Evaluating the knowledge acquisition of lower limb anatomy among medical students during the post-acute COVID-19 era

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Evaluating the knowledge acquisition of ~~applied clinical musculoskeletal~~ lower limb anatomy among ~~University of Malta first year~~ medical students during the post-acute Covid-19 era

Abstract

Introduction

Anatomy is the foundation of many medical and surgical ~~specialities~~specialties yet knowledge acquisition and retention among medical students is questionable. Over the years the anatomy teaching environment and teaching modalities have changed, even more so with the onset of the Covid-19 pandemic and the shift to a virtual environment. The aim of this study was to evaluate the knowledge acquisition of applied musculoskeletal lower limb clinical anatomy among first year medical students in Malta ~~enrolled at the University of Malta~~ following the transition back to face-to-face lectures.

Materials and Methods

The Kahoot online game-based quiz platform was used through a best out of four multiple-choice setting across 4 sessions. Scores generated by the platform along with frequencies of correctly answered questions were utilized to measure knowledge acquisition. The average scores for each question across sessions were statistically analysed using ANOVA and student's t-test accordingly.

Results

Across the 4 sessions, the positive percentage response for clinical based questions remained higher than for pure anatomy questions. ~~students were more likely to answer a clinical based question correctly, with improved knowledge acquisition across time when compared to pure anatomy questions.~~

Conclusions

Anatomy knowledge acquisition appears to be subjective to clinical based knowledge rather than pure anatomy. There may be a plethora of reasons as to this outcome including the misconception that anatomy is not essential for clinical practice as well as ~~a~~ the potential aftermath of the ~~Covid induced~~Covid-induced virtual learning environment. Further research is merit to ensure that students are provided with the best tools to enhance their knowledge acquisition, both as students and as future doctors.

Keywords

~~Gross anatomy~~Anatomy; COVID-19; Medical students; Knowledge acquisition ~~acquisition~~ ; Malta

Introduction

Anatomy is one of the foundations of medical education as it forms the basis of many medical and surgical ~~specialities~~specialties (Arráez-Aybar et al., 2010; Turney, 2007). The traditional set-up of the anatomy course consists of a mixture of didactic lectures, small group teachings and laboratory cadaver dissections when available (Older, 2004). Over the years the anatomy teaching environment and teaching modalities have changed, even more so with the onset of the COVID -19 pandemic (Gabard et al., 2012; Papa et al., 2022; Shin et al., 2022). Despite this, the level of anatomy knowledge acquisition and retention among medical students and later as young doctors~~,~~ is continuously debated and sometimes is even considered insufficient (Cottam, 1999; Fillmore et al., 2016; Waterston and Stewart, 2005). Similarly, loss ~~of~~ of anatomy knowledge acquisition and retention haves~~s~~ also been reported among other health sciences students including nursing, radiographers and chiropractic science among others (Hall and Durward, 2009; Narnaware and Neumeier, 2020; Strkalj et al., 2011).

The University of Malta is the only state university offering undergraduate and postgraduate courses in Malta, with the Faculty of Medicine and Surgery being one of the many faculties housed by this university. The undergraduate Doctor of Medicine and Surgery (MD) course is a 5-year course, with the first two years dedicated to pre-clinical subjects including anatomy. ~~The pre-clinical years follow a module approach covering body systems. Each module is made up of lectures, critical thinking small group sessions, clinical skills hands-on sessions, video dissections as well as hands on dissection sessions using donated cadavers and prosections.~~

The COVID-19 pandemic has imposed a burden on several sectors including the medical education sector. Generally medical schools across the globe shifted from face-to-face to a virtual learning environment including virtual dissection sessions (Chang et al., 2022; DK, 2020; Pather et al., 2020). Like the rest of the world, Malta reported the first Covid-19 case in March 2020, and a partial lockdown was instituted which included a shift in the delivery of the educational system from face-to-face to virtual till the end of the academic year 20202019/202110 (Cuschieri, 2020; Cuschieri and Calleja Agius, 2020). ~~The virtual learning environment was extended for the post-secondary education for the new academic year 2020/2021. The Department of Anatomy while keeping with the virtual learning environment for lectures, changed the small group teachings and dissection sessions back to face-to-face sessions with reduced student number in each session to adhere to public health measures while ensuring that the students were recipient of the best possible medical education.~~ The academic year 2021/2022 saw the shift back to face-to-face teaching for both lectures and small group sessions for all the University faculties including the Faculty of Medicine and Surgery.

The aim of this study was to evaluate the knowledge acquisition among first year medical students enrolled ~~to~~in the academic year 2021/2022 at the University of Malta by utilizing an online game-based quizzing platform following interactive lectures ~~of~~on applied musculoskeletal lower limb clinical anatomy. The musculoskeletal system module is ~~one of the modules covered in the first year of medical school. This is~~ an 8 ECTS credit module that is divided into two parts, the upper limb, and the lower limb. The upper limb section is covered during the first semester (October – January) ~~with its written and practical exams held during the January – February examination session. The~~while the lower limb section is covered during the second semester (February – May)~~, with its corresponding exams held during the June examination session~~. This is the first study of its kind in the post-acute phase of the Covid-19

pandemic, and it is expected to shed light on the anatomy knowledge acquisition landscape following musculoskeletal lower limb lectures with an objective to improve and assist students in their medical education.

Materials and Methods

Setting

The first-year medical students enrolled ~~to~~in the academic year 2021/2022 had experienced blended or full virtual teachings during their two years of sixth form college education, before enrolling into ~~full time~~full-time classroom-based teaching at medical school. In view of this unique feature, this cohort of students were considered ~~as~~ appropriate to evaluate the anatomy knowledge acquisition following lectures.

Study design

To evaluate knowledge acquisition, the Kahoot game-based quiz platform (Kahoot Inc, Oslo, Norway) was used through a best out of four multiple-choice ~~setting~~settings. The Kahoot platform generates a score if the participant correctly answers the question taking ~~in~~into consideration the time taken in seconds to answer correctly.

