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The effect of distributed practice and sleep on laparoscopic skill acquisition and retention

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Abstract

Most laparoscopic skill training is still given as a full day trainings course. However, this might lead learners to overload their cognitive capacity and therefore negatively influence learning, performance and motivation. There is compelling evidence that distributed training and sleep have a positive influence on skill acquisition and retention.

In this study, we will examine the effect of two different distributed training schedules and the effect of a powernap on laparoscopic skill acquisition and retention.

Results showed no effect between a one day spaced training and a 45 minute spaced training on skill acquisition on the basic tasks. This was also the case between the nap and the spaced-II group. But, there was a significant effect in favor of one day spaced training and nap on skill retention.

Although this study found a lack of effect during main analyses, we did replicate some effects seen in previous studies on distributed training. However, more research in needed to analyse the effect of distribution time and amount of sleep on complex laparoscopic skill acquisition and retention.

Introduction

Today, laparoscopic surgery is seen as the standard for a number of minimally invasive surgeries, like cholecystectomies, anti-reflux and bariatric surgeries (Grantcharov et al., 2004).

Laparoscopic surgeries have many advantages to traditional open surgeries (e.g. less invasive, shorter recovery time, less bleeding). However, in order for patients to benefit from these advantages, only surgeons who are skilled and well trained should perform these surgeries (Grantcharov et al., 2004).

Due to the challenges that come with learning minimally invasive surgical skills, such as mastering counter-intuitive instruments, having a two-dimensional viewing system and a reduced tactile feedback the old method of surgical training “see one, do one, teach one” does not suffice anymore in teaching these modern surgical skills (Aggarwal, Moorthy & Darzi, 2004; Arora et al., 2010; Gallagher, et al., 2005). With this, the method of teaching surgical skills has moved from the operating room to skillslabs outside the operating room. Next to finding a safe way to practice laparoscopic skills there is still the question of how to design the most effective training method.

Most hospitals and medical centres schedule staff training/ resident skill training as full day courses (Spruit, Band & Hamming, 2014). Although this might be convenient, we have to consider whether the benefits of good logistics outweigh the benefits of long-term retention and reliability of execution (Spruit, Band & Hamming, 2014). Full day courses may lead a learner to overload his cognitive system, *cognitive overload*, which could have a negative effect on learning itself, performance and motivation (Sweller, van Merrienboer & Paas, 1998).

There is compelling evidence that time is an important factor in acquiring motor skills (Karni et al., 1998). Research suggests that motor skill training methods that have rest periods, both sleep and breaks, embedded between the practice sessions or time periods that transpire after practice can have a positive effect on acquiring procedural memory (i.e. motor skills) (Benjamin & Tullis, 2010; Genzel, et al., 2012; Korman, Raz, Flash & Karni, 2003.

The aim of this study is to investigate the effect of spaced training and sleep on the acquisition of laparoscopic skills. We specifically focus on the questions: which time interval (45 minutes or a day) between trainingsessions is more effective in the acquisition and long-term retention of laparoscopic motor skills? And does a powernap have a positive effect on the acquisition and long-term retention of laparoscopic motor skills?

Spacing

Research has shown that, in general, distributing practice over time (spacing) leads to better knowledge and motor skills acquisition than an all day training course schedule (massed) (Benjamin & Tullis, 2010; Kwon, Kwon & Lee, 2015).

This ‘spacing effect’ has been well documented in declarative memory tasks but is also present with respect to motor skill learning (Adams, 1987; Cepeda, Pashler, Vul & Wixted, 2006; Rosenbaum, Carlson & Gilmore, 2001).

A meta analysis by Donovan and Radosevich (1999) showed that overall, participants in the spaced training condition performed significantly better than those in the massed training condition. In a study on the effect of spaced training on laparoscopic skills using the Minimally Invasive Surgical Trainer – Virtual Reality (MIST-VR), results showed a significant difference in retention between participant in the spaced and massed condition. Participants with a twenty minute training spaced over five minute blocks performed better than participants receiving a twenty minute training all in one time (Mackay, Morgan, Datta, Chang & Darzi, 2002). Furthermore, a more recent study done on the MIST-VR also demonstrated significantly better performance on the laparoscopic task for participants receiving three training sessions on consecutive days than participants in the massed condition (Gallagher, Jordan-Black & O'Sullivan, 2012).

As discussed, there is ample evidence of the spacing effect on motor skill acquisition. However, the magnitude of this effect varies depending on the type of task and the length of the time interval between training sessions (Donovan & Radosevich, 1999).

