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The Effect of Operating Room Temperature on the Performance of Clinical and Cognitive Tasks

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ABSTRACT

Introduction: Operating room (OR) temperature may impact the performance of health care providers. This study assesses whether hot or cold room temperature diminishes the performance of OR personnel measured by psychomotor vigilance testing (PVT) and self-report scales. **Methods:** This prospective observational study enrolled surgical/anesthesia trainees, student registered nurse anesthetists, and certified registered nurse anesthetists. Each provider participated in a test of psychomotor function and a questionnaire using a self-report scale of personal comfort and well-being. The PVT and questionnaires were completed after 30 minutes of exposure to 3 different conditions (temperature of 21°C, 23°C, and 26°C). **Results:** The cohort of 22 personnel included 9 certified registered nurse anesthetists, 7 anesthesia/surgical trainees, and 6 student registered nurse anesthetists. Mean reaction time on the PVT was comparable among baseline (280 ± 47 ms), hot (286 ± 55 ms; $P = 0.171$), and cold (303 ± 114 ms; $P = 0.378$) conditions. On the self-report score (range, 1–21), there was no difference in the self-rated subjective performance between baseline and cold conditions. However, the self-rated subjective performance scale was lower (12 ± 6, $P = 0.003$) during hot conditions. **Discussion:** No difference was noted in reaction time depending on the temperature; however, excessive heat in the OR environment was associated with worse self-rated subjective performance among health care providers. Particularly, self-rated subjective physical demand and frustration were greater under hot condition. *(Pediatr Qual Saf 2018;3:e069; doi: 10.1097/pq9.0000000000000069; Published online April 9, 2018.)*

INTRODUCTION

Health care providers' competence in the operating room (OR) is a key component of patient safety.[1] Various factors may compromise the performance of health care providers in the OR including stress, sleep deprivation, and noise.[2–4] Ambient room temperature (hot and cold) may also impact performance. The recent emphasis on normothermia in surgical patients as a quality metric means that ambient temperature in ORs may be warmer than optimal for staff performance. This is especially true in the pediatric population as they are especially vulnerable to the effects of ambient temperature due to immature thermoregulatory mechanisms.[2]

In pediatric hospitals, the OR ambient temperature may be excessively warm during procedures on patients at high risk for hypothermia such as neonates. It may be excessively cold during cases involving children with traumatic brain injury, where deliberate hypothermia may be used to improve patient outcomes.[5] However, the impact of these temperature variations on OR staff performance is unclear. The present study assessed health care providers using 2 methods: (1) psychomotor vigilance testing (PVT), which is an objective measure of physical performance; and (2) a self-report questionnaire for subjective assessment measurements. Our hypothesis was that participants in the study will have worse objective and subjective performance on the study task following exposure to increased or decreased ambient temperature in the OR.

MATERIALS AND METHODS

This study was approved by the Institutional Review Board of Nationwide Children's Hospital. As this study did not alter routine clinical care, the need for written

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To Cite: Hakim M, Walia H, Dellinger HL, Balaban O, Saadat H, Kirschner RE, Tobias JD, Raman VT. The Effect of Operating Room Temperature on the Performance of Clinical and Cognitive Tasks. Pediatr Qual Saf 2018;3:069.

Received for publication August 10, 2017; Accepted February 12, 2018.

Published online April 9, 2018.

DOI: 10.1097/pq9.0000000000000069

consent was waived. Verbal consent was obtained from the subjects. The study was registered at clinicaltrials.gov (NCT02354755). This prospective, observational study enrolled a convenience sample of surgical residents and fellows, anesthesia residents and fellows, student registered nurse anesthetists (SRNAs), and certified registered nurse anesthetists (CRNAs) who performed a 10-minute PVT and completed questionnaires in 3 phases. The questionnaire was developed at our institution adapted from the NASA-TX.[6] The participants were given a short 1-minute demonstration on the PVT machine before the start of the actual testing. Phase 1 was conducted after 30-minute exposure to ambient room temperature of 23°C (baseline temperature); phase 2 was conducted after 30-minute exposure to an ambient room temperature of 26°C (hot temperature), and phase 3 was conducted after 30-minute exposure to an ambient room temperature of 21°C (cold temperature).

Study phases were conducted in the ORs while a procedure was ongoing. Participants were not involved in patient care while performing study tasks and were positioned away from the patient and equipment to prevent interference with patient care. The ordering of study phases was determined by the patient age in each case. Given a difference in patient age between 2 consecutive cases, the surgeons preferred that the older of the 2 patients would have the higher ambient temperature. To simulate operative conditions, all participants wore OR attire that was similar to that worn during their usual work days and intraoperative conditions. Surgical residents/fellows completed the study in their sterile surgical gowns while the anesthesia providers were in scrubs. All participants wore standard OR hats and masks. The attending surgeons and anesthesiologists were not enrolled in the study because of patient safety concern so that patient care would not be interrupted.

