A MULTIFACTORIAL APPROACH FOR IMPROVING THE SURGICAL PERFORMANCE OF NOVICE VITREORETINAL SURGEONS

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Purpose: To quantitatively analyze and compare the novice vitreoretinal surgeons' performance after various types of external exposures.

Methods: This prospective, self-controlled, cross-sectional study included 15 vitreoretinal fellows with less than 2 years of experience. Surgical performance was assessed using the Eyesi simulator after each exposure: Day 1, placebo, 2.5, and 5 mg/kg caffeine; Day 2, placebo, 0.2, and 0.6 mg/kg propranolol; Day 3, baseline simulation, breathalyzer reading of 0.06% to 0.10% and 0.11% to 0.15% blood alcohol concentration; Day 4, baseline simulation, push-up sets with 50% and 85% repetition maximum; Day 5, 3-hour sleep deprivation. Eyesi-generated total scores were the main outcome measured (0–700, worst to best).

Results: Performances worsened after increasing alcohol exposure based on the total score (χ^2 = 7; degrees of freedom = 2; P = 0.03). Blood alcohol concentration 0.06% to 0.10% and 0.11% to 0.15% was associated with diminished performance compared with improvements after propranolol 0.6 and 0.2 mg/kg, respectively ($\Delta 1 = -22$ vs. $\Delta 2 = +13$; P = 0.02; $\Delta 1 = -43$ vs. $\Delta 2 = +23$; P = 0.01). Propranolol 0.6 mg/kg was positively associated with the total score, compared with deterioration after 2.5 mg/kg caffeine ($\Delta 1 = +7$ vs. $\Delta 2 = -13$; P = 0.03).

Conclusion: Surgical performance diminished dose dependently after alcohol. Caffeine 2.5 mg/kg was negatively associated with dexterity, and performance improved after 0.2 mg/kg propranolol. No changes occurred after short-term exercise or acute 3-hour sleep deprivation.

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Transformational advances in vitrectomy tools and microsurgical systems have expanded the indications for vitrectomy, enhanced surgeon capabilities, and improved patient outcomes. Despite these advances, vitrectomy and the microsurgical maneuvers enabled by vitrectomy remain among the most challenging to master, and notably, the surgical performance of inexperienced surgeons may vary, affecting their early surgical outcomes. The steep learning curve associated with vitrectomy results from many factors, including those that are modifiable and those considered essentially unmodifiable. Low-hand tremor and high dexterity are examples of advantageous traits that are modifiable only minimally through surgical teaching and are considered to some extent limited by innate physiologic capabilities.[1,2] The end result of optimizing each factor is presumed to be net enhancement of microsurgical effectiveness and performance.

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The current study examined five common external factors that may be associated with the microsurgeon's performance, including caffeine, β-blockers, sleep deprivation, physical exercise, and alcohol.[3–5] Avoiding alcohol and caffeine intake, sleep deprivation, and physical exercise in the hours before performing a procedure may facilitate better surgical performance. However, β-blockade reduces the effects of endogenous catecholamines, minimizing stress and anxiety, and it may be beneficial.[6] Virtual reality platforms,[7] wet and dry laboratory models,[7] and the Ophthalmology Surgical Competency Assessment Rubric for Vitrectomy created by the International Council of Ophthalmology[8] are some of the available tools to assess surgical vitreoretinal skills. Our group previously validated the method of quantitatively evaluating surgical performance using the Eyesi virtual reality surgical simulator parameters (VRmagic, Mannheim, Germany) for propranolol and caffeine.[5] The methods were sufficiently sensitive to detect significant dose-dependent differences in surgeon's performance.[5] The current study applies these methods to multiple surgeon variables that were previously unstudied, potentially significant, and modifiable.

Materials and Methods

Study Population

The Ethics Committee in Research of the Federal University of São Paulo, Brazil, approved this prospective, self-controlled, cross-sectional study, which adhered to the tenets of the Helsinki Declaration. All subjects were recruited and informed about the research protocol, and each volunteer provided prospective written informed consent. Fifteen vitreoretinal fellows with less than 2 years of surgical experience were selected from the Retina Division of the Federal University of São Paulo from September 2018 to March 2020. The exclusion criteria were usual daily caffeine consumption of more than two 8-ounce cups; daily alcohol intake greater than three standard drinks[9]; less than 2 hours of previous surgical experience with the Eyesi simulator; or any medical history that required long-term medication use that would interact with the test agents, such as bronchial asthma, nervous or cardiac conditions, or mental illnesses. Before entry into the research protocol, each subject underwent an electrocardiogram and ingested an oral dose of 0.6 mg/kg propranolol to test for adverse reaction.

