

Classical but Not Rap Music Significantly Improves Transferability and Long-Term Acquisition of Laparoscopic Suturing Skills: A Randomized Controlled Trial

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Abstract

Introduction Acoustic distractions have been shown to increase the level of stress and workload in the operating room (OR). Noise significantly reduces surgical performance, but experienced surgeons are able to reduce the acoustic perception of their surroundings to maintain a high level of performance in complex surgical tasks. However, music has been shown to improve learning and performance of complex motor skills. The aim of this study was to evaluate the influence of music on transferability and long-term acquisition of laparoscopic suturing skills.

Materials and Methods To evaluate the effects of music on training, subjects were asked to perform four surgeon's square knots on a bowel model within 30 minutes—prior and post 3 hours of hands-on training. To examine long-term skills, the same students were asked to perform a comparable, but more complex, task (four slip knots in a model of esophageal atresia) 6 months post initial training, as a follow-up measurement. Total time, knot stability (evaluated via tensiometer), suture accuracy, knot quality (Muresan scale), and laparoscopic performance (Munz checklist) were assessed.

Results Twenty-four students were included in the study; after simple randomization, 16 were trained while exposed to music (eight to Bach and eight to Bushido) and eight with traditional methods. Seven were lost due to follow-up. Both groups had comparable baseline characteristics and significantly improved after training, in all parameters assessed in this study. Subjects that trained with classical music were superior in terms of speed ($p = 0.006$), knot quality ($p = 0.014$), and procedural performance ($p = 0.034$) compared with controls.

Conclusion Music during acquisition of complex motor skills, like laparoscopic suturing and knot tying, is superior to traditional training. Especially music considered nondisturbing significantly improved speed, knot quality, and performance. Thus, incorporation of pleasant music into surgical skills training and the OR should be considered.

Keywords

- ▶ laparoscopy
- ▶ suturing
- ▶ surgery
- ▶ training
- ▶ learning
- ▶ music
- ▶ bach
- ▶ bushido

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Introduction

One of the most obvious distractions in the operating room (OR) is noise. In fact, acoustic distractions have been demonstrated to cause an increase in stress levels and workload in the OR. One study likened noise in the OR to that encountered on motorways.¹ Even more, not only does noise cause deterioration in the ability to communicate, it also reduces surgical performance with increasing importance depending on the complexity of the task.² While experienced surgeons are able to reduce the acoustic perception of their surroundings to maintain a high level of performance in complex surgical tasks, novice surgeons may suffer more dramatically from noise exposure.^{2,3} Thus, as most surgical teams also involve novice surgeons, it raises the question if it may be beneficial to reduce the noise level in the OR by not listening to music.

However, studies have shown that music has positive effects on the acquisition of motor skills. Recent studies have found positive effects of listening to music while conducting robot-assisted laparoscopic surgery and it has been reported that preferred music improves complex motor skills, but nonpreferred music may interfere with performance.⁴⁻⁶ Thus, it is not surprising that many surgeons utilize music to improve concentration and to mask the noise in the OR.¹

In other areas, such as exercise, music has been studied extensively and evidence largely supports the use of music: Many of these studies have focused on aerobic and endurance-based activities and commonly report improved performance.^{6,7} The studies suggest a “distraction effect” by which music reduces attention from exercise. Especially preferred music is hypothesized to alter one's focus to external information (i.e., music) rather than focusing on discomfort and fatigue.⁸ Other studies have further reported changes in mood and motivation levels when music is combined with endurance exercise, which may also lead to increased performance.⁹ Another possible mechanism by which music may be beneficial is optimization of arousal during tasks. This idea is rooted in the hypothesis that arousal and performance have an inverted-*U* shaped relationship in which too little or too much arousal will cause decrements in performance. Thus, this also means that there is a point of optimal arousal that leads to peak performance which music can help achieve.¹⁰

To date, the effect of music on acquisition of complex motor skills, like laparoscopic suturing, has not been evaluated. In the current study, we used an elaborate design to analyze both the short- and long-term retention of laparoscopic skills, while also assessing transferability of skills. The aim of this study was to evaluate the effects of music during surgical suturing training and to test whether two different genres of music might differentially influence the measured outcomes.

