Do Micropauses Prevent Surgeon’s Fatigue and Loss of Accuracy Associated With Prolonged Surgery?

An Experimental Prospective Study

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Objective: This prospective experimental study evaluates the effectiveness of micropauses (MPs) to prevent muscular fatigue and its deleterious effect on surgeons during prolonged surgical procedures.

Background: Operating is a hazard for surgeon’s health. Beyond acute injuries and blood-borne infections, back and neck pain is a poorly recognized factor causing chronic ailment in more than half the surgeons surveyed. Micropause (MP), a formal 20-second break every 20 minutes, is an accepted strategy used widely in the workplace.

Methods: We designed a crossover experimental study. Sixteen surgeons were tested 3 times: once in a control situation before any surgery (CTL) and twice after a prolonged, reproducible operation (at least 2 hours), 1 of these with formal MP (WMP) the other without (WOMP). Muscle fatigue was tested by holding a 2.5-kg weight as long as possible with a stretched arm. Accuracy was evaluated with a device, measuring the mistakes made when following a predetered path on a board. Finally, discomfort was measured by visual analog scale.

Results: We found a statistically and more importantly clinically significant difference between the CTL and WOMP groups in all 3 tests. MPs prevented completely or almost completely the effects of fatigue associated with surgery [accuracy (No. errors) CTL: 1.1, WOMP: 7.7, WMP: 1.7; fatigue (seconds) CTL: 137, WOMP: 92, WMP: 142].

Conclusions: Surgical procedures are associated with significant muscular fatigue that can be measured simply and which has a direct effect on comfort and surgical accuracy. More important, this effect is completely or almost completely prevented by MPs.

Keywords: micropause, surgical precision, surgical fatigue, experimental study, surgical education

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Operating is a hazard for a surgeon’s health. Beyond acute injuries and blood-borne infections, back and neck pain is a poorly recognized factor potentially causing chronic ailment. Although it is an established occupational disease for many professions, very few studies have looked at the prevalence of this problem among surgeons. Babar-Craig and collaborators found a prevalence of 72% of back or neck pain or even both among otolaryngologists in the United Kingdom. Of those with pain, 53% attributed their symptoms directly to surgery. This certainly demonstrates a lack of adequate training, and improvement is needed to prevent long-term disability. Beyond this, we were also concerned with the immediate effects of prolonged surgery on technical performance. Although these issues are new in the health care environment, ergonomics in the workplace have certainly been studied extensively in the last 50 years. Micropause (MP), a formal 20-second break every 20 minutes of work, is a widely accepted strategy to optimize performance, especially in sedentary work, for example, working in front of a computer. The objective of this research project was, therefore, to test our hypothesis that MP would (a) decrease the feeling of discomfort and (b) improve strength and (c) precision by comparing the performance of surgeons who had or had not taken MP during a long procedure.

MATERIALS AND METHODS

The project was approved by the Ethics Review Board of the University of Sherbrooke. Once collected, data were stored securely and analyzed in a blinded fashion by the authors.

Design

Sixteen surgeons (10 staff and 6 residents) were recruited for this crossover study. We evaluated each surgeon 3 times. Once before any surgery (control), once after a common and reproducible operation of at least 2 hours, and once after the same procedure but this time undertaken with 20-second MP every 20 minutes. The order of these evaluations was randomly assigned to each surgeon to prevent a learning effect. All procedures and tests were done in the morning in a local site adjacent to the operating room that had been set up for this purpose. “Stressor” operations were the following: open colon resection for general surgeons, craniotomy and microscopic tumor resection for neurosurgeons, parotidectomy for head and neck surgeons, and coronary artery bypass graft with loups for cardiac surgeons.

Micropauses

Every 20 minutes, an alarm would go off from a standard kitchen timer. Surgeons were instructed to stop operating, pull out of the working station, and stretch neck and shoulders. The whole process was to take less than 20 seconds (Fig. 1).

Evaluation of Discomfort

Level of discomfort was evaluated with a simple 100-mm visual analog scale, with specific answers for eyes, neck, upper back, shoulders, elbows, wrists and hands, and lower limbs. This specific test was not validated, but the relevance of using visual analog scale to evaluate subjective variables such as pain and discomfort is well documented in the literature.

Fatigue (Strength) Evaluation

The surgeon was asked to stand up still and hold a 2.5-kg weight with the dominant arm fully extended at 90-degree flexion and 15-degree abduction as long as possible without moving. This simple test is a classic in occupational health literature.
Accuracy Test

We used a low-tech system developed by our colleagues in the Faculty of Kinesiology (Fig. 2). The surgeon was asked to hold a pair of Metzenbaum scissors and follow with it a star-shaped track on a board. Contacts with the border of the track are considered errors and recorded automatically. The circuit was repeated 3 times. This test has been validated with a test–retest reliability of \( r = 0.955 \).4

Statistics

Results are presented for the whole group. Small numbers of participants prevented meaningful comparisons between age, status (staff vs residents), or type of surgery. We used repeated-measure analysis of variance with Bonferroni correction for multiple comparisons.