Study Protocol

The posterior-segment module of the Eyesi virtual reality simulator software, Version 3.4.2, was used to analyze surgical performance. We set a fixed sequence of seven simulator tasks to be repeated throughout the study with a maximal potential score of 700 (Figure 1). The main outcomes evaluated were the Eyesi generated total score (0–700, worst to best), total time to task completion (minutes), surgical tool-tip intraocular pathway (millimeters), and tremor-specific task score (0–100, worst to best). Figure 2 summarizes the study flowchart for the 5 days of analysis. Before and after each external exposure, the systemic blood pressure and heart rate were measured, followed by recorded and scored simulated surgical performance analysis.

To ensure a single-blinded study for placebo, propranolol, and caffeine intake, we used visually identical pills containing one of the three substances, such that they were indistinguishable by the participating surgeon. Each pill contained low unit doses of caffeine or propranolol, allowing weight-adjusted dosing. For alcohol, we used a calibrated Food and Drug Administration–approved AT6000 Professional Breathalyzer (Greenwon Technology Co, Ltd, Taiwan) to estimate the blood alcohol concentration (BAC), assuming a blood:breath ratio of 2,300:1.[10]

Sleep-deprived nights were analyzed using Somnologica polysomonography software, Version 3.2 (Embla Co, Broomfield, CO). A 3-hour period was prospectively determined to be the time in bed of sleep deprivation during the previous 24-hour period.[11] The entire night was recorded polysomnographically, and the surgical simulations were performed the next morning at 7 AM and then were compared with the average baseline simulation, which was calculated as the mean baseline performance for Days 1 to 4.

It is noteworthy that alcohol intake was guided prospectively by applications of the Widmark model[12] to calculate the BAC and that a safe place in the laboratory was provided for the participants to rest after this protocol day; the participants were permitted to leave only after regaining sobriety. Finally, to avoid bias, the number of push-up repetitions to be performed by each individual was not fixed in the exercise protocol but tailored to each participant using a single sequence of push-ups that counted the repetition maximum (RM)[13] number that each participant was able to perform. The individual RM was established previously in a supervised session that occurred more than 1 week before the exercise protocol. Participants performed a baseline surgical simulation followed by four push-up sets at 2-minute intervals with a load of 50 or 85% of the RM.

Statistical Analysis

The sample size calculation was prospectively performed using PASS 14 (NCSS Statistical Software,

