**Title:** Evaluation of a daily brief exercise intervention on resident physician personal resiliency and burnout

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**Study Abstract**
This study seeks to evaluate the prevalence and characterize predictors of physician burnout within anesthesia residency. A cross-sectional evaluation of burnout via the Maslach burnout inventory, perceived stress via the Perceived Stress Scale, average sleep propensity via the Epworth Sleepiness scale, social support and coping mechanisms via the Social Support and Personal Coping survey, and demographic and professional data will be collected from all four years of Vanderbilt Anesthesia residents. Maslach burnout inventory scores can be assessed within each residency class to determine the prevalence of burnout and whether year in training, stress, sleepiness, personal support or coping mechanism play a role in burnout scores.

Additionally, the study seeks to evaluate the effect of an exercise intervention on burnout and personal resiliency (i.e., less individual stress given the same workload). This will be accomplished by randomizing participants in the residency (in the intern, CA-1, and CA-2 classes) to 8 weeks of an exercise intervention (15 min of activity at 70% of max heart rate or higher, 5 days a week) to meet the activity recommendations of the Office of Disease Prevention and Health Promotion or 8 weeks of continuing their baseline activity level prior to the study. Progress will be tracked using wearable activity trackers to monitor heart rate, activity, sleep, and distance measures. Weekly surveys will be sent to assess work hours, sleepiness and stress levels. Monthly surveys will evaluate number of weekend days worked/month, workload assessments, Maslach burnout inventory, Perceived stress scale, and Epworth Sleepiness Scale. We will access institutional work hours and clinical assignment logs to validate the self-reported work schedules.

**Specific Aims and Hypothesis**

Specific Aims

1. Characterize predictors of burnout in anesthesia residency in the intern, CA-1, CA-2 and CA-3 classes
2. Evaluate the effect of an exercise intervention on burnout and personal resiliency (i.e., less individual stress given the same workload).

Hypotheses
1. The degree of burnout severity in resident physicians will be highest in the CA-2 class due to more weekend shifts and higher stress.
2. A daily exercise intervention will improve personal resiliency and decrease burnout severity in resident physicians.

**Background and Significance**

Physician burnout is a growing concern as the demand for healthcare continues to grow. In 2011, the first nationwide survey of 7,288 US physicians showed that approximately 45% experienced at least 1 symptom of burnout and this was more prevalent compared to US workers in other fields. Subsequently, Shanafelt *et al* showed that prevalence of burnout among US physicians increased to greater than 50% in 2014.[1]

Many factors play a role in the development of burnout.[2] Sinsky *et al* reported in a nationwide survey across specialties that 20% of responding physicians planned to reduce their clinical hours within the next year and another 26% planned on leaving their current clinical practice within the next 2 years.[3] Burnout and the associated physician turnover is expensive for society; it typically costs 2-3 times a physician's annual salary to replace that physician.[4] The issue is exacerbated by the time it takes to train physicians. For example, it takes at least 8 years after college graduation to train an anesthesiologist (4 years of medical school and 4 of residency) plus any additional subspecialty fellowship training. The incidence of burnout among physicians in training is variable, but has been previously been estimated at 45%.[5]

Residency is commonly acknowledged as a grueling period of medical training characterized by long hours, high stress, and few days off. Anesthesiology training may be particularly stressful due to the high patient acuity, occurrence of stressful events, deference to surgeons, and easy access to addictive substances. There is abundant literature regarding the prevalence of substance abuse and depression among anesthesiologists, suggestive of a high prevalence of burnout and lack of adequate coping mechanisms.

The gold standard for measuring job burnout in persons working in human services and health care is the Maslach Burnout Inventory–Human Services Survey (MBI–HSS).[6] The MBI–HSS consists of 22 questions in complete sentences that are specifically geared for subjects who work in human service professions. In a prior study by our group, Hyman *et al* used the Maslach Burnout Inventory to demonstrate a higher rate of burnout in perioperative physicians (i.e., surgeons and anesthesiologists) compared to nurse anesthetists and OR nurses. After adjusting for sex and age, residents scored significantly higher than other physicians in the MBI-HSS global score (1.12 [0.43-1.82, 95% confidence interval]), Emotional Exhaustion (EE) (1.54 [0.44-2.60]), and Depersonalization (DP) (1.09 [0.23-1.95]). The observed difference (0.74 [1.59 - -0.11]) in Lack of Personal Accomplishment (LPA) did not attain statistical significance. Compared with non-physicians, residents were at least a full unit higher on all items ($P < 0.05$ in all cases). Residents had better health (1.49 [0.48-2.50]) and higher workload (1.23 [0.07-2.40]) compared with attending physicians.[7] In a follow-up national study focused on anesthesiologists' burnout, coping strategies and substance use, conducted via an online survey associated with a