Sleep

There is a great body of research that indicates the beneficial effect of sleep on memory (Diekelmann & Born, 2010; Walker & Stickgold, 2004). This effect of sleep, which is known as *sleep-dependent memory*, seems to be involved in both procedural and in declarative memory (Korman et al., 2007; Tucker et al., 2006; Walker, Brakefield, Morgan, Hobson & Stickgold, 2002).

Research indicates that sleep benefits consolidation of the newly trained memory, and thereby helps preventing interference from similar tasks (Diekelman & Born, 2010). Furthermore, sleep can also initiate a delayed stage of learning that improves performances in both declarative and procedural memory without further training during the retention interval (Diekelman & Born, 2010; Walker, Brakefield, Seidman et al., 2003).

The optimal amount of sleep to benefit memory is unclear. It seems that both a night of sleep and a nap can have positive effects on procedural memory (Backhaus & Junghanns, 2006; Korman et al., 2007; Walker et al., 2002). Furthermore, some suggest that a delay between training and sleep can optimize the effect of sleep on memory consolidation (Diekelman & Born, 2010). However, it seems that for procedural memories, sleep does not need to occur immediately after training to benefit consolidation (Genzel et al., 2012; Korman et al., 2007; Walker et al., 2002). Keeping in mind that excellent skill acquisition in a short amount of time is the goal of these training methods, the question rises whether taking a powernap directly after a training period has the same effect as night time sleep or sleep after a delay.

In this paper, research is done on the effect of spaced training and a powernap on retaining laparoscopic motor skills of medical students. We specifically focus on the effect of the training conditions on task completion times. Our hypotheses are:

H_1: Participants in the one day spaced training have a significantly faster task completion time at the end of the training and at retention than participants in the 45 minute spaced training;

H_2: Participants in the group with a powernap have a significantly faster task completion time than participants in the 45 minute spaced training at the end of training and at retention.

Methods

Participants

A total of 175 students participated in this study (41 male) with age ranging from 17 to 41 (M= 21) Most of the participants were novice students, meaning that they had no experience in laparoscopy training. Participants were recruited via flyers in the cities Leiden, Utrecht, Amsterdam and Rotterdam. Although all students were allowed to participate in this study, the recruitment of participants focused mainly on medical students, since medical students are highly motivated to participate in laparoscopic training research as it is not included in their curriculum. Participants that had completed all training sessions and the retention session received a certificate.

Design and instruments

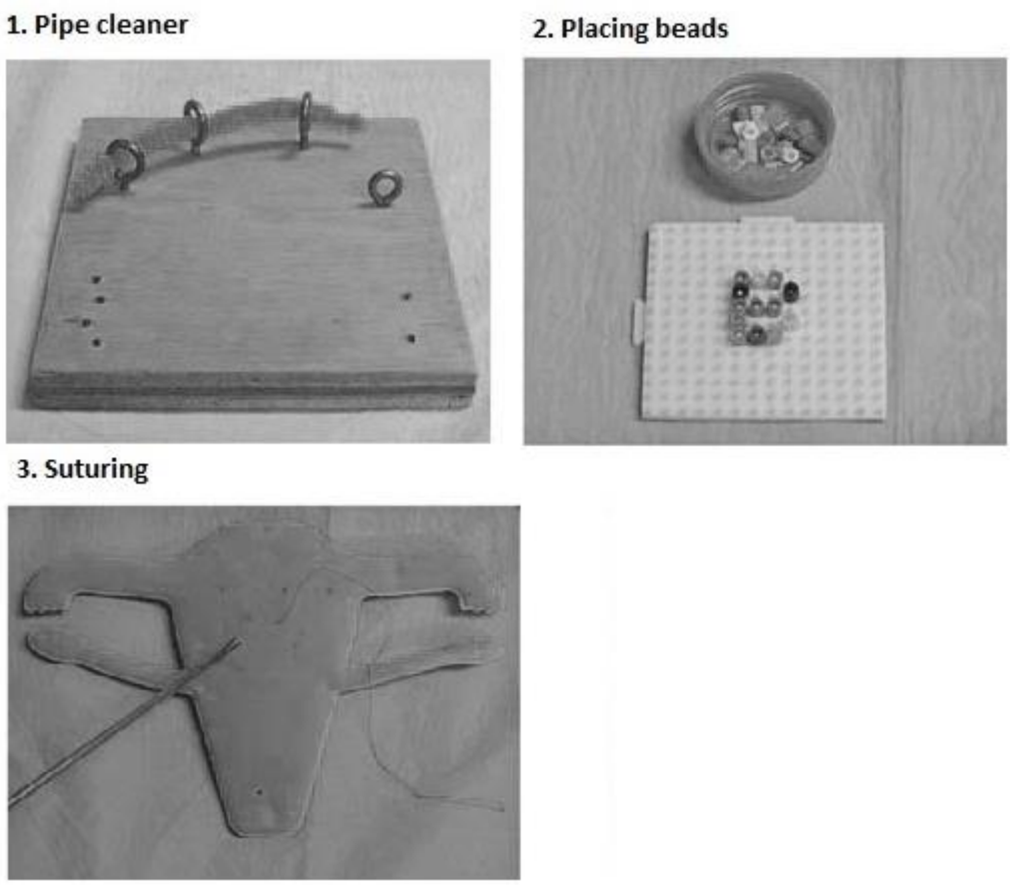
Training was received using a box-model simulation. This laparoscopic box-model consists of a box with holes on the topside of the box where laparoscopic instruments (trocars) can be inserted. In the box is a small camera and through a computer screen the trainees can see inside the box and practice their skills. This way of simulating a laparoscopic sugery is a relatively low-cost way of training surgical skills as making a box-model is fairly easy to accomplish (Clevin & Grantcharov, 2008). Another advantage of using a box-model simulation is that real laparoscopic instruments are used during the training instead of virtual ones like in a virtual reality simulation.

