Stress Among Medical Students during Simulation Training at King Saud bin Abdulaziz University for Health Sciences

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ABSTRACT
Background: Simulation training is increasingly being used as a safe format to instruct students and trainees in different skills and procedures in the field of medicine. In this study, we recorded stress levels among medical students during simulation training for a lumbar puncture (LP) procedure performed on a mannequin and investigated the association between stress and performance.
Methodology: This study was conducted on 39 fourth year female medical students. Students wore a galvanic skin response (GSR) sensor on their wrist before being asked to attempt the LP procedure on the mannequin on two separate occasions. Students' performance was assessed using a validated LP checklist on each attempt. Data were compared across all simulation attempts and for each student.
Results: Collectively, mean wrist GSR levels increased from the mental rehearsal phase 0.31 mS ± 0.40, during the first attempt 0.48 mS ± 0.62 and continued to increase significantly ($P = 0.007$) during the second attempt 0.60 mS ± 0.80. There were no significant differences ($P = 0.32$) between the checklist scores of the first and second attempts.
Conclusion: The results of our study support the previous evidence that linked simulation training with emotional and physiological stress. Performing highly intense procedures such as LP is considered to be a potential source of stress. Our findings showed that there was a continuous increase in the level of stress associated with repeated attempts during the LP simulation that had no significant impact on clinical performance. As the practice of medicine involves exposure to a remarkable number of stressors and critical conditions, we emphasize the importance of training medical students in ways to cope more effectively with these situations.
Keywords: clinical skills, medical education, medical simulation.

INTRODUCTION

Simulation training is increasingly being used as a safe format to instruct students and trainees in different skills and procedures in the field of medicine[1]. However, undergraduate medical students have reported experiencing stress during high-fidelity trauma simulation[2,3]. Furthermore, marked cortisol responses to real-life and simulated emergency situations have been detected in army nurses exposed to a combat casualty simulation[4].

Cortisol[5], α-amylase (sAA)[6] and chromogranin A (CgA)[7] have been proposed as markers of stress that can be measured in saliva. Technical advances have created new opportunities for the noninvasive assessment of stress biomarkers in saliva. The ease of use and noninvasive nature of salivary markers is especially valuable because complex multilevel models of individual differences can be studied in the laboratory or in quasi-naturalistic settings, such as simulation[6]. However, it is not clear which one of these salivary components is the best biological marker of stress.

The psychobiology of stress comprises two main systems: the hypothalamic-pituitary-adrenal (HPA) axis and the locus coeruleus/autonomic (sympathetic) nervous system (SNS). The most common serological measure of HPA activity is cortisol[5, 8], while the most common measures of SNS activity are the catecholamines, epinephrine (EPI) and norepinephrine (NE)[6]. Unfortunately, however, direct measurements of EPI or NE in saliva seem to provide a poor reflection of SNS activity. Consequently, a surrogate marker of SNS activity in saliva is being actively sought. Salivary α-amylase, an enzyme that is produced by the salivary gland, has been suggested as a noninvasive and easily obtained surrogate marker of SNS activity[6]. Levels of sAA increase in response to stressful conditions including exercise, written examinations and mental rehearsing. However, the accuracy of sAA as an accurate indicator of SNS activity remains open to debate.

The galvanic skin response (GSR), also known as skin conductance or electro-dermal activity (EDA), is a sensitive marker of emotional arousal. EDA regulates the amount of secretion from sweat glands. Changes in skin conductance are triggered by environmental conditions or stimuli, with a stronger stimulus leading to greater skin conductance[9, 10]. Skin conductance, which is

modulated by the autonomic SNS, is not consciously controlled. Therefore, skin conductance offers a physiological marker of the SNS activity in the autonomic nervous system. In 2015, a study comparing the relationship between physiologic and psychological activation of the autonomic SNS in the operating room (OR) during a simulated airway emergency used the GSR as a measure of physiologic SNS activity and the "State–Trait Anxiety Inventory" as a measure of the psychological SNS activity. It was concluded that GSR levels correlated with anxiety scores[11].

A recent study revealed the feasibility of using a new watch-sized device for continuous GSR monitoring of all OR professionals during high-fidelity surgical simulations. Large variations in individual levels of physiological activation has been found and further qualitative studies have been suggested[12].

