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ORIGINAL ARTICLE

The impact of a pre-operative mindfulness exercise on early laparoscopic skill acquisition and self-perceived performance in novice learners

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Abstract

Background: Surgeons often operate in high-stress environments, where elevated stress levels can impair performance. Mindfulness has shown promise in regulating stress in experienced clinicians and high-pressure environments. However, its effects on early technical skill acquisition and self-perception in novice learners remain unclear. This study investigated whether a brief pre-task mindfulness exercise could influence early laparoscopic skill acquisition and self-perception in novices. **Methods:** Thirty medical students were assigned either to a mindfulness group ($n=15$) or a control group ($n=15$). All completed three baseline trials of a validated laparoscopic peg-threading task. The intervention consisted of a 5-minute body scan (a mindfulness exercise focusing attention on different body parts) while the control group listened to a neutral audio recording. Both groups then performed three further post-intervention trials. Performance metrics including task completion time and instrument tracking metrics were measured during all tasks. Subjective workload was assessed using the NASA-TLX (National Aeronautics and Space Administration task load index). **Results:** Control group participants became significantly swifter at task completion when comparing baseline performance to their final trial ($P=0.002$). The mindfulness group did not achieve a significant time improvement. The control group also showed significant improvement in instrument movement smoothness ($P=0.021$), whereas the mindfulness group did not. Despite their objective performance, participants in the mindfulness group rated their own performance significantly higher than those in the control group ($P=0.047$) on the NASA-TLX. **Conclusions:** A single-session mindfulness body scan was associated with slower early skill acquisition when compared with controls. Despite slower objective skill acquisition, participants who undertook the mindfulness exercise reported significantly higher perceived performance, highlighting a dissociation between objective outcomes and self-assessment.

Keywords: *simulation; mindfulness; skill acquisition; performance; surgery*

Introduction

Stress is an inevitable aspect of the surgical environment and can significantly affect performance, making its management a key concern for surgical training. Surgeons face numerous stressors, including time pressure, technical complexity, and unforeseen complications. A moderate level of stress may be beneficial for maintaining alertness, but once stress exceeds an optimal threshold, it becomes detrimental to performance.[1,2] Excessive intraoperative stress is known to impair fine motor skills and elevate the risk of errors.[2] Surgeons have reported that intraoperative stress has a negative impact on their concentration and decision-making.[2] High stress can also undermine surgeons' non-technical abilities such as communication and team coordination.[3]

Laparoscopic procedures tend to elicit stronger stress responses and poorer performance in junior trainees than in experts.[2,3] Novice surgeons often lack effective coping mechanisms for stress and may resort to maladaptive strategies, which correlate with worse simulator performance.[4,5]

Current strategies to optimise surgical performance include simulation-based training, mental rehearsal, structured preoperative checklists, and ensuring surgical tools are ergonomically comfortable to use.[6] One approach to mental rehearsal is mindfulness training, which involves a focused, non-judgmental awareness of the present moment. Mindfulness techniques – such as meditation and controlled breathing exercises – have been shown to reduce anxiety and improve attentional control in healthcare professionals in some settings.[4,7] By promoting better emotional regulation and concentration, mindfulness may enable individuals to cope more effectively with acute stressors in high-demand environments such as the operating theatre. Disciplines ranging from elite sports to the military have also embraced mindfulness techniques to improve focus and resilience under pressure.[8,9] However, much of this literature focuses on experienced clinicians, longitudinal mindfulness training, or high-stress clinical contexts. The impact of brief mindfulness exposure on early motor learning in novice trainees remains poorly understood.[7,10]

This emerging evidence suggests mindfulness may benefit surgeons and surgical trainees. A recent pilot study involving a structured eight-week mindfulness programme for surgical interns led to significant reductions in perceived stress and improvements in executive function. Participants who underwent mindfulness training reported lower stress levels and performed better on cognitive tests compared with controls. However, despite reported psychological and cognitive benefits, the researchers found no short-term improvement in the participants' actual surgical skill.[5]

While brief mindfulness interventions have shown benefits for stress reduction and emotional wellbeing, their impact on technical performance in healthcare remains unclear. One review found that short-duration mindfulness training (<4 h) did not reliably improve healthcare providers' technical skills or reduce error rates.[7] However, many of these interventions were not delivered immediately before performance or lacked validity in high-stakes procedural contexts. Identifying mindfulness strategies that can reliably enhance both performance and wellbeing under pressure would represent a meaningful advance for surgical training. We sought to assess the effectiveness of a brief, single-session, pre-performance mindfulness exercise on simulated laparoscopic performance. Given the cognitively demanding nature of early motor learning, the effects of mindfulness in novice learners may differ from those observed in experienced surgeons operating under stress. If found to be effective, this would be a simple, low-cost intervention that would be amenable to integration into surgical training and real-world practice.