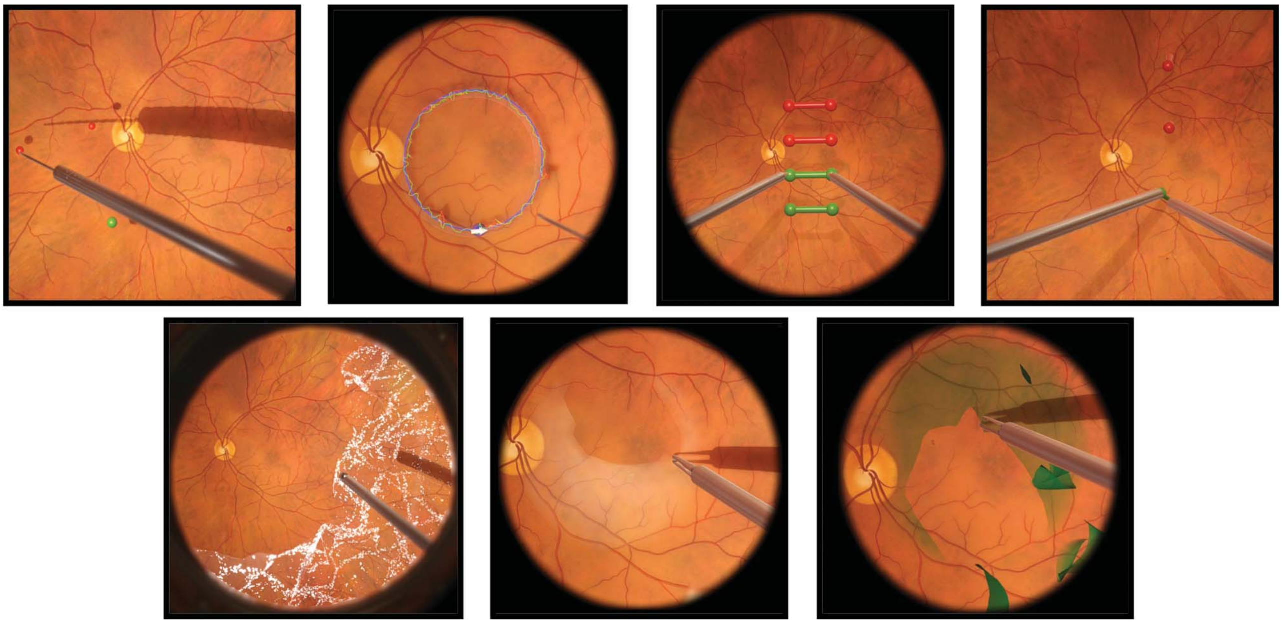

Fig. 1. Illustration of modules. The surgical simulation sequence consists of four basic modules (upper row, navigation exercise, antitremor maneuver, bimanual dumbbell touching, and bimanual cutting task, respectively) and three reality-based modules (lower row, posterior hyoid detachment, epiretinal membrane peeling, and inner limiting membrane peeling, respectively). Dr. Roizenblatt generated this figure using the Eyesi platform.

Kaysville, UT), and the data were analyzed by repeated-measures analysis of variance with the Geisser-Greenhouse–corrected F test. A sample size of 15 participants provided 85% statistical power to detect the following differences in the Eyesi-generated total score compared with the baseline surgical simulation performance: 25 points for caffeine, 20 points for propranolol, 40 points for upper limb exercise, 40 points for alcohol, and 10 points for sleep deprivation. Further statistical analyses were conducted using STATA Version 12.0 (Stata Corporation, TX) and SPSS version 20.0 (SPSS Inc, Chicago, IL). The demographic data were expressed as the mean ± SD and performance values as the median (interquartile range: 25th and 75th percentiles).

Nonparametric procedures were used to analyze the performance data: the Wilcoxon test for paired comparisons and the Friedman test with the Dunn–Bonferroni post hoc test for multiple comparisons. Because a paired analysis was conducted, the median delta was calculated as the median of the performance data after each external exposure minus the baseline performance (median [exposure−baseline]) and not as the difference between the medians (median [exposure]−median [baseline]). On Day 1 and Day 2 of the study, the baseline surgical performance was established as the simulation after the ingestion of single-blinded placebo pills. The tests were 2 sided, and P values of <0.05 were considered significant.

Results

Fifteen right-handed vitreoretinal surgeons (60% men; mean age, 29.6 ± 1.4 years; mean body mass index, 23.15 ± 2.9 kg/m^2) with fewer than 2 years of experience were recruited. Among the 15 participants, four subjects did not undergo the sleep study protocol as they moved during the study period and one subject did not perform the exercise protocol because of the inability to perform push-ups. The systemic blood pressure and heart rate values were always equal to or above 120/80 mmHg and 60 beats/minute, respectively, and no adverse side effects were observed by the test subjects after exposure to the physiologic or pharmacologic agents.

Alcohol intake was the only factor found to be independently associated with a change in the surgical simulated performance, such that deteriorated hand dexterity was observed in a progressive dose-dependent manner as measured by the total Eyesi-generated score ($\chi^2 = 7$, degrees of freedom [df] = 2; $P = 0.03$) and intraocular trajectory ($\chi^2 = 6.86$; df = 2; $P = 0.03$). Tremors increased with BAC of 0.06% to 0.10% and additional alcohol intake, resulting in BAC of 0.11% to 0.15% that was negatively associated with the total simulated score, compared with baseline. Regarding propranolol, the intraocular trajectory was shorter after a 0.2 mg/kg dose, and the total time to task completion was shorter after a 0.6 mg/kg dose. Although 2.5 mg/kg caffeine was associated