The laparoscopic skill training was divided into three training sessions and a retention session. Participants received a total training of 225 minutes consisting of sixty minutes of training and 15 minutes of instructions. All participants received the same three sessions and training time; however the time span or activity between the training sessions differed per condition. Participants randomly divided themselves in the training conditions through availability as training conditions were allocated to specific dates.

The study consisted of four training conditions: massed condition (massed), a spaced group with a one day time interval between training sessions (spaced-I), a spaced group with an 45 minute time interval between the sessions (spaced-II) and group with two powernap breaks between the sessions (nap). Participants in the massed condition received all the training sessions on one day, with only short breaks between the sessions. In the spaced-I group sessions one, two and three were given on three consecutive days. This meant that participants in this group received one training session per day. In the spaced-II group, participants also received all the training sessions on one day. However, in contrast to the massed group, the training sessions in the spaced-II group were given with a 45 minute time interval between the sessions. The last group, the nap group, is similar to the spaced-II group. But instead of two normal time intervals, participants in the nap group were instructed to do 35 minute powernaps between the training sessions. The powernaps were held in a separate room near the skillslab, where we set up five inflatable beds each with a cushion and a blanket. Each participant was also given a sleeping mask and earplugs. In order to measure the participants' activity, whether or not they had slept, we gave the participants a Fitbit Flex actometer which is a watch-like device that they wore on their left wrist. Using algorithms the Fitbit Flex measures when the participant fell asleep, how long they had slept and when they woke up.

During the training, participants had to perform three laparoscopic tasks, the pipe cleaner task, the beads task and the final task was placing a laparoscopic suture. Examples of the tasks are shown in Figure 1. The first task participants performed was the pipe cleaner task. In this task participants had to move the pipe cleaner as fast as they could from one end through four rings to the other end, using two laparoscopic graspers. The second task was placing beads on a pegboard. Participants had to place 13 beads on a pegboard so that the letter B is formed. To reduce recording time, in the current study, during filming participants only had to place eight beads and form the top half of the letter B. Depending on participants' preferences, this task can be done with one or two graspers. Before participants were allowed to practice the final task, laparoscopic suturing, they first practiced placing an 'open suture' (a non-laparoscopic suture) outside the training box- model. The reason for this was that we wanted the participants to place a specific laparoscopic suture. Letting the participants practice this specific suture outside the laparoscopic training box allowed the participants to become familiar with the specific steps required to place this suture. The final task of the training is placing a laparoscopic suture on a foam stomach. However, as placing a laparoscopic suture is almost impossible on the first try, baseline task was reduced to only the first part of the whole task. Participants only had to put the needle trough the foam stomach. Furthermore, participants filled out a questionnaires concerning demographics, music sports and gaming experiences.

All task instructions were given through an instruction video of the particular task. This was done to reduce the experimenter bias that can occur when giving instructions orally. Research showed that instruction videos have many advantages to written instructions for achieving understanding of a task (Yeung Jr, Justice & Pasic, 2009).



Figuer 1. The three laparoscopic tasks

Participants’ task performance was recorded on a computer through a video splitter and grabster converting A/V to USB. These recordings were then used to acquire the time a participant needed to perform a task. Although there were five laparoscopic training boxes the skills lab only had three computers to record on. The first performance on the first two tasks and the initial part of the third task are used to establish a base level of the participant.

Procedure

On the first training meeting, with help of PowerPoint slides participants received some information about the study. Participants were informed on the training sessions, when and where these would be given and how long the training session(s) would take and they were informed about the rules that came with participating in this study.