national educational webinar hosted by the American Society of Anesthesiologists and *Anesthesiology*, the incidence of burnout was similar to that seen in the Vanderbilt perioperative physicians in our first study (mean EE 3.5 vs. 3.3, DP 1.5 vs. 2.0, and LPA 2.3 vs. 1.5, respectively).[8]

The primary determinants of physician burnout include efficiency of practice, culture of wellness, and personal resilience.[9] Efficiency of practice is value-added clinical work divided by time and energy spent. A culture of wellness is a set of normative values, attitudes, and behaviors that promote self-care, personal and professional growth, and compassion for colleagues, patients, and self. Both of these determinants are organizational factors that are slow and challenging to change. Personal resilience is the set of individual skills, behaviors, and attitudes that contribute to personal physical, emotional, and social wellbeing. This determinant may be more amendable to intervention at the individual level.

A variety of individual interventions to ameliorate burnout have been studied with mixed results.[10,11] The most common interventions include mindfulness and meditation exercises as well as educational workshops about symptoms of burnout and coping methods. The few studies that have evaluated the effects of exercise on burnout, have promising results. Bretland *et al* showed exercise (cardiovascular or resistance training) in previously inactive participants led to increased well-being, decreased psychological distress, perceived stress, and emotional exhaustion with large effect sizes despite a small sample size (n = 49 total, n = 20 controls, n = 20 cardiovascular training, n = 9 resistance training).[12] Weight *et al* showed that a 12-week incentivized exercise program directed at the residents and fellows (n = 628) across all disciplines increased physical activity and improved quality of life scores. Participants had lower burnout scores compared to non-participants, but the differences were not statistically significant.[13] However, exercise program was self-directed and self-reported. Only 51% of the participants (n=89) reported at least 75 min of vigorous exercise per week compared to 25% of non-participants (n=88). Additionally, rather than measuring burnout with the MBI, Weight *et al* measured burnout with 2 questions adapted from the MBI scored on a 7-point Likert scale.

To enhance overall health, the U.S. government Office of Disease Prevention and Health promotion recommends an average of 150 min of moderate intensity exercise (brisk walking or tennis) weekly or 75 minutes of vigorous intensity physical activity (jogging or swimming laps).[14] Additionally, they recommend physical activity to be performed in at least 10-minute intervals.

If consistently participating in such an exercise regimen can be shown to improve personal resiliency and decrease burnout in resident physicians, such an intervention could improve resident performance and morale, reduce departmental and/or institutional costs, and enhance retention. By starting during residency, young physicians could continue to build personal resilience to decrease the prevalence of burnout throughout their careers. Additionally, if this study's results are positive, an exercise intervention could then be studied in other anesthesia professionals (i.e., faculty and CRNA) and across the medical profession more generally.

**Research Design and Methods**

This study consists of two components:
1. A cross-sectional survey of the prevalence of burnout among anesthesia residents to identify potential predictors of burnout
2. An order-randomized, 16-week within-subject crossover study evaluating whether an exercise intervention will improve personal resiliency and decrease burnout in the resident physician.

The *cross-sectional baseline survey* will include all consenting Vanderbilt anesthesia residents (interns, CA1, CA2, and CA3s). We will send a REDCap survey that contains questions regarding demographic information (age, gender, level of training, etc), activity level (current physical activity, minutes/week, etc), sleep propensity (Epworth sleepiness scale), stress (Perceived Stress Scale), and burnout (Maslach burnout Inventory). The goal will be to include all 72 residents in the study. There are no exclusion criteria.

The *interventional study* will enroll anesthesia residents from only the first 3 years (intern, CA1, and CA2). They will be invited to participate in a 16-week study in which each resident will be randomized to either an exercise intervention or usual activity (i.e., control) for the first 8 weeks. Then, in the second 8-week block, the participants will be in the opposite condition (i.e., control or the exercise intervention, respectively). We will create a randomly-generated, balanced allocation table and enter participants sequentially from a blinded list as they are enrolled.