Hypotheses:

- A brief pre-task mindfulness body scan will enhance early laparoscopic skill acquisition in novice learners, as measured by objective performance metrics across repeated simulation trials.
- A brief pre-task mindfulness body scan will positively influence novice learners' self-perceived performance and cognitive workload.

Materials and methods

Participants

Thirty medical students (years 1–5) were recruited via social media and poster advertisements. Participants were allocated to either the Mindfulness Group ($n = 15$) or the Control Group ($n = 15$). Ethical approval was obtained from the local institutional review board, and all participants provided written informed consent.

Equipment

A laparoscopic simulator (eoSim, Limbs&Things, Bristol, UK) equipped with instrument tracking software (SurgTrac, Limbs & Things, Bristol, UK)[11] was used to assess laparoscopic performance. This allowed measurement of time to completion (seconds), instrument motion metrics (total path distance, movement smoothness, and percentage time off-screen), and an ambidexterity index (AI) (the absolute difference in usage between the dominant and non-dominant hands). An AI was calculated using the following formula: $\mathrm{AI} = 1 - 2 \times (\mathrm{usage} - 0.5)$, where usage represents the fraction of time the dominant hand was used. An AI of 1 indicates complete ambidexterity. An $\mathrm{AI} < 1$ indicates a preference for the dominant hand.

Procedure

The experimental procedure is shown in Fig. 1. Participants first performed three sequential baseline trials of a validated peg-threading task[6,12] in a quiet, calm environment. Those assigned to the mindfulness group then engaged in a single, five-minute guided mindfulness exercise (a 'body scan'[13]). The body scan involved sequentially focusing attention on different areas of the body while controlling breathing rhythmically and deeply.[5,7,8] This intervention was a single, brief exposure to a mindfulness exercise rather than a structured mindfulness training programme. No baseline mindfulness assessment was performed, and participants received no prior instruction or reinforcement. Control group participants

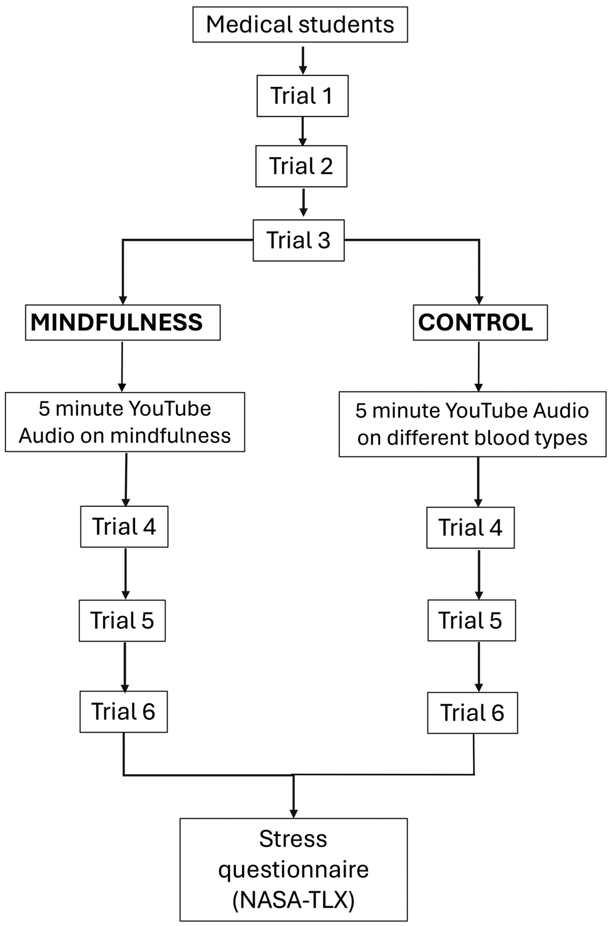
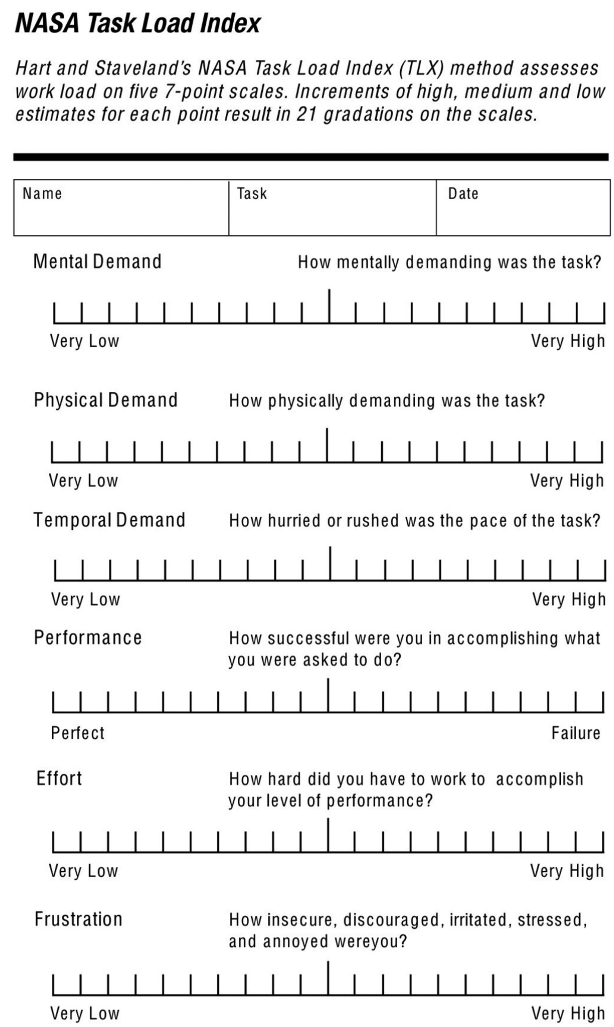