Session one. In addition to receiving general information about the study as described above during the first session, participants in the nap condition were informed on the powernap. We made sure that every participant was comfortable with the idea of doing a powernap and that they knew they could stop participation at any minute.

Training started with showing the participants instruction videos of the tasks they had to perform to establish their base level skill. After recording the base level, participants had ten minutes to practice the first task; the pipe cleaner task. After ten minutes on the pipe cleaner task, participants switched to the beads task. After ten minutes on the beads task, we showed them an instruction video of how to place a suture outside the training box. We showed this video one time after which participants practiced placing a suture outside the laparoscopic training boxes. Altogether this took about 15 minutes. For the last 15 minutes of the first training session, participants first watched an instruction video of placing a laparoscopic suture before they could practice placing one.

Session two. During session two the participants further practiced their laparoscopic skillset. The session started with the first two tasks, pipe cleaner and placing beads, respectively. For both tasks the participants had 12.5 minutes to practice. After this participants had two 12.5 minute training cycles for the laparoscopic suturing. Before each training cycle, video instruction of the task was shown to the participants. After the final practice round, task performance of participants' were recorded.

Session three. During this session, the practice time for the pipe cleaner and placing beads tasks was reduced. The final task (placing a suture) requires more practice time to master this skill. Therefore the participants only had five minutes on the pipe cleaner task and ten minutes on the beads task. Just like in session one and two, the participants were allowed to practice placing a laparoscopic suture, after they had watched the instruction video. However, in this session they were allowed to practice twice for 17.5 minutes.

Retention session. After three months, participants returned for a retention session. Performance on each task was recorded without additional training.

Results

Of the 175 participants, 26 participants did not complete the training. This left us with 149 ($N_{spaced\text{-}I}$ = 37, $N_{spaced\text{-}II}$ = 35, N_{nap} = 37, N_{massed} = 40) participants for analysis. 138 ($N_{spaced\text{-}I}$ =36, $N_{spaced\text{-}II}$ = 27, N_{nap} =36, N_{massed} = 39) participants took part in the three month retention session.

During measurement, if participants were unable to complete a task within a reasonable time of maximum ten minutes, a score of 901 was assigned. This score automatically ranked as the highest score in the non-parametric tests.

In this study we used an alpha level of .05 for all statistical tests. The groups were tested on comparability on age, gender, instruments, sports, gaming and hand preference. Non parametric test were conducted on all three task. In order to test for normality the Shapiro-Wilk test was conducted and showed no normal distribution for the test variables. Furthermore a visual inspection of the histograms led to the same conclusion.

The chi-square test showed no significant difference between the four training groups on gender and right, left-handed preferences of participants (Table 1). Furthermore, no difference was found on whether participants played games, sports or instruments (Table 1). Kruskall-Wallis and Mann-Whitney tests also showed no significant differences in age, gaming, sports and musical instruments activity (0 = I never played, 1 = I used to play, 2 = yearly, 3 = monthly, 4 = weekly, 5 = daily) between the groups. Furthermore, the nap group showed more inactivity during the breaks than the other groups as recorded by the Fitbit Flex, this in accordance with the instruction to try to sleep.

The Kruskal-Wallis test showed no significant difference between the conditions on all three baseline variables. A follow-up test was conducted on the two conditions that differed most within each baseline task. The spaced-I condition differed most from the nap

Table 1

X^2 Scores Between the Four Training Groups for Binary Variables

Variable	χ^2	*N*	*df*	*p*
Gender	1.98	149	3	.58
Left or right-handedness	1.61	145	3	.66
Instrument	2.61	145	3	.46
Games	1.81	145	3	.61
Sport	3.23	145	3	.36

condition on the first baseline task (pipe cleaner). The Mann-Whitney test showed no significant difference between the spaced-I condition (*Mdn*=137.5) and the nap condition (*Mdn*=120), *U*=571.5, *z*= -1.22, *p*= .222, *r*= -0.14 on performance time. Within the beads task the baselines of the massed (*Mdn*=364) and the spaced-II (*Mdn*=343) conditions did not differ significantly, *U*=575, *z*= -1.17, *p*= .243, *r*= -0.14. For the final baseline task (suturing) the massed (*Mdn*= 89) and the spaced-II (*Mdn*=102) conditions also showed no significant difference, *U*=636.5, *z*= -0.50, *p*= .618, *r*= -0.06.

For the main analyses, results of the first two tasks are shown in Figure 2 and 3. The results indicate an overall improvement on task performance for all participants during training.

