Full-Length Article

From Music to Medicine, Part I
Are Pianists at an Advantage When Learning Surgical Skills?

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Abstract

Background: The acquisition of procedural competence is of vital importance in the training of physicians. It has been observed that medical students with extensive musical backgrounds often learn surgical techniques more rapidly than other students, raising the question of whether there is motor skill transfer from one area to another.

Objective: It is the aim of this project to explore whether musicians can learn and perform surgical skills more rapidly than non-musicians. This study explores the claims that musicians' proficiency in playing their instrument can translate into benefits when learning complex and refined motor skills in another domain. Even basic surgical skills, such as suturing, become difficult in cognitively demanding environments such as the operating room, containing a barrage of multisensory stimuli where the surgeon must triage and respond to clinically salient information.

Method: n=40 participants: 20 with piano expertise and 20 with no formal music training learned how to do a surgical knot and sutures. They had two practice sessions and were tested after each session. The two test parameters measured were time to complete the task and an OSATS (Objective Structures Assessment of Technical Skills) score (a commonly used validated scale for rating procedural competency). Results for each group (musicians and non-musicians) were analysed and compared. In Part II of this study, the practice behaviours and learning strategies used by each group were compared.

Results: Musician participants performed the surgical tasks faster and received higher scores than the controls; for knot tying, the difference between the two groups was statistically significant (by the last test, $p = .044$ for scores and $p = .025$ for test times). Gender and proficiency using chopsticks were found to be confounding variables, exhibiting some influence on test times and scores.

Conclusion: Musical training in piano appeared to be of benefit in the initial stage of learning new simple surgical skills. This indicates that at least some aspects of a musicians' skillset (such as fine motor control, bimanual dexterity and good hand-eye coordination) might be transferrable to an ostensibly disparate domain, and may be important for incorporation in surgical training where the skill of suturing can impact both surgical outcomes, patient safety, and patient satisfaction.

Keywords*: music and medicine, motor skill acquisition, motor skill transfer, surgical knot, suturing*

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Introduction

This paper was initiated based on the pervading opinion that musicians have an advantage when applying to be admitted to medical school (reported by [1]) and have an edge when progressing as medical students. Anecdotally, it is often reported that there is a surprisingly high proportion of accomplished musicians among medical students and doctors [2], and historically, there have been several eminent surgeon-musicians who believe that their ability to play a musical instrument "likely enhanced their expert surgical performance" [3]. Also, medical students who have learned music frequently cite that playing a musical instrument, which requires a high degree of manual dexterity, has contributed to their ability to suture [4]. Furthermore, as noted in some recent media articles [5] medical professors have observed that students with extensive backgrounds in music performance seem to have an advantage in learning surgical techniques. Therefore, this project will test some of these

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claims by investigating whether musicians' proficiency in playing their instrument can translate into benefits when learning complex and refined surgical suturing. Through this research, we will explore whether there is any scientific evidence that could confirm the commonly held perception that musicians' skills give them an advantage when learning medical procedures.

There is scientific research showing that music and surgery both rely on similar motor skills. In 2001, a workshop involving expert surgeons from Europe and the United States reviewed the selection process for surgical trainees and the panel's consensus was that dexterity was the ''strongest determining factor in the level of technical (operative) skills that a [surgical trainee] attains with training and experience'' [6]. The correlation between high manual dexterity and surgical skill is strong in several studies on surgical trainees and practicing surgeons [7-9] and bimanual dexterity is often evaluated as the most important predictor of surgical technical skill [4,10]. In parallel, numerous studies have demonstrated the exceptional bimanual dexterity of musicians [11-13]. It has been established that a pianist must bimanually coordinate the production of up to 1,800 notes per minute, which demonstrates a remarkable motor skill accomplishment [14]. It is also hypothesized that motor integration processes could be a factor contributing to the varying aptitude showed by surgeons when learning surgical techniques [15]. Interestingly, the same types of processes are observed when accomplishing musical tasks [16,17]. In another study, hand-eye coordination, multi-limb coordination, spatial perception and rapid motor reaction time have been identified as essential for surgical skills [6], and these same skills are enhanced in trained musicians [18]. Another trait considered to be of benefit for surgery skills is visuospatial ability [19,20] and musicians with high levels of music motor skills show superior visuospatial abilities [21-24].

A number of studies have tested whether musical training translates into advantages when learning suturing skills. Boyd and colleagues [25] found that participants with music experience performed suturing tasks quicker when compared to non-musicians, but no difference was found when assessing suturing using the Objective Structured Assessment of Technical Skills (OSATS) tool (note: OSATS is explained further in the methods section below). Rao, Swaby and Nehra [26] also found that participants with music experience performed suturing tasks more rapidly, but quality of suturing performances was not evaluated. Another study [27] found that musicians performed better on basic suturing skills but this advantage was lost when intermediate skills were tested. Two other studies [28,29] observed that playing a musical instrument may improve surgical dexterity and suturing skills of the non-dominant hand. However, two other studies [30,31] found that those with music experience performed laparoscopic tests no better than non-musicians. Results were mixed and it must be pointed out that in most of these studies, the participants were not expert musicians, but medical students who self-reported varying levels of music expertise, their musical instruments were often unknown, the sample size small and control groups rarely used. All these factors considerably weaken the methodology of these studies. In order to carefully investigate the effect of music expertise on suturing skills, we believe it is necessary to test advanced-level musicians who trained over several years, to carefully regulate for the musical instruments played, and to have a control group who has never studied music. We chose to focus on pianists because of the use of two hands in performing piano, requiring bicordination and fine motor dexterity in both hands.

Research Questions

It has been shown that critical parallels exist between surgical and expert musical performance expecially with respect to high levels of dexterity and ambidexterity. However, no study so far has provided convincing evidence that previously acquired fine motor control through musical training translates into improved learning of medical procedural skills. The current study will test differences between participants with extensive musical training and controls when acquiring two new surgical skills. The main research question can be formulated as follows: Does proficiency in piano playing provide any advantage in the acquisition of basic surgery skills in regards to speed and quality of performance?

Hypothesis 1: In this study, surgical proficiency is measured by time and performance quality. Based on the literature, we expect musicians to score better on timing and quality of performance on every tested trial.

Hypothesis 2: We defined learning as the difference (in time and in quality) between initial and final performance scores. According to Ackerman [32,33], in skilled performance requiring rapid and/or accurate motor movements, the differences between individuals tend to get smaller with practice. Therefore, along with improvement in speed and accuracy, individuals tend to become more alike over the course of skill acquisition.