RESULTS

Discomfort Levels

Discomfort levels were statistically different for all sites among the 3 situations, except for the lower limb, where MPs offered no “protection,” and the eyes, where we did not find any difference between the control and the procedures with MP, although there was a difference between those 2 and the procedures without MP (Fig. 3).

Muscular Fatigue Evaluation

Results are presented in Figure 4. Without MPs, 2-hour oper-

FIGURE 1. Active stretching of the shoulder area done during MP.

FIGURE 2. Device used to test for precision of movements. Surgeons are asked to hold the Metzenbaum scissors and to follow the star on the board without touching the outside of the shape.

FIGURE 3. Level of discomfort reported by surgeons. Levels are reported on a scale of 0 to 100, where 0 is no discomfort and 100 is maximal discomfort. For each anatomical area, the results are reported for the control state and after a prolong operation with or without MP. All pairwise comparisons (control vs with MP, control vs without MP, and without MP vs with MP) were statistically significant (\( P < 0.05 \)) except those marked by an asterisk (\(^*\)). Repeated-measures analysis of variance with Bonferroni pairwise comparisons.

FIGURE 4. Maximal holding time of a 2.5-kg weight with dominant arm stretched out. Results are reported in seconds. \(^*P < 0.001\). Repeated-measures analysis of variance with Bonferroni pairwise comparisons.
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DISCUSSION

This research project has identified for the first time a link between long surgical procedures and a surgeon’s fatigue, decreased strength, and decreased technical accuracy. More importantly, it also found a solution to this problem. As a first level, the subjective evaluation of discomfort was relevant because Sundelin and Hagberg found that discomfort could be felt before actual muscular fatigue could be elicited. In designing this study, we included this aspect, as we thought that it would be more sensitive than the test for fatigue. Despite the very significant finding on muscular fatigue, this subjective evaluation showed interesting albeit not unexpected results (Fig. 2). First, of significance is what we did not find: identifying a difference in the lower limb fatigue would have cast a doubt over our whole set of results. Junior residents learn early in their career to move about on their feet when operating. Furthermore, years of training standing by an operating table has turned the immobile, erect position into a second nature. On the positive side and, again, not surprisingly, the maximum amount of discomfort is felt in the back and shoulders. The second point of interest in this aspect is the fact that even MP will not totally erase the fatigue of operating during long hours, but it will cut it roughly by half (eg, neck: 36–17, \( P < 0.05 \); back: 53–28, \( P < 0.05 \); shoulder: 41–17, \( P < 0.05 \)).

Results from the more objective maximum holding test (muscular fatigue) went exactly in the same direction but were even more compelling (Fig. 3). Operating on a patient will decrease strength significantly (137 seconds preoperative to 92 seconds postoperative without MP), but this can be completely prevented by MP (142 seconds postoperative with MP, \( P < 0.001 \), compared with postoperative without MP). Together, these 2 tests confirmed that fatigue is significant, can be evaluated objectively and subjectively, and can be prevented. Furthermore, we confirmed the findings of Sundelin and Hagber that subjective discomfort is more sensitive than muscular fatigue.

Although hoped-for, results from the accuracy test came as a shock (Fig. 4). This of course evaluates the link between prolonged surgery and an “artificial” accuracy test. How this decreased performance in the test translates into “real-life” operating room precision is yet to be elucidated. Nevertheless, to our knowledge, this is the first time that surgical fatigue is correlated with a test evaluating precision. Although 11 of the 16 surgeons (69%) made 1 or fewer mistakes on the test track in the control situation, none of them made fewer than 4 errors after surgery without MP. On average, the number of errors was multiplied by 8.5. Because the order of the sessions was randomized, a learning bias is ruled out. Sure enough, subjects were not blinded to the experimental arm. Is it conceivable then that surgeons would purposefully make more mistakes to improve the results of the “treatment” arm? Possibly, and certainly, this remains a weakness of this project, but on a lighter note, we propose 2 intuitive arguments to counteract this assumption. First, we challenge anyone to find a surgeon who would knowingly or subconsciously attempt to look clumsy with a pair of Metzenbaum scissors. Second, when explained the project, the experimental subjects were all skeptical as to the benefits of MP and worried that it would break the flow of the operation (although all surgeons approached agreed to participate). If there were a bias, it would be in favor of the control arm.

