Salivary Cortisol Concentrations, Grit, and the Effect of Time

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ABSTRACT

Background: Stress is a common experience in the emergency department (ED) and is a balance of personal capabilities versus demands. Residency training is meant to improve individuals' capabilities and therefore may attenuate an individual's stress response. Grit is a personality trait that may attenuate stress in individuals. In this study we explore the relationship between time of year, postshift salivary cortisol concentrations, and the influence of grit among attendings and residents in an academic ED.

Methods: Thirty-nine residents and 17 attendings were enrolled and followed for two academic years at an urban academic medical center. Postwork salivary cortisol samples were collected quarterly, and Duckworth 12-point Grit Scales were administered annually. Data from the relative quarters of the first and second years were combined, and the results were analyzed using descriptive statistics and generalized estimating equations.

Results: We analyzed 216 cortisol samples and 87 grit scores over 2 academic years. Between the first and fourth quarters of the academic year, the percentage of subjects with a detectable postshift cortisol sample decreased from 47.6% (30 of 62) to 18.4% (9 of 49). In the fourth academic quarter compared to the first, the odds that an individual had a detectable cortisol were significantly lower overall (odds ratio [OR] = 0.25, 95% confidence interval [CI] = 0.10 to 0.59, $p = 0.01$), including the subset of only trainees (OR = 0.26, 95% CI = 0.07 to 0.88, $p = 0.01$), and adjusting for grit did not meaningfully change the ORs.

Conclusion: Over the course of the academic year, the odds that an individual's postshift salivary cortisol concentration will be above detectable concentration significantly decrease over time, and this relationship is not confounded by grit.

Although stress is universal to the practice of emergency medicine, the exact stressors for each individual are highly context specific and subjective. Stressors vary depending on the person, place, time, and event. Stress arises when an individual is confronted with a situation requiring more personal resources than they have available.^{1,2} All psychological stressors cause activation of the central nervous system, which stimulates the adrenal glands to secrete

cortisol and catecholamines.^{3–6} These hormones have pleiotropic physiological and psychological effects that are sometimes contradictory. For example, there can be improvement in mental focus, but also decrease in working memory and cognitive performance.^{6–8}

The benefit of supervised clinical experience in graduate medical education is that it safely increases residents' abilities over time, even in the face of rising demands. The exact same stressors that overwhelm an

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intern may not even be consciously perceived by a senior resident. Because of the close relationship between stress and cortisol, a change in response to stress may be able to be detected as a change in cortisol concentrations over time.^{3,6,7,9–11} Some people are likely naturally more adept at managing stress than others. Grit is a noncognitive personality trait that describes the ability to prioritize long-term goals and may also mitigate an individual's perception of stress.¹²

In this study we hypothesized that participants' cortisol concentration will decrease over time as they gain more experience, training, and familiarity with emergency medicine. We also hypothesized that grit would predict each individual's response to stress. We report the results of following residents and attending physicians at an urban academic emergency department (ED) over 2 years.

METHODS

Study Setting and Population

Subjects were recruited from an academic ED in June 2016 and June 2017 at the beginning of the academic year. The principal investigator (PI) presented the study's design and goals in a 10-minute presentation at the beginning of the academic year during the scheduled weekly didactic time, and three additional recruitment e-mails were sent to all residents and attendings. All residents and attendings were solicited for enrollment during these presentations and e-mails. Interested subjects were referred to a trained research assistant to perform the study's written consent, to avoid the PI or any co-investigator from directly consenting a trainee or colleague. The only exclusion criteria was chronic exogenous glucocorticoid administration. None of the subjects who referred themselves to the research team were excluded. There was no financial compensation for participation.

Study Protocol

The study was conducted at a tertiary academic hospital in an urban setting that takes care of approximately 56,000 patients per year. All patients are seen by residents primarily who then present the patient to an attending.

Participants privately answered the Duckworth 12-item Grit Scale in the beginning of the academic year and once per annum. Salivary cortisol measurements were collected from participants with the assistance of

a trained research assistant every quarter of the academic year. Saliva samples were taken between 23:00 and 00:00 after working an evening shift at the host institution. All shifts were either from 14:00 to 23:00 or from 15:00 to 23:00. Participants were instructed to abstain from eating, drinking, or brushing their teeth 30 minutes prior to specimen collection. Participants were given a commercial Sarstedt Salivette container, which contains an absorbent cotton swab. Salivary cortisol analysis was performed by the pathology department using an electrochemiluminescence immunoassay in a Cobas c6000 analyzer (Roche Diagnostics).

