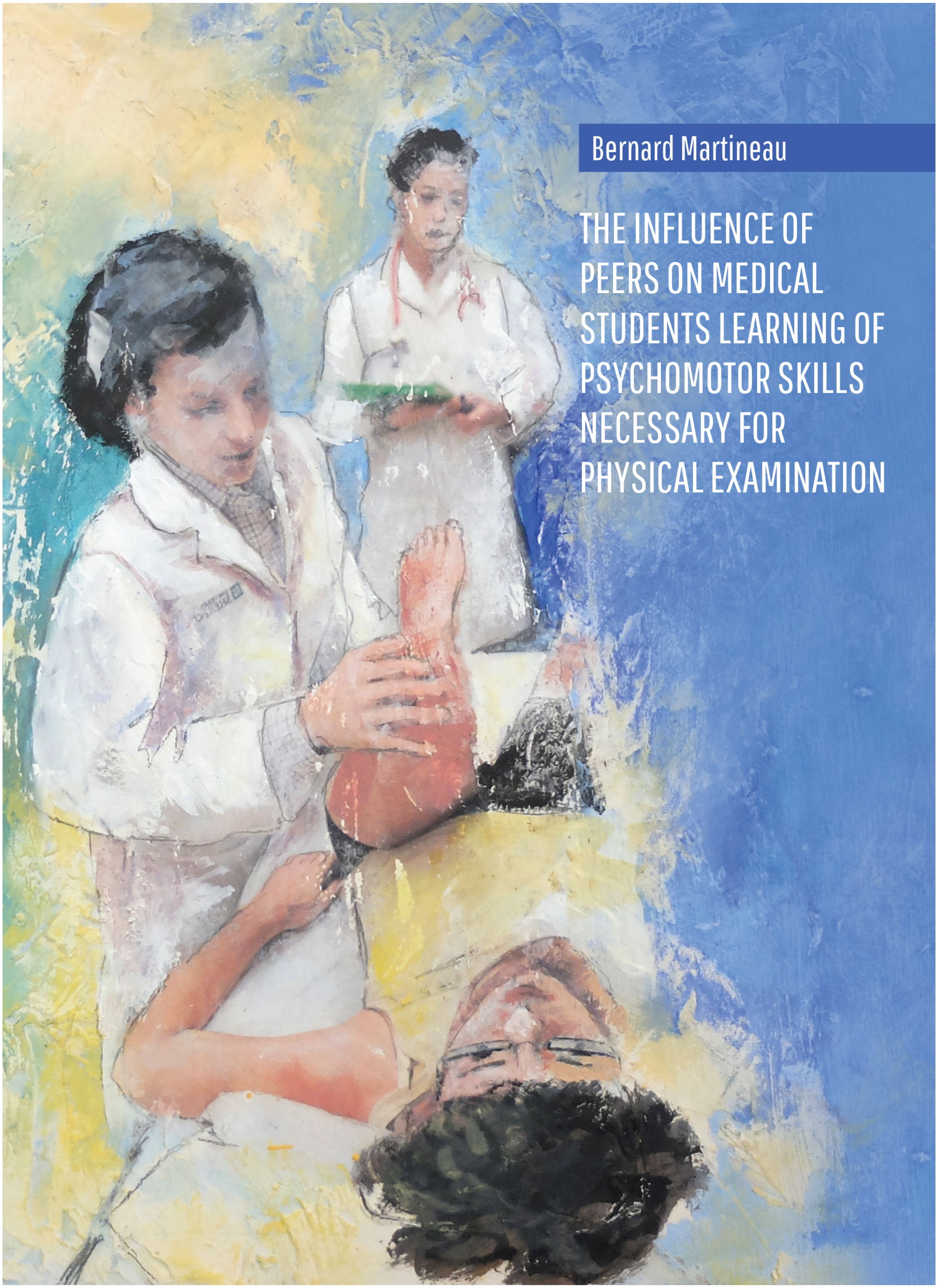

Bernard Martineau

THE INFLUENCE OF PEERS ON MEDICAL STUDENTS LEARNING OF PSYCHOMOTOR SKILLS NECESSARY FOR PHYSICAL EXAMINATION

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Cover by Sandra Tremblay
Printed by

ISBN 978-0-9950715-06

The influence of peers on medical students learning of psychomotor skills necessary for physical examination

Leren van psychomotorische vaardigheden als deel van het lichamelijk onderzoek: invloed van peers

Thesis

to obtain the degree of Doctor from the
Erasmus University Rotterdam
by command of the
rector magnificus

Prof.dr.H.A.P. Pols

and in accordance with the decision of the Doctorate Board
The public defense shall be held on

November the 2nd, 2016 at 9:30 hours
by

Bernard Martineau
Sherbrooke, Québec, Canada

ERASMUS UNIVERSITEIT ROTTERDAM

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CONTENTS

Chapter 1

The influence of peers on medical students learning of psychomotor skills necessary for physical examination

The physical examination (PE) is a core element of a physician's diagnostic decision-making process,[1] therefore potentially affecting medical care provided to patients.[2] Developing PE skills as early as possible during medical training and being able to maintain these skills is therefore of great importance. Although medical teachers view the development of skills needed to appropriately perform PE as a priority, this does not seem an easily achievable objective. A recent survey showed that a substantial proportion of American clerkship directors consider students to be inadequately prepared to perform PEs when they arrive for their clerkships.[3] Indeed, the students themselves shared this opinion.[4] This perception of inadequate preparation[5] is worrisome, specially because existing studies have not clearly established the best approach for mastery of the PE during preclinical training that would maximize retention for effective application during the clerkship.[6-8] Medical schools remain, therefore, faced with the challenge of developing effective strategies for teaching PE skills as a sine qua non to foster learning of clinical skills in broad sense at the undergraduate level.