Materials and Methods

Study Design

All participants were randomly assigned to one of three treatment conditions in this 6-month follow-up study. To assess the influence of music versus nonmusic, a modified

setup as described by our group was utilized.^{11,12} The Medical Ethics committee of the Medical Association of Hamburg (Ethik-Kommission der Ärztekammer Hamburg) declared that no formal ethical approval was required for this study.

Pre-Post Measurement Period

For the pre and post measurement a similar setup as previously described by our study group was utilized.^{11,12} In short: a standardized explanation of the study and a short instructional video was shown to all participants prior to their first assessment involving suturing and knot-tying. However, participants were not told what the specific end points of the study were.

All participants were asked to perform four surgeon's square knots laparoscopically prior to a 3-hour surgical training session. After simple randomization using a dice, subjects were assigned and trained according to their group by S.M., R.B., L.K., and J.W. (Dice assignment: one or two for Bach, three or four for Bushido, and five or six for control group). During training, music was played at 55 db to allow for normal communication. The first group of participants listened to classical music composed by Johann Sebastian Bach (J.S. Bach Essentials, Apple Music playlist), while the second group listened to German rap music composed by the Artist Bushido (Bushido Essentials and Bushido Next Steps, Apple Music playlist). All subjects were tested a second time directly after the 180-minute training period. To limit confounding factors, distractors like smartphones were forbidden. Because of the nature of the intervention, blinding for randomization allocation was not possible.

Follow-Up Measurement Period

As described earlier, to guarantee transferability prior to the follow-up assessment, all participants received a standardized explanation and viewed a short instructional video of a different knot in a different setup (esophageal atresia model) which was used in the pre-post measurement period.^{11,12} Then participants were asked to perform four slip knots laparoscopically in a time period of 30 minutes.

Participants

Participants were between 21 and 34 years old ($M = 25.97$, $SD = 3.49$) studying medicine at the University of Hamburg. A total of 88% of the participants were female in both groups, thus accurately reflecting the gender distribution at German and United Kingdom medical schools.^{13,14} Exclusion criteria were (1) participation in operative training courses, (2) performance of any open, laparoscopic operations, or (3) experience in intracorporeal suturing to eliminate operative experience as a confounder (–Fig. 1).

Assessment

For every assessment, the primary end points of training efficacy were (1) time, (2) knot quality, (3) suture placement accuracy, (4) knot strength, as well as (5) overall laparoscopic and knotting performance. To evaluate knotting performance all participants tied four knots prior to and post training, as well as in the follow-up assessment. The participants' time was

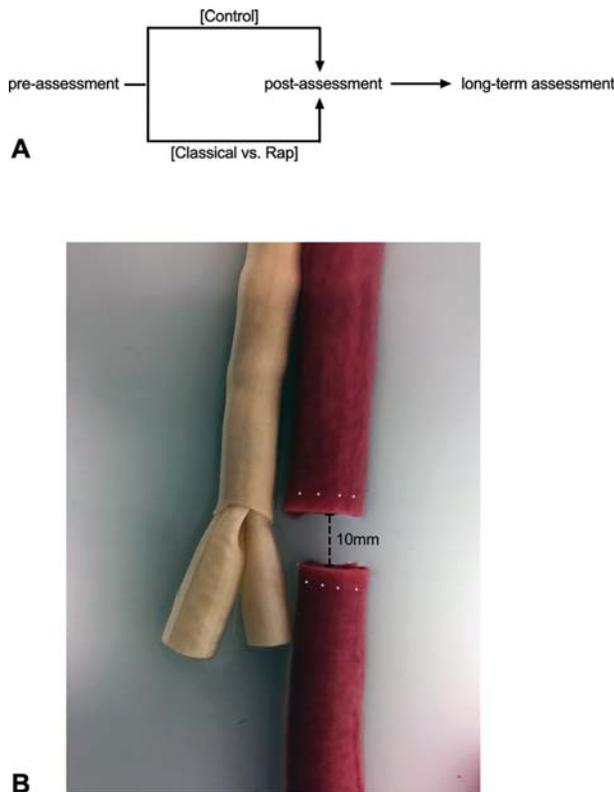


Fig. 1 Experimental design and treatment strategy. (A) Experimental design. Subjects were trained either with or without background music for three consecutive hours. Long-term effects were examined using a general linear model repeated-measures procedure for each dependent variable within group (control vs. music), as the between-subject variable, and time (pre, post, follow-up) as within-subject variables. (B) Shows the esophageal atresia model that was placed in box with a P.O.P. (pulsating organ perfusion) trainer to test temporal and request transferability.