Based on these theories of motor skills' acquisition, we expect a general decline in standard deviations of timing and performance scores over practice sessions. However, while observing a convergence of individual differences between the participants of each group (musicians and control), we anticipate that musicians will keep their score advantage.

Hypothesis 3: We know that group means improve with practice, but there is substantial asymmetry between the initial and final performance distributions for low- and high-performance groups [32,33]. Subjects that begin a task with poor performance tend to show great improvement in performance over learning trials, approaching the level of individuals with high initial performance.

We expect participants with initial performance falling in the highest range to show, on average, minor improvements over practice trials, while participants with the lowest initial scores will show substantial performance and timing increments.

Methodology

Participants

40 university students were recruited to participate in this project: 20 advanced piano students with strong performance skills (Royal Conservatory of Music grade 8 level or above, still practice regularly, and most were currently studying at the university level) and 20 university students with either minimal training (no piano training and less than 2 years of other types of musical training) or no formal training in music. All participants from both groups filled out a general questionnaire to collect demographic data and provide information on various activities that could potentially influence the results: texting frequency and video game experience [34-37], knitting and sewing experience [30], and proficiency in using chopsticks to eat [30,38]. The survey also included questions related to the music background of participants in both groups.

Demographic Information

Participant age range for each group was 19 to 28 years. The mean age for musicians was 23.5 years and for controls was 23.7 years. Participants' gender, handedness, musical background and possible confounding activities are reported in Table 1 on the following page. Significantly more musicians use chopsticks regularly and/or proficiently as compared to the control group ($\chi2(1, n = 40) = 10.157, p = .001$). There were no significant differences between the groups for all other demographic variables

Tasks

By watching a video recording with a visual demonstration and verbal explanations, participants learned how to perform a basic surgical knot on a teaching board and a simple suturing task on a synthetic skin board. These two tasks require fine motor skills, manual dexterity and hand-eye coordination [6]. The instructional videos were selected from a video-sharing service (YouTube) using standard evaluative criteria to ensure that the videos were free of bias, current, factual and neutral. Channels and uploading users were also examined. The video's purpose was free from persuasion and promotion.

Knot Tying

The knot task was a two-handed square knot with flat throws. Participants had to complete a total of 4 knots. Two sessions were held on two consecutive days. On the first day, participants learned how to perform the task from a video tutorial containing a visual demonstration and verbal directives, then practiced the task for 10 minutes and finally, performed the task as a test. On the second day, they were tested upon arrival to determine how much was retained. Participants were then given another practice period of 10 minutes and tested again. Participants had access to the video tutorial at all times during practice periods, but not during testing periods. They could replay, pause, rewind or fast forward the video. Throughout the whole procedure, no feedback was provided to participants by the administrator of the experiment.

Table 1. *Descriptive Statistics*

		Number		*Percentage*	
	Response	MUS	CON	MUS	CON
Gender	Female	15	13	75%	65%
	Male	5	7	25%	35%
Handedness (Self-described)	Left-handed	1	1	5%	5%
	Right-handed	19	19	95%	95%
Knitting / Sewing Experience*	Yes	10	8	50%	40%
Play Computer Games*	Yes	12	11	60%	55%
Texting Frequency	More Than 50 Times per Day	7	4	35%	20%
	20-50 Times per Day	8	6	40%	30%
	Less Than 20 Times per Day	5	9	25%	45%
	No Response		1	0%	5%
Chopstick ability	Use Daily/Weekly and/or Fully Proficient	9	1	45%	5%
Musicians – Highest Level Attained	Grade 8	4		20%	
	Grade 9	2		10%	
	Grade 10	5		25%	
	ARCT	1		5%	
	Bachelor of Music	7		35%	
	Master in Piano Performance	1		5%	

M = Mean; *SD* = Standard Deviation
*Categorized as "have experience" if participants regularly perform the activity and have done so for more than two years

Suturing
The suturing task was a 7-cm running subcuticular suture, a method of skin closure involving the placement of stitches below the skin, parallel with the line of the wound. Participants' practice and testing protocal was the same as the above knot-tying task.

Evaluation of Knot and Suturing Tasks
All tests were video recorded for later assessment. Video only showed the participant's gloved hands and suture working area, with no indication of participant identity, gender, type (musician or control) or stage of learning. The assessment tool used in this study was the Objective Structured Assessment of Technical Skills (OSATS). Developed by Martin and colleagues [39] and Reznick and colleagues [40], this type of assessment has been used extensively to evaluate surgical tasks and is valued for its reliability, validity, and ease of application both in a live setting [39,41] and using video recordings [42,43]. In this form of assessment, independent observers use two marking systems: a detailed task-specific checklist and a global rating scale. The checklist assessment is task specific and a new checklist must be developed for each new procedure whereas the global rating assesses generic aspects of technical performance and has a broad applicability [44]. In the checklist rating, the steps of the procedure being evaluated are broken down and each step is evaluated as "yes" or "no" based on whether the task was achieved or not. In our study, we used a validated two-handed knot checklist from Chipman and Schmitz [45] containing 4 items and a validated suturing checklist from Khan and his colleagues [44] containing 15 items. The global rating assesses operative skill in a less concrete way than the checklist, providing a "structured gestalt of performance" [39]. A number of items, all assessing aspects of operative skill, are marked from 1 to 5. Descriptive anchors are provided as guidelines for a poor score (score 1), average score (score 3), and excellent performance (score 5). The list of OSATS evaluation criteria for this study can be found in Appendix A .

Although checklists indicate whether or not discrete steps or behaviors occurred, global ratings communicate how well those behaviors were executed. Both types of data are helpful [45], but global ratings are often considered a superior method of assessment than task-specific checklists: global scoring measures the quality of the task more reliably [39], offers better rating precision [42], is a more effective discriminator between subjects [44], and provides more refinement due to each item rated on a Likert scale [46]. In our study, we also found that checklist scores correlated strongly with the global scores and yielded similar comparison results both for knot tying and for suturing. Based on these findings, when presenting results, it was decided to use the global score only.

Statistical Analysis
Statistical analysis was performed using SPSS Version 25 (SPSS, Inc., Chicago, Ill.). To analyze the reliability index of evaluators, a two-way random effects intraclass correlation coefficient (ICC) was used. For group comparisons of normally distributed data (verified using the Shapiro-Wilk test), the independent-samples t-test and two-way analysis of variance was used. For non-normal data, the Mann-Whitney U test was used. All tests were 2-sided and $p < .05$ were considered statistically significant.

