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Emotional intelligence, cortisol and α-amylase response to highly stressful hyper-realistic surgical simulation of a mass casualty event scenario

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A B S T R A C T

Lifetime exposure to stress leads to risk of suffering from cumulative detrimental physiological and psychological ailments. Due to the nature of healthcare and exposure to trauma, medical professionals are particularly susceptible to the negative impacts of high stress environments. emotional intelligence plays a role in ameliorating the risk of being negatively impacted by these stressors. As such, there is special interest to develop and implement training interventions for medical personnel that would allow them to improve emotional intelligence potential with the goal of enabling them to handle stress better and mitigate burnout. A hyper-realistic surgical simulation training session, replicating the intensity of a Mass-Casualty Event scenario, was implemented to allow medical professionals to experience this in real time. Overall, the training led to increased emotional intelligence, correlating with decreased hypothalamus-pituitary-adrenal axis and sympathetic nervous system stress biomarkers, cortisol and α-amylase. This novel training provides, at least, short-term improvements in emotional intelligence that is reflected with a physiological response. These results guide the ongoing effort to develop therapeutic tools to improve long term stress management, mitigate burnout and reduce post-traumatic stress risk after an exposure to a Mass-Casualty event scenario.

1. Introduction

Medical professionals are often at the mercy of circumstances when confronted with high stress and out of the ordinary scenarios such as a Mass Casualty Event (MCE). Although these scenarios are rare and unprecedented [23] for the majority of medical centers in the United States, there are often well-defined, coordinated operating procedures that are put in place to assure the effectiveness of the service provided in case they occur [26,35]. However, even when aware of these operating procedures, personnel do not necessarily have the mental preparation to endure and perform at their optimal efficiency in these specific circumstances [32]. The chances of having to confront a mass casualty event are slim; however, the stakes are very high since the social repercussions in the community and affected stakeholders can be very damaging [26]. Medical personnel are especially vulnerable to suffering firsthand effects of trauma, which are different and additive to the effects of burnout [9, 32]. Burnout can be defined as overwhelming exhaustion, feelings of

cynicism and detachment from the job, and a sense of ineffectiveness and lack of accomplishment [25]. For this reason, there is special interest to develop and implement training interventions for medical personnel that would allow them to experience and be mentally prepared for an scenario such as a MCE [20,26]. Hyper-realistic surgical simulation training events have been implemented to improve team performance while practicing medical procedures under realistic circumstances [19]. Additionally, these interventions have the potential of preparing medical personnel to better handle stressful environments [21]. Unfortunately, the availability of these opportunities are rare outside of the military sector and the scarcity of these opportunities limits experimental academic research of these environments.

Starting in 2012, Rocky Vista University, in coordination with military training providers, has supplemented curricula of military sponsored medical students to include a 6-day, hyper-realistic surgical training event where a series of MCE scenarios are reenacted. Over the years, more academic medical institutions have been added to this initiative.

Medical students participating in these events have, for the most part, no previous exposure to high-stress environments similar to a MCE. This setting provides a unique opportunity to evaluate the response and development of participants in a safe and controlled environment that mimics a chaotic and out of the ordinary event.

Two major components become very important to begin defining the response of medical personnel: the mental preparedness that provides resiliency, and the physiological response that mediates the physical response involved in well-being and performance. On one hand, it has been demonstrated that emotional intelligence plays a role in mitigating the risk of developing the detrimental effects of stress [4,34]. These can manifest in immediate consequences including emotional disturbance, insomnia, and increased alcohol usage [17], to long term effects including a multitude of health concern and mental health issues [39] which can lead to burnout [10,13]. Emotional intelligence is defined as the capacity to be aware of, control, and express one's emotions, and to handle interpersonal relationships judiciously and empathetically. It is malleable and can be improved [22], and in some cases, benefits have been demonstrated to be detectable months after the initial intervention [14]. On the other hand, physiological response allows for accurate objective evaluation of stress effects and have been demonstrated to be reflective of psychological stress and stress adaptation [2,8,30] which also includes some overlap with other resilience assessments such as hardiness [38]. Among all physiological biomarkers to assess a stress response, salivary measurement of cortisol and α-amylase are very popular due to their reliable representation of the Hypothalamus-Pituitary Adrenal (HPA) axis and the Sympathetic Nervous System (SNS), respectively [12]. This is relevant since psychological connections between stress management and physiological performance are known [5, 33]. Additionally, their non-invasive collection method [37] and accurate representation of stress [1,7,12] make them a reliable overview of the stress response. The effective management of the stress response and the development of training interventions to improve personnel effectiveness is an ongoing directive among emergency response organizations and the military [21]. In addition, understanding the impact of stress on vulnerable populations that were exposed to extreme situation is also a priority since these populations are associated to lower longevity and lower well-being [40]. Evaluating the various components of emotional intelligence and the physiological response of salivary cortisol and α-amylase in the context of a MCE can provide key insights in defining their effect and the development of risk-reducing training strategies. Given that stressful events such as MCEs are unlikely to disappear, continuous improvement of the mental preparedness of the personnel in charge of handling these situations is imperative. Therefore, the objective of this study was to evaluate the association of emotional intelligence with cortisol and α-amylase response during simulated mass casualty response events. An objective understanding of the response engaged by persons in high stress and specialized professions would allow for improved monitoring and stress management practices, thereby preventing long term burnout of valuable human resources.

2. Methods

2.1. Experimental design

This study was envisioned as an exploratory prospective study to evaluate the effect of a hyper-realistic surgical simulation training session on emotional intelligence measured by EQ-I2.0, cortisol and α-amylase levels. The study takes advantage of privileged access to a realistic training environment that was previously only available for the military. These surgical trainings recreate, in high detail, the operating environment of mass-casualty scenarios where participants must perform their medical role in a trauma unit in real time, thereby, providing an environment to practice specific medical procedures along with emotional management training.