In this study, we recorded stress levels among medical students during simulation training for a lumbar puncture (LP) procedure performed on a mannequin and investigated the association between stress and performance. Stress management training may be beneficial in minimizing the deleterious consequences of stress situations, thus improving patient care.

MATERIALS AND METHODS
Simulation room and participants:
A simulation room in the skills laboratory at the College of Medicine was used for all of the sessions. The laboratory was equipped with lumbar puncture trays that were almost identical to those used in an actual procedure and a mannequin was used as the simulated patient. This study was approved by The Institutional Review Board at King Abdullah International Medical Research Center (KAIMRC). This study was conducted on 39 fourth year female medical students comprising stream 1 students (high school graduate entry program) and stream 2 students (bachelor's degree graduate entry program).

Simulation scenario
Each simulation began with the student signing a consent form, reviewing the given LP procedure leaflet and attaching a GSR sensor on their wrist. Subsequently, the student was asked to rehearse the procedure mentally before being asked to attempt the LP procedure on the mannequin on two separate occasions.

The co-investigators assessed the student's performance using a validated LP[13] checklist at each attempt.

Checklist validation:
A pilot study was conducted on 10 students to determine the validity of the LP checklist. The internal consistency of the checklist using Cronbach's α was calculated as 0.82 using SPSS statistical software (IBM SPSS Statistics, SPSS Inc., Chicago IL).

GSR sensor:
Neumitra Inc. manufactured the bio-band sensor device containing two silver chloride electrodes that measure and record electrical conductance at a rate of 10 times per second. All GSRs were recorded in micro-Siemens (mS) and after each session, data from the GSR sensor were transferred to Neumitra for processing. The processed data were returned several days later and divided into each phase of the simulation using embedded time stamps[12].

Statistical analysis
Data were described as means ± standard deviation (SD) for continuous variables, and percentages for categorical variables. Paired *t*-tests were used to compare the data for the first and second attempts.

A *P*-value of 0.05 or less was considered to indicate statistical significance. The data were analyzed using the Statistical Package for the Social Sciences, Version 20.0 (IBM Corporation, Armonk, NY, USA).

RESULTS
Thirty-nine fourth year female medical students participated in this study. Of these students, 20 (51%) comprised stream 1, while the remaining 19 (49%) comprised stream 2.

Cumulative GSR:
Mean wrist GSR levels for all students in each phase of the simulation were 0.31 mS ± 0.40 (range, 0.01–1.70) in the mental rehearsal phase, 0.48 mS ± 0.62 (range, 0.01–2.18) at the first attempt, and 0.60 mS ± 0.80 (range, 0.01–2.88) at the second attempt. The mean wrist GSR for all students combined increased significantly (*P* = 0.007) from the mental rehearsal phase to the first and second attempts.

The mean wrist GSR levels of stream 1 students for each phase of the simulation were 0.20 mS ± 0.25 (range, 0.01–0.86) for the mental rehearsal phase, 0.39 mS ± 0.59 (range, 0.01–2.17) for the first attempt, and 0.49 mS ± 0.76 (range, 0.01–2.88) for the second attempt.

Mean wrist GSR levels of stream 2 students for each phase of the simulation were 0.43 ± 0.49

mS (range, 0.01–1.70) for the mental rehearsal phase, 0.58 mS ± 0.65 (range, 0.02–2.18) for the first attempt, and 0.72 mS ± 0.84 (range, 0.02–2.50) for the second attempt. There were no significant differences in mean wrist GSR levels between stream 1 and stream 2 students for the first and second attempts (P = 0.347 and 0.347, respectively).

Table 1 shows the mean wrist GSR of all participating students in the study.

Table 1 Mean wrist GSR for all participants

Mean Wrist GSR			
Attempts	**Stream 1**	**Stream 2**	**P-Value**
1ˢᵗ attempt	0.39 mS	0.58 mS	0.347
2ⁿᵈ attempt	0.49 mS	0.72 mS	0.347

Table 2 shows a comparison between mean wrist GSR levels of stream 1 and stream 2 students during the first and second attempts.