measured from the moment the needle holder touched the suture until the suture was placed and secured with three throws. The knot quality was assessed by three surgeons, all blinded to the study group (S.M., R.B., M.B.) using a quantifiable 5-point scale by Muresan et al.¹⁵

The Muresan scale analyses knot quality based on (1) tightness (knot without visible gaps between throws = 1 point, knot tight at base = 1 point), (2) adaptation (edges are opposed without extra tissue in the knot = 1 point), and (3) stability (knot holds under tension = 2 points). Accuracy was determined by measuring the distance (mm) between marked entrance and exit points of the bowel model. The quality of suturing was assessed for each knot using a validated 23-point checklist developed by Munz et al.¹⁶ Three blinded referees (S.M., R.B., M.B.) assessed the videos and completed the checklist for each knot independently.

To test knot strength a tensiometer was used. The knotted sutures were placed into the tensiometer and the loops subjected to tensile forces of 50 mm/min until the knot broke or slipped as described by Dorsey et al and Goldenberg and Chatterjee.^{17,18} The force until slippage or breakage was evaluated and reported in Newtons (N, a unit of force equal to 0.225 lb).

Statistics

Sample size was calculated based on the results of a previous study that used a similar setting^{11,12} using G*Power.¹⁹ A minimum sample size of 16 people was calculated to ensure a difference with a medium effect ($\eta^2 = 0.45$) and a power of 0.80 at the 5% significance level.

All data was analyzed with SPSS Statistics 26 and Graph-Pad Prism 8. Differences between groups were calculated using a *t*-test or ANOVA. For ordinal data, differences were calculated with the Mann-Whitney-*U*-test or Kruskal-Wallis-test and data are presented as mean \pm standard deviation. To evaluate pre-, post-, and follow-up-training gain, repeated measures ANOVAs or Friedmans' ANOVAs were used. The level of significance was set at 0.05.

Results

In total, eight students underwent surgical skills training while listening to Bach (classical music), eight listened to Bushido (German rap music), and eight underwent training without music. No subject was excluded before or after randomization, seven subjects dropped out prior to the follow-up assessment ([Supplementary Material A](#), available in the online version).

Speed

The number of knots tied within 30 minutes was significantly lower in the pre-compared with the post- and the follow-up measurement, regardless of the training method employed ([Fig. 2A](#)). Follow-up analysis indicated that the Bach group performed significantly better than the group listening to Bushido and controls.

In terms of knot tying speed there was a significant short- and long-term improvement after training ([Fig. 2B](#)). At follow-up, subjects trained with classical music were significantly faster than controls and subjects that listened to rap music.

Accuracy

Training led to a significant linear improvement of accuracy ([Fig. 2C](#)). At the follow-up there were no significant differences between the groups ($p > 0.05$).

Suturing and Knot-Tying Performance

Laparoscopic performance improved from pre-, to post-, and follow-up measurement ([Fig. 2D](#)). However, the Munz performance score did not differ between training methods.

Knot Quality

Knot quality improved significantly after training ($p = 0.019$). Moreover, subjects in the Bach group had significantly higher Muresan knot scores than control subjects at the follow-up, as shown in [Fig. 2E](#).

Knot Strength

Knot strength was significantly improved after training ($p = 0.041$), yet no significant difference between groups regarding knot strength was observed, as demonstrated in [Fig. 2F](#).