A total of 55 residents are eligible for the study. The goal will be to enroll ~ 50 anesthesiology residents into the interventional study; 16 individuals from each of the first three classes (i.e., intern, CA1 and CA2). We anticipate that about 10-15% will not successfully complete the study, yielding a desired accrual of ~43 residents (~14 per class) with complete data.

The exclusion criteria for the interventional study will be the following:
- Failure to sign informed consent
- Will not be in town and available for the full duration of the study (e.g., 2 or more weeks of vacation or absence)
- Physical inability to perform the exercise intervention (including health indications)

At study enrollment, all participants will complete the same REDCap survey as mentioned in the cross-sectional component of the study (see supplemental materials for all questions). Each person will receive a wearable activity tracker that automatically continuously collects heart rate, sleep, and activity (number of steps, calories burned, etc.). If the participant already has a smart watch, they will be asked to either also wear the study wearable activity tracker or instead wear it during the study period (note that depending on the type of smart watch they already use, we may be able to use that for the study instead of our specified study device). Participants will be expected to wear their wearable activity tracker at all times for the duration of the study except when it needs to be charged (for about 2 hours once every 4-5 days) or if they are swimming or showering.

Prior to starting the study, the PI will meet with each participant, discuss the study objectives, obtain informed consent, collect the baseline survey data, provide an in-service on the use of the wearable activity tracker (including charging and data downloading), and design a personalized exercise intervention plan. Using the wearable activity tracker, the participant and PI will assure that the individual exercise regimens can effectively achieve the target heart rates. This will also allow the PI to obtain identified activity profiles for each exercise regimen the participant plans to use during the study. Additionally, height and weight measurements will be obtained at this time as well.

The intervention will be a 15-minutes per day of vigorous exercise as monitored by a heart rate monitor. Participants will be expected to exercise at least 5 days each week, in addition to (i.e. independent of) any exercise in which the participant regularly engages. During the 15-minute exercise intervention, participants will be expected to maintain a heart rate of at least 70% of their maximum heart rate (70% of (220 – age)) – this is also known as the "cardio zone" as depicted on the wearable activity tracker.

| Age | Max HR (beats/min) | Goal HR (70% of max HR) |
|---|---|---|
| 24 | 196 | 137 |
| 25 | 195 | 137 |
| 26 | 194 | 136 |
| 27 | 193 | 135 |
| 28 | 192 | 134 |
| 29 | 191 | 134 |
| 30 | 190 | 133 |
| 31 | 189 | 132 |
| 32 | 188 | 132 |
| 33 | 187 | 131 |
| 34 | 186 | 130 |
| 35 | 185 | 130 |
| 36 | 184 | 129 |

The wearable activity tracker provides a reliable method of tracking adherence to the exercise intervention; the PI and resident researchers will screen the data files to identify 15-minutes of sustained heart rates of greater than or equal to 70% of the participant's maximum heart rate. Each participant will be given several equivalent exercise options to assure that they have clear guidance as to how to attain their personal heart rate goals regardless of their clinical assignments and daily workload.

Examples of possible 15-minute exercise regimens to be used by individuals during the intervention phase include:

- Walking quickly or running up and down stairs (e.g., in the hospital during call shifts)
- Plyometric exercises such as jumping jacks, high knees, squats, lunges, speed skaters, froggers, etc.

- Walking up an incline on a treadmill
- Jogging or running on a treadmill or elliptical
- Stationary cycling or rowing

At the end of each week of the study, participants will be prompted via email or text to complete a short online questionnaire (via REDCap) regarding their current rotation, hours worked over the past week, and self-assessments of stress and fatigue over the past week. If a survey is not completed within 24 hours, a reminder email or text will be sent to the participant. Wearable activity tracker data will also be captured and evaluated each *week* to confirm adherence to the protocol and to troubleshoot any issues related to the activity tracker.

At the end of each 4-week block (i.e. at the end of each monthly clinical rotation), participants will be prompted to complete an online REDCap survey containing the weekly survey data as well as a MBI-HSS, Perceived Stress Scale (PSS), Epworth Sleepiness scale, and number of weekend days worked (in house or home call). This will yield 5 sets of scores per participant (baseline plus 4 post-rotation samples). As with the weekly REDCap surveys, if a survey is not completed within 24 hours, a reminder email or text will be sent to the participant.