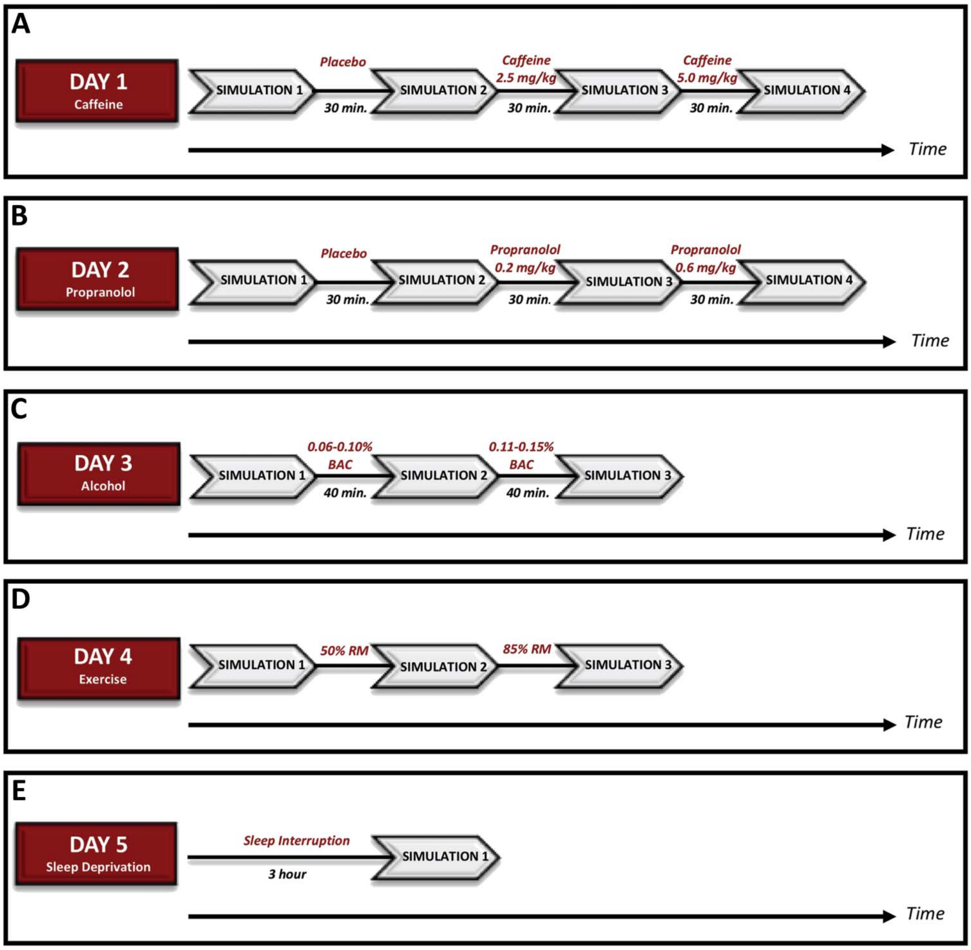

Fig. 2. Study flowchart of external interventions. **A.** Day 1, caffeine exposure; (**B**) Day 2, propranolol exposure; (**C**) Day 3, alcohol intake; (**D**) Day 4, short-term upper limb exercise, push-ups; and (**E**) Day 5, sleep deprivation with a total sleep time of 3 hours.

with decreased intraocular trajectory, this exposure did not significantly affect the total surgical score, and there was no improvement in trajectory after intake of 5.0 mg/kg of caffeine (Table 1).

When the effects of alcohol and propranolol were compared, both BAC of 0.06% to 0.10% and 0.11% to 0.15% were associated with worst performance. This was compared with the improved performance after the 0.6 and 0.2 mg/kg doses of propranolol regarding the total score, antitremor task score, and task completion time. Moreover, the intraocular trajectory was longer after the BAC of 0.11% to 0.15% compared with the 0.2 mg/kg propranolol. Although 2.5 mg/kg of caffeine was associated with reductions in the task completion time and the intraocular trajectory compared with the BAC of 0.11% to 0.15%, the total score after caffeine ingestion was decreased compared with baseline. The 2.5-mg/kg caffeine dose was associated with a worse total score compared with the improvement after the 0.6-mg/kg dose of propranolol (Table 2). The exercise and sleep regimens did not produce any significant changes in the quantifiable surgical performance parameters studied. The median delta values of performance after each external exposure for the total surgical score, tremor-specific task score, intraocular trajectory, and total time to task completion are presented in Figure 3.