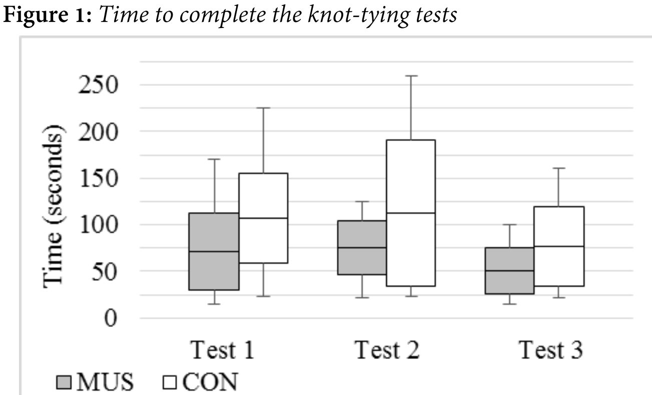
Reliability for knot tying evaluation. Intra-rater reliability: One rater (a senior surgical resident) performed the evaluations on all of the videos. To establish intra reliability 13 videos were evaluated twice without the evaluator's knowledge. For the global evaluation, an Intraclass Correlation (ICC) was performed to compare the pairs of scores and it showed excellent agreement: ICC(2,1) = .955.

Reliability for suturing evaluation. Inter-rater reliability: Two evaluators each completed the evaluations for 10 musicians and 10 controls. The same evaluator did all three tests for each participant, without being informed as to who the participant was; this ensured that the differences over the three tests performed by a particular participant were not the results of variability in the way two different evaluators might be scoring a performance. Twenty per cent (20%) of the videos were selected randomly to be rated by both evaluators for inter-rater reliability assessment; the result for global evaluation was: ICC(2,1) = .703.

Results

Knot Tying
Test Times
The total time to perform the knot-tying tests (all four knots) was recorded and mean values compared using an independent-samples t-test. Results are shown in Figure 1 and Table 2.

Figure 1: *Time to complete the knot-tying tests*



The horizontal lines within the boxes indicate mean times, the boxes indicate 1 standard deviation above and below the mean and the extensions indicate the full range of times.

Musicians completed the second and third tests in significantly less time than controls. Both groups decreased their times, but a mixed ANOVA test showed no difference between the groups with respect to the change in test time from test 1 to test 3 ($F(1, 37) = 0.135$, p .715, partial η2 = .004). The decrease in test time was significant for both groups ($F(1, 37) = 35.534$, $p < .001$, partial η2 = .490). The variability in test times also decreased (as indicated by the standard deviations) from test 1 to test 3 for both groups.

Table 2. *Comparison of knot-tying test times (in seconds)*

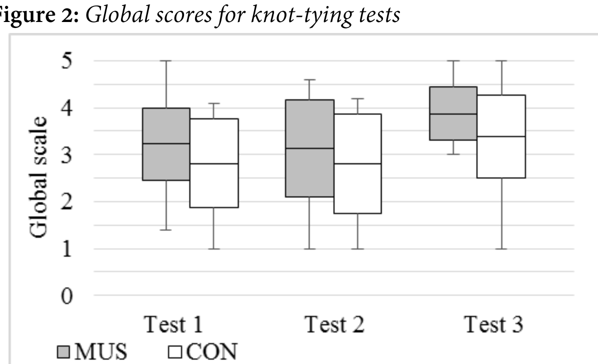
	MUS		*CON*					
Test	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
1	71.2	41.6	107.1	48.5	1.796	37	0.081	0.59
2	75.1	29.0	112.5	77.9	2.080	23.6	0.049*	0.86
3	50.5	24.2	76.6	42.9	2.366	30.0	0.025*	0.86

*$p < .05$

Quality of Performance

Comparison between musicians and control. Results were reported on three tests. Test 1 was on day 1 after 10 minutes of practice. Test 2 was on day 2 at the start of the session (to assess retention). Test 3 was on day 2 after 10 minutes of practice. The mean global ratings by participants were compared using an independent-samples t-test. The results are summarized in Figure 2 and Table 3.

Figure 2: *Global scores for knot-tying tests*



The horizontal lines within the boxes indicate mean scores, the boxes indicate 1 standard deviation above and below the mean and the extensions indicate the full range of scores.

Table 3. *Comparison of Musician and Control Mean Global Scores for Knot Tying*

	MUS		*CON*					
Test	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
1	3.23	0.77	2.81	0.95	1.543	38	0.131	0.50
2	3.13	1.03	2.81	1.059	0.970	38	0.338	0.31
3	3.87	0.57	3.38	0.885	2.086	38	0.044*	0.67

*$p < .05$

Musicians scored better on each of the three tests, but the difference was statistically significant only on test 3.

Both groups performed similarly on test 2 compared to test 1 and then improved significantly on test 3. No difference was found between groups in terms of the improvement from test 1 to test 3 — using a mixed ANOVA test there was no interaction between tests and experiment group ($F(1,38)=.07$, $p = .789$, partial η2 = .002). There was a significant main effect for time ($F(1,38) = 21.61$, $p < .001$, partial η2 = .362) and experiment group ($F(1, 38) = 4.342$, $p = .044$, partial η2 = .103).

The standard deviations were smaller by the third test, indicating a convergence of skill level. This was especially evident in the musician group; the lower scoring participants improved such that the range and standard deviations were noticeably smaller than that of the control group.

The differences between participant groups for each global evaluation criteria are presented in Table 4.

Improvement related to test 1 score. To investigate whether the improvement from test 1 to test 3 is related to the initial performance in test 1, we used a Pearson product-moment correlation coefficient to compare the test 1 score with the difference between test 1 and test 3 scores. There was a strong negative correlation for both groups with a lower test 1 score associated with a higher change in score; for musicians, $r = -.730$, $p < .001$ and for controls, $r = -.526$, $p = .017$. The same trend was found in the comparison of test 1 times and the change in test times from test 1 to test 3; for musicians, $r = -.819$, $p < .001$ and for controls, $r = -.601$, $p = .006$.