At the end of the training, there was no significant difference in performance on the pipe cleaner task between the spaced-I (*Mdn*=49) group and spaced-II (*Mdn*=54) group, *U*=524, *z*=-1.39, *p*= .164, *r*= -0.16. This was also the case between the nap (*Mdn*= 43) group and spaced-II (*Mdn*= 54) group, *U*= 505.5, *z*= -1.60, *p*= .109, *r*= -0.19. On the beads task participants in the spaced-I (*Mdn*=137) group did not significantly outperform participants in the spaced-II (*Mdn*= 139) group, U= 634.5, *z*=-0.15, *p*= .884, *r*= -0.02. There was also no significant difference between the nap (*Mdn*= 139.5) group and the spaced-II (*Mdn*= 139) group with a test score of *U*= 590, *z*= -.46, *p*= .645, *r*= -0.05.

At the retention session, performance on the pipe cleaner task differed significantly between groups *H*(3) = 15.64, *p* < .001. A follow up test showed that the spaced-I (*Mdn*= 55) group performed significantly better than the spaced-II (*Mdn*= 72.5) group, *U*=301, *z*=-2.57, *p*= .010, *r*= -0.32. While the nap (Mdn= 56) group performed significantly better than the spaced-II (*Mdn*= 72.5) group *U*=309, *z*=-2.32, *p*= .020, *r*= -0.29. However, on the beads task, participants in the spaced-I (*Mdn*= 155) group did not perform significantly better than participants in the spaced-II group (*Mdn*= 177), *U*=352.5, *z*=-1.85, *p*= .064, *r*= -0.23. This was also the case between the nap (*Mdn*= 151) and spaced-II group (*Mdn*= 177), *U*=368, *z*=-1.15, *p*= .249, *r*= -0.15.

For the main analyses on the suturing task, results are shown in Figure 4. No significant difference was found between the training groups spaced-I (*Mdn*= 172) versus spaced-II (*Mdn*= 200) and between nap (*Mdn*= 207) versus spaced-II (*Mdn*= 200) on performance time at the end of the third training, with test scores of *U*=656.5, *z*=-.92, *p*= .355, *r*= -0.11 and *U*=603, *z*=-.11, *p*= .911, *r*= -0.01, respectively.

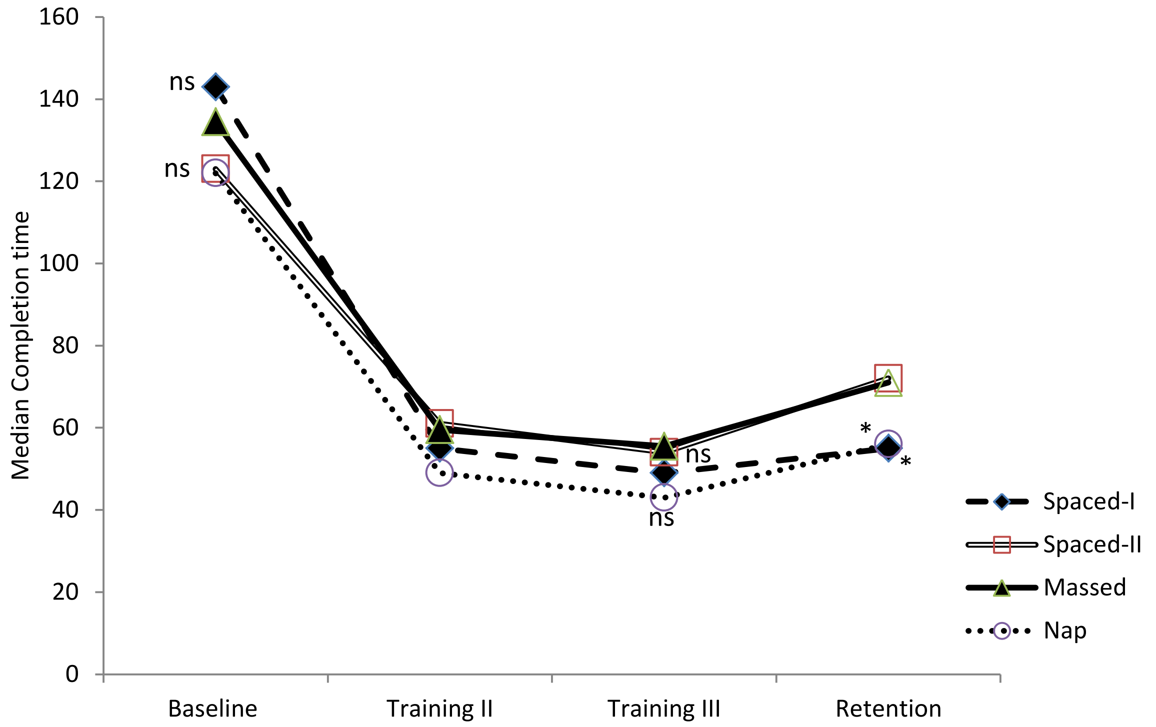


Figure 2. Median completion times (seconds) on the pipe cleaner task between spaced-I versus spaced-II groups and between nap and spaced-II groups on baseline, after training II, at the end of training and at retention for all four training groups (ns non-significant; *p < .05)