The reaction time was obtained using a 10-minute psychomotor vigilance test device. The PVT-192 Psychomotor Vigilance Task Monitor (PVT, Ambulatory Monitoring Inc., N.Y.) has been described by Dorrian et al.[7] It measures the speed at which subjects respond to a visual stimulus on a handheld, self-contained system used for assessing repetitive reactions. With an inter-stimulus interval of 2–10 seconds, participants press the button on the handheld device in response to numbers appearing on the liquid crystal display screen. The primary outcome was the mean reaction time, with worse performance indicated by higher scores (longer time to respond). Additionally, at the end of each of the 3 phases, participants rated their performance and the physical, mental, and temporal demands of the task on a scale of 1 (very low) to 21 (very high) using an online, self-report questionnaire. Participants also rated the effort required and their level of frustration in each phase on the 1–21 scale.

PVT reaction time and survey responses after the hot and cold conditions were compared with baseline (phase 1) using paired *t* tests. Due to lack of previous information on ambient temperature effects on task performance in the OR setting, no a priori power analysis was performed. Data analysis was performed in Stata/IC 13.1 (College Station, TX: StataCorp LP), and 2-tailed $P < 0.05$ was considered statistically significant.

RESULTS

The study cohort included 22 OR participants including 9 CRNAs, 7 anesthesia and surgical trainees, and 6 SRNAs. The study sample included 6 men and 16 women. No difference in mean reaction time on PVT was noted between baseline (280 ± 47 ms), hot (286 ± 55 ms, $P = 0.171$), and cold (303 ± 114 ms, $P = 0.378$) conditions. On the 1–21 scale, the baseline (room temperature) subjective self-rated performance score was 14 ± 6. Under the hot condition, self-rated performance was significantly worse (12 ± 6, $P = 0.003$), whereas under the cold condition, self-rated performance was similar to baseline (13 ± 6, $P = 0.331$). Physical demand ($P = 0.013$) and frustration ($P = 0.004$) were both elevated under the hot condition as compared with baseline temperature conditions. No significant differences in survey responses were found between the baseline and cold conditions (Table 1).

DISCUSSION

The present study found no difference based on ambient room temperature when using an objective measure

Table 1. Questionnaire Responses by Study Phase

Questions*	Baseline Mean (SD)	Hot Mean (SD)	Cold Mean (SD)	*P* Value† Hot Versus Baseline	*P* Value† Cold Versus Baseline
Performance: How successful were you in accomplishing what you were asked to do?	14 (6)	12 (6)	13 (6)	0.003	0.331
Physical demand: How physically demanding was the task?	3 (3)	5 (5)	3 (3)	0.013	0.815
Mental demand: How mentally demanding was the task?	7 (6)	8 (6)	6 (5)	0.211	0.617
Temporal demand: How hurried or rushed was the pace of the task?	7 (5)	7 (5)	6 (5)	0.625	0.140
Effort: How hard did you have to work to accomplish your level of performance?	7 (5)	8 (5)	7 (5)	0.119	0.924
Frustration: How insecure, discouraged, irritated stressed, and annoyed were you?	8 (6)	13 (6)	8 (6)	0.004	0.973

*Rated on 1–21 scale from lowest to highest.
†Paired *t* test.

of physical performance, reaction time, measured on the PVT. The preponderance of women can be explained by the fact that most of the CRNAs and SRNAs are females. The PVT has been described to evaluate sustained performance in a variety of experimental conditions has been assessed by the PVT, resulting in its acceptance as a standard assessment tool.[7] Previous studies have shown that performance on PVT is sensitive to sleep deprivation, partial sleep loss, and circadian effects.[8–13] The current study is the first to use the PVT to assess performance during changes in ambient temperature in OR personnel. We noted no statistically significant difference in performance based on the ambient room temperature (cold, baseline, or hot). However, excessive heat in the OR environment was associated with worse subjective self-rated performance among health care providers (anesthesia and surgical trainees, student nurse anesthetists, and certified nurse anesthetists). Additionally, subjective self-rated physical demand and frustration were greater under the hot condition. Therefore, it is not surprising that we noticed with the deficit in subjective performance despite similar objective performance under the different study conditions. This deficit raises the question of whether lower subjective performance may influence provider outcomes such as cumulative fatigue or burnout. The study did not show a difference in the PVT scores, although the difference in subjective measures raises the question of whether experiencing multiple temperature changes over the course of the day could contribute to an accumulation of fatigue that would lead to perceptible deficits on PVT.