2.2. Hyper realistic immersive surgical simulation training environment

The training session is conducted at Strategic Operations (STOPS) in San Diego, CA. STOPS is a current US Military provider of hyper-realistic training environments for forward surgical teams and specialized combat training. The environment recreated includes active-combat scenarios where casualties are simulated using "Cut Suits". These suits are anatomically accurate which includes blood pumps to recreate blood loss and are designed to simulate reparable surgical injuries that require the use of standardized procedures but include the complexity of a traumatic, life threatening injuries. Casualties and their injuries are dressed to be relevant to the simulated scenario such as fire-arm injuries an explosion related lacerations. Each of the casualties presents a traumatic presentation that challenges participants to stabilized the situation in real time. Since casualties arrive continuously, recreating a real-life emergency, participating teams must partake in injury triage while treating simultaneous casualties. Triage is important since some of the casualties are dressed with injuries that are beyond reasonable chance for stabilization under the scenario conditions and participants must make decisions in prioritizing care for casualties that do have a chance. Environmental realism is generated with the use of controlled explosions, fire, smoke, scents and blank ammunition. Some scenarios may include the addition of non-injured actors such as family members of the casualties or media. Participants are monitored at every moment and are evaluated by medical instructors and STOPS personnel. Further information on the hyper-realistic training session is presented in previous publications [19,21].

Each day's schedule of activities is similar with debriefings and grand rounds on cases encountered in the previous days scheduled in the morning and simulation scenarios starting after noon. Simulated emergency contingencies are started unannounced and often begin with environmental cues (explosions, a simulated attack; this is immediately followed by a flow of "victims" which are trained actors is unloaded simultaneously on the group, teams Participants are aware of the purpose of the training session but are not briefed with details of the schedule and demands of the specific scenarios recreated. Scenarios are modified every year, for every session.

2.3. Participants and emotional intelligence assessment

A total of 65 participants from three medical colleges took part in the present study. Participants were sponsored by the Department of Defense, Army, Navy and Air Force Health Professions Scholarship Program and were enrolled as medical students at either Rocky Vista University (RVU), Kansas City University of Medicine and Biosciences, or Western University of Health Sciences. All participants completed and signed consent forms to participate in the study; the study was reviewed and approved by the Rocky Vista University Institutional Review Board (IRB number: 2014-0001). Emotional intelligence was evaluated at two time points, upon arrival (day 0) and on the last day of the training session (Wrap-up, day 5). Measurements were performed using the EQ-I2.0 instrument provided by Multi-Health Systems Inc. (MHS) Toronto, ON [29]. Scores and sub scores evaluated were: Total Emotional Intelligence (EQ), Self-Perception (SP), Self-Expression (SE), Interpersonal (IS), Decision Making (DM), and Stress Management (SM). A detailed timeline of when the emotional intelligence measurements were taken is presented in Fig. 1. The study was performed over the course of two years 2016 and 2017 as two separate cohorts, one cohort each year.

2.4. Cortisol and α-amylase assessment

Salivary samples were collected from participants at various time points using the SalivaBio Oral Swab (SOS) method (Salimetrics LLC, Carlsbad, CA) which has high correlation to the passive drool collection method [16]. Time points are relatively consistent day after day where pre-event samples are collected after the morning activities are finished and post event samples are taken when the scenario is over in the
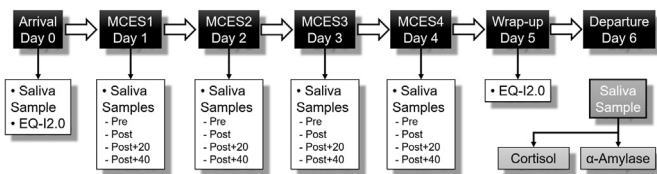
Fig. 1. Timeline of the hyper-realistic training session. Emotional Intelligence evaluations are carried out at Arrival (day 0) and on the Wrap-up day (day 5). Training on Mass Casualty Event Scenarios occurs on days 1–4. Cortisol and α-Amylase are measured on each saliva sample taken.

evening. Collection tubes within each day were maintained in ice and frozen for storage (−20 °C) prior to further analysis. Frozen samples were shipped in dry ice for in-house analysis at Salimetrics Lab and Technology Center (Carlsbad, CA) where assays were performed by their proprietary enzyme immunoassay as previously described [19]. All assays were performed in duplicates and the values used in statistical analysis were the average of the two measurements. A detailed timeline of the salivary sampling schedule is presented in Fig. 1. For day 1 through 4, an initial sample was taken before starting the schedule for the day and recovery samples were taken immediately, 20 and 40 minutes after the scheduled scenario was over.

2.5. Statistical analysis

Descriptive statistics including observation frequencies and emotional intelligence (EQ-I2.0) mean, standard deviation, minimum value and maximum value were calculated using PROC FREQ and PROC MEANS respectively on SAS/STAT v.9.4 (SAS Institute Inc., Cary NC). Pre-event/post event Pearson's emotional intelligence correlation tables along with Cronbach's alpha internal consistency measure were calculated using PROC CORR. Only standardized EQ-I2.0 values were used. Differences (Δ) between pre-event and post-event emotional intelligence were calculated for each score and sub score per individual by subtracting the pre-event value from the post-event value.

