptable angular motion restriction for the cervical spine.

Table 1: Angular motion after immobilization on a long spinal board, sked stretcher, or vacuum mattress

Motion	Planes of motion	Median (IQR)	Min	Max	Mean ± SD
Long spinal board					
Lifting	Lateral bending	5.48 (4.28, 7.50)	2.23	11.96	6.34±3.00
	Flexion-extension	7.95 (7.46, 12.05)	5.93	19.30	9.70±3.72
	Axial rotation	8.26 (7.66, 10.85)	6.36	19.33	9.63±3.49
Transfer	Lateral bending	5.10 (3.50, 7.10)	2.23	11.35	5.60±2.49
	Flexion-extension	7.30 (2.63, 10.70)	2.30	15.35	7.50±4.49
	Axial rotation	8.20 (6.50, 10.66)	5.26	19.80	9.60±4.52
Tilting	Lateral bending	10.55 (8.65, 12.84)	5.45	30.00	13.10±7.94
	Flexion-extension	6.65 (5.23, 10.94)	4.03	95.80	20.31±32.06
	Axial rotation	97.73 (88.93, 105.46)	18.10	135.50	89.89±34.35
Sked stretcher					
Lifting	Lateral bending	5.46 (3.60, 6.86)	2.61	12.53	6.43±3.71
	Flexion-extension	12.15 (7.97, 14.75)	4.37	15.25	11.17±4.09
	Axial rotation	9.63 (7.20, 17.06)	4.54	22.40	12.08±6.05
Transfer	Lateral bending	5.86 (4.10, 6.16)	3.83	9.55	5.83±1.81
	Flexion-extension	8.50 (7.60, 12.75)	5.70	19.35	10.52±4.22
	Axial rotation	9.80 (6.50, 10.90)	4.03	20.65	9.75±5.03
Tilting	Lateral bending	13.66 (9.40, 15.50)	5.60	18.20	12.58±4.08
	Flexion-extension	5.60 (5.05, 7.50)	4.00	31.40	8.92±8.61
	Axial rotation	84.06 (83.30, 87.05)	79.60	105.70	86.30±7.73
Vacuum mattress					
Lifting	Lateral bending	6.38 (4.77, 10.07)	3.42	32.67	9.45±8.56
	Flexion-extension	11.33 (9.17, 14.75)	4.29	35.00	13.74±8.93
	Axial rotation	13.87 (11.67, 14.47)	4.67	22.03	13.04±4.99
Transfer	Lateral bending	4.43 (4.40, 6.23)	2.96	11.55	6.05±3.25
	Flexion-extension	9.35 (5.30, 13.23)	3.36	20.66	10.33±5.56
	Axial rotation	11.60 (8.30, 14.70)	7.10	18.70	11.65±4.05
Tilting	Lateral bending	9.05 (5.70, 10.95)	3.80	15.60	8.57±3.48
	Flexion-extension	7.15 (5.90, 8.00)	3.40	24.46	8.61±5.71
	Axial rotation	99.20 (95.60, 105.45)	82.60	115.03	99.01±8.93

Min: minimum; Max: maximum; SD: standard deviation; IQR: interqurtile range.

3. Results

3.1. Baseline characteristics of participants

The participants for this study included 12 cases (7 males and 5 females) with the mean age of 20 ± 3.03 (range: 18-28) years and BMI of approximately 21.02 ± 2.15 kg/m^2. One participant had a history of trauma but no prior spinal injury.

3.2. Angular motion of cervical spine

Table 1 summarizes the angular motions of cervical spine after immobilization on LBS, sked stretcher, and vacuum mattress during patient's lifting, transferring and tilting. The results showed a wide range of angular motion, ranging from 2.23 to 135.5 degrees. The three highest angular motions were observed in the axial rotation plane during patient's tilting under immobilization on all devices (Vacuum mattress having the highest value of 99.01±8.93, followed by the LSB at 89.89±34.35 and the sked stretcher at 86.30±7.73 degrees). The three lowest angular motions were observed in the lateral bending plane during patient transfer using all devices (LSB having the lowest value of 5.60±2.49, followed by the sked stretcher at 5.83±1.81, and the vacuum mattress at 6.05±3.25 degrees). Findings indicate that patient's tilting causes the most angular c-spine motion in all planes, particularly in the axial rotation plane. Table 2 and figure 3 compare the angular motion of cervical spine during Lifting, transferring, and tilting after immobilization on LSB, sked stretcher, and vacuum mattress.