Figure 1. Flowchart summarising the experimental procedure.



NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

Figure 2. NASA-TLX questionnaire used to assess subjective workload and stress.[15]

instead listened to a five-minute neutral audio podcast discussing blood groups.[14] After the intervention, participants completed three further trials of the same peg-threading task.

Finally, each participant completed the NASA (National Aeronautics and Space Administration) Task Load Index (NASA-TLX) questionnaire (Fig. 2),[15] designed to subjectively assess cognitive load and perceived stress during the tasks. The NASA-TLX is a validated assessment that evaluates an operator's perceived task load across six dimensions: mental, physical, and temporal demand, performance, effort, and frustration.

Performance metrics in the final pre-intervention trial (trial 3) were used as a baseline for later comparison. Subsequent trials were analysed as percentage changes from baseline performance for each participant.

Statistical analysis

All data were analysed using PyCharm. The Shapiro–Wilk test was used to assess data for normality. For normally distributed data, the independent-samples *t*-test was applied. For data not normally distributed, the Mann-Whitney *U* test was applied. Significance was set at $P<0.05$.

The NASA-TLX questionnaire was used to assess subjective workload and stress across six dimensions. The questionnaire is scored on a scale from 0 to 20, with 0 indicating "Very Low" and 20 indicating "Very High" demand. For the self-reported performance metric, the scale is inverted such that a higher score corresponds with self-perceived failure.[16,17]

Results

As shown in Fig. 3, participants in the control group completed the laparoscopic task significantly faster at Attempt 5 ($P=0.001$) and Attempt 6 ($P=0.002$) compared to baseline