Table 2 Comparison between the mean wrist GSR of stream 1 and stream 2 students during the first and second attempts

Mean Wrist GSR			
Students	**Mental rehearsal phase**	**1ˢᵗ attempt**	**2ⁿᵈ attempt**
All	0.31 mS	0.48 mS	0.60 mS
Stream 1	0.20 mS	0.39 mS	0.49 mS
Stream 2	0.43 mS	0.58 mS	0.72 mS
Mean Wrist GSR			
Students	**Mental rehearsal phase**	**1ˢᵗ attempt**	**2ⁿᵈ attempt**
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Stream 1	0.20 mS	0.39 mS	0.49 mS
Stream 2	0.43 mS	0.58 mS	0.72 mS

Checklist scores:

Students were assessed using a validated checklist on both attempts; the checklist had a 52-point maximum score. The average score for the checklist for all students was 40 ± 5.36 at the first attempt and 39 ± 5.92 at the second attempt. There were no significant differences (P = 0.32) between the checklist scores of the first and second attempts. Figures 1 and 2 show the distribution of the checklist scores for all students for the first and second attempts.
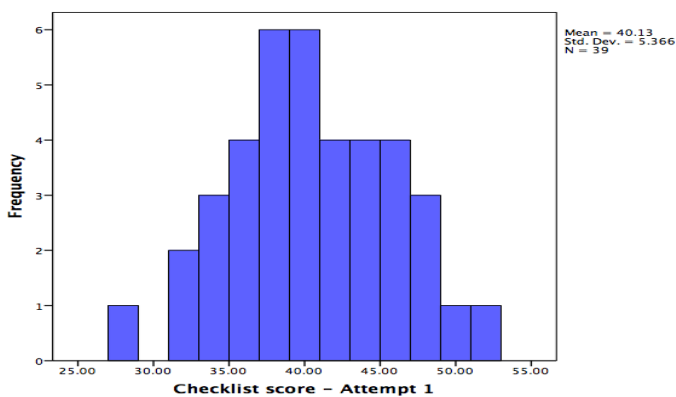

Figure 1 Distribution of the checklist score across all students for the first attempt
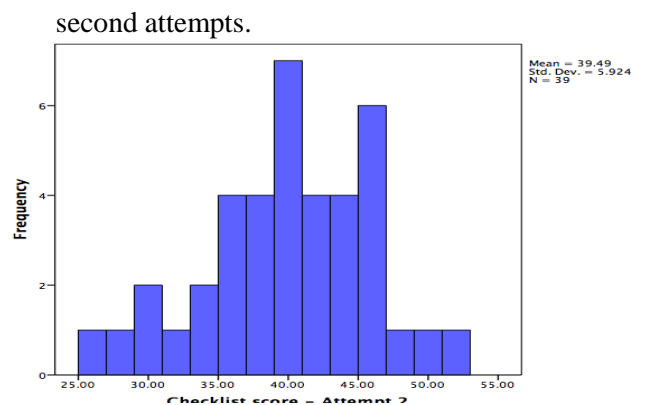

Figure 2 Distribution of the checklist score across all students for the second attempt

For stream 1 students, the average score for the checklist was 40 ± 5.75 for the first attempt and 39 ± 5.91 for the second attempt. For stream 2 students, the average score for the checklist was 40 ± 5.08 for the first attempt and 40 ± 6.02 for the second attempt. Figures 3 and 4 show the differences in the checklist scores between stream 1 and stream 2 students.
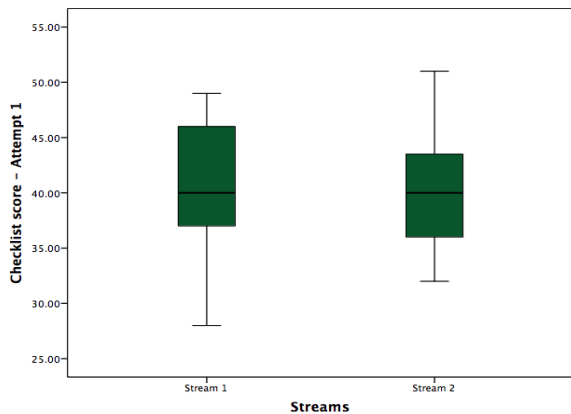
Figure 3: Differences between checklist scores of stream 1 and stream 2 students during first attempt
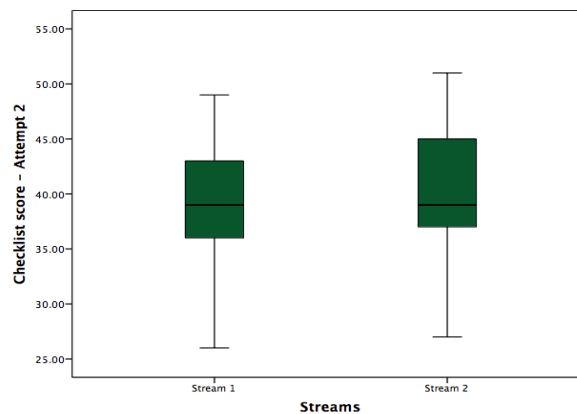