This study was carried out at the end of the lectures delivered by ~~conducted following sessions of only~~ one ~~Department of Anatomy~~ resident academic. The lecture delivery is divided into two sections; the first half of the lecture is dedicated to the pure anatomy of the pre-defined lower limb region. This is followed by ~~an~~ interactive clinical based cases which apply the pure anatomy just covered during the lecture ~~into~~to clinical settings. The Kahoot quiz was run during the last 5 minutes of the lecture. The quiz was designed to follow~~ing~~ a gradual incremental

number of questions following each lecture, with new questions introduced after each lecture. The new questions varied from pure anatomy or applied clinical anatomy questions that were covered during the current lecture. New questions were added to the previous lecture's quiz questions and presented to the students. Therefore, the same questions were run across several sessions and knowledge acquisition could be assessed across the sessions. The questions sequence was shuffled for each quiz run to avoid repetition bias. Of note, after each question, the correct answer would be shown to the students before moving on to the next question. In just one instance, d~~D~~ue to the lecture time constraints, ~~if~~ the~~a~~ quiz session could not be conducted following that~~a~~ lecture. The~~, the~~ new questions originating from this~~at~~ lecture were ~~still~~ added and ~~were~~ run during the next Kahoot quiz run (session 4). Therefore session 4 had new quiz questions covering two lectures. ~~.~~

Students were ~~voluntary~~voluntarily invited to participate in each quiz and instructed not to provide any personal details but rather to use a nickname or a faux name. Hence ~~student's~~student demographics were not collected however, enrolled first year medical students are typically of 18 – 19 years of age unless they have already graduated from another undergraduate health science degree, in which case they would be older (23+ years).

Ethical clearance to conduct this study was obtained from the University of Malta Research Committee (MED-2022-00105)

Statistical analysis

Student attendance for each lecture varied and so did participation ~~to~~in the quiz and the different quiz questions. Therefore, frequencies were utilized to quantify the percentage of

students that provided ~~a correct and incorrect answer~~correct and incorrect answers ~~for~~to each question. For this study, the Kahoot generated scores in combination with the percentage of students correctly answering each question were considered ~~as~~to reflect knowledge acquisition. The average scores for each question across the different sessions were statistically ~~analysed~~analyzed using ANOVA when the question was run across three or more weeks, while a student's t-test was used when the question ran for two weeks. A p-value of <0.05 was considered as statistically significant.

Results

The base level anatomical knowledge acquisition in first-year medical students was observed to be session-specific and varied from one region of the lower limb to another. The study took place across four rounds of quiz sessions. The students' participation in the Kahoot quiz ranged between 70%~~95~~ and 85% of the total number of enrolled~~115~~ students across these four sessions.

The first session covered an introduction to the lower limb musculoskeletal module along with the gluteal region including the hip joint and the thigh. This quiz only consisted of three questions, two clinical based questions and one pure anatomy question. Knowledge acquisition following this session appeared to be higher for the clinical based questions (97.32% and 62.83% answered correctly) rather than the pure anatomy one (42.48% answered correctly), as seen in Table 1. A significant predominant increase in quiz score was observed across the four sessions, with an associated decrease in the average time to correctly answer the questions. Indeed, knowledge acquisition for the questions "*Fracture at which femoral site can lead to avascular necrosis (AVN)?*" increased by 24.04%, while "*Which of the following nerves supplies the Gracilis muscle?*" increased by 40.52%. Conversely, the question "At which gluteal site should an IM injection be administered?" exhibited a slight decrease in knowledge acquisition by 2.27%. A summary of the knowledge acquisition of the~~re~~ three questions across the four sessions is shown in Table 1.

The second session covered the knee region. The quiz consisted of five new questions, one clinical based question while the rest were pure anatomy. Following this session, it appears that participating students were more likely to get the clinical based question correct (87.04%

answered correctly) as opposed to the other questions (74.78%, 63.16%, 70.64% and 43.90% answered correctly respectively). Knowledge acquisition across the three sessions was variable, as shown in Table 2. Indeed, only three out of five new questions were found to have a significant mean score change with the question "*Which of the following muscles is found between the lateral collateral ligament and the lateral meniscus?"* exhibiting a decrease in knowledge acquisition by 7.16%. On the other hand, the questions "*Which is the deepest structure within the popliteal fossa?*" and "*The lateral border of the femoral triangle is?*" exhibited an increase in knowledge acquisition by 16.49% and 36.10% respectively.

The third session covered the different compartments of the leg, with the quiz consisting of six new questions, three clinical based and three pure anatomy questions. Students appeared to have a better knowledge acquisition for the clinical based questions (59%, 96.12% and 91.92% answered correctly respectively) just after the lecture as opposed to the pure anatomy questions (38.17%, 62% and 26.73% answered correctly respectively). Yet, on comparing the two sets of quiz runs, knowledge acquisition was either unchanged or significantly decreased between the first and second quiz attempt, as shown in Table 3. A decrease in knowledge acquisition of 18.12% was observed for the question "*Which of the following nerves provide sensation ~~between~~ to the first web space?*", a decrease of 3.19% for "*Which examination would you perform to assess for a torn Achilles tendon?*" and a decrease of 21.21% for "*Which imagine modality would you order to diagnose a DVT?*"

The fourth session quiz covered the foot, the ankle, the myotomes, and the dermatomes of the lower limb. This last quiz consisted of eight new pure anatomy questions. Although these questions were only run once, a general low knowledge acquisition could be observed just following the lecture, as shown in Table 4.

Discussion

Anatomy knowledge is a fundamental requirement for clinical practice, yet knowledge acquisition and retention among medical students appears to be on the decline across time (Custers, 2010). Additionally, it has been noted that medical students perception on the importance of anatomy varies according to their year of study (Bhangu et al., 2010; Doomernik et al., 2017; Moxham and Plaisant, 2007; Narnaware and Neumeier, 2020). It appears that younger students perceive anatomy as unimportant and only make the effort to study in order to pass assessments (Bergman et al., 2013). This phenomenon might explain the results observed in this study, where pure anatomy knowledge acquisition (assessed as percentage of students answering correctly and the Kahoot score), both just after the lecture and over time, appeared to be lower ~~or on the decline~~ when compared to clinical based knowledge. Indeed, a~~A~~cross this study's four quiz sessions, the ~~it was evident that clinical based questions had a better knowledge acquisition and positive response by the students. Repetition of the same questions over the sessions did not appear to improve knowledge acquisition across the pure anatomy questions unlike the clinical based questions.~~ positive percent~~tage~~ response for clinical based questions remained higher than for pure anatomy questions. This remained true irrespective of the times the topic was repeated. ~~This~~ Such observations can be perceived as a selection bias in knowledge acquisition originating from their perceived attitude that only clinical related knowledge is essential to ~~become~~becoming a medical doctor. Hence, it is important to ensure that the importance of anatomy knowledge in clinical practice is rooted from the start of the course. However, there might be other reasons to this distinctive difference ~~in knowledge acquisition~~. One reason could be arising from the fact that in each year, a