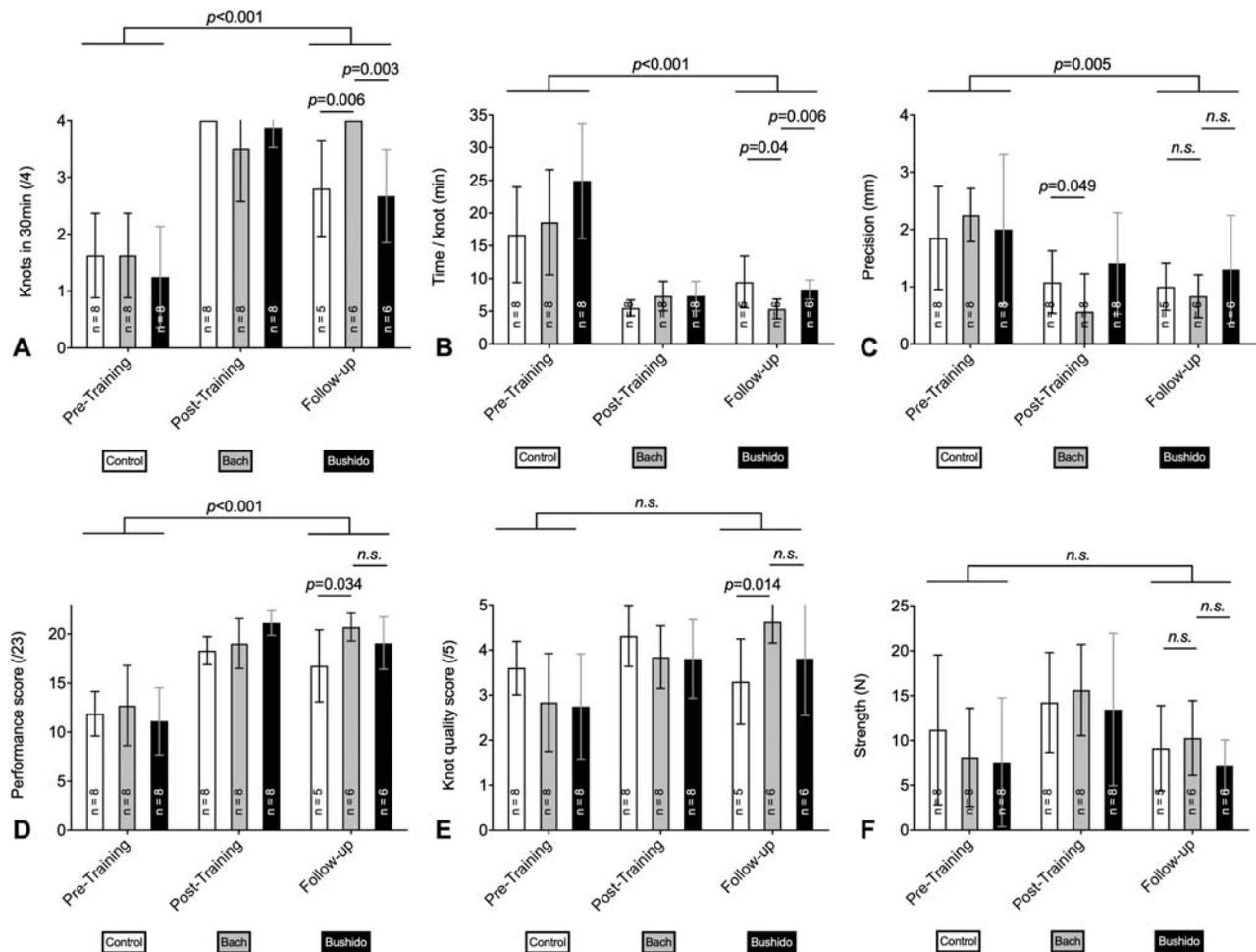


Fig. 2 Comparison of pretraining, post-training, and follow-up results in the three training groups. All aspects examined in the study showed a significant long-term improvement after training (A–F). Classical music was superior regarding speed (A, B), procedural performance (D), and knot quality (F). Data shown as mean \pm SD. Statistics: ANOVA, *t*-test or Mann-Whitney-U-test. ANOVA, analysis of variance; SD, standard deviation.

Music

The comparison of music versus nonmusic did not reveal any significant differences regarding all outcomes measured in the current study. Data of the subanalysis are not shown. Overall, within the classical music group, no subject found the music to be disturbing and 75% felt motivated by Bach. In the rap music group, 75% of the subjects felt disturbed, while 25% motivated. Moreover, preferred music appeared to result in a tendency for better overall performance, but no significant differences were found (\rightarrow Fig. 3).