Discussion

To put the doses used in this study into perspective, the 2.5-mg/kg caffeine dose corresponds to about one 25-mL cup of espresso[14] or one 8-ounce cup of drip or percolated coffee[15,16] for a person weighing 70 kg and represents the regular coffee intake among caffeine consumers in the United States. The 5.0-mg/kg caffeine dose represents the 90th percentile intake for all caffeinated beverages for all ages in the United States.[17] Regarding propranolol, the doses recommended to treat benign tremors range from 1.7 to 3.4 mg/kg[18] and for systemic hypertension, it ranges from 0.8 to 9.1 mg/kg[19] for a person weighing 70 kg. The most frequently assessed and published β-blocker on

Table 1. Median Comparison of Performance Data Between Different Levels of the Same Exposure With Corresponding *P* Values

	Baseline	After Exposure	*P**
Alcohol			
Score			
Baseline versus 0.11%–0.15% BAC	596.5 (562.0–617.2)	537.5 (459.5–585.7)	0.02
Tremor-specific score			
Baseline versus 0.06%–0.10% BAC	68.5 (46.0–80.7)	54.0 (42.00–63.2)	0.04
Baseline versus 0.11%–0.15% BAC	68.5 (46.0–80.7)	52.5 (36.50–63.2)	0.03
Propranolol			
Time (min)			
Baseline versus 0.6 mg/kg propranolol	13.53 (12.23–15.02)	12.29 (10.62–13.10)	0.006
Intraocular trajectory (mm)			
Baseline versus 0.2 mg/kg propranolol	2,224.0 (2,033.2–2,570.1)	2,080.7 (1,895.7–2,360.8)	0.03
Caffeine			
Intraocular trajectory (mm)			
Baseline versus 2.5 mg/kg caffeine	2,390.7 (2,069.6–2,842.6)	2,298.6 (2,033.5–2,552.6)	0.02

The data are expressed as the median (interquartile range).
*Wilcoxon signed-ranks test.
Min, minutes; mm, millimeters.

manual dexterity is propranolol at fixed doses of 10 mg[6,20] and 40 mg.[21] Regarding an average male adult weighing 70 kg, we established the approximate doses of 0.2 mg/kg and 0.6 mg/kg of propranolol as the weight-adjusted propranolol doses used in the current study. Finally, BAC of 0.06% to 0.10% BAC were achieved after intake of two large glasses of wine (250 mL/glass) by a 1.8-m, 70-kg, 30-year-old man, independent of the subject's alcohol history because the Widmark equation also can be used for alcoholics with a low error.[12,22]

The results of the current study showed that simulated surgical performance was negatively associated with alcohol intake in a dose-dependent way. In comparison, performance impairment after two large glasses of wine was greater than after ingestion of two 25-mL cups of espresso, the previous night's 3-hour sleep restriction, or four push-up sets with 85% RM for a 70-kg vitreoretinal surgeon with less than 2 years of surgical experience. Furthermore, although propranolol was associated with a faster procedure and shorter intraocular pathway, a significant change in overall simulated performance with propranolol intake was detected only compared with alcohol use (greater difference) or caffeine use (lower difference) with this number of study participants.

The relative risk of a vehicle collision attributed to a nondrinker increases dramatically starting at a BAC of 0.10%.[23] Based on these data, beginning in 2002, all US states reduced the legal BAC limit to operate a vehicle from 0.10% to 0.08%.[23] When analyzing the relationship between BAC and reported physiologic and behavioral effects, the impact of BAC ranging from 0.01% to 0.05% might not be obvious by casual observation. However, BAC of 0.06% to 0.10% is often correlated with impaired coordination, decreased attention/alertness, and reduced ability to make rational decisions. Also, BAC of 0.11% to 0.15% may be associated with judgment loss, slowed reactions, some visual function impairment, and drowsiness.[22] Based on these values, our surgical simulations were performed with BAC ranging from 0.06% to 0.10% and 0.11% to 0.15%. The Widmark modeling formula[12] was applied prospectively to estimate the BAC, with the constant calculated using the average of the approaches presented by Forrest[24] and Seidl et al.[25] A final titration with additional alcohol intake or increased time before the surgical simulation test was applied whenever necessary to reach the target BAC ranges. It is important to emphasize that the effect of blood alcohol on surgical judgment, critical thinking, risk-taking behavior, and other potentially affected cognitive factors was not assessed by the Eyesi surgical simulator.