substantial proportion of new medical students' recruits have already graduated from other health science bachelor's degrees including nursing, physiotherapy, and radiography. Hence, attempting to answer ~~answering~~ the clinical based questions and answering them correctly might have relied on their prior study/work experience rather than on the lecture's knowledge acquisition or on reading and study before and after the designated lecture/s. Another important aspect that needs to be considered is the fact that this study's first year students were the first recruits attending face-to-face classroom teachings after almost two years of virtual learning during their sixth form college years and university. The virtual learning modality might have altered their way of studying and knowledge acquisition~~-~~. Indeed it was previosuly reported that the shift to online learning, although convenient, had a toll on the study practices as well as on the learning outcomes (Cuschieri and Calleja Agius, 2020; Engzell et al., 2021). Additionally, during virtual teaching, it is easier for students to opt out ~~from~~of participating during online live lectures or to make the effort to prepare for the lecture beforehand, unless all lectures were pre-recorded which ~~omit~~omits any classroom interaction. Therefore, this new academic year occurring in a face-to-face manner might have been a "shock" to their customed behaviour which might have led to this study's results. It is recommended that further research is undertaken to identify whether the virtual learning environment ~~have~~has sustained an impact on the students' way of lecture preparation, studying, interaction during lectures and ultimately knowledge acquisition. Considering that medical students are the next generation of doctors and both medical knowledge including anatomy ~~along~~ with patient-and peer - interactions will be part of their daily job, it is imminent that medical schools tackle this potential Covid induced problem. Furthermore, since these were first year medical students and still new to the study and knowledge-based requirements of the medical course, it may be advisable that peer-based sessions under the supervision of academics are organised on how to go about preparing for lectures, small group sessions and examinations during the first year. Such practical sessions

might aid first year medical students understand the importance of the basic sciences including anatomy and identify "tricks" of how to retain knowledge. Other potential methods to enhance knowledge acquisition ~~-~~have already been piloted in Malta before the Covid-19 era that may be suitable to be re-visited again, including self-direct learning through doughnut rounds and ~~peer-assisted~~peer-assisted learning tutoring (Agius and Stabile, 2018; Zhang et al., 2017). Involving students in teaching either through the preparation of questions to be asked and explained to their peers (doughnut rounds) or else by preparing a short presentation to transfer knowledge to their peers (~~peer-assisted~~peer-assisted ~~-~~learning tutoring/Reciprocal Peer Tutoring (RPT)) (Mayer, 2010) might be two ways of how to engage the students into the teachings as well as enhance their knowledge acquisition especially now as most of the teaching is moving back to face-to-face modalities. A~~The~~ future study is planned for the next academic year (2022/2023) targeting the same medical student cohort to assess their musculoskeletal anatomy knowledge ~~will involve the~~ transfer/loss, acquisition and its application ~~of the first-year knowledge into the same cohort in~~as they move to the second year ~~on the musculoskeletal module describe in this study~~.

Study strengths and limitations

This study needs to be considered in light of its strengths and limitations. The study was conducted in the only state university in Malta where both local and international students are enrolled and follow the Doctor of Medicine and Surgery course. Hence this study provides an adequate overview of anatomy knowledge acquisition at a country level. Additionally, the study was conducted following a two-year period of predominant virtual learning which provides a unique opportunity to explore the interaction and knowledge acquisition following the transition back to face-to-face lectures. However, this was an observational study where students were voluntarily invited to participate. The students had the opportunity to opt out

from answering any of the quiz questions as well as from taking part in the quiz entirely which might have influenced the results of this study. Indeed, across the quiz sessions, different students might have participated, which might have affected the knowledge acquisition interpretation. Additionally, since the quiz followed an anonymous study design, students' demographic characteristics were not available and could not be interpreted as part of this study. The knowledge acquisition following the last two lectures was only assessed through one quiz session without any repetition. Therefore, caution needs to be taken when interpreting the knowledge acquisition from these lectures. Additionally, the quiz was run just after the clinical cases part of the lecture which might have induced a bias towards students being able to answer the clinical oriented questions ~~at~~with more ease than the pure anatomy questions. The level of knowledge acquisition was based on automated scores created by the Kahoot platform along with the frequencies of correctly answered questions. Although this platform has already been utilized to assess the knowledge acquisition (Narnaware and Neumeier, 2020), the study design of the current study has not been previously utilized. It is recommended that the study design is repeated with a larger population cohort as well as the knowledge acquisition ~~is~~be re-assessed across different years of study. Additionally, it is recommended that the students' perspectives on the importance of anatomy teachings and their study patterns are also evaluated.

Conclusion

Anatomy knowledge acquisition appears to be subjective to clinical based knowledge rather than pure anatomy. There may be a plethora of reasons as to this outcome including the misconception that anatomy is not essential for clinical practice as well as a potential aftermath of the Covid induced virtual learning environment. Further research is merit to ensure that

students are provided with the best tools to enhance their knowledge acquisition both as students and later as future doctors.

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Footnotes

Conflict of interests

The authors declare no conflict of interest

~~Author contributions~~

~~SC and YN were responsible for the Conceptualization; SC was responsible for the Data curation, the Formal analysis, the Methodology; the Project administration; and writing of the original draft; YN was responsible for the Writing - review & editing.~~

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Table 1. Quiz questions distributed during session 1 and the corresponding students' interaction

		At which gluteal site should an IM injection be administered?		Fracture at which femoral site can lead to avascular necrosis (AVN)?		Which of the following nerves supplies the Gracilis muscle?	
Session 1	Correctly answered (*n*)	109	97.32%	71	62.83%	48	42.48%
	Incorrect answered (*n*)	3	2.68%	42	37.17%	65	57.52%
	Average score	860.5		574.77		369.41	
	SD	213.4		456.6		441.92	
	Average time to answer Correctly in seconds	5.53		4.14		6.89	
	Average time to answer Incorrectly in seconds	11.79		3.92		9.4	
Session 2	Correctly answered (*n*)	96	92.31%	68	71.58%	47	48.45%
	Incorrect answered (*n*)	8	7.69%	27	28.42%	50	51.55%
	Average score	635.07		424.7		306.64	
	SD	310.4		370.51		380.19	
	Average time to answer Correctly in seconds	2.26		2.69		2.37	
	Average time to answer Incorrectly in seconds	2.68		2.94		2.99	
Session 3	Correctly answered (*n*)	96	94.12%	83	81.37%	60	60.00%
	Incorrect answered (*n*)	6	5.88%	19	18.63%	40	40.00%
	Average score	825.76		703.31		468.36	
	SD	259.01		367.42		415.09	
	Average time to answer Correctly in seconds	1.94		2.21		3.61	