Time (speed) and quality performance. In order to understand whether gaining speed might have been a trade-off with quality performance or whether the results of doing the task faster was a consequence of acquiring better skills, we analysed how improvement in time relates to quality performance. We investigated for an association between the knot-tying times with the global scores for each of the 3 tests using a Pearson correlation coefficient. There was a strong, negative correlation between the two variables for each test with lower times associated with higher scores. For test 1, r = -.702, p < .001, for test 2: r = -.646, p < .001 and for test 3: r = -.571, p < .001. We also found that a greater change in scores from test 1 to test 2 was moderately correlated with a decrease in test time from test 1 to test 2 (r = -.484, p < .001).

Table 4. *Comparison of Each Global Item for Knot Tying (Mean Values and Independent-samples t-test Results are Shown)*

	Test 1			*Test 2*			*Test 3*		
Global Evaluation Item	MUS	CON	t	MUS	CON	t	MUS	CON	t
Time and Motion	2.90	2.40	1.965	2.95	2.45	1.726	3.45	3.15	1.324
Flow of Operation	3.20	2.60	1.763	3.00	2.70	0.86	4.15	3.40	2.699*
Knowledge of Procedure	3.25	2.70	1.655	3.30	2.70	1.53	4.05	3.40	2.249*
Overall Appearance	3.65	3.65	0	3.35	3.40	0.13	3.85	3.70	0.482
Overall Performance	3.15	2.70	1.696	3.05	2.80	0.73	3.85	3.25	2.281*

*$p < .05$

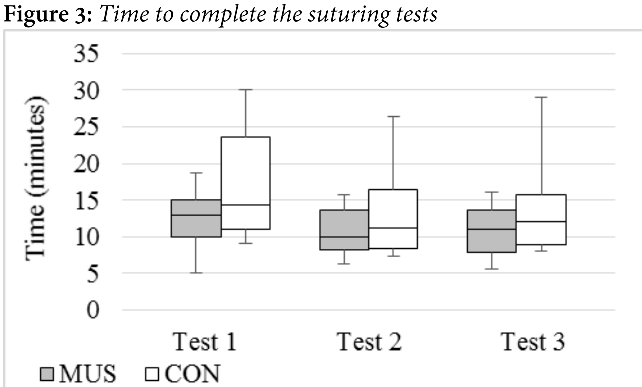
Suturing Results

Test Times

The distribution of suturing test durations was non-normal and therefore compared using the Mann-Whitney U test. Results are shown in Figure 3 and Table 5.

The musicians completed each test in less time, but the differences were not significant. As indicated by the interquartile range and the extensions in Figure 3, some control participants' test times were very long in comparison to the musician group whose variability was much smaller.

Figure 3: *Time to complete the suturing tests*



The horizontal lines within the boxes indicate median times, the boxes indicate the interquartile range and the extensions indicate the full range of times.

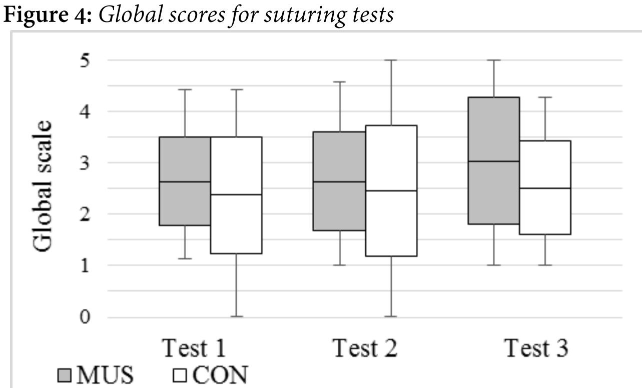
Table 5. *Comparison of Suturing Test Times (in Minutes)*

	Median					
Test	MUS	CON	*U*	*z*	*p*	*r*
1	13.0	14.3	140.0	-1.62	0.105	0.26
2	10.0	11.2	141.0	-0.91	0.632	0.14
3	10.9	12.0	132.5	-1.39	0.165	0.22

Quality of Performance

Suturing comparison between musicians and control. The mean global ratings by participant group were compared using an independent-samples t-test. Results are summarized in Figure 4 and Table 6. Musicians scored higher on each test, but the difference between groups is not significant. The largest difference between groups was on test 3.

Figure 4: *Global scores for suturing tests*



The horizontal lines within the boxes indicate mean scores, the boxes indicate 1 standard deviation above and below the mean and the extensions indicate the full range of scores.

Table 6. *Comparison of Musician and Control Mean Global Scores for Suturing*

	MUS		*CON*					
Test	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's D
1	2.64	0.87	2.37	1.14	-0.848	38	0.402	0.28
2	2.64	0.96	2.46	1.27	-0.518	38	0.607	0.17
3	3.04	1.23	2.51	0.91	-1.550	38	0.130	0.37

The scores for both groups changed very little from test 1 to test 2. The musician group had more improvement for test 3, but the mixed ANOVA test found no significant difference between groups with respect to this improvement—there was no interaction between tests and experiment group ($F(1,38)=.574$, $p = .453$, partial $\eta^2 = .015$).

The differences for each evaluation criteria are presented in Table 7. By test 3, the musicians' medians were higher; however, the differences between groups for individual items was not statistically significant.

Table 7. *Comparison of Each Suturing Global Item (Median Values and Mann-Whitney U test Results are Shown)*

		Test 1			*Test 2*			*Test 3*	
Evaluation Item	MUS	CON	U	MUS	CON	U	MUS	CON	U
Respect for Tissue	3.00	3.00	187	2.50	2.50	182	3.00	3.00	145
Time and Motion	2.00	2.00	181	2.00	2.00	181	3.00	2.50	163
Instrument Handling	2.50	2.00	177	2.50	2.00	172	3.00	2.00	143
Suture Handling	3.00	2.50	186	3.00	2.00	170	3.00	2.50	130
Flow of Operation	2.00	2.00	194	2.50	2.00	187	3.00	2.50	152
Knowledge of Procedure	3.00	2.50	177	2.50	3.00	190	3.00	3.00	147
Overall Performance	2.50	2.00	173	2.50	2.00	189	3.00	2.00	153

Improvement related to test 1 score. To investigate whether the improvement from test 1 to test 3 is related to the initial performance in test 1, we used a Pearson product-moment correlation coefficient to compare the test 1 score with the difference between the test 1 and test 3 scores. There was a moderate negative correlation for musicians and a strong negative correlation for controls with a lower test 1 score associated with a higher change in score; for musicians, $r = -.370$, $p = .108$ and for controls, $r = -.621$, $p = .003$. The same trend was found in the comparison of test 1 times and the change in test times from test 1 to test 3; for musicians, $r_s = -.360$, $p = .142$ and for controls, $r_s = -.722$, $p < .001$.