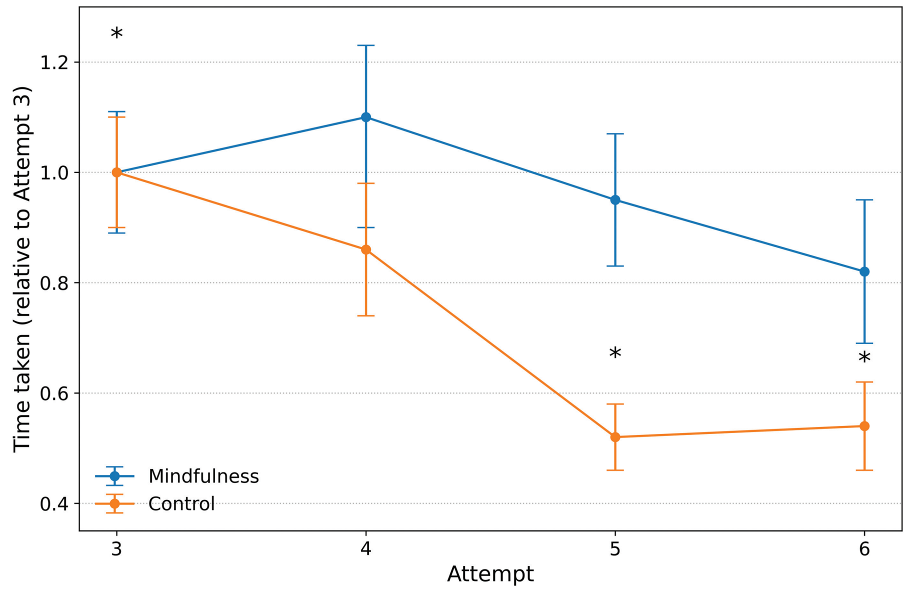


Figure 3. Time taken to complete the laparoscopic task, normalised to baseline (Attempt 3) across Attempts 3–6 (mean ± SEM). Note: * indicates a significant result.

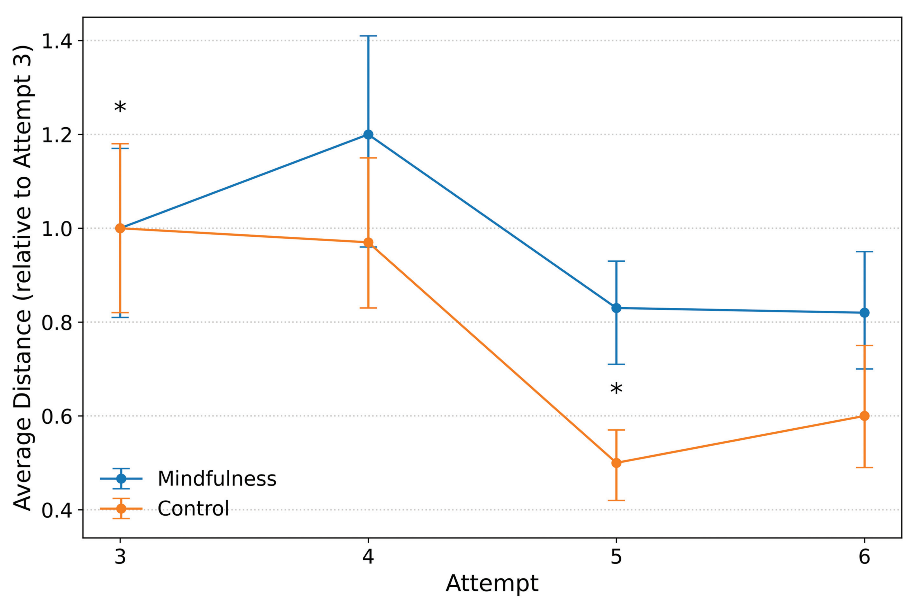


Figure 4. Average distance travelled by instruments (normalised to Attempt 3 baseline) across Attempts 3–6 (mean ± SEM). Note: * indicates a significant result.

Attempt 3. In contrast, the mindfulness group did not exhibit significant reductions in task time over the same period.

As shown in Fig. 4, the control group demonstrated a significantly greater reduction in the distance travelled by instruments compared to the mindfulness group at Attempt 5 ($p = 0.038$), suggesting more efficient instrument handling with practice. No significant between-group differences were observed at other timepoints. Both groups showed modest reductions in instrument travel over time, relative to baseline.

No significant changes in AI were observed over time in either group (Fig. 5), indicating that hand dominance remained stable throughout the task sequence.

