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Analysis of performance and stress caused by a simulation of a mass casualty incident

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ABSTRACT

Objective: To determine the stress that is potentially produced in professional health workers due to a mass casualty incident (MCI) simulated exercise, and its relation to prior academic training and the role played in the simulation.

Methods: Observational study of stress in a MCI. For this work, two MCI drills comprised of 40 victims each were conducted. Two randomized groups of 36 students each were created: Master's Students Group (MSG) and Undergraduate Student Group (USG). The role performed by each student (triage or sectorization) was assessed. The stress level was determined by prior and subsequent measurements of alpha-amylase (αA), HR, SBP and DBP.

Results: The percentage of victims that were correctly triaged was 88.6%, 91.84% for MSG and 83.76% for the USG ($p = 0.004$). The basal αA was 97,107.50 ± 72,182.67 IU/L and the subsequent αA was 136,195.55 ± 90,176.46 ± IU/L ($p < 0.001$). The baseline HR was 78.74 ± 14.92 beats/min and the subsequent HR was 95.65 ± 23.59 beats/min ($p = 0.000$). We found significant differences in the αA between students who performed the triage and those who performed sectorization but there were no differences between undergraduate and Masters' students.

Conclusion: Conducting a simulated exercise caused stress in personnel involved in the MCI, with a greater impact on participants who performed triage, although it was not influenced by their prior academic level. The stress level in our case did not affect or determine the performance of acquired skills.

1. Introduction

Mass casualty incidents (MCI) are defined by the World Health Organization (WHO) as “events which generate more patients at one time than locally available resources can manage using routine procedures” (World Health Organization, 2007). Although these types of events are more frequently than believed (Castro Delgado et al., 2016), a health professional has to use their knowledge and practical skills under a high-pressure situation in order to provide the correct health care (Cuartas Álvarez and Castro Delgado, 2009). Among the main processes to consider, we find triage, defined as “classification of patients into different categories according to their severity and prognosis in order to determine their priority for care and evacuation” (Castro Delgado et al., 2015).

Training of health professionals not only requires the transmission of knowledge and skills, but their training has to be conducted in

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environments that are as similar as possible to real situations (Kaddoura, 2010). Training in these kinds of environments implies the creation of stress for the student (Maran and Glavin, 2003), which is necessary so that the student acquires confidence in their ability to apply their knowledge in real-life situations. This stress has been measured in different studies (Karasch et al., 2011), mainly related to the application of specific techniques on individual patients (Ignacio et al., 2016), but studies on the capacity of a MCI simulation to generate stress on the student has not been conducted, and how this stress is related to the learning process has not been studied either.

A research study by Fernández-Castillo and Gutiérrez Rojas, 2009, concluded that students who obtained a high score in their degree of anxiety also had low levels of selective attention (Fernández-Castillo and Gutiérrez Rojas, 2009). However, another study by Oblitas, 2004 concluded that subjects who had a high degree of anxiety usually focused more on their own thoughts and fears than the exam task at hand (Oblitas, 2004). The results obtained from a study on stress and student assessment did not find a clear relationship between their anxiety and academic performance (Álvarez et al., 2012). In summary, the studies coincided in that a certain degree of anxiety was desirable, and was needed for performing tasks that were important for the subjects. However, high levels of anxiety made difficult the execution of a task, resulting in overall low performance. Psychosocial stress induces various adaptation responses of physiologic systems with particular increasing activities in the hypothalamus-pituitary-adrenal axis (HPA) as well as in the sympathetic-adrenal-medullary (SAM) system. Many studies have shown that salivary alpha amylase could be used as a better index of acute stress than cortisol, with a longer latency time (Vineetha et al., 2014; Valentin et al., 2015).