Discussion

In recent years, modernization of medical training, including the implementation of the European Working Time Directive, has resulted in a need to acquire surgical proficiency during a shorter period of time. It has been estimated that between 15,000 and 20,000 hours are required to train a surgeon.²⁰ However, surgeons' training length varies from around 8 years in Europe (48 h/wk; 2,304 hours annually) to 5 years in the United States (80 h/wk; 3,840 hours annually).²¹ Hence, there is a need to improve efficacy in the OR or in surgical training

courses, to shorten the learning curve and achieve functional competence. Fortunately, it appears that music improves acquisition of complex motor skills such as laparoscopic suturing and knot tying, especially music that is considered nondisturbing.

Patients may suffer significant injury due to improper medical management.²² Within acute care settings, the OR is a frequent source of adverse events and errors can be catastrophic.²³ Adverse events are often triggered by a combination of factors, such as demanding caseloads, pressure to perform complex tasks, and conflicting priorities, resulting in worse concentration, increased stress, and poor teamwork.^{24,25} Previous studies in other high-reliability professions have shown that distractions or multitasking can have a detrimental effect on performance.²⁶ Thus, many surgeons avoid music in the OR.

However, various recent studies report beneficial effects of music on performance of complex motor skills. On the most basic level, music appears to reduce muscle fatigue and consecutively improves laparoscopy surgery.^{4,27} The choice of music may affect performance additionally during complex motor skills. In the current study Bach, which was