	Average time to answer Incorrectly in seconds	1.71		3.64		4.34	
Session 4	Correctly answered (*n*)	96	95.05%	86	86.87%	83	83.00%
	Incorrect answered (*n*)	5	4.95%	13	13.13%	17	17.00%
	Average score	806.12		701.8		644.93	
	SD	302.07		369.23		373.72	
	Average time to answer Correctly in seconds	1.7		2.21		3.06	
	Average time to answer Incorrectly in seconds	2.64		2.65		3.77	
		The f-ratio value is 15.51898. The p-value is < .00001		The f-ratio value is 12.72854. The p-value is < .00001		The f-ratio value is 14.95159. The p-value is < .00001	

Table 2. Quiz questions distributed during session 2 and the corresponding students' interaction

		At which position is the knee mostly stable?		Which of the following muscles is found between the lateral colleteral ligament and the lateral meniscus?		Which is the deepest structure within the popliteal fossa?		The lateral border of the femoral triangle is?		Which examination would you perform to assess for a torn meniscus?	
Session 2	Correctly answered (*n*)	86	74.78%	60	63.16%	77	70.64%	36	43.90%	94	87.04%
	Incorrect answered (*n*)	29	25.22%	35	36.84%	32	29.36%	46	56.10%	14	12.96%
	Average score	628.89		356.41		551.03		204.23		691.72	
	SD	382.81		354.68		404.71		311.43		347.37	
	Average time to answer Correctly in seconds	2.89		6.1		3.25		3.36		2.78	
	Average time to answer Incorrectly in seconds	4.33		7.15		4.17		3.27		3.94	
Session 3	Correctly answered (*n*)	87	85.29%	67	65.69%	84	82.35%	67	65.69%	75	74.26%
	Incorrect answered (*n*)	15	14.71%	35	34.31%	18	17.65%	35	34.31%	26	25.74%
	Average score	719.41		518.31		694.25		518.5		573.02	
	SD	335.91		398.79		354.97		402.69		371.42	
	Average time to answer Correctly in seconds	2.63		3.76		2.64		3.75		3.96	
	Average time to answer Incorrectly in seconds	5.02		3.87		9.68		4.89		3.82	
Session 4	Correctly answered (*n*)	87	86.14%	56	56.00%	88	87.13%	80	80.00%	82	82.83%
	Incorrect answered (*n*)	14	13.86%	44	44.00%	13	12.87%	20	20.00%	17	17.17%
	Average score	713.14		411.84		714.6		608.86		648.23	

SD	362.93	409.65	357.52	377.96	378.34
Average time to answer Correctly in seconds	2.13	3.97	2.3	3.41	2.77
Average time to answer Incorrectly in seconds	3.73	4.55	5.95	3.9	3.25
	The f-ratio value is 2.21018. The p-value is .111312	The f-ratio value is 4.93846. The p-value is .007707	The f-ratio value is 6.45344. The p-value is .001783.	The f-ratio value is 38.62831. The p-value is < .00001.	The f-ratio value is 2.96296. The p-value is .053051.

Table 3. Quiz questions distributed during session 3 and the corresponding students' interaction

		Which of the following nerves innervate the lateral compartment of the leg?		Which of the following nerves provide sensation ~~between~~ to the first web space?		At which position will you palpate for the posterior tibial pulse?	
Session 3	Correctly answered (*n*)	36	38.710%	62	62.00%	59	59.00%
	Incorrect answered (*n*)	57	61.290%	38	38.00%	41	41.00%
	Average score	261.15		474.33		428.56	
	SD	370.11		406.68		385.37	
	Average time to answer Correctly in seconds	4.77		3.93		4.75	
	Average time to answer Incorrectly in seconds	5.27		4.2		5.08	
Session 4	Correctly answered (*n*)	36	38.71%	43	43.88%	64	65.98%
	Incorrect answered (*n*)	57	61.29%	55	56.12%	33	34.02%
	Average score	243.71		327.48		457.25	
	SD	352.62		411.17		393.24	
	Average time to answer Correctly in seconds	5.24		3.4		4.43	
	Average time to answer Incorrectly in seconds	5.6		4.46		4.5	
		The f-ratio value is 0.12469. The p-value is .72435		The f-ratio value is 6.89608. The p-value is .009268.		The f-ratio value is 0.29101. The p-value is .590142.	

		Which of the following nerves innervate the lateral compartment of the leg?		Which of the following nerves provide sensation between the first web space?		At which position will you palpate for the posterior tibial pulse?		Which examination would you perform to assess for a torn achilles tendon?		Which imagine modaility would you order to diagnose a DVT?		What is the muscle action of the anterior compartment of the leg?	
Session 3	Correctly answered (*n*)	36	38.710%	62	62.00%	59	59.00%	99	96.12%	91	91.92%	27	26.73%
	Incorrect answered (*n*)	57	61.290%	38	38.00%	41	41.00%	3	2.91%	8	8.08%	74	73.27%
	Average score	261.15		474.33		428.56		862.7		739.58		188.5	
	SD	370.11		406.68		385.37		216.05		300.66		326.73	
	Average time to answer Correctly in seconds	4.77		3.93		4.75		1.7		2.93		5.35	
	Average time to answer Incorrectly in seconds	5.27		4.2		5.08		3.59		5.08		5.22	
Session 4	Correctly answered (*n*)	36	38.71%	43	43.88%	64	65.98%	92	92.93%	70	70.71%	39	41.05%
	Incorrect answered (*n*)	57	61.29%	55	56.12%	33	34.02%	7	7.07%	29	29.29%	56	58.95%
	Average score	243.71		327.48		457.25		741.39		534.13		263.61	
	SD	352.62		411.17		393.24		326.9		413.56		359.95	
	Average time to answer Correctly in seconds	5.24		3.4		4.43		2.43		3.09		5.27	
	Average time to answer Incorrectly in seconds	5.6		4.46		4.5		4.03		3.49		5.23	

The f-ratio value is 0.12469. The p-value is .72435	The f-ratio value is 6.89608. The p-value is .009268.	The f-ratio value is 0.29101. The p-value is .590142.	The f-ratio value is 10.175. The p-value is .001639.	The f-ratio value is 15.6991. The p-value is .000101.	The f-ratio value is 2.54884. The p-value is .111865.