The hypothesis of this study is that health professionals who perform triage in simulations experience physiological changes with a concomitant increase of stress. The main object of this study was to determine the level of stress that was potentially produced on participating personnel during and by a simulation exercise that recreates a mass casualty incident. The more specific objectives were to analyze individual variables associated to the level of stress, to establish if there was a relationship between the level of stress and the prior academic level of the intervening individual and/or his/her role in the simulation, in order to determine if the level of stress had an influence on their capacity to use their acquired abilities. As amylase is a biological marker of stress, it was also decided that another specific objective would be to analyze the relationship between concentration of amylase and the rest of the physiological indicators, such as blood pressure (BP) and heart rate (HR).

2. Materials and Methods

An observational study on the stress that is potentially produced by a MCI simulation was conducted, within the Sectoral Health Plan as part of the Territorial Plan of Civil Protection of the Region of Murcia (PLATEMUR), with the collaboration of the Catholic University of Murcia (UCAM) and the University of Murcia (UMU). The research project was approved by the Ethics Committee at the Management of Urgencies and Emergencies 061 of the Region of Murcia (GUERM-061). All the participants (victims or health workers) participated voluntarily, signing a consent form to that respect.

For this work, 2 MCI simulations were conducted, comprised of 40 victims each (10 green, 17 yellow, 10 red and 3 black). The objective of the health professionals was to conduct a search for victims, their triage and sectorization (Fig. 1). The triage system used was START (Simple Triage and Rapid Treatment), which required the use of the following emergency techniques: opening an airway (OAA), which had to be performed in 15% (6/40) of the cases, and hemorrhage compression (HC) in 12.5% (5/40) of the cases. The correct performing of triage and the emergency techniques were assessed by 3 health professionals (all instructors in Advanced Prehospital Trauma Life Support and experts in triage and MCI) from the GUERM-061.

2.1. Sample Selection

For each of the simulations, the allocation of roles (triage or sectorization and treatment) were randomly assigned to each of the students from each of the study groups created (comprised of 34 students each), which were: Master's Students Group (MSG), comprised by the students enrolled in the Master's program of Emergency and Special Care Nursing at the UCAM (class of 2015–2016), and another Undergraduate Student Group (USG), comprised by 3rd year students enrolled in the Nursing Degree at the University of Murcia, who were enrolled in the Critical Care course. All the participants received the same training prior to the conducting of the simulation. The training consisted of theoretical classroom training for 2 h and the resolution of clinical cases for another 2 h. An instructor in Advanced Prehospital Trauma Life Support and expert in triage and MCI conducted this training.

2.2. Measurement of Stress and Activation

The basal (αAB) and subsequent (αAS) levels of the α-amylase enzyme were measured in all the participants through a passive diffusion system by collecting saliva into a tube, with an extraction time of 1 min. The αA was measured with a commercial kit (Olympus®) and the protocol used was the one recommended by the International Federation of Clinical Chemistry and Laboratory Medicine (IFCCLM). The assay was adapted to an automatic analyzer (Olympus AU400®). The method produced an inter-assay Coefficient of Variation (CV) of 3% and a linear regression coefficient of 0.992.

2.3. Statistical Analysis

The following variables were recorded for all the participants: age, weight, height, Body Mass Index (BMI = weight in kilograms/height; Castro Delgado et al., 2016), weekly physical activity, medical antecedents of interest (MAI), dental problems, presence or not of plaque, gingivitis, medication, use of vitamins and/or antioxidants, smoker or not and the timing of the last meal. The other variables analyzed in this study were: mean number of triaged victims, mean number of victims that were correctly triaged, correct performing of OAA, correct measuring of HC. The main variable (MV) of the study was the increase in concentration of α-amylase (IαA), which was determined with the following formula: IαA = αAB-αAS. Also, the HR and BP were determined, with this last divided into BP-Systolic (BPS) and BP-Diastolic (BPD).