Mastering the PE necessitates the integration of many components such as knowledge of anatomy and physiology, psychomotor skills necessary to perform the appropriate manoeuvres and procedures, and, of course, clinical reasoning. The teaching of PE skills generally occurs with students in small groups of various sizes.[9, 10] Sessions for teaching PE skills usually follow a set order. The session begins with a demonstration of the skills to be learned. The demonstration's purpose is to give students a mental image of a specific PE technique, which will then be practised. Teachers frequently take time during the demonstration to indicate which physical signs are being targeted with each specific PE manoeuvre. After this initial demonstration by an expert, students practice the PE manoeuvre on their peers or standardized patients in the second part of the session. Great importance is attributed to hands-on learning opportunities in which students can practise the required psychomotor skills. This small-group approach allows for intensive individual practice time and provides students with the opportunity to observe their peers performing the same gestures. Furthermore, students may receive feedback from teachers and peers. Peer interaction, which occurs throughout a PE learning session, could play an important role on the initial acquisition of PE skills. By building upon Bandura's social cognitive theory,[11] one can argue that, through observation and feedback, peers influence the performance of their fellow students and modify their own behaviour towards performance improvement.

Notwithstanding the importance of the PE at the undergraduate level and the large use of group sessions in PE teaching, little is actually known about the factors that promote PE acquisition in a small-group environment. This thesis aimed at helping to clarify this issue by investigating the influence of peers on medical students' acquisition of the psychomotor skills necessary to perform the PE. First, the conceptual frameworks that guided the development of this thesis will be presented.

This is followed by a summary of the literature providing relevant information about the influence of peer observation, peer feedback, and order of practice in the PE session (i.e., the time at which the student practised during the session leading to a different order of exposure to observation, practice, and feedback) on PE psychomotor-skills acquisition. This review serves as the basis for presenting the research questions addressed by this thesis and the objectives of the studies undertaken to answer them.

Thesis conceptual framework

In most medical schools, the PE is generally taught in small groups in a natural learning setting. One advantage of learning in small groups is that it affords students the opportunity to improve their performance through the help of others.[12] Students practise and observe their peers practising while receiving teacher comments. In addition, students may interact directly with one another, giving and receiving comments in order to improve their performance. In other words, in a small-group setting, peers might influence each other through observation and peer feedback. In many schools, the decision to use small groups for PE learning is based on logistic issues. Nevertheless, this decision is also pedagogically sound in light of the social cognitive framework proposed by Bandura.[11]

Bandura postulates that individuals observe and interact with their environments in learning a new behaviour. Herein, two concepts from his theory have been retained that are more relevant to the learning of psychomotor skills. First, learning depends in part on observing others, allowing the development of models that the learner attempts to imitate, whether unconsciously or consciously. Bandura identified three possible models for observational learning: (1) a live model, (2) a verbal instructional model, and (3) a symbolic model. A live model is a person that demonstrates or acts out the behaviour to be learned. This is an integral part of PE learning activities, in which students are given the chance to observe a demonstration by an expert, followed by observing new learners practising the same PE skills. The verbal instructional model (descriptions and explanation of the target behaviours) is also integrated into PE learning sessions. Students receive instructions from teachers at the beginning of the activity as well as during practice through feedback. Peers contribute their own feedback, which may also improve skill acquisition. The symbolic model (i.e., real or fictional people displaying behaviour in books, films or multimedia) could be a part of PE learning sessions if a video of an expert performing the examination were used instead of a live demonstration.

The second concept of Bandura's theory that is pertinent to this thesis is the emphasis on an internal cognitive process that creates links between the observed model and the development of new behaviours. This concept assumes that observation does not necessarily result in the adoption of an observed behaviour. The learner selects what he observes and demonstrates choice when acting, and people can learn new information through observation without demonstrating this new behaviour automatically. The process of learning through modelling is goal directed and for learning to happen, first, students must pay close attention to the skill being demonstrated during the PE learning session. In addition, they must have the ability to retain the new information for the purpose of reproducing the expected skill set. Finally, the ability to reproduce PE skills, necessitates practice and repetition to achieve enhanced performance. Learners must be motivated, either internally or externally (such as through reinforcement provided by feedback), to acquire new skills.

Bandura[11] views observation as being core to the learning process. Nevertheless, he does not explain the internal cognitive processes that allow the learner to reproduce the movement after observing a model. In response to this question, Adams's research[13] on the psychomotor performance resulted in his closed-loop theory. In his view, a learner acquires a reference model through practice, forming perceptual traces in the memory that are responsible for movement imitation. Learners compare their movement execution with the initial model observed, which serves as their first reference model. Through practice, learners refine the reference model to produce the actions required to achieve the target goals. Feedback also plays a central role in Adams's's[13] closed-loop theory because comments on performance from others allow learners to adjust their movements. Adams's theory explained the cognitive processes that develop gesture refinement through feedback, allowing learners to compare their actual performance to a reference model to close the gap between the two. Later, Adams[14] added that observation begins the learning process by providing an initial model that the learner will try to reproduce.

To enhance the understanding of the mechanisms of movement reproduction, Schmidt[15] put forward the schema theory, focusing on the elements in the reference model. Every time a movement is executed, the learner gathers four pieces of information: (1) the starting point as the proprioception of the body or limbs; (2) specifications of the motor action such as speed, force, and height; (3) the sensory consequences of the learner's actions as perceived through the perceptual sensation of the movement; and (4) the final outcome of the gestures performed, which are then interpreted as a success or failure in comparison to the initial model. These pieces of information are subsequently put together to construct a schema of adaptive rules that will help generate the specific movement pattern. This schema allows the learner to produce a new movement or refine an existing one, depending on prior experience or context.