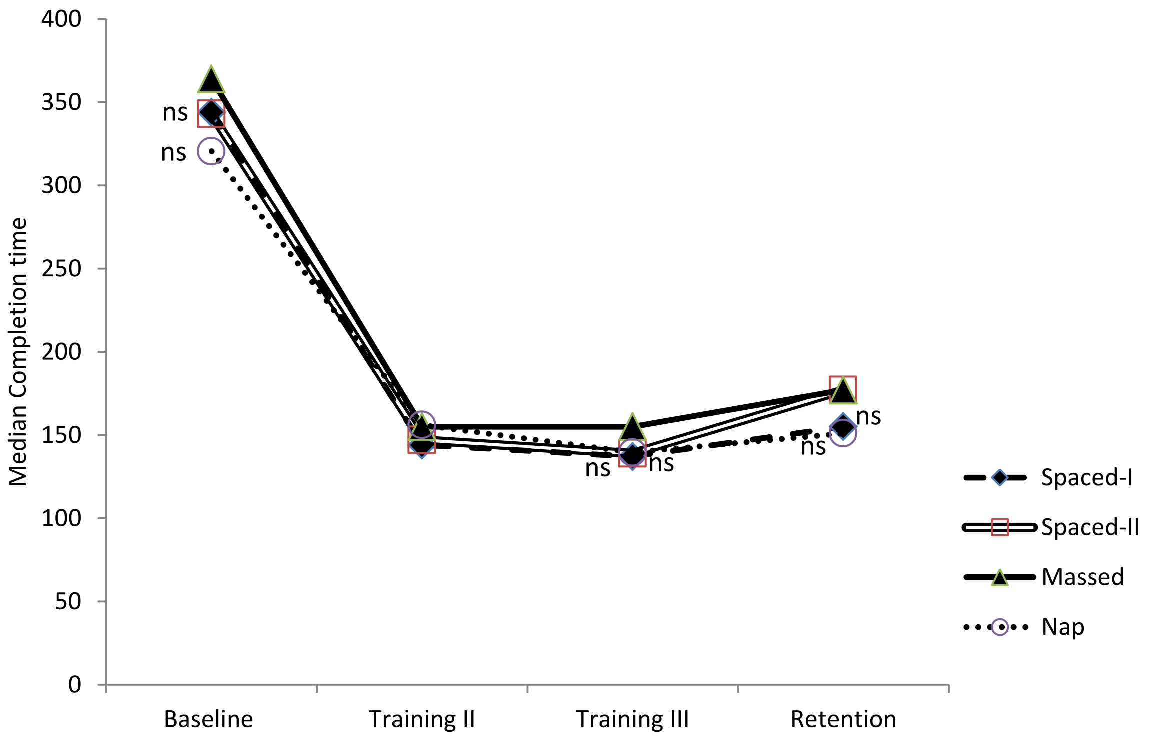


Figure 3. Median completion times (seconds) on the beads task between spaced-I versus spaced-II groups and between nap and spaced-II groups on baseline, after training II, at the end of training and at retention for all four groups (ns non-significant)

Performance progress was significant between the second and third training for all conditions. The Wilcoxon signed rank test showed test scores of, *z*= -3.05, *p*= .001, *r*= -0.35 for spaced -I; *z*= -3.30, *p*= .001, *r*= -0.40 for spaced-II; *z*= -3.95, *p*= .001, *r*= -0.44 for massed and, *z*=-3.72, *p*= .001, *r*=-0.44 for nap. There was no significant improvement between measurements at the end of the training and at retention (Fig. 3).

Analyses on performance during retention showed no significant difference between the spaced-I (*Mdn*= 340.5) group and spaced-II (*Mdn*= 514) group, *U*=392, *z*=-1.31, *p*= .190, *r*= -0.17. There was also no significant difference between the nap (*Mdn*= 286) group and spaced-II (*Mdn*= 514) group, *U*=356, *z*=-1.50, *p*= .133, *r*= -0.19.