If this study is the first to document in such a complete fashion the relationship between surgery and its deleterious consequences, a large body of evidence explores its pathophysiology. Static exercises of which surgery is the epitome will cause muscular tension associated with decrease blood flow, metabolites accumulation, and energy depletion. This, in turn, will lead to discomfort and muscular fatigue. We have all experienced this when reading at a desk, working on a computer, or driving a car for a long ride. This chain of events is deleterious to surgeons who dive into this “toxic soup” 10 to 30 hours per week throughout their career. The results of this specific study do not allow us to make the next step and link these recurrent episodes of muscular fatigue and discomfort with chronic pain, but others have looked at this relationship before. Galinsky et al have documented that chronic musculoskeletal disorders are the result of the cumulative effect of repeated microtraumas presenting as light- to moderate-intensity discomfort at the time of the original task. This study documented for the first time moderate discomfort and, therefore, “trauma” associated with surgery. Although formal causality is still numerous studies away, this could provide an intriguing insight into the high percentage of surgeons affected by chronic pain.

Fatigue potentially causing chronic pain is a significant concern for surgeons’ quality of life and, therefore, health care delivery, but it becomes also relevant to actual patient care because Voight et al have shown in a different environment that this fatigue will decrease accuracy. Our results confirm this for the first time in the context of the operating room. From almost none to an average of 8 mistakes is a major difference. Identifying and quantifying the problem are important, but finding a solution is much more gratifying. We simply followed the path set by a voluminous body of literature: numerous studies have demonstrated in different environments that MPs can break the vicious cycle of static exercises leading to acute discomfort (eventually chronic pain) and decreased accuracy.

A complete review of the literature on micropause/microbreaks is beyond the scope of this article, and the interested reader will find a good overview in the meta-analysis from Barredo and Mahon. Two qualities are needed for these breaks to be successful: (a) they must...
be active rather than passive\textsuperscript{20} and (b) they must be much more frequent than intuitively required. In other words, if one is left to decide when to pause, breaks will become too few and too far apart, and the interval too long.\textsuperscript{14,21} As a matter of fact, Rohmert\textsuperscript{12} has demonstrated that the time for recuperation is exponentially related to the degree of fatigue, which is a combination of intensity and duration of the exercise. An increase of 50\% in the duration of exercise requires a recuperation period 4 times longer. Furthermore, recuperation is much faster in the early part of the break.\textsuperscript{11} This is why we chose the format of 20 seconds every 20 minutes, which is supported widely in the literature mostly involved with computer work. Feedback was formally sought from the surgeons who participated in the experience. The consensus was that early in the operation, pauses seemed to be coming too frequently. After the first hour on the other hand the regular breaks were welcome and even anticipated. Certainly, nobody felt that it impaired performance, but the rule was clear: you have to quit whatever you are doing when the alarm goes off. This study was not designed to evaluate formally the effect of stopping for 1 minute every hour on the workflow in the operating room. After the work of Zheng et al,\textsuperscript{22} who have reported that workflow during an operation is interrupted on average 4.1 minutes per hour because of personnel or equipment-related events (shift change, equipment missing, repositioning, pagers), we have found, in practice, that nurses will use the MP to take care of many of these potential disruptions. Further studies are needed to elucidate the role, positive or negative, of MP on operating room workflow.

Workflow is but the tip of the iceberg when it comes to implementing MP. Interestingly, despite the spectacular results and the very positive response we had when discussing the results with the surgeons involved, few of them have continued to use MPs spontaneously. The authors (S.D. and D.D. are staff otolaryngologists) confess not to adhere to this habit as religiously as they should for short cases, but the more senior author, now in his late 40s, has come to rely on MPs for major head and neck cases. The reasons for this low compliance are not easy to identify, but they probably include a feeling of invincibility, a lack of awareness, a touch of laziness, and a leave-me-alone attitude. In summary, we are dealing with surgeons. To overcome these obstacles, we have found that the nursing staff has to buy in completely. The circulating nurse must “enforce” the breaks, which set the rhythm of the operation. Finally, contrary to the hypothesis, first-time users should start MPs with longer, more complex operations, where the benefits will be immediately palpable.

In conclusion, we have studied the effect of MPs on the performance and stress in an operating room.\textsuperscript{27} The authors (S.D. and D.D.) are staff otolaryngologists, and (D.D.) is also a staff oral and maxillofacial surgeon. The project was directed by S.D., who was extensively involved in all aspects of the project and primary individual in charge of the redaction of the manuscript.

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Dr Darveau was involved in elaborating the protocol and writing the manuscript. He was the primary individual in charge of collecting and interpreting the data. Dr Dorion was involved in all aspects of the project and primary individual in charge of the redaction of the manuscript.

REFERENCES