Although the negative effects of acute alcohol intoxication of decreased cognitive function and motor skills have been well documented, to the best of our knowledge, no available studies have reported the impact on vitreoretinal surgical skills. The correlation between the BAC levels and the numerically quantified surgical performance presented in the current article is innovative and has not been reported previously. The correlation between the BAC levels and the time since the first drink can be calculated using the Widmark formula. Using that formula, the time for reaching 0.06% to 0.10% BAC in the elimination periods of alcohol metabolism also represents the

Table 2. Comparison of the Median Delta of Performance Data Between Different Exposures, With Corresponding *P* Values

	Exposure 1	Exposure 2	*P**
Alcohol versus propranolol			
Score			
0.11%–0.15% BAC versus 0.2 mg/kg propranolol	−43.0 (−120.5 to −5.7)	+23.0 (−29.0 to +54.0)	0.01
0.06%–0.10% BAC versus 0.6 mg/kg propranolol	−22.0 (−62.0 to +16.5)	+13.0 (−12.0 to +49.0)	0.02
0.11%–0.15% BAC versus 0.6 mg/kg propranolol	−43.0 (−120.5 to −5.7)	+13.0 (−12.0 to +49.0)	0.007
Time (min)			
0.11%–0.15% BAC versus 0.2 mg/kg propranolol	+0.46 (−0.52 to +2.91)	−0.83 (−2.76 to +0.94)	0.009
0.06%–0.10% BAC versus 0.6 mg/kg propranolol	−0.05 (−0.78 to +0.84)	−1.35 (−2.94 to −0.51)	0.005
0.11%–0.15% BAC versus 0.6 mg/kg propranolol	+0.46 (−0.52 to 2.91)	−1.35 (−2.94 to −0.51)	0.01
Intraocular trajectory (mm)			
0.11%–0.15% BAC versus 0.2 mg/kg propranolol	+204.8 (−25.5 to +338.8)	−221.7 (−374.9 to +93.1)	0.006
Tremor-specific score			
0.11%–0.15% BAC versus 0.2 mg/kg propranolol	−15.0 (−26.2 to +1.25)	+8.0 (−11.0 to +25.0)	0.009
0.06%–0.10% BAC versus 0.6 mg/kg propranolol	−7.5 (−19.0 to +2.7)	+5.0 (−14.0 to +20.0)	0.008
Alcohol versus caffeine			
Time (min)			
0.11%–0.15% BAC versus 2.5 mg/kg caffeine	+0.46 (−0.52 to +2.91)	−0.71 (−1.82 to +0.77)	0.009
Intraocular trajectory (mm)			
0.11%–0.15% BAC versus 2.5 mg/kg caffeine	+204.8 (−25.5 to +338.8)	−78.7 (−185.1 to +33.23)	0.008
Caffeine versus propranolol			
Score			
2.5 mg/kg caffeine versus 0.6 mg/kg propranolol	−13.0 (49.0 to +12.0)	+7.0 (−17.0 to +64.0)	0.03

The data are expressed as the median delta (interquartile range).
*Wilcoxon signed-ranks test.
Min, minutes (min); mm, millimeters.

minimal time for the alcohol effect to be cleared systemically and not affect the surgical dexterity.

When determining surgical dexterity after alcohol intake compared with sleep deprivation, the literature shows poorer performance on a laparoscopic surgical simulator with alcohol,[26] which agreed with our findings for vitreoretinal microsurgery. These results support the necessity to define professional regulations regarding alcohol consumption and surgical responsibilities. There are currently no defined criteria for acceptable intraoperative blood alcohol levels, short of no observable evidence of intoxication.

The present findings indicated that a 2.5-mg/kg caffeine dose was associated with a shorter intraocular tool travel path and tended to reduce the task completion time, but this caffeine-induced increase in motor speed was commensurately associated with a worst performance score. The faster physical performance and shorter reaction times after caffeine consumption are potentially offset by anxiety, tremor, and others. All of the cognitive and motor effects of caffeine remain to be defined during microsurgery. Of note, the caffeine effects are partially attenuated by tolerance.[27] To obtain a homogenous study population and avoid bias as a result of personal caffeine tolerance or withdrawal, we excluded individuals with a daily caffeine consumption of more than two 8-ounce cups or alcohol intake greater than three standard drinks. The detrimental effect of a 2.5-mg/kg caffeine on fine dexterity compared with a 0.6-mg/kg propranolol agrees with our previous study that showed that caffeine is negatively associated with surgical performance in novice vitreoretinal surgeons and that the outcome is partially neutralized by propranolol.[5]