The data are presented using frequency, mean and standard deviation. For comparing the results between the two study groups, the Wilcoxon rank test (W) was used for those cases where normality in the data was not found, and the Student's *t*-test (*t*) for those cases where normality was found. For the cases of number of victims found, well-triaged victims, victims whose airways were opened, and victims who experienced hemorrhage compression, a Chi-square test with the Yates correction was applied, as these were nominal variables. All the statistical results were obtained through the statistical package SPSS® v21. The results were considered to be statistically-significant if $p < 0.05$.

3. Results

The average age of the participants was 26.00 ± 6.61 (27.11 ± 7.75 for the MSG and 24.89 ± 5.09 for the USG), with a mean weight of 66.75 ± 14.48 (66.11 ± 14.68 for the MSG and 67.44 ± 18.28 for the USG), height of 1.69 ± 0.09 m (1.68 ± 0.85 for the MSG and 1.69 ± 0.09 for the USG), with a BMI of 22.93 ± 3.67 (22.79 for the MSG and 23.06 ± 4.37 for the USG). The mean physical activity that the volunteers said to perform was 3.97 ± 3.73 h/week (3.81 ± 2.97 for MSG and 4.14 ± 4.39 for USG). Between the two groups (MSG and USG), no significant

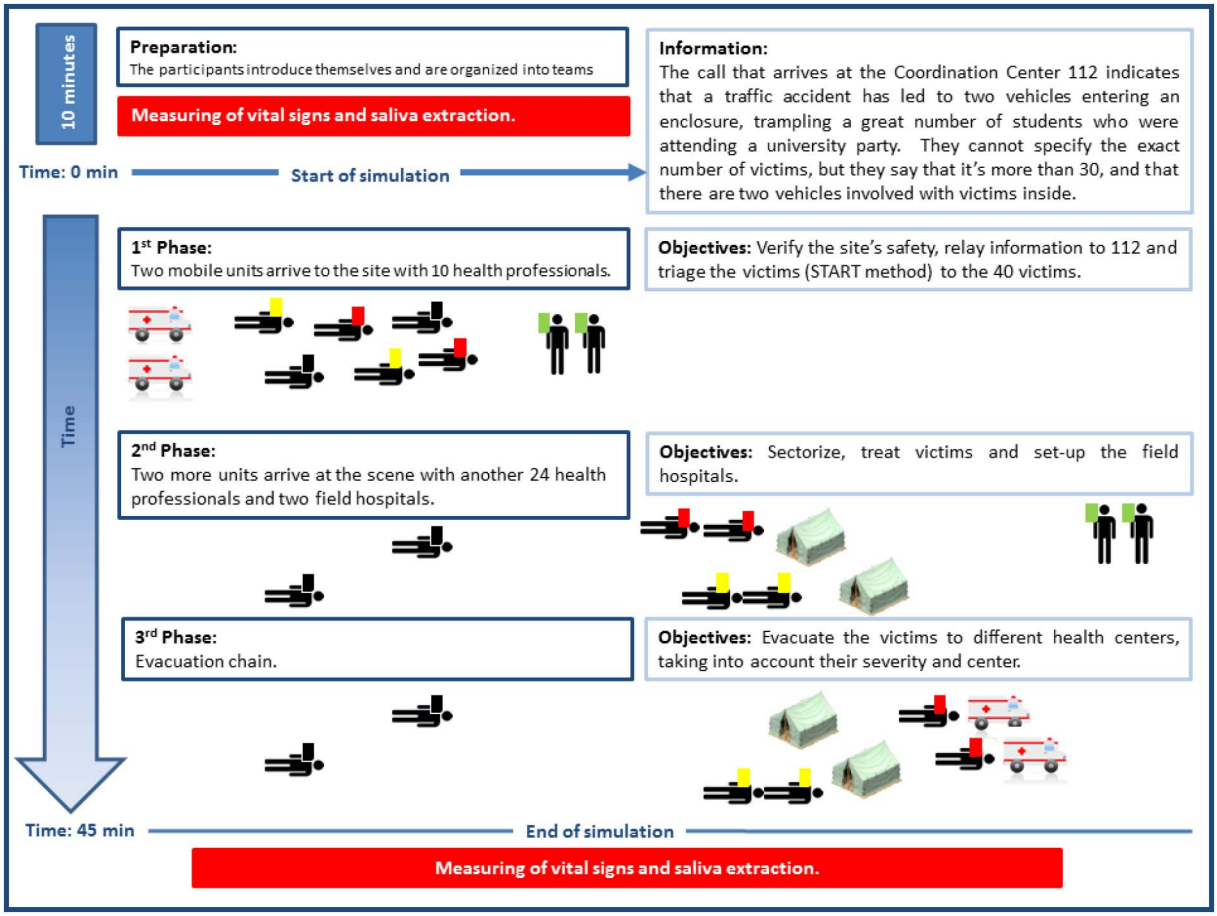

Fig. 1. Diagram of the flow of activity.

differences were found in the mean values of the variables age, weight, height, BMI, physical activity, taking of medication, etc. None of the pathologies or the medicines declared influenced the measurement of hormones or enzymes through the saliva. The overall professional experience of the MSG was 2.13 ± 3.99 years, and 0.78 ± 2.48 in the specific area of emergencies; the USG had not finished their university studies as of yet, thus, they did not have any professional experience as nurses.

The mean number of triaged victims per student who participated in the triage activity was 5 ± 1.63, with the results for the MSG being 6.12 ± 1.45, and 3.87 ± 0.83 for the USG, with significant differences ($p = 0.002$) in favor of the MSG. The mean of the victims that were correctly triaged by each participant was 4.43 ± 1.82 (88.6% correctly-diagnosed triaged victims), being 5.62 ± 1.76 (91.84% of the triaged victims correctly diagnosed) for the MSG, and 3.25 ± 0.88 (83.76% correct) for the USG, with a significant difference found ($p = 0.004$) in favor of the MSG. OAA was performed on all the victims that needed it, with the mean number of victims per volunteer being 0.75 ± 0.68 (100% of the techniques performed), with the results according to group being 0.87 ± 0.64 (58% of the maneuvers performed) for the MSG and 0.62 ± 0.74 (42% of the maneuvers performed) for the USG, with no statistically-significant differences found ($p = 0.483$). Also, HC was performed on all the victims that needed it, with the mean number of victims per volunteer being 0.62 ± 0.61 (100% of the maneuvers), with 0.62 ± 0.74 performed by the MSG (50% of the maneuvers) and 0.62 ± 0.51 by the USG (50% of the maneuvers), without statistically-significant differences found ($p = 1.0$).

There were no significant differences found between the first and second simulations as for the number of victims triaged per participant ($p = 0.897$), the mean number of victims that were correctly triaged ($p = 1.00$), the mean number of correctly-performed OAA ($p = 1.00$), or the correct performing of the HC ($p = 1.00$).

The αAB was 97,107.50 ± 72,182.67 UI/L, with a significant increase after the simulation, with αAS equal to 136,195.55 ± 90,176.46 UI/L [sample mean difference = IαA = 39,088.05 (22,990.02–55,186.08) UI/L, $p < 0.001$]. Table 1 shows the results of αA before and after the simulation for each of the groups. The HR-Basal was 78.74 ± 14.92 beats/min and the HR-Subsequent was 95.65 ± 23.59 beats/min [sample mean difference, 16.91 (12.31–21.53) beats/min, $p = 0.000$]. The BPS-Basal was 117.92 ± 11.22 mmHg and the BPS-Subsequent was 116.94 ± 14.03 mmHg [sample mean difference, 0.972 (1.82–3.76) mmHg, $p = 0.490$]. The BPD-Basal was 70.58 ± 8.57 mmHg and the BPD-Subsequent was 71.94 ± 8.86 mmHg [sample mean difference, 1.36 (1.16–3.88) mmHg, $p = 0.285$]. The analysis between groups showed that there were statistically-significant differences in the αA between the volunteers that performed triage and those that only performed sectorization (Fig. 2). There were no significant differences found in the αA between the undergraduate and Master's students. As for the HR and BP, there were no significant differences with respect to the role played or their prior academic training.