3.3. Patient Lifting

During patient lifting, a higher angular motion was observed with vacuum mattress immobilization in flexion extension (Coefficient = 4.45; 95%CI: 0.46 – 8.45; p =0.029) and axial rotation (Coefficient = 3.70; 95%CI: 0.58 – 6.81; p =0.020) planes. However, the predictive margins of immobilization did not differ clinically in the angular motion of flexion extension and axial rotation planes during lifting with all devices as shown in Figure 4.

3.4. Patient transfer

During patient transfer, a higher angular motion was observed with sked stretcher in the flexion-extension plane (Co-

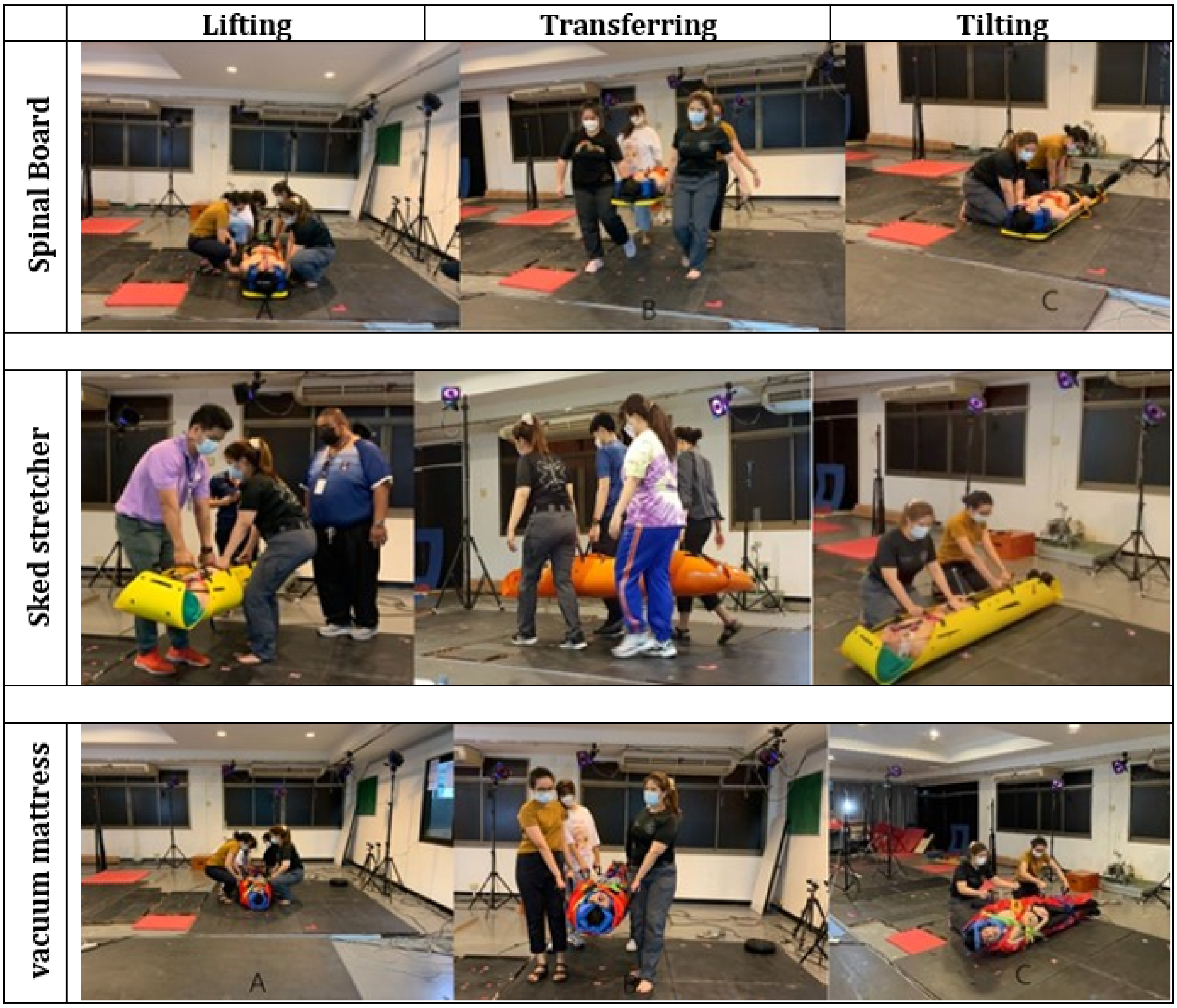

Figure 2: Evaluating the three fixation devices, namely spinal board, sked strecher, and vacuum mattress during lifting, transfering and tilting of patients.

efficient = 2.98; 95%CI: 0.11 – 5.84; p = 0.042). However, the predictive margins of immobilization did not differ clinically in the angular motion of the flexion-extension plane during transfer with all devices as shown in Figure 5.

3.5. Patient tilting

During patient tilting to 90 degrees, a higher angular motion was observed with vacuum mattress immobilization in lateral bending (Coefficient = -4.08; 95%CI: -7.68 - -0.48; p = 0.026) for the vacuum mattress. However, the predictive margins of immobilization did not differ clinically in the angular motion of the lateral bending plane during tilting with all devices as shown in Figure 6.

4. Discussion

This study employed a dynamic simulation system to evaluate the efficacy of three immobilization devices including LSB, vacuum mattress, and sked stretcher, in limiting cervical spine movement across three planes. The spinal board is the standard device for immobilization.

Based on the finding of the present study, patients on the vacuum mattress experience significantly higher angular motion in flexion extension and axial rotation during lifting, as well as lateral bending during 90-degree tilting. In addition, patients on the sked stretcher showed significantly higher angular motion in flexion-extension during the transferring. However, the predictive margins for immobilization across all devices did not demonstrate clinically significant differences among the three immobilization devices.