Time (speed) and quality performance. A Spearman's rank-order correlation was run to assess the relationship between suturing test times and global scores. There was a moderate negative correlation for tests 1 and 3 in which lower test times were associated with higher scores. For test 1, $r_s = -.434$, $p = .005$, for test 2: $r_s = -.125$, $p < .107$ and for test 3: $r_s = -.382$, $p = .018$.

Influence of Confounding Variables

Knitting/Sewing, Video Games, Texting

We collected information on three types of activities which could possibly have an effect on knot tying and suturing performances. The number of participants with experience doing these activities and the effect it has on knot-tying and suturing are shown in three tables in Appendix B. For knot tying and for suturing, we found no significant difference between those with experience doing the activity versus those with little or no experience.

Chopstick Experience

Participants were asked how often they use chopsticks, and how they would rate their skills. We categorized participants as having significant experience using chopsticks if they either use chopsticks frequently (more than once per week) and/or rated themselves as fully proficient. Ten musicians and one control participant met these criteria.

With only one control participant, we could not test for interaction between group and chopstick usage. However, we compared the time required to complete the tasks between musicians with chopstick experience/proficiency and those without and results are shown in Table 8.

Experienced users performed the knot tying faster for all three tests but were slower when completing suturing for all three tests. However, the differences were not significant.

Table 8. *Effect of Chopstick Proficiency on Time Required to Complete the Task*

	Use Frequently and/or Proficient		*Little or No Experience*					
Test	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
Knot 1 Time (s)	71.9	41.21	90.4	42.09	-0.993	18	.334	0.468
Knot 2 Time (s)	67.8	31.8	83.1	24.76	-1.161	18	.262	0.547
Knot 3 Time (s)	41.6	25.04	59.4	20.85	1.728	18	.101	0.814
Suturing 1 Time (min)	3.48	0.80	2.98	0.68	1.508	18	.149	0.711
Suturing 2 Time (min)	3.20	0.94	3.06	1.15	0.298	18	.769	0.141
Suturing 3 Time (min)	4.10	0.69	3.64	0.30	1.943	18	.068	0.916

A comparison was made on the quality of performance in the musician group between those with experience and those with little experience using chopsticks. Proficiency in chopstick use does show an impact on knot tying and suturing as shown in Table 9.

Musicians with more chopstick usage/proficiency scored higher on all 3 tests than those with less experience. For suturing, the difference in test 1 and 2 is statistically significant.

We compared the knot-tying and suturing performance of musicians and controls only for those participants with little or no chopstick experience (see Appendix C). In all the knot-tying tests and the last suturing test, the musicians scored.higher than controls, but the difference is not significant in any of the tests.

Table 9. *Comparison of Mean Global Ratings for Participants with Significant Chopstick Experience with Those with Little or no Experience (Musician Group Only)*

	Use Frequently and/or Proficient		*Little or No Experience*					
Test	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
Knot 1	3.48	0.801	2.98	0.67	1.508	18	0.149	0.71
Knot 2	3.20	0.94	3.06	1.15	0.298	18	0.769	0.14
Knot 3	4.10	0.69	3.64	0.30	1.943	18	0.068	0.92
Suturing 1	3.14	0.78	2.14	0.65	3.117	18	0.006*	1.47
Suturing 2	3.12	0.87	2.17	0.83	2.516	18	0.022*	1.19
Suturing 3	3.41	1.18	2.67	1.22	1.386	18	0.183	0.65

Gender

Knot tying. We investigated for any gender influence on the knot tying tests; results are summarized in Tables 10 and 11. Control group females performed noticeably better on each test with significant differences on tests 2 and 3, while musician males performed better on tests 1 and 3 (although differences were not significant). To explore this further, a two-way ANOVA was performed for each test to determine if there is interaction between participant group and gender; it was found that there was a statistically significant interaction for test 3 (F (1, 36) = 6.01, p = .019, partial $\eta2$ = .143). Simple main effects analysis showed that the male musician group scored significantly higher than male controls, F (1, 36) = 10.203, p = .003, $\eta2$ = .221, but there was no significant difference between female musicians and controls, F (1, 36) = 0.179, p = .674, $\eta2$ = .005.

With respect to test times, the female controls performed the test significantly faster, however there was no difference between the genders for the musician group.

Suturing. We investigated for any gender influence on the suturing tests; results are summarized in Tables 12 and 13. For the musicians, females performed better on the first two tests, and males performed better on the third tests; however, the differences are small and not significant. For the controls, females performed better than males on all three tests, but the differences were not significant. With respect to test times there was no difference between the genders for musicians. The control females were noticeably faster, but the difference was not statistically significant.

Table 10. *Effect of Gender on Knot-Tying Performance. Means of Global Scores and Results of the Independent-samples t-test are Shown for Each Test*

Group	Test	Female		Male					
		M	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
MUS	1	3.17	0.69	3.40	1.03	-0.563	18	.581	0.27
	2	3.31	0.89	2.60	1.33	1.363	18	.190	0.64
	3	3.77	0.57	4.16	0.52	-1.350	18	.194	0.64
CON	1	3.00	0.98	2.46	0.84	1.240	18	.230	0.58
	2	3.20	0.95	2.09	0.91	2.548	18	.020*	1.20
	3	3.66	0.75	2.86	0.92	2.108	18	.049*	0.99

*$p < .05$

Table 11. *Effect of Gender on Knot-Tying Test Times. Means of Test Times (in Seconds) and Results of the Independent-samples t-test are Shown for Each Test*

Group	Test	Female		Male					
		M	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
MUS	1	84.4	36.9	71.4	57.5	0.594	18	0.560	0.28
	2	80.7	27.9	54.0	25.8	1.722	17	0.103	0.84
	3	52.5	24.8	44.6	24.0	0.619	18	0.544	0.29
CON	1	88.0	42.1	139.9	42.8	2.575	17	0.020*	1.25
	2	81.0	52.2	166.4	74.6	2.943	17	0.009*	1.43
	3	61.9	36.5	103.7	42.8	2.303	18	0.033*	1.09

*$p < .05$

Table 12. *Effect of Gender on Suturing Performance. Means of Global Scores and Results of an Independent-samples t-test are Shown for Each Test*