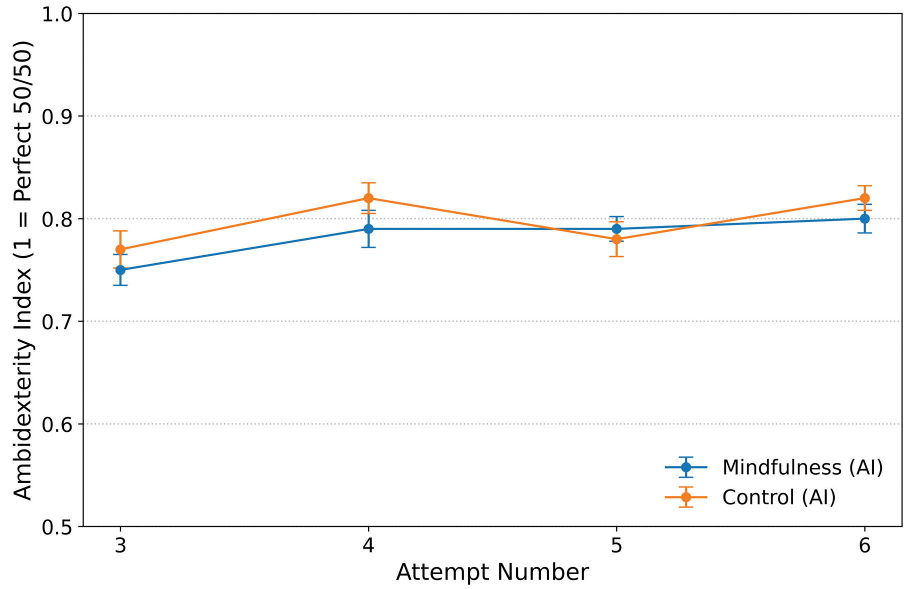


Figure 5. AI across Attempts 3–6 (mean ± SEM; AI = 1 indicates perfect balance between hands).

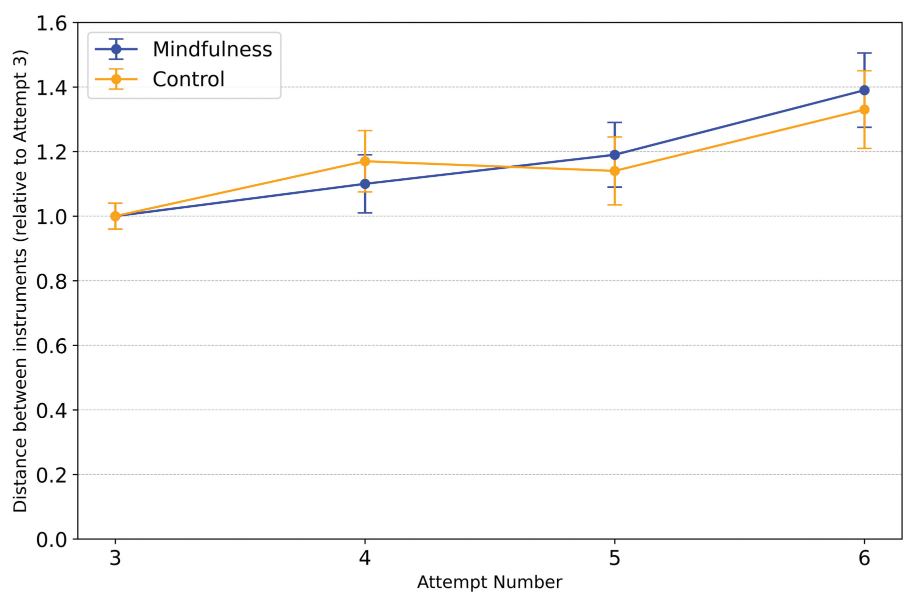


Figure 6. Average distance between instruments (cm), normalised to baseline (Attempt 3), across Attempts 3–6 for both groups.

As shown in Fig. 6, the average distance between instruments remained stable across all attempts for both groups. There were no significant within-group changes or between-group differences.

Instrument speed remained consistent across trials in both groups, with no significant changes from baseline or differences between mindfulness and control conditions (Fig. 7).

Fig. 8 shows that average instrument acceleration remained stable across all trials in both groups. There were no significant changes relative to baseline, nor any differences between the mindfulness and control conditions, indicating no measurable effect of the intervention on motor acceleration profiles.

As shown in Fig. 9, the control group exhibited a significant improvement in instrument movement smoothness at