Data were entered in a secure REDCap database administered by our institution on secure servers. Only the PI had access to individual subject-level data. Data analysis were performed with Stata 9.0.

Data Analysis

The respective quarters from each of the 2 years were combined and were analyzed in aggregate (i.e., chronological quarters 1 and 5, 2 and 6, 3 and 7, and 4 and 8 were combined). Grit scores were dichotomized into high versus low scores relative to the mean grit score of the entire study population. To determine the odds of a positive salivary cortisol sample, we performed a regression using generalized estimating equations using a logit link, a binomial distribution, and an exchangeable correlation structure. Generalized estimating equations are useful when examining data that was repeatedly collected from the same individuals, and we have used it in similar analyses.^{13,14} Additional analyses were performed to explore the relationship between detectable cortisol concentration, time of year, and the influence of grit on the relationship. The primary analyses of interest used data from all study subjects. A secondary analysis was performed using only the restricted subset of trainees only.

Institutional Review

This study was approved by the institution's Committee on Clinical Investigations and the Department of Emergency Medicine's Medical Education Executive Committee.

RESULTS

We enrolled 39 residents and 17 attendings between the 2 years. All subjects enrolled during the first year reconsented to participate the second year, and new

subjects were also enrolled the second year. All subjects enrolled during the first year were followed for a full eight quarters, and subjects enrolled the second year were followed for four quarters, for a mean ($\pm$ SD) of 6.7 ($\pm$ 1.86) quarters. No subjects dropped out after consenting to participation. Research assistants contacted subjects every quarter to attempt to coordinate data collection, but not all 56 subjects were available during all quarters of the study period. Participants completed a total of 87 Grit Scales with a mean score of 3.7 (95% confidence interval [CI] = 3.6 to 3.8). Twenty-five (28.7%) of the Grit Scales were completed by PGY-1s, 21 (24.1%) were completed by PGY-2s, 11 (12.6%) were completed by PGY-3s, and 30 (34.5%) were completed by attendings (Table 1).

Of 420 possible subject-quarters, a total of 313 salivettes were distributed to subjects. Of those, 87 samples were not returned, and 10 samples were collected but had an insufficient volume of saliva to analyze and were treated as missing. A total of 216 samples were available for final analysis. Fifty-six (25.9%) samples were taken from PGY-1s, 44 (20.4%) from PGY-2s, 29 (13.4%) from PGY-3s, and 87 (40.3%) from attendings. Mean concentration of the samples was 0.371 μ g/dL (0.019–13.12 μ g/dL; SD $\pm$ 1.44 μ g/dL).

Due to the high incidence of undetectable cortisol concentrations, we dichotomized the samples into undetectable and detectable groups for analysis. A total of 135 saliva samples had undetectable cortisol concentrations and 81 had detectable cortisol concentrations. The mean ($\pm$ SD) age of subjects at the time of the saliva collection was 31.0 ($\pm$ 5.6) years old. We

collected 63 (29.2%) cortisol samples during the combined first academic quarters of the 2 years (i.e., chronologically quarters 1 and 5), 51 (23.6%) during the combined second quarters, 53 (24.5%) during the combined third quarters, and 49 (22.7%) during the combined fourth quarters of the year. Samples that were quantity not sufficient were distributed as such: one in the first chronological quarter, three in the second quarter, two in the third quarter, one in the fifth quarter, one in the seventh quarter, and two in the eighth quarter.

The proportion of undetectable cortisol samples increased from 52.4% (33/63) to 81.6% (40/49) over time from the combined first quarters to fourth quarters (Table 2). The odds of having a detectable cortisol concentration in the fourth quarters relative to the first were significantly decreased (odds ratio [OR] = 0.25, 95% CI = 0.10 to 0.59, p = 0.01) even after adjusting for the effect of high-grit status (OR = 0.23, 95% CI = 0.10 to 0.56, p = 0.01). Inclusion of an interaction term between high-grit status and time into the model was not statistically significant (p = 0.818). A box plot of subjects' Grit Scales stratified by detectable versus undetectable cortisol concentrations by quarter is summarized in Figure 1. Post hoc one-way power analysis confirmed a sufficiently large sample size to detect a change in the proportion of negative cortisol values (β = 0.93).