At the end of each 8-week block, participants' weight will be obtained.

At the completion of the study, the number of weekends worked will be extracted from OpenTempo. Additionally, all participants will be asked in the terminal REDCap survey if they intend to continue an exercise regimen after the study based on their experience during the study.

In addition to the baseline demographic survey, the following table is a visual representation of the data collection plan throughout the study.

| | **Baseline** | **Weekly** | **Week 4** | **Week 8** | **Week 12** | **Week 16** |
|---|---|---|---|---|---|---|
| *Maslach burnout inventory (MBI-HSS)* | X | | X | X | X | X |
| *Perceived Stress Scale* | X | | X | X | X | X |
| *Epworth Sleepiness Scale* | X | | X | X | X | X |
| *Social support and personal coping (SSPC-14)* | X | | | | | X |
| *Visual analog scale (stress / fatigue)* | | X | | | | |
| *Self-reported hours* | | X | | | | |
| *Activity tracker data reports* | | X | | | | |
| *OpenTempo follow-up* | | | | | | X |
| *Weight assessment* | X | | | X | | X |
| | | | | | | |

The following scales will be used in this study.

1. Maslach Burnout Inventory – Human Services Study (MBI-HSS) is the gold standard for measuring job burnout in persons working in human services and health care.[7] The MBI-HSS consists of 22 questions in complete sentences scored on a 7-point Likert scale that are

specifically geared for subjects who work in human service professions. The MBI-HSS will be administered every 4 weeks for total of 5 set of scores per participant.

2. "Perceived Stress Scale (PSS) is the most widely used psychological instrument for measuring the perception of stress."[15] It is a 10 question survey scored on a 5-point Likert scale. Higher PSS scores have been associated with failure to quit smoking, controlling blood glucose levels in diabetics, etc. The questions are geared to assessing an individual's feelings over the past month. The PSS will be administered every 4 weeks.
3. Visual analog scale is widely used to assess perceived stress and has been shown to correlate the perceived stress scale.[16] A similar scale has been used to assess fatigue and correlates with more complex fatigue measures such as the fibromyalgia impact questionnaire (FIQ) and has been shown to be valid as an endpoint measure in Fibromyalgia clinical trials.[17] Similarly, a unidimensional 0-100-point scale will be used assess fatigue and stress on a weekly basis.
4. Social support and personal coping (SSPC-14): The SSPC-14 was developed by Hyman et al and used in prior studies with the purpose of evaluating an individual's coping strategies and social support system.[8] Each question is scored with a 9-point scoring system where, for most questions, a higher score represents better coping/ support.
5. Epworth sleepiness scale (ESS): The ESS is an 8-question survey scored on a 4-point Likert scale designed to assess average sleep propensity. The scale does not specify a recall period, but is instead intended to cover a time span of weeks – months rather than a few hours or days.[18]

Risks to participants

The risks to participants are minimal. All participants' study data will be de-identified, to the extent possible, after data collection to protect participant confidentiality and privacy. Identifying information will be maintained in a separate database from the study data.

For the cross-sectional survey, there are minimal risks to participants as all data will be de-identified. For the interventional part of the study, they will be asked to participate in cardiovascular activity that will maintain their heart rate at 70% of their max heart rate (220-age) for 15 minutes, 5 times a week. The PI will meet with each participant to ensure they are able to do this safely. If the participant is unable to do this safely, they will be excluded from the study. The intended participants are generally healthy individuals who will be able to participate in cardiovascular activity and maintain a heart rate of greater than 70% of their maximum heart rate for 15 minutes or greater. This amount of activity is recommended by the U.S. government Office of Disease Prevention and Health promotion.

Data and safety monitoring plan:

The PI and the study team will continuously monitor participant progress and safety issues throughout the study and be available to answer any questions throughout the study. To ensure participants' safety and data integrity, the PI and key members of the research members of the study team will meet regularly (e.g. at least once a month, if not more frequently) to review and discuss the data and any potential issues or challenges related to the study.

Adverse Events

Adverse research events (i.e., those affecting subject or others due to the conduct of this research), should they occur, will be immediately reported, as appropriate, to Occupational Health and the IRB.