Table 4. Quiz questions distributed during session 4 and the corresponding students' interaction

		Which of the following tendons attach to the 5th Metatarsal bone?		Which of the following are the nerve roots for the femoral nerve?		Which of the following bones articulate with the calcaneum?		Which of the following myotomes contribute to the knee jerk?	
Session 4	Correctly answered (*n*)	29	31.87%	83	80.58%	46	46.46%	72	70.59%
	Incorrect answered (*n*)	62	68.13%	20	19.42%	53	53.54%	30	29.41%
	Average score	194.83		621.14		362.48		553	
	SD	330.8		258.06		429.01		406.86	
	Average time to answer Correctly in seconds	5.35		3.69		2.82		3.26	
	Average time to answer Incorrectly in seconds	5.8		4.49		4.36		4.16	

		Which of the following nerves provide sensation to the heal?		Which of the following bones does NOT form part of the medial longitudinal arch?		Which of the following ligaments is found on the lateral part of the ankle?		In which muscle layer of the sole are the lumbricals found?	
Session 4	Correctly answered (*n*)	28	29.17%	38	39.18%	33	34.02%	39	39.80%
	Incorrect answered (*n*)	68	70.83%	59	60.82%	64	65.98%	59	60.20%
	Average score	203.33		268		231.33		305.11	
	SD	351.09		372.06		356.26		413.97	
	Average time to answer Correctly in seconds	4.17		4.62		4.72		2.96	
	Average time to answer Incorrectly in seconds	5.44		4.45		5.35		4.04	

Evaluating the knowledge acquisition of lower limb anatomy among medical students during the post-acute Covid-19 era

Abstract

Introduction

Anatomy is the foundation of many medical and surgical specialties yet knowledge acquisition and retention among medical students is questionable. Over the years the anatomy teaching environment and teaching modalities have changed, even more so with the onset of the Covid-19 pandemic and the shift to a virtual environment. The aim of this study was to evaluate the knowledge acquisition of applied musculoskeletal lower limb clinical anatomy among first year medical students in Malta following the transition back to face-to-face lectures.

Materials and Methods

The Kahoot online game-based quiz platform was used through a best out of four multiple-choice setting across 4 sessions. Scores generated by the platform along with frequencies of correctly answered questions were utilized to measure knowledge acquisition. The average

scores for each question across sessions were statistically analysed using ANOVA and student's t-test accordingly.

Results

Across the 4 sessions, the positive percentage response for clinical based questions remained higher than for pure anatomy questions.

Conclusions

Anatomy knowledge acquisition appears to be subjective to clinical based knowledge rather than pure anatomy. There may be a plethora of reasons as to this outcome including the misconception that anatomy is not essential for clinical practice as well as the potential aftermath of the Covid-induced virtual learning environment. Further research is merit to ensure that students are provided with the best tools to enhance their knowledge acquisition, both as students and as future doctors.

Keywords

Anatomy; COVID-19; Medical students; Knowledge acquisition; Malta

Introduction

Anatomy is one of the foundations of medical education as it forms the basis of many medical and surgical specialties (Arráez-Aybar et al., 2010; Turney, 2007). The traditional set-up of the anatomy course consists of a mixture of didactic lectures, small group teachings and laboratory cadaver dissections when available (Older, 2004). Over the years the anatomy teaching environment and teaching modalities have changed, even more so with the onset of the COVID -19 pandemic (Gabard et al., 2012; Papa et al., 2022; Shin et al., 2022). Despite this, the level of anatomy knowledge acquisition and retention among medical students and later as young doctors is continuously debated and sometimes is even considered insufficient (Cottam, 1999; Fillmore et al., 2016; Waterston and Stewart, 2005). Similarly, loss of anatomy knowledge acquisition and retention have also been reported among other health sciences students including nursing, radiographers and chiropractic science among others (Hall and Durward, 2009; Narnaware and Neumeier, 2020; Strkalj et al., 2011).

The University of Malta is the only state university offering undergraduate and postgraduate courses in Malta, with the Faculty of Medicine and Surgery being one of the many faculties housed by this university. The undergraduate Doctor of Medicine and Surgery (MD) course is a 5-year course, with the first two years dedicated to pre-clinical subjects including anatomy.

The COVID-19 pandemic has imposed a burden on several sectors including the medical education sector. Generally medical schools across the globe shifted from face-to-face to a virtual learning environment including virtual dissection sessions (Chang et al., 2022; DK, 2020; Pather et al., 2020). Like the rest of the world, Malta reported the first Covid-19 case in

March 2020, and a partial lockdown was instituted which included a shift in the delivery of the educational system from face-to-face to virtual till the end of the academic year 2020/2021 (Cuschieri, 2020; Cuschieri and Calleja Agius, 2020). The academic year 2021/2022 saw the shift back to face-to-face teaching for both lectures and small group sessions for all the University faculties including the Faculty of Medicine and Surgery.

The aim of this study was to evaluate the knowledge acquisition among first year medical students enrolled in the academic year 2021/2022 at the University of Malta by utilizing an online game-based quizzing platform following interactive lectures on applied musculoskeletal lower limb clinical anatomy. The musculoskeletal system module is an 8 ECTS credit module that is divided into two parts, the upper limb, and the lower limb. The upper limb section is covered during the first semester (October – January) while the lower limb section is covered during the second semester (February – May). This is the first study of its kind in the post-acute phase of the Covid-19 pandemic, and it is expected to shed light on the anatomy knowledge acquisition landscape following musculoskeletal lower limb lectures with an objective to improve and assist students in their medical education.

Materials and Methods

Setting

The first-year medical students enrolled in the academic year 2021/2022 had experienced blended or full virtual teachings during their two years of sixth form college education, before enrolling into full-time classroom-based teaching at medical school. In view of this unique feature, this cohort of students were considered appropriate to evaluate the anatomy knowledge acquisition following lectures.

Study design

To evaluate knowledge acquisition, the Kahoot game-based quiz platform (Kahoot Inc, Oslo, Norway) was used through a best out of four multiple-choice settings. The Kahoot platform generates a score if the participant correctly answers the question taking into consideration the time taken in seconds to answer correctly.