In our secondary analysis of residents only, the odds of having a detectable cortisol concentration in the fourth quarters relative to the first were significantly decreased, without and with adjustment for grit (OR = 0.26, 95% CI = 0.07 to 0.88, p = 0.03; OR = 0.24, 95% CI = 0.07 to 0.85, p = 0.03, respectively). Inclusion of an interaction term between high-grit status and time into the model was not statistically significant (p = 0.98). These results are summarized in Table 3.

Table 1
Descriptive Characteristics of Study Population Accounting For Multiyear Enrollment of Subjects

Number of unique subjects	56
Number of unique trainees	39
Subject age at sample collection, mean ($\pm$ SD)	31.0 ($\pm$ 56.0)
Subject-quarters of data	313
Cortisol samples, total	216
PGY-1	56 of 216 (25.9%)
PGY-2	44 of 216 (20.4%)
PGY-3	29 of 216 (13.4%)
Attending	87 of 216 (40.3%)
Grit scores, total (mean, 95%CI)	87 (3.7, 3.6–3.8)
PGY-1	25 of 87 (28.7%)
PGY-2	21 of 87 (24.1%)
PGY-3	11 of 87 (12.6%)
Attending	30 of 87 (34.5%)

DISCUSSION

In this study we serially measured postshift salivary cortisol concentrations of resident and attending emergency physicians and found that the odds of detecting cortisol decreased over time. This relationship was not confounded or modified by grit, and a similar trend was observed in both residents and attendings. These results provide surrogate evidence that stress in individuals decreases over the course over the year in an academic ED. This study contributes to the literature

Table 2

Salivary Cortisol Samples Above and Below Detectable Assay Threshold by Quarter, Stratified by Training Status

Salivary Cortisol Concentration	Q1	Q2	Q3	Q4	Total
All Subjects					
Below assay	33 (52.4%)	25 (49.0%)	37 (69.8%)	40 (81.6%)	135 (62.5%)
Above assay	30 (47.6%)	26 (51.0%)	16 (30.2%)	9 (18.4%)	81 (37.5%)
Total	63	51	53	49	216
Trainees only					
Below assay	24 (58.5%)	14 (46.7%)	25 (78.1%)	22 (84.6%)	85 (65.9%)
Above assay	17 (41.5%)	16 (53.3%)	7 (21.9%)	4 (15.4%)	44 (34.1%)
Total	41	30	32	26	129

Figure 1. Grit scale versus detectable (+) or undetectable (–) post-shift salivary cortisol level, for each combined academic quarter (Q1–Q4).

by examining physiologically quantifiable measurements of stress.

Stress is ubiquitous in the practice of emergency medicine. Although the most salient sources of stress may vary from one emergency physician to another, the experience of stress in emergency medicine is universal. Stress is not always a bad thing; some amount of stress is useful because it promotes arousal and helps concentration on tasks.^{4,6,8} However, when left

unchecked, stress has many negative cognitive, emotional, and physical consequences.^{1,4,15} The epidemic of burnout in emergency medicine has highlighted the unhealthy balance of beneficial and detrimental psychological forces affecting physicians, such as stress.

Discussions about stress, burnout, and mental health in medical professionals are more common now than ever before the literature, the medical community, and the lay press.^{16–18} Emergency physicians are some of the most at-risk physicians in medicine, and this topic is pertinent to practicing physicians, physicians in training, and those who are responsible for training and leading physicians.^{12,16,19–21} The trainees in our study had fewer samples with detectable cortisol at the end of the year compared to the beginning. This is an interesting finding because salivary cortisol measurements have never been used in this way, in a population like this. Furthermore this phenomenon may reflect an improvement in their general wellness, or it may be a reflection of their training. Future research into wellness, stress inoculation training, and other performance-enhancing psychological skills may benefit from an accurate and objective means of an individual's, as well as a group's, level of stress.^{1,6} Developing the capacity to handle stressful medical and traumatic resuscitations is a hallmark of

Table 3

Odds of a Detectable Cortisol Sample Above Assay by Quarter, With and Without Adjustment for Grit