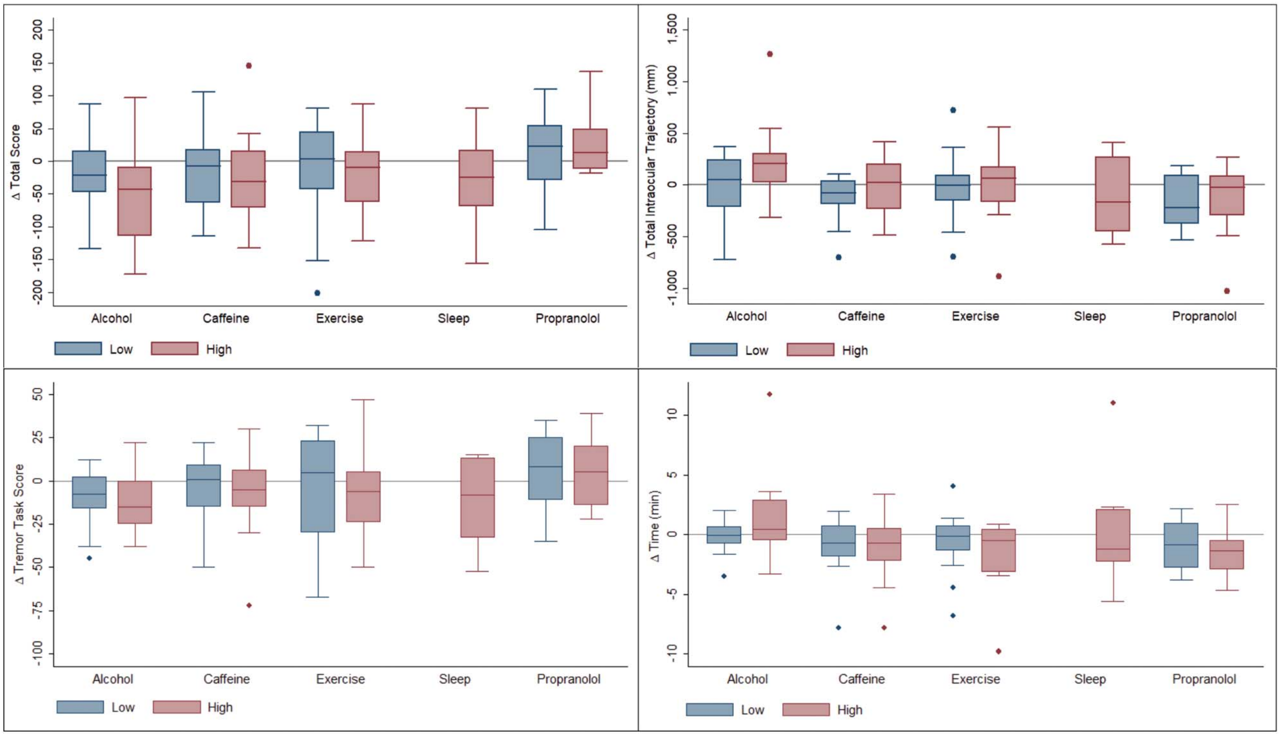

Fig. 3. The boxplots show the median delta of performance after each external exposure for the total surgical score, tremor-specific task score, intraocular trajectory, and total time to task completion. The length and position of each box represent the interquartile range of the data and the horizontal line across indicates the median delta.

Propranolol has been used clinically to reduce anxiety-related and tremor-related disorders.[18] Intraoperatively, these sympathetic responses may jeopardize a surgeon's performance when a complex task is underway. Among the most frequent adverse effects associated with propranolol are hypotension, bradycardia, bronchospasm, fatigue, nausea, and sexual dysfunction.[28] Contraindications include asthma, chronic obstructive pulmonary disease, and atrioventricular block. Adverse effects related to propranolol are dose dependent, and low-dose therapy is rarely associated with severe adverse reactions.[29] No side effects related to low-dose propranolol were reported in this study.