These theories on observational learning stress the importance of practice and the cognitive process that takes place in the learners' mind to correct movements and achieve better performance. When learning the PE in a small group, students observe, try to practise what they have observed, and take into account any comments made by other participants or the teacher, with a view to acquiring the new psychomotor skill. Learners do not simply imitate what they have perceived. They are cognitively active in assessing all information, including feedback derived internally and from the environment, while trying to achieve the target objective (in this case, developing a new PE skill set) and enhance their performance.

Indeed, the importance of feedback in processing information to enhance and refine the acquisition of psychomotor skills is a key component of the aforementioned theories on observational learning.[11,13,15] Feedback can be internal, when learners compare their performance with their own reference models (acquired through observation and practice). It can also originate from external information, as represented by the verbal instructional model, which was Bandura's second source for modelling.[11] Feedback, whether from instructors or peers, influences information processing when learners target improving their performance.[11] Feedback provides an external viewpoint that complements any modelling achieved through observation and practice, because it allows learners to perceive the discrepancy between their actual performance and their goal. Consequently, feedback becomes a high valued learning tool, since it helps learners apply and adapt a corrective process to their learning in order to improve the targeted performance level.

To recapitulate, learning through modelling requires observation. Through observation, learners form a model that constitutes a mental blueprint of the task to be learned, which acts as a constant reference or guide while they perform the task. Consequently, this blueprint serves to detect and correct any mistakes in order to enhance performance. This internal process is reinforced by external feedback that is also used to reduce the gap between learner performance and the blueprint. This framework provides the basis for synthesizing the contributions of past research on the influence of peer observation, peer feedback, and the order of practice on learning.

Peer observation

Bandura's works on learning through modelling[11] advocated that observation provides a template for practice, generating the opportunity to correct one's own actions, while practising the skill, based on knowledge of the outcomes.[16] Observation has been recognized as such a key element in fostering the acquisition of motor-skill acquisition. Since much of the observation that occurs in PE sessions refers to observing colleagues as they practise, peer observation is certainly a relevant issue to consider when examining the influence of peers on the acquisition of psychomotor skills.

In medical education, two studies have confirmed the benefits of observation in learning psychomotor skills. The first, conducted by Custers et al.[17], confirmed the importance of modelling when they showed that observing videos of experts executing a simple surgical procedure (i.e., the excision of a skin lesion and closure of the resulting wound) increased students' performance compared to those who only read a description of the procedure before performing it. This study also demonstrated that there is no significant advantage of observing more than one model. Yet this study investigated the influence of modelling on specific surgical skills, which differ greatly from PE skills. Surgical tasks involve fine, serial, discrete, closed motor skills aimed at surgical treatment taught to more advanced students,[18] whereas PE implies serial gross motor skills aimed at searching for physical signs as diagnostic clues, usually taught to novices. Furthermore, the study investigated the effect of observing an expert rather than a peer.

Schwind[19] and his collaborators conducted the second study, which is closer to PE learning. During a clerkship surgery rotation, 49 students were randomly assigned either to a group that received formal instruction on PE of the chest, abdomen, and vascular system, consisting of a video demonstration of examination performed by a physician as well as a live demonstration carried out by a nurse instructor, or to a group that did not receive this instruction when starting the clerkship. In a mid-term test, the students who had received the instruction performed better than those who had not, thereby confirming the importance of observing the skills to be learned to enhance performance. This study had also involved an expert as an initial observation model.

While these two studies in the medical field demonstrate the learning benefits of observing an expert model, it is not clear if peer observation also plays a role in learning PE skills. To our knowledge, only studies in fields other than medicine have provided some empirical evidence in support of the positive influence of peer observation on learning psychomotor skills. For example, Granados and Wulf[20] investigated whether the benefits of learning in dyads could be attributed more to observation or to actual dialogue between participants. Forty-eight volunteers with no previous experience participated in a speed cup-stacking exercise that they practised as dyads in one of four subgroups: no observation–no dialogue, observation–no dialogue, no observation–dialogue, and observation–dialogue. Participants in dyads that only observed the target behaviour improved significantly their performance (i.e., produced faster movement times and made fewer errors) when compared to the other conditions. This study seems to confirm the value of observation in psychomotor skills learning, at least when a simple task is concerned.

Considering that mastering the use of a stabilometer is a more complex task, Shea, Wulf, and Whitacre[21] conducted a study in which thirty-six university students with no previous experience participated in a learning exercise in dyads or alone. Practice in dyads providing for observing peers practising these targeted skills yielded higher results immediately after the practice and in the retention test. The authors concluded that a combination of practice and observation fostered learning more than practice alone.

Would a peer model at the same level of expertise as the learners also help to improve learner performance in medical tasks? That remains to be demonstrated, at least with respect to PE learning. As described above, studies have confirmed the positive impact of observation on performance, at least in the case of observing an expert model. Few studies, however, have investigated the impact of peer observation on performance in medicine. Nevertheless, based on the demonstrated positive effects of peer models on acquiring psychomotor skills outside the field of medicine, it could be postulated that peer observation might positively influence the learning of psychomotor skills by undergraduate medical students engaged in learning the PE.

Peer feedback

The second element that must be considered while studying peer influence on PE learning is peer feedback. When learning the PE in small groups, medical students exchange with their peers and make comments to help them to perform a better PE. I wanted to study the specific influence of the comments provided by peers during the PE practice. The first step, however, to understanding the influence of peer feedback on the acquisition of motor skills learning is defining feedback, which I do in the next paragraph. That is followed by a review of the literature on the impact of feedback on learning and on research targeting the effectiveness of peer feedback. Lastly, I will review certain characteristics that could contribute to impact of peer feedback on psychomotor learning performance.