Time point by day Least Square (LS) means were estimated using a Generalized Linear Mixed Model (GLMM) on Log transformed cortisol values and on Log and squared transformed α-amylase values; this is because cortisol and α-amylase native values are not normally distributed. These specific transformations were selected after normality evaluation of residuals from model fitting of several transformation alternatives. These models included the repeated measurements by subject and fixed effects of year and sex therefore, the individual subject was defined as the experimental unit. Effect estimations were performed using PROC GLIMMIX from SAS. Emotional intelligence post-event score and sub score associations were estimated in two modes (individual pre-event predictor and all pre-event predictors), both by GLMMs, and included the effects of year and sex defined as fixed effects with the repeated measurements by subject which defined it as the experimental unit.

Associations between pre-event and post-event emotional intelligence to cortisol and α-amylase values were evaluated in two modes. First, predicting pre-event and post-event emotional intelligence scores and sub scores using all cortisol and α-amylase time points across days (each done independently); and second, predicting emotional intelligence differentials of scores and sub scores using all cortisol and α-amylase time points across days (independently as in previous). All these models include year and sex defined as fixed effects (to be able to estimate its significance). For this part transformed values were used as described previously.

Significant differences were declared at P ≤ 0.05. Family-wise statistical significance was denoted with a Bonferroni adjusted confidence threshold when detected (0.05 divided by the number of tests performed per family of tests).

3. Results

Emotional intelligence scores and sub scores for the pre-event, post-event and difference (Δ) assessed through the EQ-I2.0 instrument are presented in Table 1. Pre-event scores are, on average, always improved in this study in the post-event scores. This observation is also evident in Δ values always being positive. Internal consistency measured by Cronbach' standardized alpha was 0.8988 for the pre-event, 0.9186 for the post-event and 0.9480 across the two time points.

Correlation between pre-event and post-event emotional intelligence scores and sub scores are presented in Fig. 2A. Significant Pearson's correlations were present in the all pairwise comparisons with the exception of post-event Decision Making vs. pre-event Interpersonal and post-event Interpersonal vs. pre-event Decision Making. Significant coefficients ranged from 0.3241 to 0.8851. Associations detected through single predictor GLMMs adjusted by year and sex displayed the exact same pattern as Pearson's correlations (Fig. 2B); post-event Decision Making vs. pre-event Interpersonal and post-event Interpersonal vs. pre-event Decision Making are the only pairwise comparisons that were not significant. Associations detected through GLMMs that include all pre-event scores and sub scores as predictors displayed a very different picture (Fig. 2C). Only two post-event subcomponents displayed significant associations; first, post-event Self-Perception, which detected a significant association to pre-event Self-Perception and Stress Management. Second, post-event Stress Management was predicted by pre-event Stress Management. Results presented show that both pairwise correlations and adjusted models display strong associations that can often complicate conjoined interpretation of their true practical relevance. For that reason, the use of all-inclusive adjusted models presented further in the has the ability of accounting for collinearity issues that are unaccounted in pairwise comparisons and presenting a clearer association picture with higher inferential potential.

Cortisol and α-amylase estimated LS mean levels are presented in Fig. 3. Salivary cortisol levels (Fig. 3A) display a cyclical daily pattern on all four days of MCE simulations cortisol assays had an assay CV of 1.22% for 2016 and 0.67% for 2017, α-amylase assays had a CV 3.04% for 2016 and 9.43% for 2017. For each of these days the pre-session level is significantly higher than all of the recovery values for the same day. In addition, pre-session cortisol levels show an increase after the first day suggesting a cumulative increase of preemptive stress. Recovery cortisol values are consistently decreasing (post-session +40 min vs immediately post-session) as recovery time elapses even when not significant on time

Table 1

Emotional Intelligence (EQ-I2.0) descriptive statistics. Pre-event, post-event, Difference (Δ). Main sub scores are also described.

	Score/Sub score	N	Mean	Std. Dev.	Minimum	Maximum
Pre-event	EQ	63	102.38	11.93	70	127
	SP	63	102.32	10.46	82	125
	SE	63	101.95	12.51	71	129
	IS	63	101.08	13.70	53	129
	DM	63	105.03	12.00	75	132
	SM	63	99.84	15.31	64	134
Post-event	EQ	56	106.16	13.12	83	129
	SP	56	106.05	10.56	83	127
	SE	56	103.80	13.31	70	131
	IS	56	103.14	13.57	69	127
	DM	56	108.05	12.64	80	134
	SM	56	104.98	17.01	68	134
Δ	EQ	55	3.60	7.21	−9	34
	SP	55	3.89	6.70	−10	27
	SE	55	1.62	6.81	−15	21
	IS	55	2.18	9.12	−23	37
	DM	55	1.91	8.22	−16	30
	SM	55	5.29	8.07	−13	29

EQ = Emotional Quotient, SP = Self-Perception, SE = Self-Expression, IS = Interpersonal, DM = Decision Making, SM = Stress Management.

A

Post-event

Pre-event		EQ	SP	SE	IS	DM	SM
	EQ	**4.6E-16****	**2.7E-10****	**1.1E-10****	**8.4E-07****	**1.4E-06****	**2.0E-11****
	SP	**2.1E-10****	**1.8E-13****	**1.5E-06****	**0.0004****	**1.2E-05****	**7.9E-07****
	SE	**3.1E-07****	**0.0003****	**6.8E-18****	**0.0158***	**0.0036***	**8.6E-05****
	IS	**7.0E-06****	**0.0012****	**0.0141***	**6.2E-13****	0.1070	**0.0002****
	DM	**6.2E-06****	**0.0001****	**3.5E-05****	0.2179	**2.1E-12****	**0.0015****
	SM	**3.7E-14****	**2.9E-09****	**5.6E-07****	**1.9E-05****	**5.7E-05****	**3.0E-19****