	Q1	Q2	Q3	Q4
All subjects (n = 232)				
Unadjusted model	Reference	1.13 (0.54–2.35)	0.47 (0.22–1.0)	0.25 (0.10–0.59) ^a
Adjusted model	Reference	1.1 (0.50–2.23)	0.45 (0.21–0.97)	0.23 (0.10–0.56) ^b
Trainees only (n = 134)				
Unadjusted model	Reference	1.62 (0.63–4.18)	0.40 (0.14–1.12)	0.26 (0.07–0.88) ^c
Adjusted model	Reference	1.53 (0.59–4.02)	0.38 (0.13–1.08)	0.24 (0.07–0.85) ^d

Data are reported as OR (95% CI). ^ap = 0.01; ^bp = 0.01; ^cp = 0.03; ^dp = 0.03.

emergency medicine, and salivary cortisol measurements may be a means to measure that ability.

In our study, individuals with all levels of grit exhibited the same trend of decreasing salivary cortisol concentrations over time. This is interesting because we suspected that individuals with little grit might have had a different trajectory than those with lot of grit. The concept of grit has become very popular in the lay press and may be a useful concept in cognitive performance, but it is still an area of active investigation.^{12,22–24} Some research has shown that grit in emergency physicians is predictive of burnout.²² Grit may be a useful measure to assess risk of prematurely departing residency training early.²⁵ Other work has shown that levels of grit in emergency physician are about the same as those in other medical and surgical specialties and West Point cadets.^{12,25–28}

These results are important because if salivary cortisol concentrations were found to be reliable and predictive of stress, then cortisol could be used as a metric in education and training, as well as physician well-being. This study also provides some additional findings about the importance of grit in emergency physicians. More work is needed to establish if quantitative physiological or psychological measures of stress are valid or useful.

LIMITATION

This study is limited by the relatively small sample size, the fact that it was conducted at a single site, and the nonrandom self-selection of study participants. There is no clear consensus on when or how cortisol measurement should be used in measuring stress over an entire shift, and postshift salivary cortisol samples may not be the most sensitive or specific measurement.³

We did not control for recent shift burden or recent shift type when coordinating which dates to collect saliva from the participants. Potential dates were coordinated between the research assistant and the subject to find a mutually agreeable time, but it was not specifically required that it was the first shift of its type in a set of shifts or any other arrangement. The effect of proximal shift burden (or lack of burden) and its effect on subsequent salivary cortisol concentrations is unknown, and given the volume of shifts that residents and attendings work, and the permutations of shift order, it would have been logistically impossible to schedule seemingly commensurate dates among subjects.

The concept of grit has been critiqued and may not provide any more additive information about a person's personality than can be gleaned by other means.²⁹ Furthermore, a holistic framework encompassing stress, cortisol, well-being, and cognitive performance has not been clearly established.

Future multicenter work involving more trainees would be needed to validate these findings. Additionally, although we restricted the sample collection to similar shifts at a single institution, it was not possible to ensure that all of the shifts for the subjects were all equally stressful. Further adjustment for on-shift stressors would provide more insight, but it begs the question of this current project and how to measure stress quantitatively.

CONCLUSIONS

Detectable concentrations of salivary cortisol are common in the beginning of the academic year, but the incidence decreases over time, suggesting an effect of training. Individuals with low grit and individuals with high grit share this same trend. This effect is observed in both trainees and attendings, and further investigation is needed to examine the role of stress and resilience in emergency medicine trainees.

References

1. Lauria MJ, Gallo IA, Rush S, Brooks J, Spiegel R, Weingart SD. Psychological skills to improve emergency care providers' performance under stress. *Ann Emerg Med* 2017;70:884–90.
2. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24:385–96.
3. Michaud K, Matheson K, Kelly O, Anisman H. Impact of stressors in a natural context on release of cortisol in healthy adult humans: a meta-analysis. *Stress* 2008;11:177–97.
4. LeBlanc VR, Bandiera GW. The effects of examination stress on the performance of emergency medicine residents. *Med Educ* 2007;41:556–64.
5. Harvey A, Nathens AB, Bandiera G, Leblanc VR. Threat and challenge: cognitive appraisal and stress responses in simulated trauma resuscitations. *Med Educ* 2010;44:587–94.
6. LeBlanc VR. The effects of acute stress on performance: implications for health professions education. *Acad Med* 2009;84(10 Suppl):S25–33.
7. Arora S, Sevdalis N, Nestel D, et al. The impact of stress on surgical performance: A systematic review of the literature. *Surgery* 2010;147(318–30):e6.