In a literature review on the role of feedback in education, Hattie and Timperley[22 (p. 81)] defined feedback as "information provided by an agent (e.g., teacher, peer, book, parent, self-experience) regarding aspects of one's performance or understanding". With respect to clinical education, Van de Ridder et al.[23 (p. 193)] proposed a similar definition: "specific information about the comparison between a trainee's observed performance and a standard, given with the intent to improve the trainee's performance". This implies that learners receive information from a teacher or from another learner concerning the technique to be learned. Key components of feedback are comments on actual task performance and suggestions on the subsequent steps to be taken in order to raise the learner's level of performance.[23, 24] When learning PE skills in groups, both feedback (from teachers and peers) and observing others performing the skills are part of this learning process. A peer is one type of provider who could give information to enhance performance.

To assess feedback efficiency, Hattie and Timperley[22] made a synthesis of over 500 meta-analyses that included 450,000 effect sizes in 180,000 studies on the impact of numerous factors that could contribute to student achievement. The average effect of all factors contributing to schooling was 0.40. They found 12 meta-analyses on the influence of feedback that had an average effect size of 0.79. This finding confirmed the power of feedback. According to Hattie and Timperley, feedback is expected to facilitate learning by increasing learners' awareness of the gaps between their current level of performance and the desired one.

In a meta-analyse of 131 empirical studies, however, Kluger and DeNisi[25] found that the average effect size of feedback on performance was only 0.40, because one-third of the studies had a negative effect size. These authors consider that feedback interventions do not always have the intended positive effect, because learners can perceive such interventions as threatening, depending on how they are given.[25, 26] Kluger and DeNisi concluded that a more systematic approach to giving feedback could enhance learning and skill performance, while safeguarding learner self-esteem. Their findings echoed those of various authors who developed a more structured form of feedback consisting of an intermediate check of performance against expected performance criteria, accompanied by feedback on observed strengths and weaknesses as well as tips for performance improvement.[26-28]

Peer feedback, however, tends to occur in a less formal fashion that may not comply with this advocated structured form of feedback. Topping[29] suggested that peer feedback could be seen as a formative assessment that supplements the more formal feedback from teachers. It can also be seen as an arrangement structured by a teacher or initiated by learners in order to increase performance.

Would this less-structured form of feedback also play a role in learning? The influence of peer feedback on future performance has been demonstrated in the area of writing skills, as evidenced by improved performance subsequent to comments from a student at the same educational level.[30] In a meta-analysis of 123 studies on effective instructions for improving writing skills in adolescents, Graham and Perin[31] found an effect size of 0.75 for peer assistance. Could peer feedback have the same positive impact on medical students' acquisition of PE skills?

Some arguments have been raised against the potential role of peer feedback in medical students' learning. Norcini[32] questioned this assumption because he believed that peer judgments might suffer from low reliability and validity, which makes them of limited use in fostering learning. Most studies in the medical field have explored the ability of students to accurately assess peer performance, rather than focusing on the effects of peer feedback on student performance. These studies investigated the reliability and validity of student assessments compared to a gold standard, namely assessment by teachers.[33, 34] These studies carried out in various medical specialties have yielded variable results. For example, in studies on psychomotor skills with residents, 1st-year postgraduate medical residents (PGY1) overrated their peers' performance in comparison to their teachers' marks.[35] Obstetrics and gynaecology residents underrated it,[36] whereas the rating was similar to that of experts for general-surgery residents.[37] Despite raising questions about the reliability of peer feedback, these studies provided no evidence—either for or against— the effects of peer feedback on learner performance.

Another potential obstacle to peer feedback affecting student performance is that peer feedback is not considered as valuable as feedback provided by teachers, who are considered more knowledgeable.[38, 39] Nevertheless, despite students' tendency to prefer teachers' comments, peer feedback has been suggested to be potentially more effective, because it creates uncertainty, which might encourage students to engage in self-assessment of their own performance, as demonstrated by Yang, Badger, and Yu.[40] Their study compared two groups of six students who had to revise an English essay on the same topic: one received comments from the teacher; the other from peers. Students receiving teacher feedback integrated most of the comments, while students who received peer feedback incorporated around 50% of the comments. That notwithstanding, the essay quality in the two groups was similar, suggesting that how students view their peers' comments does not affect the benefit they might gain from them.[40]

The aforementioned studies explored students' perception of peer feedback or, in the medical field, the reliability of peer judgments, yet no clear evidence that peer feedback fosters learning is provided. To the best of my knowledge, no studies have explored if peer feedback during PE group learning facilitates learning, and, therefore, if it improves the performance of PE psychomotor skills.

To summarize, studies on peer feedback have provided some evidence that it may foster skill acquisition or improve performance, at least in the area of writing.[30] In medicine however, whether peer feedback has a positive impact on the acquisition of the psychomotor skills required for performing the PE remains to be demonstrated. Furthermore, few studies use student final performance as an outcome measurement of feedback influence. If such an effect exists, the specific characteristics of peer feedback that might influence learning and thereby affect students' performance of the PE in a small-group learning setting would also have to be investigated.

The literature on characteristics that could influence feedback efficiency is huge. Thurlings et al.[45] conducted a literature review from 2000 to 2012 on the effect of certain characteristics of feedback on teachers' learning. The researchers included studies on feedback, whether from teachers or peers. These authors found 40 variables that had been tested according to different learning theories that they extracted from 61 experimental studies. Thurlings et al. concluded that feedback and peer feedback mechanisms are complex, involving many variables. Based on their review, these authors concluded that, to be efficient, feedback should be task- or goal-oriented, specific, and clear, and have no bias; that it should be given frequently; that it should be constructive and support learning processes; and, when focused on errors, it should be elaborate and encourage the learner to actively engage in filling the gap between performance and the desired outcome.