This study was carried out at the end of the lectures delivered by one resident academic. The lecture delivery is divided into two sections; the first half of the lecture is dedicated to the pure anatomy of the pre-defined lower limb region. This is followed by interactive clinical based cases which apply the pure anatomy just covered during the lecture to clinical settings. The Kahoot quiz was run during the last 5 minutes of the lecture. The quiz was designed to follow a gradual incremental number of questions following each lecture, with new questions

introduced after each lecture. The new questions varied from pure anatomy or applied clinical anatomy questions that were covered during the current lecture. New questions were added to the previous lecture's quiz questions and presented to the students. Therefore, the same questions were run across several sessions and knowledge acquisition could be assessed across the sessions. The questions sequence was shuffled for each quiz run to avoid repetition bias. Of note, after each question, the correct answer would be shown to the students before moving on to the next question. In just one instance, due to the lecture time constraints, the quiz session could not be conducted following that lecture. The new questions originating from this lecture were added and run during the next Kahoot quiz run (session 4). Therefore session 4 had new quiz questions covering two lectures.

Students were voluntarily invited to participate in each quiz and instructed not to provide any personal details but rather to use a nickname or a faux name. Hence student demographics were not collected however, enrolled first year medical students are typically of 18 – 19 years of age unless they have already graduated from another undergraduate health science degree, in which case they would be older (23+ years).

Ethical clearance to conduct this study was obtained from the University of Malta Research Committee (MED-2022-00105)

Statistical analysis

Student attendance for each lecture varied and so did participation in the quiz and the different quiz questions. Therefore, frequencies were utilized to quantify the percentage of students that provided correct and incorrect answers to each question. For this study, the Kahoot generated

scores in combination with the percentage of students correctly answering each question were considered to reflect knowledge acquisition. The average scores for each question across the different sessions were statistically analyzed using ANOVA when the question was run across three or more weeks, while a student's t-test was used when the question ran for two weeks. A *p*-value of <0.05 was considered as statistically significant.

Results

The base level anatomical knowledge acquisition in first-year medical students was observed to be session-specific and varied from one region of the lower limb to another. The study took place across four rounds of quiz sessions. The students' participation in the Kahoot quiz ranged between 70% and 85% of the total number of enrolled students across these four sessions.

The first session covered an introduction to the lower limb musculoskeletal module along with the gluteal region including the hip joint and the thigh. This quiz only consisted of three questions, two clinical based questions and one pure anatomy question. Knowledge acquisition following this session appeared to be higher for the clinical based questions (97.32% and 62.83% answered correctly) rather than the pure anatomy one (42.48% answered correctly), as seen in Table 1. A significant predominant increase in quiz score was observed across the four sessions, with an associated decrease in the average time to correctly answer the questions. Indeed, knowledge acquisition for the questions "*Fracture at which femoral site can lead to avascular necrosis (AVN)?*" increased by 24.04%, while "*Which of the following nerves supplies the Gracilis muscle?*" increased by 40.52%. Conversely, the question "At which gluteal site should an IM injection be administered?" exhibited a slight decrease in knowledge acquisition by 2.27%. A summary of the knowledge acquisition of the three questions across the four sessions is shown in Table 1.

The second session covered the knee region. The quiz consisted of five new questions, one clinical based question while the rest were pure anatomy. Following this session, it appears that participating students were more likely to get the clinical based question correct (87.04% answered correctly) as opposed to the other questions (74.78%, 63.16%, 70.64% and 43.90%

answered correctly respectively). Knowledge acquisition across the three sessions was variable, as shown in Table 2. Indeed, only three out of five new questions were found to have a significant mean score change with the question "*Which of the following muscles is found between the lateral collateral ligament and the lateral meniscus?"* exhibiting a decrease in knowledge acquisition by 7.16%. On the other hand, the questions "*Which is the deepest structure within the popliteal fossa?*" and "*The lateral border of the femoral triangle is?*" exhibited an increase in knowledge acquisition by 16.49% and 36.10% respectively.

The third session covered the different compartments of the leg, with the quiz consisting of six new questions, three clinical based and three pure anatomy questions. Students appeared to have a better knowledge acquisition for the clinical based questions (59%, 96.12% and 91.92% answered correctly respectively) just after the lecture as opposed to the pure anatomy questions (38.17%, 62% and 26.73% answered correctly respectively). Yet, on comparing the two sets of quiz runs, knowledge acquisition was either unchanged or significantly decreased between the first and second quiz attempt, as shown in Table 3. A decrease in knowledge acquisition of 18.12% was observed for the question "*Which of the following nerves provide sensation to the first web space?*", a decrease of 3.19% for "*Which examination would you perform to assess for a torn Achilles tendon?*" and a decrease of 21.21% for "*Which imagine modality would you order to diagnose a DVT?*"

The fourth session quiz covered the foot, the ankle, the myotomes, and the dermatomes of the lower limb. This last quiz consisted of eight new pure anatomy questions. Although these questions were only run once, a general low knowledge acquisition could be observed just following the lecture, as shown in Table 4.

Discussion

Anatomy knowledge is a fundamental requirement for clinical practice, yet knowledge acquisition and retention among medical students appears to be on the decline across time (Custers, 2010). Additionally, it has been noted that medical students perception on the importance of anatomy varies according to their year of study (Bhangu et al., 2010; Doomernik et al., 2017; Moxham and Plaisant, 2007; Narnaware and Neumeier, 2020). It appears that younger students perceive anatomy as unimportant and only make the effort to study in order to pass assessments (Bergman et al., 2013). This phenomenon might explain the results observed in this study, where pure anatomy knowledge acquisition (assessed as percentage of students answering correctly and the Kahoot score), both just after the lecture and over time, appeared to be lower when compared to clinical based knowledge. Indeed, across this study's four quiz sessions, the positive percent response for clinical based questions remained higher than for pure anatomy questions. This remained true irrespective of the times the topic was repeated. Such observations can be perceived as a selection bias in knowledge acquisition originating from their perceived attitude that only clinical related knowledge is essential to becoming a medical doctor. Hence, it is important to ensure that the importance of anatomy knowledge in clinical practice is rooted from the start of the course. However, there might be other reasons to this distinctive difference. One reason could be arising from the fact that in each year, a substantial proportion of new medical students' recruits have already graduated from other health science bachelor's degrees including nursing, physiotherapy, and radiography. Hence, attempting to answer the clinical based questions and answering them correctly might have relied on their prior study/work experience rather than on the lecture's knowledge acquisition or on reading and study before and after the designated lecture/s.