Group	Test	Female		Male					
		M	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
MUS	1	2.74	0.9	2.34	0.75	0.889	18	.386	0.42
	2	2.66	1.04	2.60	0.78	0.126	18	.901	0.06
	3	2.98	1.29	3.23	1.14	-0.382	18	.707	0.18
CON	1	2.72	1.21	1.71	0.62	2.047	18	.056	0.97
	2	2.62	1.47	2.16	0.75	0.772	18	.450	0.36
	3	2.68	0.92	2.20	0.85	1.131	18	.273	0.53

Table 13. *Effect of Gender on Suturing Test Times. Median of Test Times (in Minutes) and Results of a Mann –Whitney U Test are Shown for Each Test*

Group	Test	Median					
		Female	Male	*U*	*z*	*p*	*r*
MUS	1	12.3	14.3	28.0	-0.829	0.407	0.19
	2	10.7	9.7	24.0	-0.600	0.549	0.14
	3	10.9	11.3	23.0	-0.531	0.595	0.13
CON	1	12.5	17.9	27.0	-1.466	0.143	0.33
	2	9.5	16.7	18.0	-1.686	0.092	0.40
	3	10.7	13.3	33.0	-0.991	0.322	0.22

Discussion

Playing an instrument, the piano in particular, is an activity that requires fine motor control, excellent bi-manual dexterity and good hand-eye coordination; three important qualities often associated with basic surgical skills. We wanted to know if prior musical experience relevant to the development of manual dexterity would positively influence basic suturing performance, so we tested differences between expert musicians and controls when acquiring new surgical skills. We hypothesized that a background in music performance would correlate positively with skill-task performance.

Hypothesis 1: In knot tying, musicians completed two of the three tests in significantly less time than controls (test 2: $p = .049$; test 3: $p = .025$). For performance quality, the musicians scored better on each of the three tests, but the difference is statistically significant only on test 3 ($p = .044$). In suturing, the differences between groups was not significant, however the musicians completed all three tests in less time than the control group. As for the assessment of performance quality, once again, the differences were not signiciant, but the musicians scored higher on each test; the largest difference between the groups was on test 3. We were expecting musicians to score better on timing and quality of performance and this first hypothesis was confirmed: in knot tying, musicians did significantly better in timing and quality of performance, and in suturing, while the differences were not significant, the musicians consistently did better.

Hypothesis 2: According to general theories of motor skills' acquisition, we tend to observe a general decline in standard deviations over practice sessions. In knot tying, the variability in test times decreased from test 1 to test 3 for both groups while musicians kept their score advantage. For quality of performance, the standard deviations are smaller by the third test indicating a convergence of skill level within each group, and this is especially the case for the musician group. For suturing, we did not see the same degree of convergence of skill level as indicated by the variability of test scores, although the range of musicians' suturing test times reduced considerably more than that of the controls. While observing a convergence of individual differences between the participants of each groups, we anticipated that musicians would keep their score advantage and that second hypothesis was confirmed (although more evident for knot tying).

Hypothesis 3: We did further analysis to investigate whether the improvement from test 1 to test 3 was related to the initial performance. In the quality of performance in knot tying, there was a strong negative correlation for both groups with a lower test 1 score associated with a higher change in score (musicians: $r = -.730$; control group: $r = -.526$). In the quality of performance in suturing, there was a moderate negative correlation for musicians ($r = -.370$) and a strong negative correlation for controls ($r = -.621$) with a lower test 1 score associated with a higher change in score. The same trends were also observed when comparing the times for the knot and suturing test 1 with the change in times from test 1 to test 3. This confirmed our third hypothesis, according to which participants with the lowest initial scores would show substantial performance increments.

Lastly, our analysis showed that for knot tying, there was a strong, negative correlation between knot-tying times and the global scores for each of the 3 tests (test 1: $r = -.702$; test 2: $r = -.646$; test 3: $r = -.571$), with lower times associated with higher scores. As for suturing, there was a moderate negative correlation for tests 1 ($r_s = -.434$) and 3 ($r_s = -.382$) in which lower test times were associated with higher scores. This is an indication that quality was not sacrificed for better timing, but rather demonstrates that as less time was required to complete the task, the quality of the performance was improving simultaneously.

Participants with extensive musical training did show advantages when learning suturing skills. Even though these benefits are not always statistically significant, there is a consistent trend for musicians to do better in timing and quality of performance, both for knot tying and suturing. This is in line with study findings by Boyd and colleagues [25] and Rao, Swaby and Nehra [26], who found that participants with music experience performed suturing tasks quicker (knot and sutures were considered as one task).

While the results indicate musicians have a benefit in learning and performing the tasks in this study, it is important to note that we cannot conclude there is a causal effect. In the literature [4,6,47,48] some argue that dexterity is genetic and therefor not an ability that could be developed by training. Thus a student with high genetic dexterity would have a greater chance of succeeding and advancing in her piano studies. That same student could also have a greater ability to learn the motor skill tasks in this study, not nessearily as a result of her piano expertise, but due to her genetic disposition to excel at fine motor tasks.

Limitations

Particular Type of Training

This study measured how quickly participants would be able to do the task and assessed the quality of how well they did the task. However, we could not separate these factors from the influence of the specific type of training that was provided, namely imitating a model doing the task on video accompanied by verbal directives. Our study reported performance data on two specific tasks, but those results also reflected how participants were able to grasp what was presented in the video and to what extent they perceived that they were performing in the same way as the person on the video. Had the training been different – with on-site modeling or with feedback from a tutor – the level of skills attained might have been very different. Typically medical students learn technical skills in two ways: simulation labs with an opportunity for deliberate practice and feedback, and in the clinical environment under close supervision. The type of training in this experiment (video training with no feedback) might have been to the advantage of musicians who are used to learning by imitation. Most technical skills at the piano are demonstrated by the teacher and then reproduced by the student in a similar fashion to watching the instructional video and reproducing the exact same action.

Chopstick Effect

There appears to be some effect of chopstick use and this could have brought some ambiguity into our comparison of musicians and controls (i.e., is the difference between groups more an effect of the greater number of chopstick users). It is an interesting finding that needs to be studied more carefully (i.e., more participant numbers, more inclusion of chopsticks in the experimental procedure and/or a chopstick test within the experiment).