More specifically, in assessing peer feedback characteristics in the area of writing skills, Gielen et al.[30] constructed an experiment with 43 first-year students in secondary school to test the effect of peer-feedback characteristics on learning performance and feedback accuracy. The task was to write three essays on different articles with the purpose of studying characteristics of different types of essay. The students had to produce draft and final versions with intermediate feedback from a peer. The authors identified the essential characteristics of peer feedback that might foster learner performance. They consider that feedback should be given frequently; should be specific, clear, and accurate; and should include justifications to improve the performance of writing skills. Within their high school population, however, interventions for enhancing afterthought concerning feedback did not increase learning. On the other hand, in their study on quality of feedback reports on consultation by general practitioners, Prins et al.[42] noted a preference for more reflective remarks from more mature feedback providers. The authors also noted the importance of the feedback receiver actively seeking out feedback. Feedback seeking has been studied in organisational psychology,[43, 44] but has just begun to be an issue in medical education.[45-47]

In the light of this literature review, some peer feedback characteristics appear to be more relevant within the natural learning environment of PE learning sessions: feedback amount, specificity, and accuracy, as well as the active seeking of feedback. The majority of investigations into the impact of these characteristics are on feedback in general, but similar results might be expected with peer feedback. Each characteristic will be explored more deeply to clarify the expectations regarding the impact on learning performance.

Concerning the amount of peer feedback necessary to improve psychomotor skills, a controversy has arisen that has not been completely explained by past studies. Contrary to the initial belief that increased feedback enhances motor-skill acquisition,[13] many studies have demonstrated a degrading effect of frequent feedback, at least, with simple motor tasks.[48-50] The so-called “guidance hypothesis”[51] explained this dilemma by presuming that frequent feedback reduces the student’s need to put memory into play, because information was provided through feedback. In an experiment on using a ski simulator to learn slalom techniques, Wulf, Shea, and Matschiner[52] demonstrated that frequent feedback was initially useful for learning complex motor skills, until participants had acquired a certain degree of expertise. These authors hypothesised that error detection and correction mechanisms are not possible in the absence of feedback, because feedback provided early in the training helps learners start reflecting about their performance. After ‘self-reflection’ starts, feedback is not as useful because learners had developed their own correction mechanisms.[48]

One experiment in the field of medical education returned similar results: increased feedback is more beneficial for learning psychomotor skills when a learner begins training on laparoscopic suturing skills. O’Connor et al.[53] attempted to determine the amount of feedback necessary to achieve and maintain a performance plateau in laparoscopic suturing. Nine medical students, divided into three groups, participated in this experiment. The first group received no feedback, the second one got feedback alone, and the third received feedback once plus instructions on the procedure over a long training period (an hour each day, six days a week for four weeks). The groups receiving feedback performed better, at least at the beginning of the training. The small number of participants limits the inferences that can be made from these findings, which moreover are also not generalisable to training in other specialities.

Both laparoscopic suturing and the PE are complex activities for novice medical students. Considering the length and quantity of signs to be learned in the PE, it seems that a greater amount of feedback would be more likely to enhance the performance of motor skills in the case of novice learners. In light of empirical evidence on the influence of the amount of feedback on learning, it could be assumed that students who receive more feedback will learn faster, at least at the beginning, until they reach a minimal expertise[48] or plateau.[53] Yet there is a possibility that too much peer feedback might have a counterproductive effect on performance if the task is not sufficiently complex or if students have a more advanced level of expertise.[48]

The second characteristic of feedback that influences its effects on learning identified in the literature reviews conducted by Thurlings et al.[41] is the specificity of feedback. They argue that the feedback provider must give specific information to learner on his or her performance, with concrete indications on how to reduce the gap between the learner's performance and the expected performance. As an example, they cited a Phye and Sanders[54] study which tested the efficiency of specific feedback versus general feedback in research on using verbal analogy for a problem-solving task. Seventy-five psychology students were divided into two groups to learn the task: one received specific feedback and the other general advice. The researchers found that the specific feedback group was clearly superior to the one who received general advice in a retention task. In the study on writing skills referred to above, Gielen et al.[31] also concluded that peer feedback has to be specific and clear to be effective.

Strijbos, Narciss, and Dunnebier[55] obtained contradictory results in an experiment conducted to determine the impact of peer-feedback content on learning how to revise a text containing various errors. Eighty-nine graduate teacher trainees were assigned, during the learning exercise, to one of five groups differing in the feedback received: concise general written feedback from a high competent peer; concise general written feedback from a low competent peer; elaborate specific written feedback from a high competent peer; elaborate specific written feedback from a low competent peer; no feedback (control group). Surprisingly, the authors found that the groups with concise general feedback outperformed those with elaborate specific feedback during the training and that the groups with low competent peers did better than those with high competent peers on the post-tests. The authors accounted for these contradictory results by citing some methodological limits, namely the input of peer feedback was artificial, because it was in a written form that excluded the exchanges between students that are more frequent during PE training.

If the last study is excluded, specific feedback seems more effective than general or nonspecific feedback, at least in fields outside medicine, possibly because they may have provided a better correction mechanism that helped learners to identify and reduce the errors in their performance To our knowledge, however, no studies clearly link feedback specificity to PE psychomotor skills performance. Nevertheless, based on most of the studies conducted in other areas and consistently with theories on observational learning, we could expected the specificity of peer feedback to have a positive influence on the acquisition of PE psychomotor skills in the case of medical students.