Another important aspect that needs to be considered is the fact that this study's first year students were the first recruits attending face-to-face classroom teachings after almost two years of virtual learning during their sixth form college years and university. The virtual learning modality might have altered their way of studying and knowledge acquisition. Indeed it was previosuly reported that the shift to online learning, although convenient, had a toll on the study practices as well as on the learning outcomes (Cuschieri and Calleja Agius, 2020; Engzell et al., 2021). Additionally, during virtual teaching, it is easier for students to opt out of participating during online live lectures or to make the effort to prepare for the lecture beforehand, unless all lectures were pre-recorded which omits any classroom interaction. Therefore, this new academic year occurring in a face-to-face manner might have been a "shock" to their customed behaviour which might have led to this study's results. It is recommended that further research is undertaken to identify whether the virtual learning environment has sustained an impact on the students' way of lecture preparation, studying, interaction during lectures and ultimately knowledge acquisition. Considering that medical students are the next generation of doctors and both medical knowledge including anatomy with patient-and peer - interactions will be part of their daily job, it is imminent that medical schools tackle this potential Covid induced problem. Furthermore, since these were first year medical students and still new to the study and knowledge-based requirements of the medical course, it may be advisable that peer-based sessions under the supervision of academics are organised on how to go about preparing for lectures, small group sessions and examinations during the first year. Such practical sessions might aid first year medical students understand the importance of the basic sciences including anatomy and identify "tricks" of how to retain knowledge. Other potential methods to enhance knowledge acquisition have already been piloted in Malta before the Covid-19 era that may be suitable to be re-visited again, including self-direct learning through doughnut rounds and peer-assisted learning tutoring (Agius and

Stabile, 2018; Zhang et al., 2017). Involving students in teaching either through the preparation of questions to be asked and explained to their peers (doughnut rounds) or else by preparing a short presentation to transfer knowledge to their peers (peer-assisted learning tutoring/Reciprocal Peer Tutoring (RPT)) (Mayer, 2010) might be two ways of how to engage the students into the teachings as well as enhance their knowledge acquisition especially now as most of the teaching is moving back to face-to-face modalities. A future study is planned for the next academic year (2022/2023) targeting the same medical student cohort to assess their musculoskeletal anatomy knowledge transfer/loss, acquisition and its application as they move to the second year.

Study strengths and limitations

This study needs to be considered in light of its strengths and limitations. The study was conducted in the only state university in Malta where both local and international students are enrolled and follow the Doctor of Medicine and Surgery course. Hence this study provides an adequate overview of anatomy knowledge acquisition at a country level. Additionally, the study was conducted following a two-year period of predominant virtual learning which provides a unique opportunity to explore the interaction and knowledge acquisition following the transition back to face-to-face lectures. However, this was an observational study where students were voluntarily invited to participate. The students had the opportunity to opt out from answering any of the quiz questions as well as from taking part in the quiz entirely which might have influenced the results of this study. Indeed, across the quiz sessions, different students might have participated, which might have affected the knowledge acquisition interpretation. Additionally, since the quiz followed an anonymous study design, students' demographic characteristics were not available and could not be interpreted as part of this study. The knowledge acquisition following the last two lectures was only assessed through

one quiz session without any repetition. Therefore, caution needs to be taken when interpreting the knowledge acquisition from these lectures. Additionally, the quiz was run just after the clinical cases part of the lecture which might have induced a bias towards students being able to answer the clinical oriented questions with more ease than the pure anatomy questions. The level of knowledge acquisition was based on automated scores created by the Kahoot platform along with the frequencies of correctly answered questions. Although this platform has already been utilized to assess the knowledge acquisition (Narnaware and Neumeier, 2020), the study design of the current study has not been previously utilized. It is recommended that the study design is repeated with a larger population cohort as well as the knowledge acquisition be re-assessed across different years of study. Additionally, it is recommended that the students' perspectives on the importance of anatomy teachings and their study patterns are also evaluated.

Conclusion

Anatomy knowledge acquisition appears to be subjective to clinical based knowledge rather than pure anatomy. There may be a plethora of reasons as to this outcome including the misconception that anatomy is not essential for clinical practice as well as a potential aftermath of the Covid induced virtual learning environment. Further research is merit to ensure that students are provided with the best tools to enhance their knowledge acquisition both as students and later as future doctors.

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Footnotes

Conflict of interests

The authors declare no conflict of interest

Table 1. Quiz questions distributed during session 1 and the corresponding students' interaction

		At which gluteal site should an IM injection be administered?		Fracture at which femoral site can lead to avascular necrosis (AVN)?		Which of the following nerves supplies the Gracilis muscle?	
Session 1	Correctly answered (*n*)	109	97.32%	71	62.83%	48	42.48%
	Incorrect answered (*n*)	3	2.68%	42	37.17%	65	57.52%
	Average score	860.5		574.77		369.41	
	SD	213.4		456.6		441.92	
	Average time to answer Correctly in seconds	5.53		4.14		6.89	
	Average time to answer Incorrectly in seconds	11.79		3.92		9.4	
Session 2	Correctly answered (*n*)	96	92.31%	68	71.58%	47	48.45%
	Incorrect answered (*n*)	8	7.69%	27	28.42%	50	51.55%
	Average score	635.07		424.7		306.64	
	SD	310.4		370.51		380.19	
	Average time to answer Correctly in seconds	2.26		2.69		2.37	
	Average time to answer Incorrectly in seconds	2.68		2.94		2.99	
Session 3	Correctly answered (*n*)	96	94.12%	83	81.37%	60	60.00%
	Incorrect answered (*n*)	6	5.88%	19	18.63%	40	40.00%
	Average score	825.76		703.31		468.36	
	SD	259.01		367.42		415.09	
	Average time to answer Correctly in seconds	1.94		2.21		3.61	

	Average time to answer Incorrectly in seconds	1.71		3.64		4.34	
	Correctly answered (*n*)	96	95.05%	86	86.87%	83	83.00%
	Incorrect answered (*n*)	5	4.95%	13	13.13%	17	17.00%
	Average score	806.12		701.8		644.93	
Session 4	SD	302.07		369.23		373.72	
	Average time to answer Correctly in seconds	1.7		2.21		3.06	
	Average time to answer Incorrectly in seconds	2.64		2.65		3.77	
		The f-ratio value is 15.51898. The p-value is < .00001		The f-ratio value is 12.72854. The p-value is < .00001		The f-ratio value is 14.95159. The p-value is < .00001	

Table 2. Quiz questions distributed during session 2 and the corresponding students' interaction