Duration of the Effect Observed

It is also important to consider robustness of the effect observed in this study, as these positive correlations could be short lived. A study by Masud, Undre, and Darzi [9] showed that manual dexterity is a strong predictor of surgical skill acquisition, but only for the initial sessions. In their study, participants with very high manual dexterity scores performed significantly better than others, but only in the 1st and 2nd sessions. By the 4th practice sessions, these differences were eliminated. This phenomenon can also be observed in other studies looking at the impact of video gaming on suture performance. Regular engagement with video games has a positive effect on suturing, but only in the initial stage, as this advantage is lost after a few sessions of practice [49] and only in simple tasks [34]; all advantage is lost when intermediate skills are tested [27]. As for musicians learning surgical skills, this study is one of numerous we are conducting on the this topic. We are currently evaluating the potential benefit over a longer period of time with more difficult surgical tests including laparoscopic tasks.

Conclusion

Motor tasks that require rapid and accurate movements depend on learning and practice over an extended period of time. Understanding how individuals develop certain skills and predicting which individuals are most likely to excel represent critical issues. Researchers, admission officers, and undergraduate and graduate program directors, are interested in finding out the determinants of individual differences in skilled performance. Our study tested whether musicians who have attained high motor performance expertise on their musical instrument would show any benefits when acquiring basic motor skills in another domain. We found that the musicians we studied consistently showed better performance when learning basic surgical skills.

Research in this domain is pertinent at this time; a recent New York Times article [50] pointed out that "Faculty members at medical schools in the United States and Britain have noticed a marked decline in the manual dexterity of students and residents". The article goes on to speculate that some reasons for this may include too much time on personal devices and less time in participating in hands-on activities such as those affiliated with music making. Our results corroborate this hypothesis that expertise in a domain requiring fine motor skills may be of benefit in learning a new technical skill later in life.

Further research in this area is needed before findings could have any clinical claims or application, given the limitations inherent in this study. Future work will further develop our understanding of what elements gives musicians an advantage over non-musicians when learning new technical skills. This could help inform students in any discipline that requires fine motor tasks. Eventually, this study may have medical school admissions implications. Currently, admissions committees review applicants' files by combining subscores from each component (typically GPA (Grade Point Average), MCAT (Medical College Admission Test), interview and CASPer (Computer-Based Assessment for Sampling Personal Characteristics)). It is conceivable that high level music accomplishment can be accounted for in the applicant's scoring considerations, if sufficient correlations between music expertise and surgical acquisition can be made in the future.

References

1. American Music Conference. Research Briefs: Did You Know? Available at: http://advocacyformusiced.weebly.com/uploads/4/9/7/1/49713193/amc_-_research_briefs,_did_you_know.pdf. Accessed May 18, 2019.
2. Hond P. The hippocratic overture. *Columbia Magazine*. 2015, spring; 1-5. Available at: http://magazine.columbia.edu/features/spring-2015/hippocratic-overture
3. Rui M, Lee JE, Vauthey J-N, Conrad C. Enhancing surgical performance by adopting expert musicians' practice and performance strategies. *Surgery*. 2018; 163(4): 894-900.
4. Hughes DT, Forest SJ, Foitl R, Chao E. Influence of medical students' past experiences and innate dexterity on suturing performance. *Am J Surg*. 2014; 208(2): 302-306.
5. Jackson P. From musician to physician: why medical schools are recruiting for musical ability. 2018 [cited 27 June 2019]. Available from: https://www.cbc.ca/news/canada/newfoundland-labrador/medicine-music-connection-1.4770372
6. Cuschieri A, Francis N, Crosby J, Hanna GB. What do master surgeons think of surgical competence and revalidation? *Am J Surg*. 2001; 182(2): 110-116.