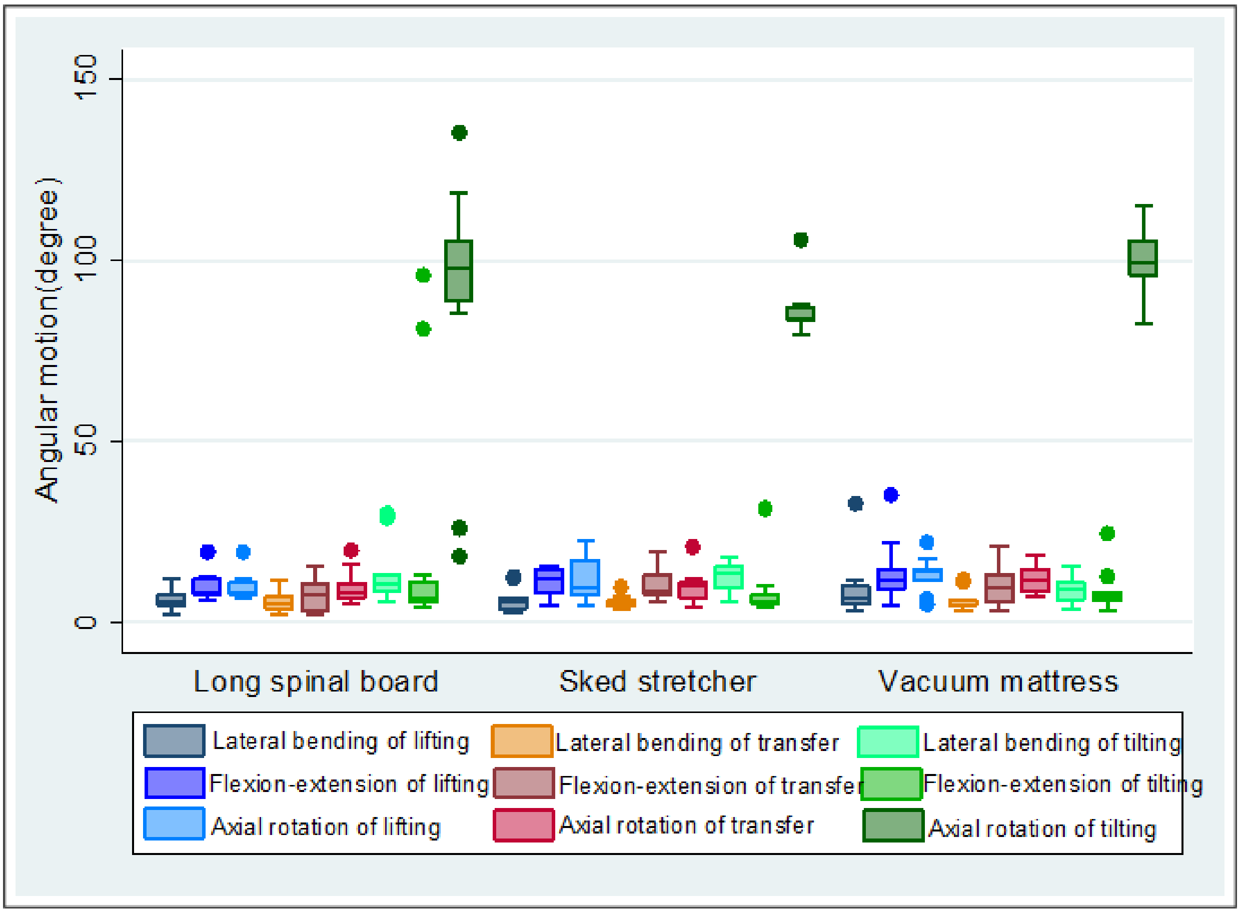

Figure 3: Box plot of cervical angular motions based on immobilization devices.

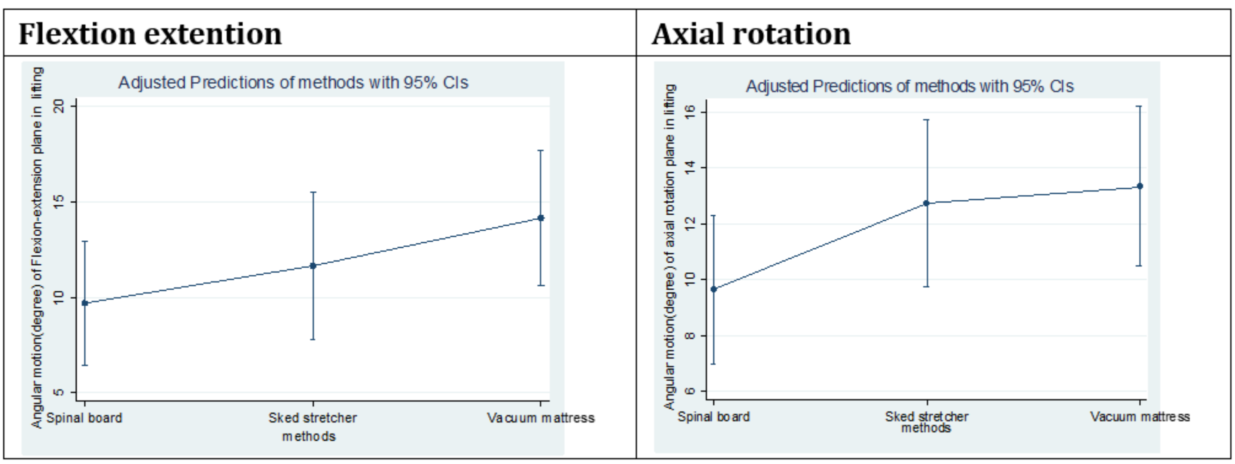

Figure 4: Margins plots of angular motion of flexion-extension and axial rotation planes during lifting after immobilization on long spinal board, sked stretcher and vacuum mattress. CI: confidence interval.