Feedback accuracy is the third characteristic that could be explored. According to Bandura,[11] the comments made by any provider should be as accurate as possible to fill the performance gap in the perspective that feedback has to complement the observation made by the learner. The point of view that accurate feedback is better than inaccurate feedback has been reported in some literature reviews.[22, 41, 56] It implies that the feedback provider should be a teacher—a content expert—in order to maximize the impact of feedback on learner performance. Peers, however, are not experts. Peer feedback can be viewed as collaborative learning[23] or as a formative assessment,[29] because the accuracy of peer feedback varies. Gielen et al.[31] defined accuracy of peer feedback in terms of consistency across assessors or concordance of peer feedback with teacher feedback. They tested the hypothesis that the accuracy of comments made by peers would improve the performance of writing skills in high-school students. They found a large variation in the accuracy of peer comments, ranging from totally inaccurate to fully accurate comments in every paragraph; no significant correlations between the accuracy of peer feedback and the learner writing performance were established. One explanation is that students assess the pertinence and accuracy of comments made by their peers before integrating them and correcting their errors, since peers are not seen as a knowledge authority and reliable source of information, as explained by Yang et al., [40] who demonstrated the superior performance of peer feedback over teacher feedback, despite students' preference for teacher comments. For these reasons, I do not expect that peer feedback accuracy would influence student performance of psychomotor skills in conducting the PE.

The fourth factor that may influence feedback effectiveness is peer feedback seeking during the PE learning session. Medical students frequently ask: "How I am doing?" It implies that the learners are not passive and are seeking feedback in order to gauge and adjust their performance. In organisational psychology, feedback seeking has been demonstrated to be a positive characteristic in adding a resource that the individual can use for learning and development.[43, 44] This has also been found to hold true in medical education.[45-47] Crommelink and Anseel[47] conducted a literature review (principally outside of medical education) to understand feedback-seeking behaviour. They viewed feedback-seeking behaviour as a useful strategy to help learners develop new skills. How frequently learners seek feedback depends on several factors such as the preservation of learner ego and image, the learner's interest in the task, and the quality of interaction between peers or supervisors. Bok et al.[46] conducted semi-structured interviews with clerks and found that the frequency of feedback seeking during clerkship depends on the potential risks and benefits anticipated by the learner in a context of assessment. Their results confirmed results found by Teunissen et al.[45] in a previous survey of 166 obstetrics–gynaecology residents. Teunissen et al. concluded that feedback-seeking behaviour depends on the supervisory style of supervisors, influencing learner perceptions of the benefits in seeking feedback, depending on their goal orientation.

These aforementioned studies concerned factors that influence feedback seeking. Nevertheless, the impact of peer feedback-seeking on learner performance remains to be demonstrated. To the best of my knowledge, only one study has attempted to measure such. Hwang and Francesco[52] conducted a study with eight undergraduate groups of business-administration students to determine if there were a relationship between different types of feedback seeking. This study showed that the students used peers as feedback sources outside of class, but the researchers found no statistical evidence relating peer feedback seeking and exam performance.

Moreover, no experimental research has targeted peer feedback-seeking behaviour pertaining to the acquisition of psychomotor skills, even less so with respect to the link between the amount of feedback seeking and learning performance. There is currently no evidence that peer feedback seeking during small-group activities might enhance performance. Nevertheless, it is expected that feedback seeking during practice sessions in small groups will influence PE performance, because the feedback sought by a learner is arguably more likely to be integrated by students striving to reduce the gap between performance and the desired outcome. Thus, feedback seeking could end up allowing better error detection and correction of poor motor-skill movement.

Order of practice

The third element for consideration in studying the influence of peers in a small-group setting is the order of practice. As stated earlier, small-group activities constitute a major instructional strategy for learning the PE. It allows students to observe and practise a skill while being coached by a teacher. In addition to having the opportunity to practise the task, students can observe their colleagues practising during the session. This method requires a student to volunteer to go first, while the others benefit from initial peer observation. Many students are reluctant to be first. They may feel disadvantaged by not having the chance to observe a peer before taking their turn. Others may be apprehensive of being the centre of attention or being overloaded with feedback from teachers and peers. This raises the question of whether all students in a small-group learning activity have the same opportunity to acquire the psychomotor skills. This would not be true if the order of practice in a small group were to influence learning and therefore the performance achieved at the end of the activity.

Observation can be done before, during, or after one individual's practice. Students going first do not have the chance to observe their peers beforehand, but they can afterwards. Demonstrations usually are given before the students begin practising. Ste-Marie et al.16 criticized, however, the lack of studies demonstrating that this is indeed the best approach. For example, two studies were conducted, one with children learning a ball-striking task58 and another with adults learning the volleyball service.54 These studies revealed that novices perform better initially when a model is presented before and during practice, suggesting that the order of practice in a learning session could influence learning. Neither study, however, was conducted in a small-group setting, and they used an expert model as the reference model for demonstration purposes. Thus, based on these studies, it is difficult to hypothesise what would be the influence of the order of practice/observation on acquiring skills during peer observation.

As seen above, the findings of various studies48, 50 have resulted in controversy in terms of the amount of feedback that students could receive during practice. As things stand, it could be expected that frequent feedback would initially enhance performance until the learner had achieved a minimum of skill mastery, considering that learning the PE is a complex task for novice medical students. The first student would receive more feedback, perhaps yielding an advantage, while the other students, receiving less feedback, would be somehow penalized. This would only apply, however, if it is determined that the amount of feedback has a positive impact on PE psychomotor performance.

Five research questions, which constitute this thesis, are presented below to address the aforementioned themes.

Research questions

1. Does peer observation influence the acquisition of psychomotor skills necessary to master the PE?

Observing an expert has been demonstrated to be beneficial in teaching suturing skills to first-year surgical residents[17] and teaching PE skills to clerks.[19] Less is known about peer observation among undergraduate medical students. The first study reported here, conducted in a natural learning environment, aimed at determining if peer observation while learning the PE influences the acquisition of the psychomotor skills necessary to master an integrated PE. First, I investigated whether observing a peer practising PE skills fostered learning in comparison to practising without observation. Second, whether the number of peers observed (i.e., one or two) during practice affected acquisition of the skill to be learned. It was expected that students observing peers would perform significantly better than students who did not. In keeping with previous findings,[17] there would be no added value of observing more than one peer. The results of this study are reported in Chapter 2.