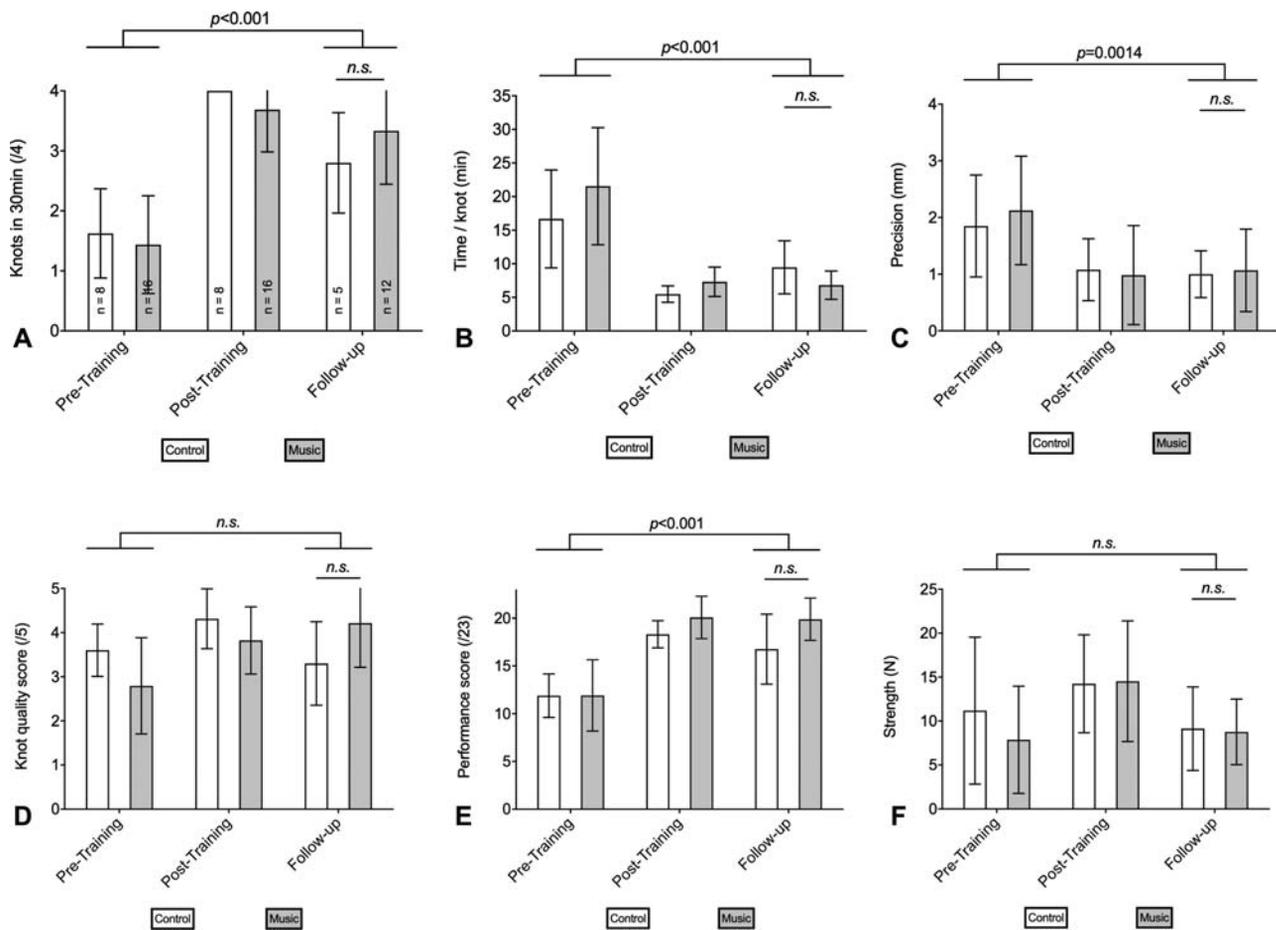


Fig. 3 (A–F) Comparison of pretraining, post-training, and follow-up results for preferred versus nonpreferred music. There were no significant differences between these two groups. Data shown as mean \pm SD. Statistics: ANOVA, *t*-test or Mann-Whitney-*U*-test. ANOVA, analysis of variance; SD, standard deviation.

considered as pleasant by the majority of the subjects, improved speed, procedural performance, and knot quality. In previous studies classical music was also preferred by physicians and nurses working in the OR.²⁸ Thus, classical music may lead to beneficial outcomes in most situations.

In another study, surgeons were evaluated while using a laparoscopic simulator under four different conditions: silence, mental loading (applying mental arithmetic tasks), auditory stress (listening to different music types on each ear), and auditory relaxation (listening to classical music). The study revealed that classical music was superior in improving accuracy, but had no effect on completion time.²⁹ In a similar setting three conditions were tested: silence, activating music, and relaxing classical music. The group that listened to activating music demonstrated the worst performance in terms of task time, procedural performance, and distraction. However, the study did reveal a trend for improved surgical performance, if participants considered the music they were listening to as pleasant.³⁰ Consequently, we recommend playing any music in the OR or in surgical training courses, as long as the team considers the music as pleasant.

The main strengths of this study are the randomization of the participants, utilization of predefined specific criteria, and a validated setup.^{31,32}

A potential limitation of this pilot study is the participation of medical students, rather than surgical residents. However, previous studies have shown that medical students and surgical residents, with minor laparoscopic experience, show comparable baseline performance and improvement capabilities.^{31,33,34} Another limitation of the study design is the possibly limited transferability to real life OR settings, as the training in this study was conducted in a skills laboratory setting. However, several randomized controlled trials show excellent practice transfer after training had been conducted on basic models, like intracorporeal suturing and knot tying.³⁵

In conclusion, listening to music may aid in the acquisition of complex motor skills, such as laparoscopic suturing and knot tying and is superior to traditional surgical training. This is particularly the case when music is considered nondisturbing, significantly improving speed, knot quality, and performance. Thus, it should be considered to incorporate pleasant music into surgical training courses and in the OR setting.

Authors' Contributions

S.M. conceptualized and designed the study, acquired the data, acted as course instructor, and approved the final manuscript as submitted. R.B. acquired the data, acted as

course instructor, and approved the final manuscript as submitted. J.B. conceptualized and designed the study, acquired the data, performed statistics, and approved the final manuscript as submitted. L.K. acquired the data, acted as course instructor, and approved the final manuscript as submitted. J.W. acquired the data, acted as course instructor, and approved the final manuscript as submitted. K.R. conceptualized and designed the study and approved the final manuscript as submitted. M.B. conceptualized and designed the study, acquired the data, acted as course instructor, performed statistics, drafted the initial manuscript, and approved the final manuscript as submitted. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Note

Olympus Europe provided a location and the equipment to conduct the study, but no consumables.

Ethical Approval

The Medical Ethics committee of the Medical Association of Hamburg (Ethik-Kommission der Ärztekammer Hamburg) declared that no formal ethical approval was needed for this study.

Funding

None.

Conflict of Interest

None declared.

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