Figure 4 Differences between checklist scores of stream 1 and stream 2 students during second attempt

There were no significant differences in mean checklist scores between stream 1 and stream 2 students for the first and second attempts (P = 0.841 and 0.498, respectively). Table 3 shows a comparison between the checklist scores for stream 1 and stream 2 students during the first and second attempts.

Table 3 Comparison between the checklist scores of stream 1 and stream 2 students during the first and second attempts.

Checklist Scores			
Attempts	Stream 1	Stream 2	P-Value
1st attempt	40	40	0.841
2nd attempt	39	40	0.498

DISCUSSION

The results of our study have revealed that stress increased significantly for all students through all phases of the simulation, starting with the mental rehearsal phase and throughout both attempts. Similarly, Phitayakorn, Minehart, Pian-Smith, Hemingway and Petrusa[12] observed continuous emotional activation through their surgical simulation.

Clinical setting and certain factors, such as time pressure, lack of sleep and coffee consumption may have affected the students' stress levels. Striving for academic excellence could also be considered to be a stress factor [14,15]. Interestingly, the presence of the students' colleagues as co-investigators may have also contributed to the increased level of stress.

Despite elevated stress levels, there was no significant disparity between the performance of the students at both attempts. This raises the question of the relationship between stress and performance. Activation of a physiological response during a tense situation may result in a certain amount of stress, which is not necessarily a negative condition in that relatively low levels of stress could motivate the individual to perform better. In contrast, extreme stress may be devastating and subsequently impair individual's general performance[16].

For all phases of the simulation, there were no significant differences in the mean wrist GSR levels of stress and mean checklist scores between stream 1 and stream 2 students. Thus, our findings demonstrate that high educational levels had an unremarkable impact on both stress and performance; this is in contrast to the findings of some previous studies [17,18, 19, 20].

Some limitations of this study should be noted. First, our study was performed on female students only; therefore, sex differences regarding stress development could not be assessed [14,19]. Additionally, the small sample size and minimal number of attempts may have limited the findings; a larger study and perhaps more attempts may have produced more accurate results. Thus, despite these limitations, our findings allow us to propose an important suggestion to improve education and clinical practice throughout medical schools. Based on the advantages of the GSR sensors, which are essentially the practicality and acceptance by the participants of this approach[12], we recommend their use in preparing medical students in simulation-based training to cope and respond more satisfactorily to stressful events in real clinical practice.

CONCLUSION

In conclusion, the results of our study support the previous evidence that linked simulation training with emotional and physiological stress. Performing highly intense procedures such LP is considered to be a potential source of stress. Our findings showed that there was a continuous increase in the level of stress associated with repeated attempts during the LP simulation that had no significant impact on clinical performance. Moreover, being enrolled in either a bachelor's degree graduate entry program or a high school graduate entry program appeared to have no notable influence on either increased stress levels or on performance. As the practice of medicine involves exposure to a remarkable number of stressors and critical conditions, we emphasize the importance of training medical students in ways to cope more effectively with these situations.