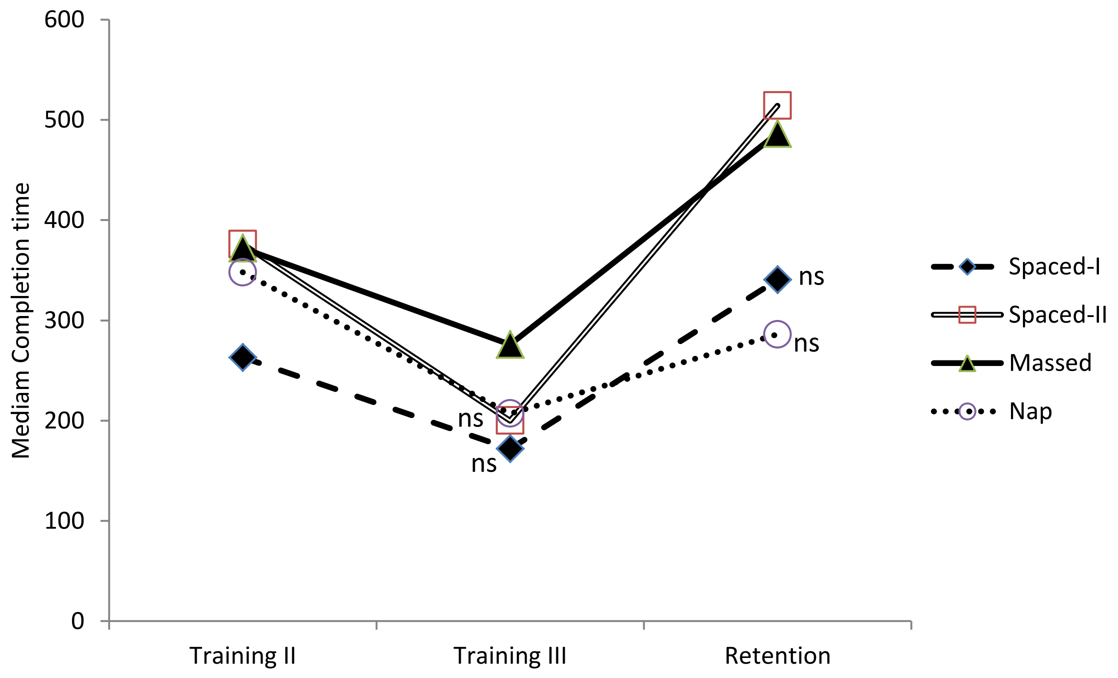


Figure 4. Median completion time for the suturing task between spaced-I versus spaced-II groups and between nap and spaced-II groups after the second training, at the end of training and at retention for all four groups (ns non-significant)

Because of the lack of effect we found during the main analyses extended analyses were done. Replicating findings from previous studies, at the retention session of the basic laparoscopic tasks, participants in the spaced-I group performed significantly better than the massed group on both the pipe cleaner, U= 403.5, *z*=-3.17, *p*= .002, *r*= -0.37 and beads task, U= 459.5, *z*=-2.12, *p*= .034, *r*= -0.25. Furthermore, the nap (*Mdn*= 56) group performed significantly better than the massed (*Mdn*= 72) group *U*= 374.5, *z*=-2.94 *p*= .003, *r*= -0.35 on the pipe cleaner task.

At the end of the training, completion times on the pipe cleaner and beads task showed a low correlation with amount of time asleep, with correlations of r_s = .355, *p* = .029 and r_s = .326, *p* = .046, respectively. Completion times during retention correlated significantly with amount of time asleep on the pipe cleaner task, r_s = .349, *p* = .037, but not on the beads task, r_s = .221, *p* = .201.

At the end of training of the suturing task, we also found a significant effect between the spaced-I (*Mdn*= 172) group and the massed group (*Mdn*= 276), *U*= 491, *z*= -2.40, *p*= .017, *r*= -0.27. Furthermore, there was a significant difference between conditions massed and nap on performance level during the retention test. The nap (*Mdn*= 286) condition performed significantly better than the massed (*Mdn*= 486.5) condition, *U*= 392, *z*= -2.61, *p*= .009, *r*= -0.31. This effect was also shown between the spaced-I group and massed were the spaced-I (*Mdn* = 340.5) group had a significantly better retention than the massed (*Mdn* = 486.5) group, *U*= 433.5, z= -2.44, p= .015, *r*= -0.29).

For the suture task, amount time asleep did not correlate completion times at the end of the training and during retention, r_s = .158, *p* = .352 and r_s =.186, *p* = .279, respectively.

Discussion

Next to replicating the effect of spaced training on skill acquisition shown in previous studies, this study's aim was to examine the effect of different time intervals between training session and the effect of a powernap on laparoscopic skill acquisition. In contrast to previous studies, results in this study showed a lack of effect during the main analyses. However, the extended analyses did show some significant difference between training groups on performance levels. Overall, after receiving the same amount of training time, participants in the spaced-I group performed better than participants in the spaced-II group. This was also the case between the nap and spaced-II group were participants in the nap group performed better than participants in the spaced-II group (see Fig 2, 3 and 4). This is demonstrated by lower completion times on task performance. Furthermore, we showed significant retention for the spaced-I and nap group on the pipe cleaner task and also for the nap group on suturing.