8. Staal MA. Stress, Cognition, and Human Performance: A Literature Review and Conceptual Framework. 2004. Available from: https://human-factors.arc.nasa.gov/flightcognition/Publications/IH_054_Staal.pdf. Accessed January 17, 2019.
9. Bedini S, Braun F, Weibel L, Aussedat M, Pereira B, Dutheil F. Stress and salivary cortisol in emergency medical dispatchers: a randomized shifts control trial. *PLoS One* 2017;12:1–15.
10. Yang Y, Koh D, Ng V, et al. Stress among emergency department nurses. *J Occup Environ Med* 2001;43:1011–8.
11. Melamed S, Ugarten U, Shirom A, Kahana L, Lerman Y, Froom P. Chronic burnout, somatic arousal and elevated salivary cortisol levels. *J Psychosom Res* 1999;46:591–8.
12. Wong ML, Anderson J, Knorr T, Joseph JW, Sanchez LD. Grit, anxiety, and stress in emergency physicians. *Am J Emerg Med* 2018;36:1036–9.
13. Joseph JW, Davis S, Wilker EH, et al. Modelling attending physician productivity in the emergency department: a multicentre study. *Emerg Med J* 2018;35:317–22.
14. Zeger SL, Liang KY. Longitudinal data analysis for discrete and continuous outcomes. *Biometrics* 1986;42:121–30.
15. Lupien SJ, Maheu F, Tu M, Fiocco A, Schramek TE. The effects of stress and stress hormones on human cognition: implications for the field of brain and cognition. *Brain Cogn* 2007;65:209–37.
16. Shanafelt TD, Mungo M, Schmitgen J, et al. Longitudinal study evaluating the association between physician burnout and changes in professional work effort. *Mayo Clin Proc* 2016;91:422–31.
17. Verghese A. How Tech Can Turn Doctors Into Clerical Workers. *N Y Times Mag* 2018. Available at: <https://nyti.ms/2GllkYC>. Accessed January 17, 2019.
18. Schulte B. Time in the bank: a Stanford plan to save doctors from burnout. *Washington Post*. 2015. Available at: https://wapo.st/1Nx0HdF?tid=ss_mail&utm_term=.8e87fba1305b. Accessed January 17, 2019.
19. Cydulka RK, Korte R. Career satisfaction in emergency medicine: the ABEM longitudinal study of emergency physicians. *Ann Emerg Med* 2008;51(714–22):e1.
20. Sinsky CA, Dyrbye LN, West CP, Satele D, Tutty M, Shanafelt TD. Professional satisfaction and the career plans of US physicians. *Mayo Clin Proc* 2017;92:1625–35.
21. Accreditation Council for Graduate Medical Education. Common Program Requirements. Sect III B. 2011. Available at: https://www.acgme.org/Portals/0/PFAssets/Program-Requirements/110_emergency_medicine_2017-07-01.pdf. Accessed January 17, 2019.
22. Dam A, Perera T, Jones M, Haughey M, Gaeta T. The relationship between grit, burnout and well-being in emergency medicine residents. *AEM Educ Train* 2018;3:14–9.
23. Olson N, Olson AS, Williamson K, Hartman N, Branzetti J, Lank P. Faculty assessment of emergency medicine resident grit: a multicenter study. *AEM Educ Train* 2018;3:6–13.
24. Duckworth A. *Grit: The Power of Passion and Perseverance*. 1st ed. New York: Scribner, 2016.
25. Burkhart RA, Tholey RM, Guinto D, Yeo CJ, Chojnacki KA. Grit: a marker of residents at risk for attrition? *Surgery* 2014;155:1014–22.
26. Salles A, Cohen GL, Mueller CM. The relationship between grit and resident well-being. *Am J Surg* 2014;207:251–4.
27. Halliday L, Walker A, Vig S, Hines J, Brecknell J. Grit and burnout in UK doctors: a cross-sectional study across specialties and stages of training. *Postgrad Med J* 2017;93:389–94.
28. Duckworth AL, Peterson C, Matthews MD, Kelly DR. Grit: perseverance and passion for long-term goals. *J Pers Soc Psychol* 2007;92:1087–101.
29. Credé M, Tynan MC, Harms PD. Much ado about grit: a meta-analytic synthesis of the grit literature. *J Pers Soc Psychol* 2017;113:492–511.