Data availability:

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of interest:

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

REFERENCES

1. **Gohar A, Al-hihi E(2012):** Simulation in internal medicine training. Missouri Medicine,110(2):129-132.
2. **Pai D, Ram S, Madan SS, Soe H, Barua A(2014):** Causes of stress and their change with repeated sessions as perceived by undergraduate medical students during high-fidelity trauma simulation. National Medical Journal of India,27(4):192-197.
3. **Bong CL, Lightdale JR, Fredette ME, Weinstock P(2010):** Effects of simulation versus traditional tutorial-based training on physiologic stress levels among clinicians: a pilot study. Simulation in Healthcare,5(5):272-278.
4. **McGraw LK, Out D, Hammermeister JJ, Ohlson CJ, Pickering MA, Granger DA(2013):** Nature, correlates, and consequences of stress-related biological reactivity and regulation in Army nurses during combat casualty simulation. Psychoneuroendocrinology,38(1):135-144.
5. **Hellhammer DH, Wüst S, Kudielka BM(2009):** Salivary cortisol as a biomarker in stress research. Psychoneuroendocrinology,34(2):163-171.
6. **Granger DA, Kivlighan KT, El-Sheikh M, Gordis EB, Stroud LR(2007):** Salivary α-amylase in biobehavioral research. Annals of the New York Academy of Sciences, 1098(1):122-144.
7. **Takatsuji K, Sugimoto Y, Ishizaki S, Ozaki Y, Matsuyama E, Yamaguchi Y(2008):** The effects of examination stress on salivary cortisol, immunoglobulin A, and chromogranin A in nursing students. Biomedical Research,29(4):221-224.
8. **Adam EK, Hoyt LT, Granger DA(2011):** Diurnal alpha amylase patterns in adolescents: Associations with puberty and momentary mood states. Biological Psychology,88(2):170-173.
9. **Boucsein W(2012):** Electrodermal activity. Springer Science & Buisness Media.
10. **Villarejo MV, Zapirain BG, Zorrilla AM(2012):** A stress sensor based on Galvanic Skin Response (GSR) controlled by ZigBee. Sensors,12(5):6075-6101.
11. **Phitayakorn R, Minehart RD, Hemingway MW, Pian-Smith MC, Petrusa E(2015):** Relationship between physiologic and psychological measures of autonomic activation in operating room teams during a simulated airway emergency. The American Journal of Surgery,209(1):86-92.
12. **Phitayakorn R, Minehart R, Pian-Smith M, Hemingway M, Petrusa E(2015):** Practicality of using galvanic skin response to measure intraoperative physiologic autonomic activation in operating room team members. Surgery,158(5):1415-1420.
13. **Berg K, Riesenberg LA, Berg D, Mealey K, Weber D, King D, Justice EM, Geffe K, Tinkoff K(2012):** The Development of a Validated Checklist for Adult Lumbar Puncture Preliminary Results. American Journal of Medical Quality,28(4):330-334.
14. **Waghachavare VB, Dhumale GB, Kadam YR, Gore AD(2013):** A Study of Stress among Students of Professional Colleges from an Urban area in India. Sultan Qaboos University Medical Journal,13(3):429-436.
15. **Arora S, Hull L, Sevdalis N, Tierney T, Nestel D, Woloshynowych M, Darzi A, Kneebone R(2010):** Factors compromising safety in surgery: stressful events in the operating room. The American Journal of Surgery,199:60–65.
16. **Angeli A, Minetto M, Dovio A, Paccotti P(2004)**: The overtraining syndrome in athletes: a stress-related disorder. Journal of Endocrinological Investigation,27:603-612.
17. **Clarke S, Horeczko T, Cotton D, Bair A(2014)**: Heart rate, anxiety and performance of residents during a simulated critical clinical encounter: a pilot study. BMC Medical Education,14(1):153.
18. **Keady, Darcy A(1999)**: Student Stress: An Analysis of Stress Levels Associated with Higher Education in the Social Sciences. https://scholar.google.com/scholar?cluster=3356468887200236222&hl=en&as_sdt=0,5&sciodt=0,5#d=gs_qabs&p=&u=%23p%3DvoI4aauSlC4J
19. **Abdulghani HM, AlKanhal AA, Mahmoud ES, Ponnamperuma GG, Alfaris EA(2011):** Stress and Its Effects on Medical Students: A Cross-sectional Study at a College of Medicine in Saudi Arabia. Journal of Health, Population, and Nutrition,29(5):516-522.
20. **LeBlanc VR, Bandiera GW(2007):** The effects of examination stress on the performance of emergency medicine residents. Medical Education,41(6):556–564.