The analysis of the relationship between stress and the percentage of correct diagnosis at the triage stage did not find any relationships between them ($r = 0.02$; $p = 0.93$), as shown in Fig. 3. Also, there were no significant relationships found between the physiological indicators of stress and age, MCI, physical activity, years of professional experience or years of experience in emergency situations. No significant results were found between the increase of amylase and the increase of the other vital signs measured (HR and BP), either.

Table 1
Comparison of global and group Alpha-amylase results, before and after the MCI simulation.

Group		Alpha-amylase (IU/L)		
		Basal	Subsequent	Significance
Training	MSG	98,451.11 (± 73,909.64)	135,935.55 (± 94,408.49)	$p = 0.037^{*}$
	USG	95,763.88 (± 71,436.64)	136,455.55 (± 87,079.41)	$p = 0.002^{*}$
Role	Triage	131,912.50 (± 63,739.49)	200,257.50 (± 85,866.61)	$p < 0.001^{**}$
	Sectorization	87,163.21 (± 71,867.70)	117,892.14 (± 83,376.21)	$p < 0.001^{**}$
Global Results		97,107.50 (± 72,182.67)	136,195.55 (± 90,176.46)	$p < 0.001^{**}$

MSG: Master's Students Group; USG: Undergraduate Student Group.
* $p < 0.5$.
** $p < 0.001$.

4. Discussion

The level of stress is a factor that should be taken into account during the process of learning techniques that are to be used in adverse situations, such as in emergencies and disasters, although an excess of stress can hinder the acquisition of new skills. This level of stress has been measured at different times in the case of specific techniques (Janzen et al., 2016), but not in simulations of multiple casualty incidents.

αA has been utilized as a good indicator of acute stress in diverse studies (Vineetha et al., 2014; Valentin et al., 2015; Nater and Rohleder, 2009; Granger et al., 2007; Schoofs et al., 2008). The αA values obtained in our studies, both basal and subsequent, were very similar to those obtained by Tecles et al. (2014) for stress in oral presentations, also finding that the subjective tests of stress assessment were not related to enzymatic or hormonal variables such as αAB or cortisol (Tecles et al., 2014).

In our case, the randomizing of the two groups that had a different academic background allowed us to analyze the relationship between the level of stress and prior training. All the participants received the same 4 h of training in order to avoid variability in previous knowledge on the triage system, and the performing of both medical techniques (OAA and HC) by both groups were verified prior to the experiment. There was not sufficient evidence to declare one of the triage protocols superior in all aspects to the others, and few studies address the validation of triage tools. In our case we opted for the START triage system as it is one of the most commonly used (Streckbein et al., 2016; Culley and Svendsen, 2014).

As expected, in our case, even though both groups had received the same theoretical training before the exercise, a higher degree of