**Statistical Analysis and Power:**

**Aim 1**: The degree of burnout among residents will be quantified using baseline MBI measurements. Summaries of the total MBI score and each component score will be made using the median and inter-quartile range, and these summaries will be stratified according to baseline demographics and other characteristics (e.g., residency class). We will then use multiple regression methods to quantify the adjusted associations between these factors and the total and component MBI scores. In regression analyses, all quantitative covariates will be modeled using restricted cubic splines with up to four knots. Multiple-degree-of-freedom tests will be used to quantify the variability explained by nonlinear terms. In the absence of strong evidence of nonlinearity, these terms will be excluded from the model. No interactions will be considered. Model assumptions will be checked using graphical and quantitative regression diagnostics, and alternative model formulations or data transformations will be considered as necessary. The adjusted associations between covariates and outcomes will be summarized using an estimate, 95% confidence interval, and Wald-type significance test at the 5% level. For quantitative covariates with nonlinear associations, graphical methods will be used to summarize these associations.

**Aim 2**: The effect of intervention on the change in the degree of burnout across study phases (as measured by the total MBI scores and component scores) and other outcomes will be quantified using mixed-effects regression methods. For these analyses, we will use the difference scores as the primary outcome (e.g., $MBI_{post} - MBI_{pre}$), such that each participant will contribute two outcome measurements. These measurements will be regressed onto the treatment/control indicator variable, the indicator for crossover order (i.e., 0 if control-then-treatment, 1 if treatment-then-control), as well as baseline covariates, which will be modeled in a manner similar to that described for the Aim 1 analyses. We will additionally use a random intercept, indexed by study participant, to model the within-participant correlation among repeated measures. The effect of intervention will be quantified using an estimate, 95% confidence interval, and Wald-type significance test at the 5% level.

For all primary analyses, we will adhere to intent-to-treat principles. Thus, all available data will be used in primary analyses regardless of participant dropout or adherence to study protocols. We will conduct two sets of secondary analyses, including per-protocol analysis using only those participant records that were in compliance with the study protocol, and by substituting the treatment/control indicator variable for a variable that quantifies the total amount of exercise time associated with the study intervention.

In the event that substantial missingness (>10%) occurs in one or more covariates, we will use the chained-equations multiple imputation method, and Rubin's rules to account for this added uncertainty.
The statistical power associated with the Aim 2 analyses was approximated using methods based on the paired t-test, for which the power is affected by the within-participant variability in MBI score. We assume that this variability is small relative to the variability between participants. Specifically, we assume that the MBI total score standard deviation is approximately 7 points, which is roughly half of the between-participants variability observed in previous studies. Under these assumptions, the proposed study size of 40 participants renders 80% power to detect a 3-point change in the average MBI difference-score across study phases. This effect size equates to a 10% change in the typical MBI total score in prior studies of healthcare professionals.

**Participant Incentives and Inducements**

Participants in the interventional study will be compensated for their time and effort. All residents who complete the study will receive a $25 gift card upon their successful completion of *each* 8-week block ($50 total per participant). In addition, each resident who completes the entire study successfully will be entered into a raffle for a $250 gift card organized by residency class (one each for the intern, CA-1, and CA-2 classes). Based on prior studies involving anesthesia resident participants, this level of compensation should be sufficient to induce enrollment and on-going active participation without being coercive.

The study will have a website to permit the investigators to disseminate information to participants, to support participants' issues and concerns, and to enhance participant adherence to the data collection and exercise intervention regimens. In addition, the PI will contact each participant every week to make sure they are 'on track', to assure capture of data from their wearable activity monitor, and to answer any questions or address any concerns. All interaction with the study and its personnel will be completely voluntary and escapable. The study will not affect the residents' patient care duties or their standing in the training program.

**Timeline**

After receiving IRB approval, participants will be consented and enrolled. Study set-up will occur in the two weeks prior to the first study rotation. Set up will include collection of baseline data, distributing and configuring the wearable activity trackers and associated apps, and establishing each participant's preferred exercise regimen. Each participant's data collection will then occur over the next 16 weeks. Data analysis and manuscript preparation is expected require an additional 12 weeks.

**Dissemination Plan**

The results of the study will be presented at a national conference (most likely at IARS or ASA depending on timing). A peer-reviewed journal publication will contain the primary outcome data (i.e., changes in the Maslach burnout inventory scores with and without the exercise intervention). It is anticipated that this manuscript will be prepared and ready for publication during the summer of 2018.

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