2. Does the initial quality of the PE observed (i.e., observing a well-performing vs. a poorly performing peer) influence the acquisition of the psychomotor skills necessary to master the PE?

The purpose of this study was to further investigate the influence of peer observation on the acquisition of the psychomotor skills required to execute a PE. More specifically, the purpose was to investigate the influence of the quality of the observed peer PE skills performance. It was anticipated that the quality of the observed performance would influence the students' acquisition of PE skills. Accordingly, it was expected that students observing a well-performing peer would improve PE performance relative to observing a peer who performed poorly. The results are presented in Chapter 3.

3. Does peer feedback influence the acquisition of the psychomotor skills necessary to master the PE?

In the first two studies, the influence of peer observation as well as its quantity and quality were explored. The purpose of this study was to investigate the influence of peer feedback on the acquisition of the psychomotor skills required to execute a PE in a natural small-group setting. It was assumed that peer feedback would be any information about the task or performance provided by peers during the learning activity. It was expected that students who learned in an environment that allowed peer feedback would perform significantly better after the learning activity than students who did not receive peer feedback. Another intent was to verify if the preference for teacher versus peer feedback, as feedback provider, was similar to that encountered in the literature,[40] and if it affected the contribution of peer feedback to learning the PE. This study and its results are reported on in Chapter 4.

4. Which characteristics of peer feedback influence the acquisition of the psychomotor skills necessary to master the PE?

Students can probably benefit from observing their peers and receiving feedback when learning psychomotor skills, such as for the PE, in a small-group setting. This may depend, however, on the type of feedback received. This study looked at four peer feedback characteristics that may favour learning PE psychomotor skills in small-group practice. Based on the literature, it is believed that the amount of peer feedback, the degree of peer feedback specificity, and the degree of feedback seeking will positively influence the performance of a student learning the PE in a small group. It was further believed that the degree of peer feedback accuracy would not influence the performance of students learning the PE in small groups, because, in the PE practice session, learners had to make a decision concerning the validity of the comments made by their peers (i.e., accept or reject them). Inaccurate comments would open dialogue between learners who had a chance to correct their errors, favouring a better integration of comments made by other learners and, consequently, better PE performance. This conclusion is consistent with Yang et al.[40], who demonstrated the superior performance of peer feedback over teacher feedback, despite the student's preference for comments from teachers, who are seen as authorities and reliable sources of information that do not necessitate self-reflection on the validity of arguments. The results of this study are reported on in Chapter 5.

5 Does the order of practice influence the acquisition of the psychomotor skills required for the PE?

Based on the literature, it is not clear whether students can equally benefit from small-group learning, depending on the order of practice within the group. Each student had a different combination of practice/observation and received a different amount of feedback. The purpose of these last two combined studies was to investigate whether the order of practice influenced the acquisition of the motor skills required by medical students to perform a PE. The first study compared different combinations of practice/observation on PE performance. In the second study, the influence of order of practice on the amount of peer feedback received by students was investigated, as well as an association between the latter and PE performance. It was expected that students would have similar PE performances whatever the practice order, because they continue to observe and integrate peer feedback throughout the practice session. The results of this research are reported in Chapter 6.

In short, the general hypothesis for this thesis is that medical students' learning of the psychomotor skills necessary for the PE is influenced by peer observation and peer feedback. Chapters 2 and 3 report on studies into the influence of peer observation on the acquisition of the psychomotor skills that medical students need to master the PE. Chapters 4 and 5 present studies that looked at the influence of peer feedback on this performance. Chapter 6 reports on a study aimed at determining if the order of practice within a group modifies the effect of peer observation and peer feedback on performance. Finally, the last chapter summarises the findings of this research, discusses their implications for medical education, and suggests issues to be further explored in future research.

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Chapter 2

To observe or not to observe peers when learning physical examination skills; that is the question

Published as Martineau B, Mamede S, St-Onge C, Rikers R and Schmidt HG. To Observe or Not to Observe Peers when Learning Physical Examination Skills; that is the Question. BMC Med Educ. 2013; 13:55.

Abstract

Background: Learning physical examination skills is an essential element of medical education. Teaching strategies include practicing the skills either alone or in-group. It is unclear whether students benefit more from training these skills individually or in a group, as the latter allows them to observing their peers. The present study, conducted in a naturalistic setting, investigated the effects of peer observation on mastering psychomotor skills necessary for physical examination.

Methods: The study included 185 2nd-year medical students, participating in a regular head-to-toe physical examination learning activity. Students were assigned either to a single-student condition (n = 65), in which participants practiced alone with a patient instructor, or to a multiple-student condition (n = 120), in which participants practiced in triads under patient instructor supervision. The students subsequently carried out a complete examination that was videotaped and subsequently evaluated. Student's performance was used as a measure of learning.

Results: Students in the multiple-student condition learned more than those who practiced alone (81% vs 76%, $p < 0.004$). This result possibly derived from a positive effect of observing peers; students who had the possibility to observe a peer (the second and third students in the groups) performed better than students who did not have this possibility (84% vs 76%, p <. 001). There was no advantage of observing more than one peer (83.7% vs 84.1%, p > .05).

Conclusions: The opportunity to observe a peer during practice seemed to improve the acquisition of physical examination skills. By using small groups instead of individual training to teach physical examination skills, health sciences educational programs may provide students with opportunities to improve their performance by learning from their peers through modelling.