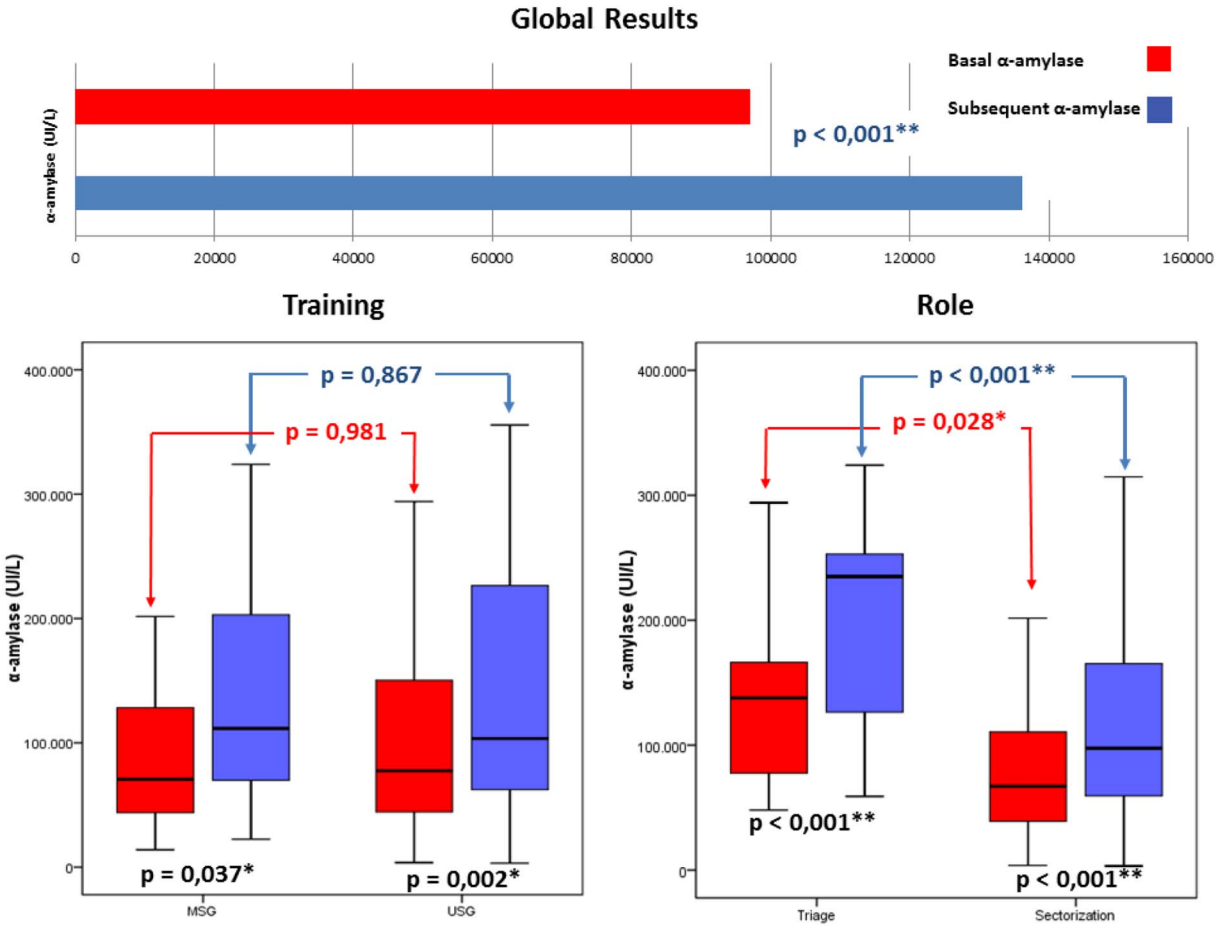

Fig. 2. Results of α-amylase.

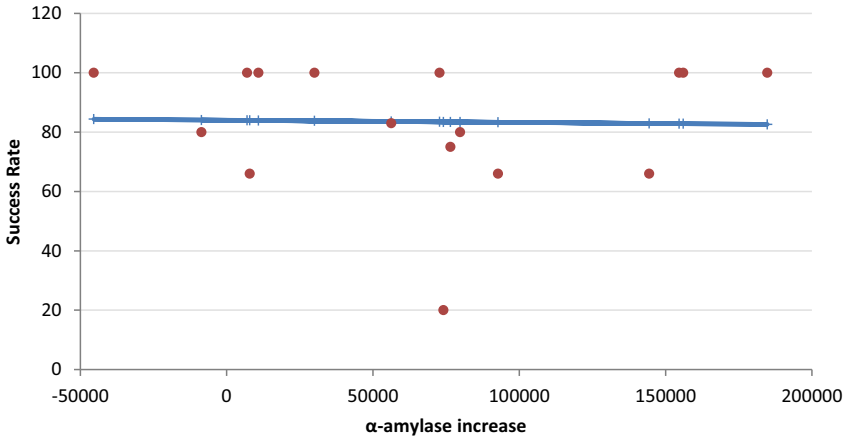

Fig. 3. Success percentage in relation to particular triage stress by increasing α-amylase.