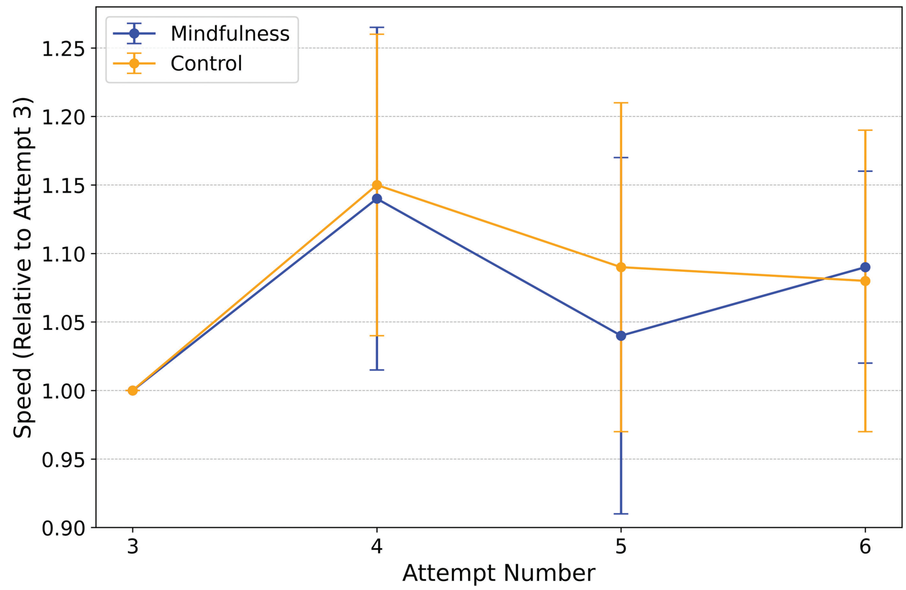


Figure 7. Average instrument speed (mm/s) normalised to baseline (Attempt 3) for mindfulness and control groups across Attempts 3–6.

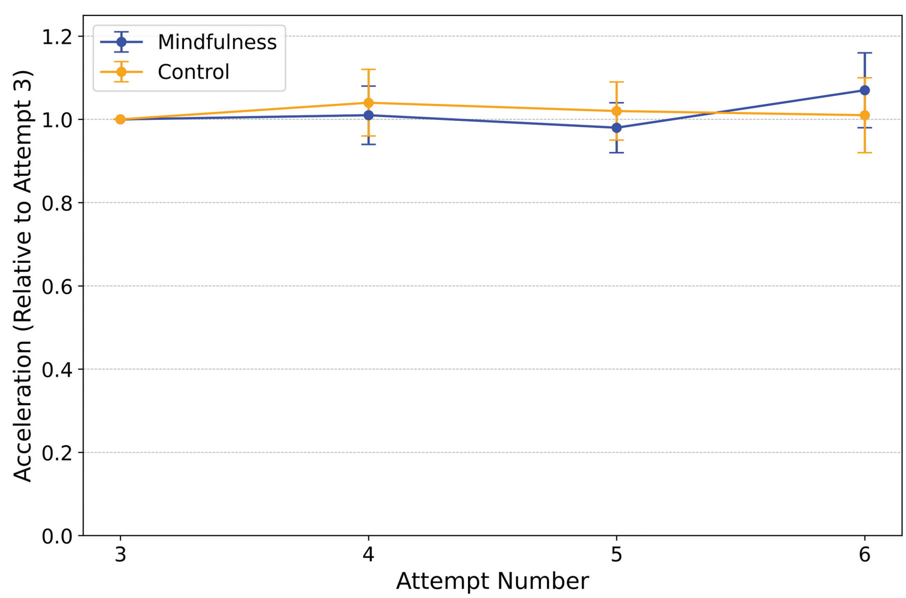


Figure 8. Average instrument acceleration (mm/s^2) normalised to Attempt 3 across Attempts 3–6 for both groups.

Attempt 5 compared to the mindfulness group ($P = 0.021$). No other significant group differences in smoothness were observed at other timepoints.

Self-reported workload, as measured by the NASA-TLX (Fig. 10), revealed that participants in the mindfulness group rated their own performance significantly higher than those in the control group ($P = 0.047$). No significant differences between the groups were observed in perceived mental, physical, or temporal demand, effort, or frustration.