B

Post-event

Pre-event		EQ	SP	SE	IS	DM	SM
	EQ	**1.5E-15****	**6.0E-10****	**2.2E-10****	**2.1E-06****	**3.2E-06****	**6.7E-11****
	SP	**5.3E-11****	**2.8E-13****	**5.7E-07****	**0.0003****	**6.7E-06****	**6.5E-07****
	SE	**1.4E-06****	**0.0003****	**1.6E-16****	**0.0322***	**0.0090***	**0.0002****
	IS	**1.0E-05****	**0.0018****	**0.0148***	**1.1E-12****	0.1450	**0.0003****
	DM	**5.8E-06****	**0.0001****	**4.5E-05****	0.2325	**4.4E-13****	**0.0016****
	SM	**1.2E-13****	**6.9E-09****	**8.7E-07****	**4.4E-05****	**0.0001****	2.3E-18

Adjusted by year and sex

C

Post-event

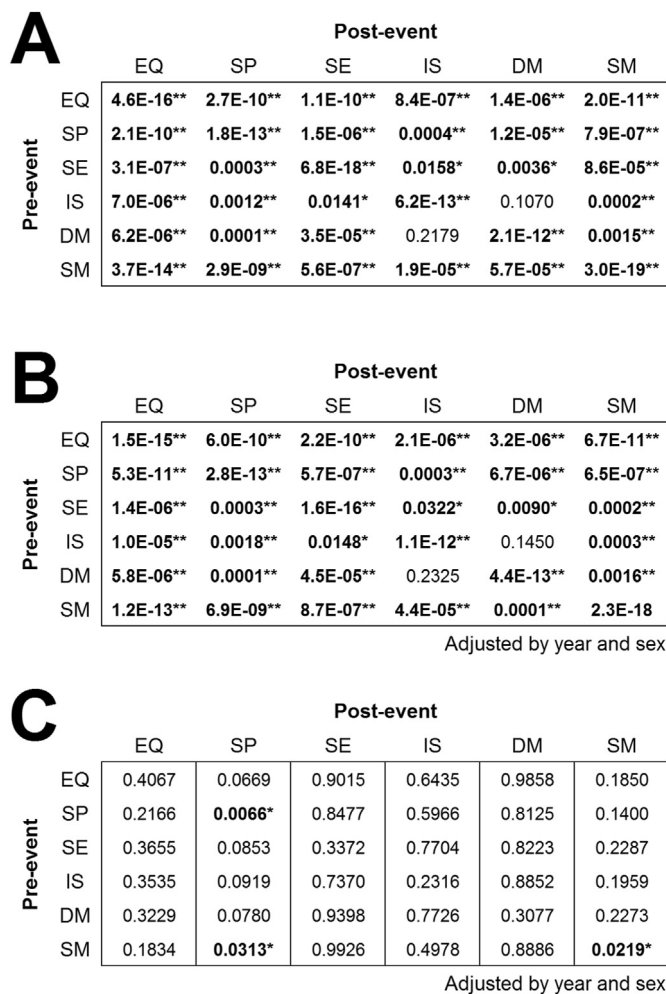| Pre-event		EQ	SP	SE	IS	DM	SM
	EQ	0.4067	0.0669	0.9015	0.6435	0.9858	0.1850
	SP	0.2166	**0.0066***	0.8477	0.5966	0.8125	0.1400
	SE	0.3655	0.0853	0.3372	0.7704	0.8223	0.2287
	IS	0.3535	0.0919	0.7370	0.2316	0.8852	0.1959
	DM	0.3229	0.0780	0.9398	0.7726	0.3077	0.2273
	SM	0.1834	**0.0313***	0.9926	0.4978	0.8886	**0.0219***

Adjusted by year and sex

Fig. 2. Emotional Intelligence internal correlations and associations. A. Significance testing of Person's correlation of pre-event and post-even scores and sub scores. B. Significance testing of single pre-event predictors of post-event scores and sub scores adjusted by year and sex. C. Significance testing of all pre-event predictors of post-event scores and sub scores adjusted by year and sex. Significant value cells are bolded and marked with an asterisk, a double asterisk denotes Bonferroni threshold significance. EQ = Emotional Quotient, SP = Self-Perception, SE = Self-Expression, IS = Interpersonal, DM = Decision Making, SM = Stress Management.

Fig. 3. Salivary cortisol and α-amylase least mean estimates at each time point. A. Least mean estimates of salivary cortisol concentration (μg/dl). B. Least mean estimates of salivary α-amylase concentration (U/ml). Estimates are adjusted by year and sex. Bars indicate Standard Errors. Brackets with an asterisk highlight relevant significant associations detected.

point by day besides for day 2 (P = 0.3536 for day 1; P = 0.0297 for day 2; P = 0.0696 for day 3 and P = 0.0756 for day 4) but significant on the time point main effect difference (P = 0.0009). Alpha-amylase levels on the first day of MCE simulation had no significant variation (Fig. 3B). This period faded away gradually as α-amylase level patterns gradually became more evident starting on day 2 where initial and post-session +40 min of recovery were different. By days 3 and 4, significant differences between initial and recovery values are consistent.