A previous study by Johnson et al. used healthy volunteers with no injury to compare the comfort, speed, and ability to immobilize the LSB versus the vacuum mattress. The vacuum mattress was faster and more comfortable, but the LSB was better at controlling head movement. (13) The LSB increases pressure ulcer incidence and severity compared with

Table 2: Comparison of angular motion of neck during lifting, transferring, and tilting after immobilization on long spinal board, sked stretcher, and vacuum mattress based on coefficient mixed-effects multilevel regression

Angular Motion type	Devices	Coefficient	95% CI	P -value
During Lifting				
Lateral bending	Vacuum mattress	3.15	-1.16, 7.46	0.152
	Sked stretcher	0.15	-4.30, 4.60	0.948
	Long spinal board	Reference	-	-
Flexion - extension	Vacuum mattress	4.45	0.46, 8.45	0.029
	Sked stretcher	1.95	-2.36, 6.26	0.376
	Long spinal board	Reference	-	-
Axial rotation	Vacuum mattress	3.70	0.58, 6.81	0.020
	Sked stretcher	3.10	6.99, 12.27	0.060
	Long spinal board	Reference	-	-
During transferring				
Lateral bending	Vacuum mattress	0.45	-1.63, 2.53	0.671
	Sked stretcher	0.28	-1.82, 2.36	0.797
	Long spinal board	reference	-	-
Flexion - extension	Vacuum mattress	2.70	-0.09, 5.50	0.058
	Sked stretcher	2.98	0.11, 5.84	0.042
	Long spinal board	reference	-	-
Axial rotation	Vacuum mattress	1.80	-0.97, 4.58	0.203
	Sked stretcher	-0.13	-2.97, 2.70	0.926
	Long spinal board	Reference	-	-
During tilting				
Lateral bending	Vacuum mattress	-4.08	-7.68, -0.48	0.026
	Sked stretcher	-0.09	-3.94, 3.77	0.965
	Long spinal board	reference	-	-
Flexion - extension	Vacuum mattress	-8.35	-18.97, 2.27	0.123
	Sked stretcher	-9.96	-21.38, 1.47	0.088
	Long spinal board	reference	-	-
Axial rotation	Vacuum mattress	7.58	-6.57, 21.72	0.294
	Sked stretcher	-5.77	-20.90, 9.37	0.455
	Long spinal board	reference	-	-

CI: confidence interval.

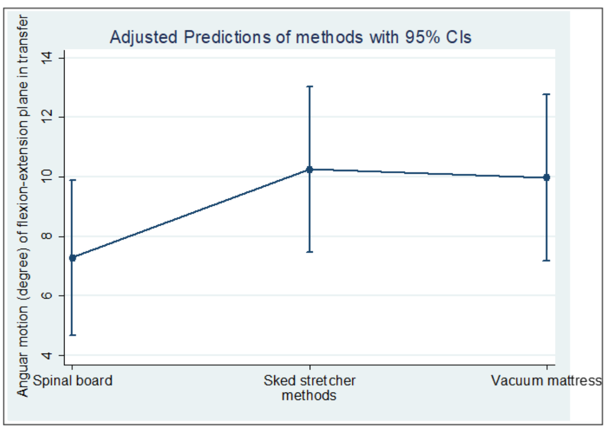

Figure 5: Margins plots of angular motion of flexion-extension plane during transfer after immobilization on long spinal board, sked stretcher and vacuum mattress. CI: confidence interval.

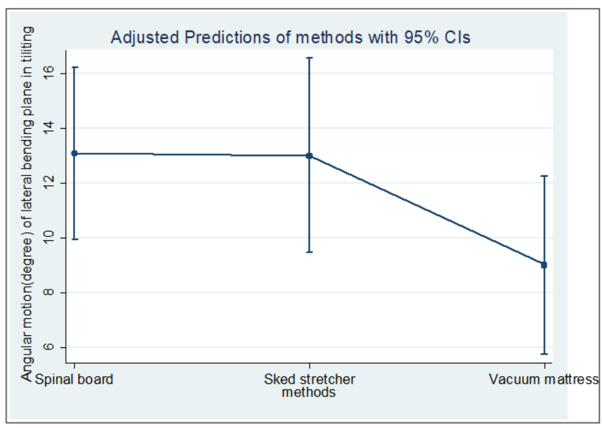

Figure 6: Margins plots of the relation between angular motion of lateral bending plane during tilting after immobilization on long spinal board, sked stretcher and vacuum mattress. CI: confidence interval.

vacuum mattresses (14).