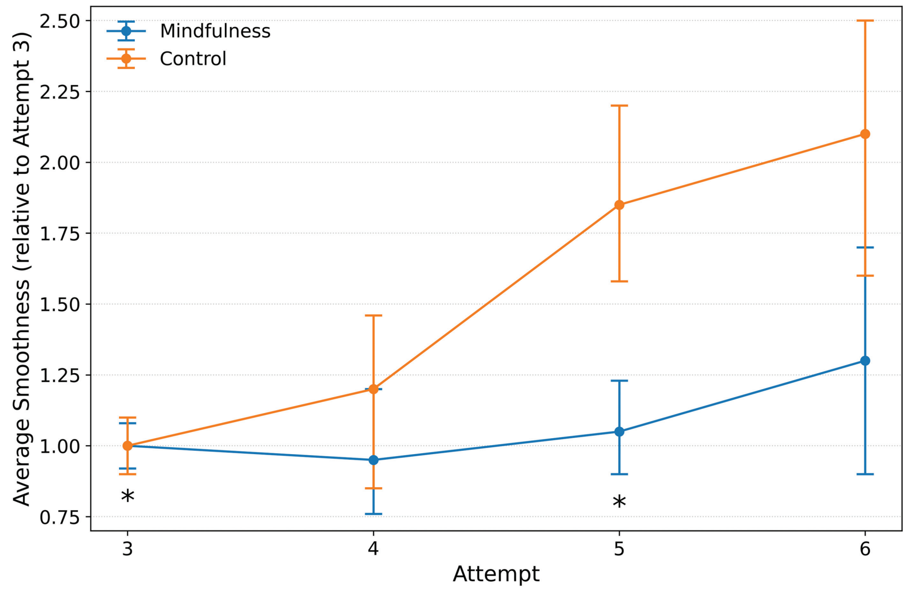


Figure 9. Average smoothness of instrument movements (derived measure in mm^3/s^3) across Attempts 3–6, expressed relative to Attempt 3 baseline (mean ± SEM). Note: * indicates a significant result.

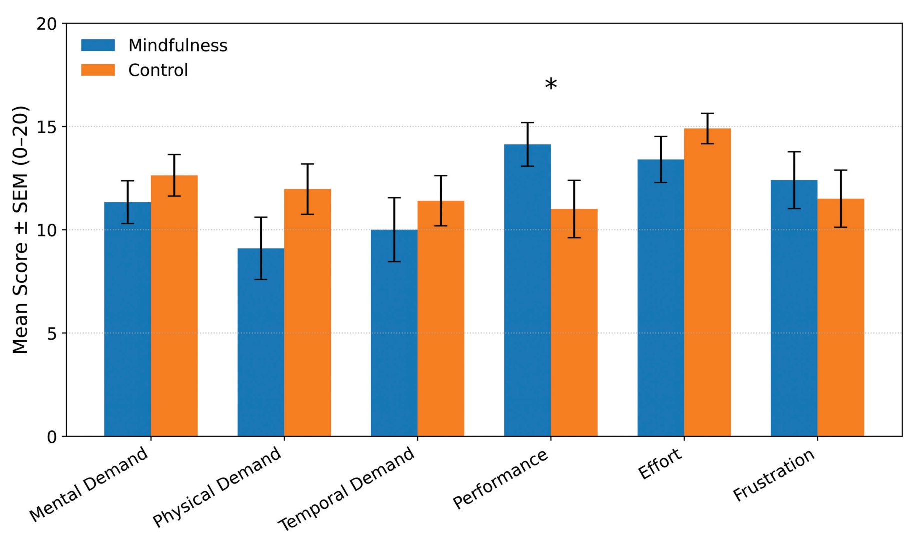


Figure 10. NASA-Task Load Index (NASA-TLX) scores comparing subjective workload components between mindfulness and control groups (mean ± SEM). Note: * indicates a significant result.

Discussion

Performance

By the final trial, the control group had achieved a statistically significant reduction in task completion time (improving significantly from baseline trial 3 to trial 6 ($P = 0.002$), whereas the mindfulness group did not exhibit a statistically significant time reduction ($P = 0.26$). The control group also showed significant improvement in instrument movement smoothness ($P = 0.021$), whereas the mindfulness group did not. Our findings suggest that a brief, single-session mindfulness body scan did not enhance – and may have transiently hindered – early simulated laparoscopic skill acquisition in novice learners. This opposes our initial hypothesis.

It is important to emphasise that our participants were novice learners rather than trained surgeons. Early technical skill acquisition is cognitively demanding and relies heavily on explicit, task-focused attentional control.[18,19] In this phase of learning, directing attention externally towards task goals and error correction is known to facilitate motor learning. By contrast, experienced surgeons possess established motor schemas and greater automaticity. In such individuals, mindfulness may support stress regulation and performance stability under pressure.[4,5] Thus, the effects of mindfulness in surgical education are likely stage-dependent rather than universally beneficial.[20]

Consideration should be given as to why our mindfulness intervention dampened the practice-driven learning curve. The body scan directs attention inward and encourages non-judgemental awareness of bodily sensations. Immediately prior to a visuomotor task requiring external precision, this inward attentional orientation may be counterproductive for novices who depend on conscious error monitoring and active engagement.[18,19,21] Some evidence suggests that mindfulness can diminish goal-directed arousal or "future focus," thereby impairing task motivation.[9] The control group may also have used the break to subconsciously strategise or may have benefitted from a rest, without losing their performance impetus.