7. Francis NK, Hanna GB, Cresswell AB, Carter FJ, Cuschieri A. The performance of master surgeons on standard aptitude test. Am J Surg. 2001; 182(1): 30-33.
8. Datta V, Mandalia M, Mackay S, Chang A, Cheshire N, Darzi A. Relationship between skill and outcome in the laboratory-based model. Surgery. 2002; 131(3): 318-323.
9. Masud D, Undre S, Darzi A. Using manual dexterity to predict the quality of the final product in the small bowel anastomosis after a period of training. *Am J Surg.* 2012; 203(6): 776-781.
10. Hofstad EF, Våpenstad C, Bø LE, Langø T, Kuhry E, Mårvik R. Psychomotor skills assessment by motion analysis in minimally invasive surgery on an animal organ. *Minim Invasive Ther Allied Technol.* 2017; 26(4): 240-248.
11. Rosser JC, Rosser LE, Savalgi RS. Objective evaluation of a laparoscopic surgical skill program for residents and senior surgeons. *Arch Surg.* 1998; 133(6): 657-661.
12. Kopiez R, Galley N, Lehmann AC. The relation between lateralisation, early start of training, and amount of practice in musicians: A contribution to the problem of handedness classification. *Laterality.* 2010; 15(4): 385-414.
13. Furuya S, Altenmüller E. Acquisition and Reacquisition of Motor Coordination in Musicians. *Ann N Y Acad Sci.* 2015; 1337: 118-124.
14. Münte TF, Altenmüller E, Jäncke L. The musician's brain as a model of neuroplasticity. *Nat Rev Neurosci.* 2002; 3: 473-478.
15. Debaere F, Wenderoth N, Sunaert S, Van Hecke P, Swinnen SP. Changes in brain activation during the acquisition of a new bimanual coodination task. *Neuropsychologia*. 2004; 42(7): 855-867.
16. Lewis PA, Wing AM, Pope PA, Praamstra P, Miall RC. Brain activity correlates differentially with increasing temporal complexity of rhythms during initialisation, synchronisation, and continuation phases of paced finger tapping. *Neuropsychologia.* 2004; 42(10): 1301-1312.
17. Zatorre RJ, Chen JL, Penhune VB. When the brain plays music: Auditory – motor interactions in music perception and production. *Nat Rev Neurosci.* 2007; 8(7): 547-558.
18. Green C, Bavelier D. The cognitive neuroscience of video games. In: Humphreys L, Messaries P, eds. Digital Media: Transformations in Human Communication. New York, NY: Peter Lang Publications; 2004: 211-224.
19. Fried GM, Feldman LS, Vassiliou MC, Fraser SA, Stanbridge D, Ghitulescu G, Andrew CG. Proving the value of simulation in laparoscopic surgery. *Ann Surg.* 2004; 240(3): 518-528.
20. Hegarty M, Waller D. Individual differences in spatial abilities. In: Shah P, Miyake A, eds. The Cambridge Handbook of Visuospatial Thinking. Cambridge: Cambridge University Press; 2005: 121-169.
21. Schlaug G, Jancke L, Huang Y, Staiger JF, Steinmetz H. Increased corpus callosum size in musicians. *Neurophychologia.* 1995; 33(8): 1047-1055.
22. Rauscher F, Shaw G, Levine L, Wright E, Dennis W, Newcomb R. Music training causes long-term enhancement of preschool children's spatial–temporal reasoning. *Neurol Res.*1997; 19(1): 2-8.
23. Brochard R, Dufour A, Després O. Effect of musical expertise on visuospatial abilities: Evidence from reaction times and mental imagery. *Brain Cogn*. 2004; 54(2): 103-109.
24. Pietsch S, Jansen P. Different mental rotation performance in students of music, sport and education. L*earn Individ Differ*. 2012; 22(1): 159-163.
25. Boyd T, Jung I, Van Sickle K, Schwesinger W, Michalek J, Bingener J. Music experience influences laparoscopic skills performance. *JSLS.* 2008; 12(3): 292-294.
26. Rao ND, Swaby J, Nehra D. Can a hobby influence medical students' suturing skills? *Ann R Coll Surg Engl.* 2015; 97(9): 387-391.
27. Glaser AY, Hall CB, Uribe SJ, Fried MP. The effects of previously acquired skills on sinus surgery simulator performance. *Otolaryngol Head Neck Surg. 2*005; 133(4): 525-530.
28. Jalink MB, Heineman E, Pierie JP, Ten Cate Hoedemaker HO. The effect of a preoperative warm-up with a custom-made nintendo video game on the performance of laparoscopic surgeons. *Surg Endosc.* 2015; 29(8): 2284-2290.
29. Harenberg S, McCaffrey R, Butz M, Post D, Howlett J, Dorsch KD, Lyster K. Can multiple object tracking predict laparoscopic surgical skills? *J Surg Educ.* 2016; 73(3): 386-390.
30. Madan AK, Frantzides CT, Park WC, Tebbit CL, Kumari NV, O'Leary PJ. Predicting baseline laparoscopic surgery skills. *Surg Endosc.* 2005; 19(1):101-104.
31. Panait L, Larios JM, Brenes RA, Fancher TT, Ajemian MS, Dudrick SJ, Sanchez JA. Surgical skills assessment of applicants to general surgery residency. *J Surg Res.* 2011; 170(2): 189-194.
32. Ackerman PL. Individual differences in skill learning: an integration of psychometric and information processing perspectives. *Psychol Bull.* 1987; 102: 3-27.
33. Ackerman PL. New developments in understanding skilled performance. *Curr Dir Psychol Sci.* 2007; 16(5): 235-239.
34. Rosenberg BH, Landsittel D, Averch TD. Can video games be used to predict or improve laparoscopic skills? *J Endourol*. 2005; 19(3): 372-376.
35. Rosser JC, Lynch PJ, Cuddihy L, Gentile DA., Klonsky J, Merrell R. The impact of video games on training surgeons in the 21st century. *Arch Surg*. 2007; 142(2): 181-186.
36. Badurdeen S, Abdul-Samad O, Story G, Wilson C, Down S, Harris A. Nintendo Wii video-gaming ability predicts laparoscopic skill. *Surg Endosc.* 2010; 24(8): 1824-1828.
37. Zeng W, Woodhouse J, Brunt LM. Do preclinical background and clerkship experiences impact skills performance in an accelerated internship preparation course for senior medical students? *Surgery.* 2010; 148(4): 768-776.
38. Harper JD, Kaiser S, Ebrahimi K, Lamberton GR, Hadley HR, Ruckle HC, Baldwin DD. Prior video game exposure does not enhance robotic surgical performance. J *Endourol*. 2007; 21(10): 1207-1210.
39. Martin JA, Regehr G, Reznick R, MacRae H, Murnaghan J, Hutchison C, Brown M. Objective structured assessment of technical skill (OSATS) for surgical residents. *Br J Surg*. 1997; 84(2): 273-278.
40. Reznick RK, Regehr G, MacRae H, McCulloch W. Testing technical skills via an innovative "Bench Station" examination. *Am J Surg.* 1997; 173(3): 226-230.
41. Faulkner H, Regehr G, Martin J, Reznick R. Validation of an objective structured assessment of technical skill for surgical residents. *Acad Med.* 1996; 71(12): 1363-1365.

42. Alam M, Nodzenski M, Yoo S, Poon E, Bolotin D. Objective structured assessment of technical skills in elliptical excision repair of senior dermatology residents: A multirater, blinded study of operating room video recordings. *JAMA Dermatol*. 2014; 150(6): 608-612.
43. Chang OH, King LP, Modest AM, Hur HC. Developing an objective structured assessment of technical skills for laparoscopic suturing and intracorporeal knot tying. *J Surg Educ*. 2016; 73(2): 258-263.
44. Khan MS., Bann SD, Darzi AW, Butler PE. Assessing surgical skill using bench station models. *Plast Reconstr Surg*. 2007; 120(3):793-800.
45. Chipman JG, Schmitz CC. Using objective structured assessment of technical skills to evaluate a basic skills simulation curriculum for first-year surgical residents. J *Am Coll Surg*. 2009; 209(3): 364-370.
46. Regehr G, MacRae H, Reznick RK, Szalay D. Comparing the psychometric properties of checklists and global rating scales for assessing performance on an OSCE-format examination. *Acad Med*. 1998; 73(9): 993-997.
47. Causby R, Reed L, McDonnell M, Hillier S. Use of objective psychomotor tests in health professionals. *Percept Mot Skills*. 2014; 118(3): 765-804.
48. Elneel F, Carter F, Tang B, Cuschieri A. Extent of innate dexterity and ambidexterity across handedness and gender: implications for training in laparoscopic surgery. *Surg Endosc*. 2008; 22(1): 31-7.
49. Tsai CL, Heinrichs WL. Acquisition of eye-hand coordination skills for videoendoscopic surgery. *J Am Assoc Gynecol Laparosc*. 1994; 1(4, Part 2): S37.
50. Murphy K. Your surgeon's childhood hobbies may affect your health. 2018 [cited 27 June 2019]. Available from: https://www.nytimes.com/2019/05/30/well/live/surgeons-hobbies-dexterity.html?em_pos=small&ref=headline&nl_art=8&te=1&nl=well-family&emc=edit_ml_20190530

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