Except between spaced-I and massed on suturing, interestingly, no significant differences in performance was found on the three tasks between the groups at the end of training. This is in contrast to a study on distributed practice done by Spruit, Band and Hamming (2014) using the same laparoscopic tasks. This study showed a significant effect in favor of the spaced training group at the end of the training on all three tasks. The difference in results might be due the differences in time intervals between the training sessions. In the current study time intervals between training sessions were either of a day or 45 minutes, the study of Spruit, Band and Hamming (2014) had time intervals of one week between sessions. However, another study on laparoscopic skill acquisition using a one day time interval did show a significant effect in favor of spaced training although different tasks and laparoscopic simulations were used (Gallagher, Jordan-Black & O'Sullivan, 2012).

The lack of effect between groups on the first two tasks and the lack of progress between training II and at the end of training might be due to the fact that the time intervals and nap time were not long enough to positively affect participants' performance. Though, a more reasonable explanation might be that participants require less time to become proficient in these basic tasks. Furthermore, in the current study participants only had to do three laparoscopic tasks, giving them less tasks to focus on and more training time per task resulting in no significant difference between groups performance.

The result that the spaced-I group and the spaced-II group did not significantly differ from each other at the end of the training leads to the conclusion that both time intervals between training sessions are evenly equipped in ascertaining complex laparoscopic skills. However, the fact that spaced-I group significantly differed from the massed group and the spaced-II did not, suggest that having a longer time interval between sessions does have a better effect on acquiring complex laparoscopic skills and even skill retention (see Fig. 4). It might be that both time intervals are too short to significantly affect skill acquisition during training. This is in line with a previous meta-analysis showing reduced spacing effects for high complexity tasks with short time intervals (Donovan & Radosevich, 1999).

In general, although not significantly, the nap group does perform better on the suturing task than the spaced-II group at the end of training. The lack of effect might be due to the fact that although participants in the nap group were more inactive during the breaks than the spaced-II group, we cannot guarantee that participants actually fell asleep as the Fitbit Flex only records motion activity and inactivity of a person. This reasoning is supported by the fact that the participants in spaced-II group, has exactly the same median completion time score as participants in the nap group at the end of training. However, there is research that suggests strong correlations of total sleep time between the Fitbit and a polysomnography and a high validity for measuring sleep duration (Ferguson, Rowlands, Olds & Maher, 2015; Mantua, Gravel & Spencer, 2016). Interestingly, participants in the nap group did significantly outperform participants in the massed conditions during retention suggesting that sleep/ inactivity does have a positive effect on retention of complex laparoscopic skills resulting in an overall lower completion time in contrast to the other groups. Furthermore, it is also interesting to note the participants in the spaced-I group, who by default have sleep imbedded in their training program, also significantly outperformed participants in the massed group during retention.

Although results in this study are not as clear as seen in previous studies, our findings do have some implications for both developing training programs on this subject. Overall, it seems that having ‘sleep’ imbedded in the training improves retention. This suggests that, in developing future training programs, developers might need to consider implementing time between training sessions for trainees to be inactive. However, for logical reasons, arranging places to take a nap for trainees during training might not always be feasible. Therefore, it is worth looking at distributing practice over a minimum of three consecutive days when developing training programs for both basic and complex laparoscopic skills.

On the effect of sleep on laparoscopic skill acquisition and retention, future studies should focus on accurately measuring whether or not participants have slept instead of activity and inactivity of the participants. This way, more can be said about the effect of sleep on skill acquisition and retention. Furthermore, it would be interesting to see what different length of sleep has on learning new skills.

The present study does have some limitations. First, the number of participants per group is relatively small. A larger sample might have made a difference between groups, since median completion times on some tasks are fairly close together. Second, recording participant’s task performance could only be done three at a time. This led to a maximum wait time of around thirty minutes for the other two participants before they could record their performance on the tasks. This wait might have had an effect on task performance. Third, results from this study cannot be generalized to laparoscopic training in an OR. Training on a box-model simulator does improve laparoscopic skills in a save way, It does not, however, teach participants other important factors necessary for a good performance in the OR.

Although we cannot say that one day spacing is significantly better than 45 minute spacing skills or that a nap is better than spaced-II in acquisition and retention of laparoscopic skills. Results from this study do indicate that more research is needed on distribution time, sleep and amount of sleep during and/ or after training in order to design the perfect training for both basic and complex laparoscopic tasks.

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