The findings of study by Prasarn ML et al. were in favor of using vacuum mattress versus LSB alone in preventing motion at an unstable cervical spine injury (11).

In the study by Nolte PC et al. with one healthy male, using a vacuum mattress during transportation resulted in twofold as much motion of the cervical spine compared to a spine board (15). These findings are in line with the results of the studies by Rahmatalla et al. and Mahshidfar et al., who found more cervical motion with a vacuum mattress during transportation (16, 17).

Given that the predictive margins for immobilization among the long spinal board, vacuum mattress, and sked stretcher have not shown clinically significant cervical spine movement differences, we advise implementing a customized approach when choosing transport equipment for individual patients. The long spinal board is widely accessible and cost-effective, making it a standard option for emergency medical services. Due to its buoyancy and durability, it is easy to clean, decontaminate, and can be employed in diverse environments, including water rescues. The sked stretcher, with its versatile and compact design, facilitates effortless transportation and storage. It is suitable for confined spaces, rugged terrains, and vertical rescues. Additionally, the vacuum mattress offers greater patient comfort than long spinal boards and sked stretchers, owing to its adaptable nature, and it minimizes the risk of pressure ulcers and discomfort during prolonged transport times. It conforms to the patient's body shape, providing tailored support and immobilization, and is compatible with various settings, including helicopter evacuations, due to its lightweight design and ease of use.

Each immobilization device has its benefits. The long spinal board is a cost-effective and widely available option that provides rigid support. The sked stretcher is versatile and suitable for various rescue scenarios, while the vacuum mattress offers enhanced patient comfort and customized immobilization. The choice of the device will depend on the specific needs and constraints of the emergency and the patient's condition.

5. Limitations

The study population consisted of 12 volunteers, less than the calculated sample size. We had limits on the force and the people who transported the volunteers, and we changed the person the next day of the experiment. Some random sequences were alternated because of the reflective markers attached to the transport device, which wasted the time of the new installation. The subjects were healthy and fully conscious adults of average height and weight. Thus, results may not be generalizable to all adults and special population patients, such as pediatric patients (18), as they have physical characteristics and needs that may require different immobilization methods. Motion capture system using eight optoelectronic cameras BTS bioengineering (Smart DX 5000, Italy) had limited ability to capture some direction due to obscure camera, which may have affected the results. Finally, this study focused solely on lifting, transferring, and tilting procedures. Additionally, the study participants were volunteer from Mahidol University, which may limit the results' generalizability (external validity) when applied to emergency medical services.

6. Conclusion

Based on the finding of the present study, patients on the vacuum mattress experience significantly higher angular motion in flexion extension and axial rotation during lifting, as well as lateral bending during 90-degree tilting. In addition, patients on the sked stretcher showed significantly higher angular motion in flexion-extension during the transferring. However, the predictive margins for immobilization across all devices did not demonstrate clinically significant differences among the three immobilization devices.

7. Declarations

7.1. Acknowledgments

The authors would like to thank all participating staff and volunteers. Furthermore, we thank the team from the college of sports science and technology, Mahidol university.

7.2. Conflict of interest

The authors declare that they have no competing interests.

7.3. Fundings

No funding was obtained for this study.

7.4. Authors' contribution

All authors made a significant contribution to the work reported, whether that is in conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. All authors read and approved the final version.

7.5. Ethical considerations

This study was approved by the Faculty of Medicine, Committee on Human Rights Related to Research Involving Human Subjects, Ramathibodi hospital, Mahidol university (COA. MURA2021/725).

7.6. Availability of data and material

The datasets used and/or analyzed during the current study are avilable form the corresponding author on reasonable request.

7.7. Using artificial inteligence chatbots

None.