Associations between emotional intelligence measured through EQ-I2.0, salivary cortisol and α-amylase were carried out by GLMMs time point by day (Fig. 4). These associations allow us to interpret the relation pattern of salivary cortisol and α-amylase levels throughout the days and across pre and post-event emotional intelligence evaluations. These all-inclusive models (Emotional intelligence and biomarkers together) are more effective than pairwise correlations and adjusted models that independently evaluate Emotional intelligence, cortisol or α-amylase associations. Overall (Fig. 4A), the effect emotional intelligence on cortisol had both decremental (negatively associated) and incremental (positively associated) effects that appear at later days of the event. For pre-event emotional intelligence values, only Stress Management sub-
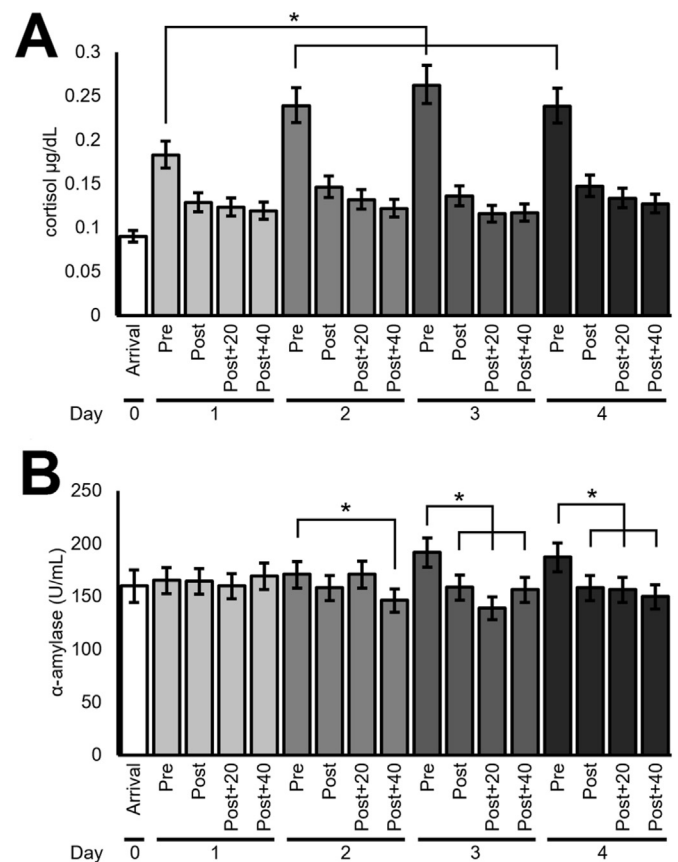
component displayed significant decremental associations to higher cortisol levels. For post-event emotional intelligence values, Emotional Quotient main score, Interpersonal and Stress Management sub scores displayed significant associations to higher cortisol levels that had mixed decremental and incremental effects. Consistent association between pre and post event scores were only found for Stress Management, where higher cortisol levels pre-session on day 3 were consistently detected to have a decremental predictive effect. In contrast to cortisol, α-amylase (Fig. 4B) displayed an overall association to pre-event levels where more significant associations were observed in the earlier days of the event including arrival values on day 0. Decremental and incremental effects were more frequent for α-amylase as opposed to cortisol levels. Pre-event emotional intelligence scores had more frequent significant predictive associations than post-event scores. Association consistency across pre and post-event scores was observed at arrival, on day 0, for Emotional Quotient main score where higher α-amylase values displayed a consistent incremental effect; this was also observed in the Stress Management sub component. Decision Making displayed a consistent mixed effect on post-session +20 min (incremental) and post-session +40 min (decremental) α-amylase values. No sex effects were observed for this mode. Year differences were observed on both cortisol and α-amylase for the post event Self Expression where the participants in 2016 displayed lower scores that those that participated in 2017.

Emotional intelligence scores and sub score differentials explain a different type of association to cortisol and α-amylase where the potential of improvement is more easily visualized. For this mode, cortisol levels displayed no associations to emotional intelligence but α-amylase level did (Fig. 5). Delta α-amylase values displayed a more complicated pattern

A

	Day	Time point	Pre-event						Post-event					
			EQ	SP	SE	IS	DM	SM	EQ	SP	SE	IS	DM	SM
Δ cortisol	0	Arrival	0.4653	0.1716	0.9189	0.2196	0.7617	0.7703	0.3798	0.7229	0.4267	0.2535	0.3996	0.8600
	1	Pre	0.4421	0.3446	0.1517	0.9575	0.5310	0.8805	0.2572	0.1771	0.1729	0.5359	0.3968	0.6559
		Post	0.2587	0.3764	0.2352	0.7249	0.1540	0.1501	0.2305	0.3915	0.0925	0.9517	0.4050	0.1824
		Post+20	0.9606	0.8531	0.3175	0.5420	0.8261	0.6643	0.7718	0.8393	0.2551	0.3470	0.7788	0.5165
		Post+40	0.7828	0.5373	0.2119	0.2958	0.8915	0.6033	0.8229	0.8602	0.3164	0.4380	0.8182	0.4742
	2	Pre	0.6157	0.6779	0.2476	0.4178	0.6592	0.4873	0.8051	0.9217	0.2320	0.4442	0.7240	0.7073
		Post	0.8395	0.7860	0.9713	0.8821	0.9698	0.5041	0.3673	0.9640	0.3103	0.6130	0.3376	0.3539
		Post+20	0.6781	0.2643	0.8642	0.8617	0.5258	0.8208	0.8008	0.6065	0.6177	0.8683	0.9248	0.8014
		Post+40	0.2517	0.4152	0.5376	0.1075	0.9536	0.3292	0.3484	0.4713	0.8834	0.1013	0.6813	0.4824
	3	Pre	0.1870	0.3392	0.5336	0.8689	0.2371	**0.0184**	**0.0308**	0.0840	0.0793	0.4266	0.1060	**0.0175**
		Post	0.8020	0.3505	0.3399	0.3196	0.4631	0.5334	0.3676	0.2641	0.7748	0.0930	0.4162	0.8798
		Post+20	0.1671	0.1303	0.7405	0.1839	0.1959	0.3948	0.1515	0.3935	0.3885	0.2281	**0.0492**	0.4676
		Post+40	0.6183	0.4949	0.7126	0.7807	0.7605	0.6464	0.7882	0.8269	0.7277	0.9454	0.2893	0.9201
	4	Pre	0.3696	0.1341	0.6476	0.3276	0.4791	0.0629	0.2714	0.0909	0.4915	0.3396	0.9523	0.0556
		Post	0.1258	0.0932	0.7501	0.1621	0.9071	**0.0166**	0.2031	0.2021	0.9470	0.0720	0.6216	0.0560
		Post+20	0.1374	0.6899	0.0667	0.1198	0.5669	0.2310	0.2834	0.3379	0.1655	0.1650	0.6843	0.4476
		Post+40	0.2872	0.3810	0.0990	0.9378	0.3786	0.3736	0.3833	0.2976	0.1775	0.9623	0.4478	0.5866
		Sex: F vs M	0.9181	0.6460	0.7860	0.8744	0.7808	0.1468	0.6787	0.8379	0.8137	0.7837	0.4359	0.2559
		Year: 2016 vs 2017	0.6284	0.6126	0.2135	0.6355	0.4502	0.3564	0.2125	0.7462	**0.0386**	0.2389	0.1415	0.8659