education (Master's vs undergraduate) resulted in better results during the performing of the techniques. The results for the MSG were in agreement with another study, in which the performance of the Master's students in a MCI simulation in which drones were utilized as an aid for finding victims, was assessed (Pardo Ríos et al., 2016). Even then, it was noted that no significant differences were found for the increase of the level of stress between both groups (MSG and USG), so that in our case their prior academic level did not have an effect on the level of stress found after the experiment. Other studies on the stress levels of students from different academic years during the exam period did not find statistically-significant differences on the increase of stress either (Álvarez et al., 2012). This could be due to the fact that mass casualty incidents are exceptional situations even for personnel who have a greater academic level. A greater academic level results in the better performing of techniques and better use of the skills learned while under the same level of stress, so that it is believed that training does not decrease stress during exceptional situations, but allows for the better application of the techniques and skills learned. We believe that this is especially relevant in the case of the MCI. In the different roles played by the participants (triage or sectorization), we did find statistically-significant differences, with a greater stress generated in those students who performed triage. This could be due to the fact that during triage, there was a decision-making process that the health professionals were not accustomed to during their normal day-to-day work, and this equally affected the volunteers in the USG as well as in the MSG. The fact that the triage group had more αAB than the sectorization group can be explained by a phenomenon named “anticipatory stress”, in which the volunteers, once informed of their different roles, start to suffer a certain increase in their level of stress (Engert et al., 2013). The fact that there was an increase in the physiological indicators of stress after the conducting of the exercise as compared to the period before the exercise shows that the MCI simulations create a degree of stress on the participants, especially for those that conducted the triage. This materializes the conditions of stress that are searched for in these types of exercises and the differences between the possible roles played. Nevertheless, it should be noted that only the alpha-amylase concentration and HR showed statistically-significant results.

As for the possible relationship between the ability to use what was learned and the level of stress, at first both things were thought to be related, but in our study, we did not find any correlation. Therefore, in our case, the percent of successes was independent from the level of stress, although it was likely related to the student's prior knowledge, his/her ability to learn and academic level.

Another important aspect that should be taken into account was the lack of a statistically-significant relationship between the increase of amylase and the increase of the physiological variables such as BP. In another similar study, changes in variables such as HR, BP, gender, personality traits, etc., were not found either (Pardo Ríos et al., 2016). The fact that we did not find statistically-significant relationships between the increased stress levels and variables such as age, years of experience or physical activity showed that the exceptional nature of the MCI in the day-to-day work was enough to generate stress in the case of a simulation. Therefore, for future studies, αA could be considered the “*gold standard*” when measuring acute stress in situations of simulation and academic activity.

Although the simulation exercises were designed to be homogeneous so that they would be reproducible, we could consider the existence of non-perceived variations as a limitation of this study in the conducting of both exercises. We have tried to minimize this limitation through the randomization of those who intervened. Another possible limitation comes from the selection of the sample size. This MCI simulation was subject to many constraints, so that it was not possible to obtain an ideal sample size, large enough to challenge these results with the entire student population.

As a conclusion of this study, we can attest that the conducting of a simulation exercise of a mass casualty incident provoked stress on the participating personnel, with a greater impact on the participants who performed triage, without an influence from their prior academic studies. The HR could be used to physiologically assess these situations, but variables such as BP have not been useful in these types of situations, as they have not been linked to other physiological parameters that were exclusive to stress such as αA. The level of stress did not determine the practical use of acquired skills.

Conflict of Interests

The authors declare that there are no conflicts of interests.

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Meetings

This work and these data have not been previously published anywhere.

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