References

1. Athinartrattanapong N, Yuksen C, Leela-Amornsin S, Jenpanitpong C, Wongwaisayawan S, Leelapattana P. Prediction Score for Cervical Spine Fracture in Patients with Traumatic Neck Injury. Neurol Res Int. 2021;2021:6658679.
2. Vazirizadeh-Mahabadi M, Yarahmadi M. Canadian C-spine Rule versus NEXUS in Screening of Clinically Important Traumatic Cervical Spine Injuries; a systematic review and meta-analysis. Arch Acad Emerg Med. 2023;11(1):e5.
3. Yuksen C, Sittichanbuncha Y, Patumanond J, Muengtaweepongsa S, Sawanyawisuth K. Clinical predictive score of intracranial hemorrhage in mild traumatic brain injury. Ther Clin Risk Manag. 2018;14:213-8.
4. Feller R, Furin M, Alloush A, Reynolds C. EMS Immobilization Techniques. StatPearls. Treasure Island (FL): StatPearls Publishing Copyright © 2023, StatPearls Publishing LLC.; 2023.
5. Hauswald M, Braude D. Spinal immobilization in trauma patients: is it really necessary? Curr Opin Crit Care. 2002;8(6):566-70.
6. Hulldin M, Kängström J, Andersson Hagiwara M, Claesson A. Perceived exertion using two different EMS stretcher systems, report from a Swedish study. Am J Emerg Med. 2018;36(6):1040-4.
7. White CCt, Domeier RM, Millin MG. 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;18(2):306-14.
8. Castro-Marin F, Gaither JB, Rice AD, R NB, Chikani V, Vossbrink A, et al. Prehospital Protocols Reducing Long Spinal Board Use Are Not Associated with a Change in Incidence of Spinal Cord Injury. Prehosp Emerg Care. 2020;24(3):401-10.
9. Clemency BM, Natalzia P, Innes J, Guarino S, Welch JV, Haghdel A, et al. A Change from a Spinal Immobilization to a Spinal Motion Restriction Protocol was Not Associated with an Increase in Disabling Spinal Cord Injuries. Prehosp Disaster Med. 2021;36(6):708-12.
10. Milland K, Al-Dhahir MA. EMS Long Spine Board Immobilization. StatPearls. Treasure Island (FL): StatPearls Publishing Copyright © 2023, StatPearls Publishing LLC.; 2023.
11. Prasarn ML, Hyldmo PK, Zdziarski LA, Loewy E, Dubose D, Horodyski M, et al. Comparison of the Vacuum Mattress versus the Spine Board Alone for Immobilization of the Cervical Spine Injured Patient: A Biomechanical Cadaveric Study. Spine (Phila Pa 1976). 2017;42(24):E1398-e402.
12. Etier BE, Jr., Norte GE, Gleason MM, Richter DL, Pugh KF, Thomson KB, et al. A Comparison of Cervical Spine Motion After Immobilization With a Traditional Spine Board and Full-Body Vacuum-Mattress Splint. Orthop J Sports Med. 2017;5(12):2325967117744757.
13. Johnson DR, Hauswald M, Stockhoff C. Comparison of a vacuum splint device to a rigid backboard for spinal immobilization. Am J Emerg Med. 1996;14(4):369-72.
14. Pernik MN, Seidel HH, Blalock RE, Burgess AR, Horodyski M, Rechtine GR, et al. Comparison of tissue-interface pressure in healthy subjects lying on two trauma splinting devices: The vacuum mattress splint and long spine board. Injury. 2016;47(8):1801-5.
15. Nolte PC, Uzun DD, Häske D, Weerts J, Münzberg M, Rittmann A, et al. Analysis of cervical spine immobilization during patient transport in emergency medical services. Eur J Trauma Emerg Surg. 2021;47(3):719-26.
16. Rahmatalla S, DeShaw J, Stilley J, Denning G, Jennissen C. Comparing the Efficacy of Methods for Immobilizing the Cervical Spine. Spine (Phila Pa 1976). 2019;44(1):32-40.
17. Mahshidfar B, Mofidi M, Yari AR, Mehrsorosh S. Long backboard versus vacuum mattress splint to immobilize whole spine in trauma victims in the field: a randomized clinical trial. Prehosp Disaster Med. 2013;28(5):462-5.
18. Rozzelle CJ, Aarabi B, Dhall SS, Gelb DE, Hurlbert RJ, Ryken TC, et al. Management of pediatric cervical spine and spinal cord injuries. Neurosurgery. 2013;72 Suppl 2:205-26.