B

	Day	Time point	Pre-event						Post-event					
			EQ	SP	SE	IS	DM	SM	EQ	SP	SE	IS	DM	SM
Δ α-amylase	0	Arrival	**0.0414**	**0.0393**	0.1102	0.5930	0.1046	0.0693	**0.0189**	0.0876	**0.0341**	0.8062	**0.0160**	**0.0126**
	1	Pre	0.6398	0.9358	0.8317	0.2212	0.5700	0.5490	0.6344	0.5618	0.4193	0.1405	0.7503	0.5509
		Post	0.8671	0.4431	0.7203	0.7734	0.9789	0.8841	0.0849	0.1881	0.0938	0.1196	0.2709	0.2436
		Post+20	0.0777	0.1937	0.4679	0.1922	**0.0095**	0.3782	0.2310	0.4406	0.6098	0.3742	**0.0274**	0.6116
		Post+40	**0.0022**	0.0565	**0.0136**	0.1335	**0.0030**	**0.0046**	0.1127	0.4690	0.4180	0.6034	**0.0281**	0.0603
	2	Pre	0.1454	0.2147	0.5042	0.4033	0.4909	0.0735	0.0899	0.0905	0.3374	0.2875	0.4978	0.0520
		Post	0.1632	0.1151	**0.0227**	0.3643	0.6230	0.9350	0.4694	0.6275	0.5871	0.3347	0.5632	0.2489
		Post+20	**0.0095**	**0.0199**	0.0656	**0.0061**	0.0512	0.2387	0.2528	0.5139	0.0888	0.0727	0.8463	0.8618
		Post+40	0.0831	0.1125	**0.0382**	0.2504	0.3275	0.3805	0.8815	0.5665	0.8171	0.6778	0.7854	0.9961
	3	Pre	0.8229	0.4491	0.9077	0.3021	0.1257	0.9758	0.7402	0.9941	0.6895	0.0804	0.1925	0.3788
		Post	0.0529	0.4117	**0.0098**	**0.0258**	0.2221	0.6699	0.9183	0.7664	0.4645	0.3639	0.6727	0.6611
		Post+20	0.2564	0.4279	0.2097	0.6364	0.1204	0.7641	0.4101	0.2219	0.7373	0.5801	0.8764	0.3088
		Post+40	0.5221	0.5078	0.9666	0.2807	0.6869	0.9242	0.4387	0.4348	0.7008	0.1994	0.8551	0.8326
	4	Pre	0.9995	0.8605	0.1831	0.1520	0.3714	0.7869	0.9963	0.7578	0.0722	0.0933	0.3995	0.6663
		Post	0.0725	**0.0144**	0.3525	0.2090	0.4430	0.1675	0.1986	0.3396	0.3545	0.2061	0.8249	0.1580
		Post+20	0.7840	0.7436	0.8529	0.4935	0.0995	0.1423	0.3909	0.4966	0.3372	0.2588	0.0930	0.0902
		Post+40	0.3527	0.8640	0.6647	0.1932	0.6607	0.2393	0.7753	0.6733	0.8935	0.4043	0.5975	0.4241
		Sex: F vs M	0.2774	0.4964	0.2917	0.2280	0.9403	0.3573	0.9991	0.9218	0.8131	0.8608	0.6458	0.8745
		Year: 2016 vs 2017	0.7931	0.8474	0.1884	0.3702	0.8193	0.8771	0.1390	0.4722	**0.0113**	0.9484	0.0725	0.4419

Fig. 4. Associations between emotional Intelligence scores and sub scores to Cortisol and α-Amylase differential values. A. P values of cortisol differential association (adjusted to initial concentration per day) of pre-event and post-event scores and sub scores adjusted by year and sex. B. P values of Alpha-Amylase differential association (adjusted to initial concentration per day) of pre-event and post-event scores and sub scores adjusted by year and sex. Significant values that have decremental effects (negatively associated) to Emotional Intelligence scores and sub scores are highlighted in red while incremental effects (positively associated) are highlighted in green. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

with mixed decremental and incremental predictive effects (Fig. 5B). Higher α-amylase levels were decremental and incremental at post-session measurements on day 1, 2 and 3; and decremental on post-session +20 min measurements on day 3 for Δ Emotional Quotient main score. Self-Expression, Interpersonal, Decision Making and Stress Management differentials displayed some overlapped effects on some time point similar to the main EQ. A similar year effect only associated to Δ Self-Expression was observed as well in this mode for both biomarkers. In summary, α-amylase levels show a higher potential for predicting improvements in emotional intelligence scores and sub scores as compared to cortisol levels and this is seen across both pre event, post event and differential scores.