In addition, we used a very short intervention. This may have been insufficient to positively influence performance. Most evidence focuses on longitudinal mindfulness programmes with reinforcement of applicable skills. Our intervention lacked the opportunity for medical students to develop mindfulness techniques; instead it induced relaxation and bodily awareness. Lebares et al.[5] found that a comprehensive eight-week mindfulness-based stress reduction programme was effective in enabling faster skill acquisition in surgical interns. To be effective, mindfulness interventions may therefore need to be of greater intensity and/or duration in order to impact genuine skill acquisition.

Another important factor to consider is that our study involved novice surgeons with no prior laparoscopic experience. Novice surgeons exhibit a particularly steep learning curve. They are often preoccupied with fundamental hand-eye coordination and activation of unfamiliar instruments.[11,12] The effect of our intervention may therefore be different in the context of more experienced surgeons who are in a different phase of learning.[5]

Self-perception and overconfidence

NASA-TLX ratings of mental demand, effort, frustration, and overall workload were statistically comparable between groups. This suggests that the brief mindfulness exercise did not appreciably ease the perceived difficulty or anxiety of performing the surgical tasks. This outcome differs somewhat from findings in longer interventions.[5] The lack of acute stress reduction in this study could be due to the brevity of the mindfulness intervention. The control group's neutral rest might also have provided a minor stress reprieve in itself.[22]

An intriguing secondary finding from our study was the divergence between perceived and actual performance amongst those who practised mindfulness. Despite performing no better than controls and showing impaired learning, the mindfulness group believed they performed better. They rated their own task execution significantly higher on the NASA-TLX performance scale than the control group. This dissociation between objective performance and perceived competence represents a metacognitive distortion rather than a simple reporting bias.[16] A boost in self-appraisal might be interpreted as a psychological benefit of the mindfulness exercise – perhaps the body scan fostered a more present-focused, non-judgemental mindset that made participants less harshly aware of their mistakes.[23] While reduced self-criticism may be psychologically beneficial, inflated self-assessment in the absence of objective competence has implications for real, competency-based progression and decision-making in surgical training.[24] Self-assessment in medicine is frequently flawed, and clinicians (especially novices) often over rate their competence.[16] The danger is that a trainee who believes they are doing better than they are may be less inclined to seek feedback or to diligently improve.

Variations in duration, frequency, and instructional context have been shown to significantly influence the efficacy of mindfulness interventions across learning and performance domains.[8] Future research could examine whether different mindfulness strategies, such as longer or repeated interventions or coupling meditation with structured performance reflection, might yield different findings. It may also be valuable to investigate whether specific subgroups benefit more than others; for instance, highly anxious trainees might derive stress-regulation advantages that indirectly support performance, while others may become overly relaxed or disengaged. Evidence from performance psychology indicates that trait anxiety can moderate the effectiveness of mindfulness interventions, with greater benefits seen in individuals who initially struggle with stress or attentional control.[4] This could also apply to those at different stages of medical training, with mindfulness interventions potentially having different consequences in novice compared to experienced surgeons.

This study has several important limitations. The mindfulness intervention was a single, brief exposure and does not represent mindfulness training, which typically involves repeated practice over weeks.[2] The simulated task was low-stakes, with minimal emotional or clinical stress, conditions under which mindfulness benefits may be attenuated. Finally, baseline mindfulness traits were not assessed prior to the intervention.

Conclusion

In conclusion, in this simulation-based study of novice learners, a brief, single-session mindfulness body scan did not enhance – and may transiently hinder – early laparoscopic skill acquisition, despite improving perceived performance. These findings highlight that mindfulness is not universally beneficial and that its effects depend on learner stage, task demands, and timing.

Conflict of interest

K.A. and I.I. have no conflict of interest to declare. M.H. helped to develop the simulator used in this study (as part of eoSurgical Ltd., which was acquired by Limbs & Things).

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Data availability statement

The data that support the findings of this study are available from the corresponding author K.A. upon reasonable request.

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