Our results showed that propranolol was positively associated with hand dexterity and with decreased intraocular trajectory and surgical simulation completion time. This improvement was even more evident when propranolol was compared with caffeine or alcohol use. In the last comparison, even a 0.2-mg/kg dose of propranolol was positively associated with performance. β-Blockers are associated with a longer reaction time; however, the total time to finish the course was shorter compared with the participant's baseline surgical simulation. The present findings suggested that the improved surgical performance following propranolol agreed with previous reports.[6,20,21] However, the weight-adjusted and quantitative comparison of propranolol versus alcohol, caffeine, exercise, and sleep deprivation is innovative in the vitreoretinal literature and potentially relevant to surgeon performance.

Intense exercise in the form of push-ups with a loading dose of 85% RM and sleep deprivation in the form of acute sleep interruption did not significantly modify the simulated surgical performance. Push-ups were chosen as a suitable exercise modality for this protocol because the exercise allowed a weight adjustment ("dosing") similar to that for caffeine, propranolol, and alcohol exposures. The current exercise protocol was adapted from the methodology of Gajewski,[13] who reported increased tremor amplitude after four sets of bilateral elbow flexion/extension with a barbell with a training load of 85% RM. Tremor was not distributed equally along the frequency domain, such that the greatest increases were found for rather low frequencies (from 2 to 4 Hz) and high frequencies (from 10 to 20 Hz). Interestingly, surgeon physiologic hand tremor has approximately rhythmic and sinusoidal frequencies predominantly in the six- to 12-Hz range.[30] Therefore, the difference in frequencies analyzed was consistent with the divergent results obtained here.

Regarding sleep deprivation, our finding agreed with those of Erie et al,[31] who concluded that acute sleep deprivation in nine post-call and sleep-deprived (<3 hours sleep in previous 24 hours) ophthalmology residents had no detectable effect on the simulated surgical performance measured using the Eyesi surgical simulator. Likewise, Govindarajan et al[32] conducted a population-based study that analyzed the surgical outcomes of 1,448 physicians during a daytime procedure after treating patients from midnight to 7 AM or by the same doctors when stopping patient care at midnight. They found no differences in deaths, readmissions, or complications. Therefore, although it is intuitive that acute sleep deprivation impairs vigilance, alertness, and neurocognitive processes, the current evidence does not yet provide compelling grounds for drawing consistent conclusions about a quantifiable impact on surgical outcomes.

A strength of the current study is that it was a prospective, self-controlled analysis that quantitatively compared the association of caffeine, propranolol, alcohol, physical exercise, and sleep deprivation with simulated surgical performance in a homogeneous sample of novice vitreoretinal surgeons. In addition, all tested factors were based on a weight-adjusted protocol, and caffeine and propranolol administration was single blinded. Finally, sleep deprivation in this protocol was recorded objectively by polysomnography.

The study limitations were that some isolated exposures trended toward progressive impairment in the overall simulated score in a dose-dependent manner, which did not reach significance in this sample, even though our study was theoretically powered to detect changes in the surgical simulated performance. Second, the current findings were restricted to a novice vitreoretinal surgeon population, and further studies should be conducted to determine their applicability to experienced surgeons. Third, no published evidence supports transfer of the Eyesi-generated scores to the operating room with consequent direct changes in patient anatomic and functional outcomes. Therefore, our findings are not considered recommendations for novice surgeons to incorporate into their clinical routines but rather emerging information on potential factors that may allow surgeons to favorably modify performance factors during microsurgery. It is worth mentioning that it is challenging to evaluate the novice surgeon's anxiety level as a variable. Differences between simulator testing and actual surgery, as well as differences in the effect of various supervising faculty on an individual trainee, are highly variable. No simultaneous or immediately sequential exposure to multiple investigational factors was conducted in this study.

In conclusion, alcohol consumption in the hours before a surgical procedure was the only external exposure analyzed that was associated directly with compromised performance in a dose-dependent manner among novice vitreoretinal surgeons. The potentially beneficial propranolol association with surgical fine dexterity was evident when compared with impairment after caffeine/alcohol consumption. There was also no change in the simulated surgical performance after 1 night of 3-hour sleep or after a short session of upper limb physical exercise. The current data should be considered when making recommendations that guide novice vitreoretinal surgeons in optimizing microsurgical performance.

Key words: alcohol, caffeine, novice surgeon, pars plana vitrectomy, physical exercise, propranolol, sleep deprivation, surgical performance.

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