Our preliminary data show that an elevated OR temperature has a limited impact on an objective measure of physical performance, the PVT. However, the health care providers' subjective self-reported sense of well-being was affected by an elevated ambient temperature. No such impact was noted by a cold environment.

The OR temperature is frequently maintained around 23°C to prevent hypothermia, a common complication of prolonged anesthesia and surgery with an incidence as high as 70%.[14] The incidence may be higher and the physical consequences even greater in the neonatal population, thus emphasizing the importance of such issues for those involved in the perioperative care of infants and children.[15,16] Hypothermia can occur due to exposure to the cold OR environment, evaporation of skin sterilizing solutions, and the impairment of thermoregulation by various anesthetic agents.[17] Hypothermia is associated with increased intraoperative blood loss, a higher incidence of morbid cardiac events, and an increased risk of surgical-site infections.[18,19] Therefore, maintaining normothermia has become a quality improvement measure in many institutions. Preventive measures may include increasing the ambient room temperature, forced air warming systems, heated mattresses, chemical warmers, and the warming of intravenous infusions and fluid.[18,20–22]

Although increasing ambient room temperature is a simple maneuver that makes physiological sense, a hot OR may impact those involved in patient care. This could result in decreased surgeon comfort levels, thereby impacting self-perceived performance as evidenced by the self-reported measures in this study. Although maintenance of normothermia remains a primary perioperative concern, this should be balanced with the potential impact on the well-being of the OR personnel and its hypothetical impact on physical performance. A survey conducted among British medical students reported that 12% suffered a near or actual syncopal episode in the OR and that 79% attributed their event to an elevated temperature in the OR.[23,24] When evaluating surgical trainees performance during a simulated laparoscopic procedure, similar to our study, no difference was noted in technical performance at 2 ambient temperatures (19 and 26°C).[25] However, the participants perceptions of distraction and physical demand were greater when exposed to an increased ambient temperature.

Various measures have been studied in an attempt to limit the impact of an elevated ambient temperature on physical well-being and performance. Cooling vests as worn by firemen and adapted to the surgical environment have been trialed in clinical settings.[26] The preliminary tests have found measurable benefits in terms of lower skin temperature and sweat rates, leading to improved surgeon comfort. As with ambient temperature, various other physical and environmental factors may affect performance including the type of gown, gloving, and light exposure. The majority of the literature has focused on investigating which gowns offer better protection from contamination with less emphasis regarding their impact on comfort and physical performance. The magnitude of sweating is less with disposable gowns when compared with reusable gowns.[27–29] The evidence for the influence on performance by double gloving is conflicting, with studies finding no significant difference when comparing single and double gloves.[30–32] Conversely, other studies have found double-gloving significantly impairs a surgeons' perception of comfort, sensitivity, and dexterity.[33,34] Exposure to short wavelength light compared with polychromatic light increases psychomotor vigilance and reduces sleepiness.[35,36]

A few limitations of our study include that we did not collect data on age, weight, or health issues of the patients; baseline ambient temperature range between 21°C (69.8°F) to 26°C (78.8°F), and there was no attempt to correlate performance with deviations in the patients' core body temperature. Our routine clinical intraoperative standard is to maintain the patient's core body temperature between 36°C and 37.5°C. Although we had planned to stop the study if the patient's core temperature reached suboptimal levels, especially during the cold trial, this did not occur during data collection, and therefore no study data were omitted. The subjects served as their own controls. The hot condition was invariable hotter than the baseline condition, whereas the cold condition was invariable colder. We could not precisely control for variations in baseline temperature. Environmental stress such as temperature is affected by sleep deprivation and certainly could have affected the subjective reports. Another point to be noted is that we used VAS items from the NASA-TLX but did not use the entire set of questions and did not calculate a task-specific composite score. We note the limitation that this could have led to missing other aspects of subjective performance that depended on temperature. Lastly, 1 other factor that the study lacked was we did not question the subjects about the sleep state which may have been beneficial to have taken into consideration.

The OR is a complex system with various factors that may impact the comfort and the physical performance of those involved in the perioperative environment. Measures that make sense to prevent perioperative complications, such as increasing the ambient environment of the room to prevent hypothermia, may have unanticipated effects on the performance of the health care personnel. Most operations are performed efficiently and safely despite the potential for interference and errors from different sources. Optimizing the OR temperature to make the patient, anesthesiologist, and surgeon more comfortable will improve safety and quality. A balance should be obtained especially between heating the OR for the pediatric population and its potential subjective impact on staff performance. Future studies should revolve around determining the optimal room temperature, which will minimize the risk of hypothermia and yet have limited impact on perioperative health care providers.

ACKNOWLEDGMENTS

The authors gratefully acknowledge statistical analysis performed by Dmitry Tumin, PhD.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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