		At which position is the knee mostly stable?		Which of the following muscles is found between the lateral colleteral ligament and the lateral meniscus?		Which is the deepest structure within the popliteal fossa?		The lateral border of the femoral triangle is?		Which examination would you perform to assess for a torn meniscus?	
Session 2	Correctly answered (*n*)	86	74.78%	60	63.16%	77	70.64%	36	43.90%	94	87.04%
	Incorrect answered (*n*)	29	25.22%	35	36.84%	32	29.36%	46	56.10%	14	12.96%
	Average score	628.89		356.41		551.03		204.23		691.72	
	SD	382.81		354.68		404.71		311.43		347.37	
	Average time to answer Correctly in seconds	2.89		6.1		3.25		3.36		2.78	
	Average time to answer Incorrectly in seconds	4.33		7.15		4.17		3.27		3.94	
Session 3	Correctly answered (*n*)	87	85.29%	67	65.69%	84	82.35%	67	65.69%	75	74.26%
	Incorrect answered (*n*)	15	14.71%	35	34.31%	18	17.65%	35	34.31%	26	25.74%
	Average score	719.41		518.31		694.25		518.5		573.02	
	SD	335.91		398.79		354.97		402.69		371.42	
	Average time to answer Correctly in seconds	2.63		3.76		2.64		3.75		3.96	
	Average time to answer Incorrectly in seconds	5.02		3.87		9.68		4.89		3.82	
Session 4	Correctly answered (*n*)	87	86.14%	56	56.00%	88	87.13%	80	80.00%	82	82.83%
	Incorrect answered (*n*)	14	13.86%	44	44.00%	13	12.87%	20	20.00%	17	17.17%
	Average score	713.14		411.84		714.6		608.86		648.23	

SD	362.93	409.65	357.52	377.96	378.34
Average time to answer Correctly in seconds	2.13	3.97	2.3	3.41	2.77
Average time to answer Incorrectly in seconds	3.73	4.55	5.95	3.9	3.25
	The f-ratio value is 2.21018. The p-value is .111312	The f-ratio value is 4.93846. The p-value is .007707	The f-ratio value is 6.45344. The p-value is .001783.	The f-ratio value is 38.62831. The p-value is < .00001.	The f-ratio value is 2.96296. The p-value is .053051.

Table 3. Quiz questions distributed during session 3 and the corresponding students' interaction

		Which of the following nerves innervate the lateral compartment of the leg?		Which of the following nerves provide sensation to the first web space?		At which position will you palpate for the posterior tibial pulse?	
Session 3	Correctly answered (*n*)	36	38.710%	62	62.00%	59	59.00%
	Incorrect answered (*n*)	57	61.290%	38	38.00%	41	41.00%
	Average score	261.15		474.33		428.56	
	SD	370.11		406.68		385.37	
	Average time to answer Correctly in seconds	4.77		3.93		4.75	
	Average time to answer Incorrectly in seconds	5.27		4.2		5.08	
Session 4	Correctly answered (*n*)	36	38.71%	43	43.88%	64	65.98%
	Incorrect answered (*n*)	57	61.29%	55	56.12%	33	34.02%
	Average score	243.71		327.48		457.25	
	SD	352.62		411.17		393.24	
	Average time to answer Correctly in seconds	5.24		3.4		4.43	
	Average time to answer Incorrectly in seconds	5.6		4.46		4.5	
		The f-ratio value is 0.12469. The p-value is .72435		The f-ratio value is 6.89608. The p-value is .009268.		The f-ratio value is 0.29101. The p-value is .590142.	

		Which of the following nerves innervate the lateral compartment of the leg?		Which of the following nerves provide sensation between the first web space?		At which position will you palpate for the posterior tibial pulse?		Which examination would you perform to assess for a torn achilles tendon?		Which imagine modaility would you order to diagnose a DVT?		What is the muscle action of the anterior compartment of the leg?	
Session 3	Correctly answered (*n*)	36	38.710%	62	62.00%	59	59.00%	99	96.12%	91	91.92%	27	26.73%
	Incorrect answered (*n*)	57	61.290%	38	38.00%	41	41.00%	3	2.91%	8	8.08%	74	73.27%
	Average score	261.15		474.33		428.56		862.7		739.58		188.5	
	SD	370.11		406.68		385.37		216.05		300.66		326.73	
	Average time to answer Correctly in seconds	4.77		3.93		4.75		1.7		2.93		5.35	
	Average time to answer Incorrectly in seconds	5.27		4.2		5.08		3.59		5.08		5.22	
Session 4	Correctly answered (*n*)	36	38.71%	43	43.88%	64	65.98%	92	92.93%	70	70.71%	39	41.05%
	Incorrect answered (*n*)	57	61.29%	55	56.12%	33	34.02%	7	7.07%	29	29.29%	56	58.95%
	Average score	243.71		327.48		457.25		741.39		534.13		263.61	
	SD	352.62		411.17		393.24		326.9		413.56		359.95	
	Average time to answer Correctly in seconds	5.24		3.4		4.43		2.43		3.09		5.27	
	Average time to answer Incorrectly in seconds	5.6		4.46		4.5		4.03		3.49		5.23	

The f-ratio value is 0.12469. The p-value is .72435	The f-ratio value is 6.89608. The p-value is .009268.	The f-ratio value is 0.29101. The p-value is .590142.	The f-ratio value is 10.175. The p-value is .001639.	The f-ratio value is 15.6991. The p-value is .000101.	The f-ratio value is 2.54884. The p-value is .111865.

Table 4. Quiz questions distributed during session 4 and the corresponding students' interaction

		Which of the following tendons attach to the 5th Metatarsal bone?		Which of the following are the nerve roots for the femoral nerve?		Which of the following bones articulate with the calcaneum?		Which of the following myotomes contribute to the knee jerk?	
Session 4	Correctly answered (*n*)	29	31.87%	83	80.58%	46	46.46%	72	70.59%
	Incorrect answered (*n*)	62	68.13%	20	19.42%	53	53.54%	30	29.41%
	Average score	194.83		621.14		362.48		553	
	SD	330.8		258.06		429.01		406.86	
	Average time to answer Correctly in seconds	5.35		3.69		2.82		3.26	
	Average time to answer Incorrectly in seconds	5.8		4.49		4.36		4.16	

		Which of the following nerves provide sensation to the heal?		Which of the following bones does NOT form part of the medial longitudinal arch?		Which of the following ligaments is found on the lateral part of the ankle?		In which muscle layer of the sole are the lumbricals found?	
Session 4	Correctly answered (*n*)	28	29.17%	38	39.18%	33	34.02%	39	39.80%
	Incorrect answered (*n*)	68	70.83%	59	60.82%	64	65.98%	59	60.20%
	Average score	203.33		268		231.33		305.11	
	SD	351.09		372.06		356.26		413.97	
	Average time to answer Correctly in seconds	4.17		4.62		4.72		2.96	
	Average time to answer Incorrectly in seconds	5.44		4.45		5.35		4.04	