A

Day	Time point	Δ EQ	Δ SP	Δ SE	Δ IS	Δ DM	Δ SM
0	Arrival	0.9473	0.0770	0.4256	0.7274	0.5953	0.6021
1	Pre	0.8923	0.9665	0.7101	0.7245	0.6789	0.9652
	Post	0.9194	0.9737	0.6498	0.5845	0.5859	0.8128
	Post+20	0.1422	0.2153	0.3663	0.4225	0.0928	0.2239
	Post+40	0.3370	0.7684	0.2416	0.7200	0.1662	0.2288
2	Pre	0.1494	0.1062	0.3754	0.3095	0.0745	0.5575
	Post	0.7294	0.8307	0.8378	0.4165	0.7800	0.6638
	Post+20	0.7609	0.5073	0.5198	0.6000	0.9715	0.7858
	Post+40	0.5361	0.4181	0.5030	0.7876	0.8577	0.7091
3	Pre	0.1515	0.2527	0.1064	0.4684	0.1017	0.7568
	Post	0.1906	0.6211	0.1006	0.3396	0.6283	0.2058
	Post+20	0.6714	0.5067	0.9804	0.6476	0.8037	0.8366
	Post+40	0.4047	0.5887	0.3080	0.5661	0.5904	0.5707
4	Pre	0.8521	0.6261	0.6913	0.6095	0.2641	0.9484
	Post	0.8525	0.8454	0.6494	0.6828	0.4221	0.6465
	Post+20	0.4421	0.6890	0.6568	0.4902	0.1104	0.5362
	Post+40	0.9862	0.3798	0.6931	0.9727	0.9259	0.8002
	Sex: F vs M	0.5995	0.1707	0.9538	0.7791	0.0651	0.6768
	Year: 2016 vs 2017	0.4606	0.5694	0.5240	0.4185	0.5044	0.4627

(Δ cortisol)

B

Day	Time point	Δ EQ	Δ SP	Δ SE	Δ IS	Δ DM	Δ SM
0	Arrival	0.5792	0.6968	0.3386	0.5529	0.4981	0.1580
1	Pre	0.8648	0.4607	0.3419	0.8328	0.7073	0.9408
	Post	0.0394 (red)	0.0224 (red)	0.0584	0.2787	0.0519	0.3404
	Post+20	0.3819	0.5658	0.7542	0.4259	0.5234	0.3920
	Post+40	0.1515	0.4217	0.1340	0.3465	0.1354	0.3840
2	Pre	0.3352	0.3420	0.2681	0.9267	0.2288	0.6754
	Post	0.0067 (green)	0.0091 (green)	0.0228 (green)	0.0597	0.0530	0.0811
	Post+20	0.0513	0.0263 (red)	0.6320	0.2598	0.0471 (red)	0.0777
	Post+40	0.0751	0.3689	0.0525	0.0906	0.2527	0.3026
3	Pre	0.2176	0.2569	0.9755	0.4867	0.2552	0.0870
	Post	0.0463 (green)	0.1762	0.0220 (green)	0.1654	0.1617	0.2766
	Post+20	0.0422 (red)	0.0093 (green)	0.1282	0.1520	0.7090	0.0349 (red)
	Post+40	0.7051	0.9223	0.3088	0.8346	0.7907	0.8532
4	Pre	0.5972	0.7545	0.8244	0.6478	0.5848	0.4825
	Post	0.2695	0.0648	0.6221	0.3650	0.6782	0.6588
	Post+20	0.5671	0.2360	0.5027	0.9807	0.4593	0.9756
	Post+40	0.7540	0.7302	1.0000	0.3256	0.2367	0.5011
	Sex: F vs M	0.3636	0.9322	0.3291	0.1755	0.3587	0.1851
	Year: 2016 vs 2017	0.2384	0.8920	0.2403	0.3058	0.2442	0.4836

(Δ α-amylase)

Fig. 5. Associations between Emotional Intelligence differential scores and sub scores to Cortisol and α-Amylase differential values. A. P values of cortisol differential association (adjusted to initial concentration per day) of differential scores and sub scores adjusted by year and sex. B. P values of α-amylase differential association (adjusted to initial concentration per day) of differential scores and sub scores adjusted by year and sex. Significant values that have decremental effects (negatively associated) to Emotional Intelligence scores and sub scores are highlighted in red while incremental effects (positively associated) are highlighted in green. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

4. Discussion

This study reports cortisol and α-amylase associations to Emotional intelligence scores and sub scores measured through the EQ-I2.0 tool. Mild increases in Emotional intelligence in response to a simulated MCE scenarios engaged daily during a 6-day long training session were observed. These findings provide insight into complex physiological and psychological processes within the context of a very high stress scenario.

Lifetime exposure to stress has a cumulative risk increase of detrimental physiological and psychological ailments. The risk for particular detrimental effects is not the same at every stage of life. For example, the detrimental impact of chronic stress in adulthood can be potentially reversed once the stressor disappears, but this does not appear to be the case for aging and younger populations. This neurobiological property of adulthood explains the rate of disorder differences in populations exposed to stress at different stages of people's lives [24]. Unfortunately, an extreme acute stress event like a MCE can overwhelm such capacity and have lasting traumatic effects in people directly or even indirectly exposed [6,18,27]. Because of the specific high stress environment to which emergency medical personnel are exposed to, their risk for developing psychological trauma is higher and can manifest itself immediately after an extreme event [17,18] or can progressively manifest over a long period of time due to chronic exposure [14,39]. It is well documented that individuals with higher emotional intelligence are more resilient to long term effects of stress [34,36]. For this reason, the implementation of resilience training has become very relevant and shown important developments. For example, implementation of a resilience training intervention for emergency medicine residents has demonstrated measurable beneficial effects after 6 months of a single 2-hour session [14]. In the present study, this interventional approach which was developed with the purpose of preparing medical personnel for emergency traumatic response in the context of an extremely stressful event as a MCE. The results demonstrating internal associations of emotional intelligence scores and sub scores presented in this study show that a consistent improvement can be achieved using a dual technical and emotional training approach which could be implemented with some optimization as an intervention. Although this study does not provide an evaluation of the long-term capacity of this intervention, it provides relevant feedback on how participants respond to high intensity training and the short-term improvement potential of their emotional intelligence. This effect is evident when interpreting internal association modeled with all scores and sub scores included; for these models, specific relevance of Self-Perception and Stress Management sub components were crucial. Therefore, the argument can be made that participants with higher initial scores in these two categories are better suited for coping with the intensity of a highly stressful environment.

The hyper-realistic environment reenacted in this study provided a strong stimulus that contrasted the differences of the HPA and SNS response and their short-term adaptation to extreme stress. The response of these systems is accurately represented by cortisol and α-amylase temporal levels as assessed in this study. HPA and SNS are intimately interconnected and provide continuous feedback that cross regulate each other. These systems have strong participation in fear conditioning and consolidation of emotional memories which have been implicated in hyper arousal and re-experiencing symptoms of PTSD [31]. During the peritraumatic period (<24 hr after the stimulus), the HPA does not necessarily mimic the SNS response and this disparity of responses is attributed to have a strong predictive potential of negative outcomes in PTSD risk models. More precisely, increased SNS activity along with decreased HPA activity are associated with higher PTSD risk in adults [28]. HPA/SNS disparity can be evaluated by measuring cortisol and α-amylase ratios, which provides an important image of individual's resilience to detrimental effects of stress [1,2,15]. The present study presents a reference point that characterizes a high stress environment of the magnitude of a MCE in controlled and safe conditions for the participant, this simulated environment assures that the type and amount of stress to which participants are exposed is even across individuals.

The incorporation of emotional intelligence to the interpretation of HPA/SNS response patterns to high stress provides an additional context and interpretation of what was observed. The results presented showed an overall potential of cortisol values to predict post-event emotional intelligence values while α-amylase values showed a wider and much larger potential to predict pre-event values. The difference in the predictive potential of these two systems is a reflection of each individual's

emotional status at the moment of the event that is dictated by their specific genetic inheritance and their life experience [3,11]. In addition, the temporal difference in their association to emotional intelligence indicates a fundamental difference between the two systems. The SNS (reported by α-amylase) has an immediate response after the stimulus occurs that makes evidence of individual's pre-event emotional status variability; that SNS response is gradually modulated by subsequent HPA activation (reported by cortisol) where current HPA modulation is initiated by the ongoing SNS response for the current stress event. For this reason, the gradual looping modulation of HPA/SNS feedback makes inherent HPA variation evident only after some time has passed.

High cortisol levels detected at pre-session measurements on day 3 of the study showed a consistent negative association to pre-event and post-event Stress Management sub scores. This finding suggests that monitoring stress victims (such as medical personnel) for high cortisol levels a couple days after a highly traumatic event can be indicative of lower resilience potential. Promptly identifying individuals with a lower resilience potential may be a significant factor in assisting human resource management decisions to reduce long-term psychological damage. In terms of α-amylase, the mixed responses observed in this study complicate their interpretation and require further study. Fortunately, a consistent association was observed in arrival α-amylase values where the arrival value was predictive of an incremental effect for several emotional intelligence components. This association can be exploited in practice by monitoring periodically medical personnel for their α-amylase levels to deficiencies that could indicate poor resilience potential in case an event would occur. The evaluation of differentials suggests that a high intensity stressful event as well as interventions tend to have a more pronounced impact in the SNS response and opposed to the HPA response. This observation can be limited by the length of the intervention used in this study, but may reflect more closely the development of a real event as a MCE do not extend over a long period of time. It is important to note that sex differences were not detected in this study and year effect was only detected for Self Expression for both cortisol and α-amylase.

Although the main relevance of this study is in terms of describing the physiological stress response and its association to emotional intelligence within a MCE context, the main limitation of this study is their lack of long-term assessment of participants and a substantial pre assessment of each participants psychological and biological make-up. All this in addition to this population being highly selected academic population. These are features that should be followed up and will be reported on in the future, with these additions may be able to clarify clinical findings which may have confounded effects that could bias the interpretation of this stress response phenomenon. The addition of long-term evaluation of emotional intelligence along with psychological and psychiatric developments of participants of this program can provide a fuller picture that includes the effect on burnout. In addition, the continued addition of participants to this educational program will assist in clarifying the more complicated phenomenon observed in this study. So far, the study further demonstrates an achievable approach for improving emotional intelligence in medical students that should envision its inclusion in the formal curricula of more medical colleges.

5. Conclusion

HPA and SNS response patterns represented by salivary cortisol and α-amylase levels display a predictive association to emotional intelligence training. Cortisol and α-amylase levels measured at specific time points have different predictive potentials for specific emotional intelligence sub components. While understating these temporal associations can paint a reliable picture of the specific emotional skills required for handling and performing efficiently in an extreme stress environment, they can also direct monitoring protocols to detect vulnerable individuals with poor resilience potential. This novel training provides short-term increases in emotional intelligence, providing positive therapeutic value that may be useful to enhance stress management and mitigate burnout.

CRediT authorship contribution statement

Isain Zapata: Data curation, Formal analysis, Investigation, Methodology, Writing - original draft. **Joseph Farrell:** Investigation, Writing - original draft. **Svetlana Morrell:** Investigation, Writing - original draft. **Rebecca Ryznar:** Investigation, Writing - review & editing. **Tuan N. Hoang:** Conceptualization. **Anthony J. LaPorta:** Conceptualization, Funding acquisition, Project administration, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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