Background

Physical examination (PE) is a core element of physicians'daily activities and plays an important role in adequate diagnostic performance.[1] Much attention is dedicated, therefore, to the development of medical students' skills to appropriately perform PE. However, this does not seem to be an easy endeavour because a recent survey showed that a substantial proportion of American clerkship directors consider students to be less prepared than necessary to perform PE when they arrive at the clerkships,[2] an opinion shared by the students themselves.[3] To face this challenge, most medical schools have developed specific strategies for teaching PE skills at the undergraduate level.[2] These strategies, built upon theories of motor skills acquisition, mostly involve demonstration of the skill followed by practice with feedback.[4] Great importance is attributed to offering opportunities for students to practice the PE skills extensively. Students often have the chance to practice alone or together with their peers, but it is not known whether students benefit more from individual or group practice.

Observation has been recognized as a key strategy to foster motor skills acquisition;[5] however, it is not clear if observation may also play a role in teaching PE skills. If it does, students might benefit from practicing in groups, with an opportunity to observe their peers. The present study investigates whether peer observation has a beneficial influence on the acquisition of PE skills.

The decision to teach PE in groups is often made on the basis of practical considerations. For example, a lack of trainers or simulated patients may compel the school to organise PE teaching in-group sessions. Still, this decision may also be pedagogically sound if one considers research on observational learning. Bandura's works on learning through modeling[6] advocate that observation provides a template for practice, generating the opportunity to correct one's own actions, while practicing the skill, based on knowledge of the outcomes. Theories of acquisition of psychomotor skills,[7] built upon this construct, suggest that observing a model leads learners to develop a mental blueprint of the to-be-learned task, which acts as a reference while performing the task. Consequently, they use this blueprint to compare it with their own performance while practicing the to-be-learned task,[8] which aids in detecting and correcting mistakes. Moreover, Schunk[9] has suggested that watching a peer might help to reinforce one's self-efficacy, which may positively influence the performance.

Studies in domains outside medicine have provided some evidence in support of the positive influence of observation on learning psychomotor skills. For example, Shea, Wulf and Whitacre[10] demonstrated that practice in dyads, which allows observing a peer practicing the skill, was superior than learning alone to mastering the use of a stabilometer. They concluded that a combination of practice and observation fosters learning more than practicing alone. Aiming at determining if the benefits of learning in dyads derived from observation or from dialogue between participants, Granados and Wulf[11] investigated mastery of cup stacking skills. They demonstrated that participants from conditions in which it is possible to observe another learner learned more, i.e., produced faster movement times and made fewer errors, than participants from conditions that allowed dialogue between peers.

In medicine, the first studies on modelling focused on surgical skills. Custers, Regehr, McCulloch, Peniston, and Reznick[12] confirmed the importance of modelling in showing that observing videos of experts executing a simple surgical procedure (i.e., the excision of a skin lesion and closure of the resulting wound) increased students' performance compared to those who only read a description of the procedure before executing it. This study also demonstrated that there is no significant advantage of observing more than one model. However, this study investigated the influence of modeling on specific surgical skills, which differ greatly from PE skills. Surgical tasks involve fine, serial, discrete, close motor skills aimed at surgical treatment, taught to more advanced students,[13] whereas PE implies serial gross motor skills aimed at searching physical signs for diagnostic clues, usually taught to novices.

The study reported here, conducted in a naturalistic environment, aimed at determining if peer observation while learning physical examination influences the acquisition of psychomotor skills necessary to master an integrated PE skills. We investigated, first, whether observing a peer while practicing PE skills fosters learning in comparison to practicing without observation; and second, whether the number of peers observed (i.e., one or two) during the practice affects acquisition of the to-be-learned skill. It is expected that students observing peers will perform significantly better than students who do not observe peers, but, consistent with previous findings,[12] there will be no added value of observing more than one peer.

Methods

Participants

One hundred and eighty-seven (187) second-year students participated to the study (mean age = 22.1; 73 males). Two students were removed from the analyses due to missing data. We randomly assigned students to one of two learning settings: (1) the single-student condition and (2) the multiple-students condition. In the first setting students practiced alone without the opportunity to observe a peer. In the second setting, students practiced in groups of three, having therefore the opportunity to observe two peers.

Setting

This study was conducted at the University of Sherbrooke. The undergraduate medical education program wherein we conducted the experiment is a four-year Problem-Based Learning (PBL) curriculum including an 18-month clinical clerkship. To prepare students for the clerkship, clinical skills are taught through a series of activities within organ-based system modules. More specifically, PE skills are taught at three different moments within the curriculum: PBL sessions; transdisciplinary activities and various PE practice sessions.[14] In PBL sessions, specialist tutors teach in separate, focused sessions, the PE exam of specific organs related to their discipline. They used educational strategies such as demonstration, practice, coaching, and feedback from tutors and peers. During transdisciplinary activities, clinical skills from different disciplines are combined with teaching of communication, clinical reasoning and PE sequence combination learned during PBL sessions. During practice sessions, which take place twice per semester, students practice their PE skills on two to four standardized or real patients, receiving feedback from mentors.

Ethics approval

Ethics approval was obtained from the Ethic research committee for Education and Social sciences of Sherbrooke University. All participants provided written, informed consent.

Materials and procedures

The learning activity

The task to be learned by the students was a complete head-to-toe PE (excluding neurological and locomotor exam) taught during an activity offered to facilitate the integration of the different components of PE that students had learned separately during their organ-based system modules. At the end of the activity, students are expected to have mastered the sequence of the integrated PE, and to complete it in ten minutes.

This activity, coached by a Patient-Instructor (PI), is regularly offered in the middle of the last semester of the second year of the undergraduate program. PIs are volunteers who work as simulated patients in several educational activities in the undergraduate medical program.

Before the present study, the PIs received a 30- hours training on the specific sequences of PE to be coached. The training, provided by the first author, who is a clinician, aimed at standardizing coaching to be provided by the team of patient instructors.

Procedure

PIs met participants to teach them the head-to-toe physical examination. Each participant had 45 minutes with a PI, which translated into a 45-minute session for the participants in the single-student condition and a 135-minute session for the participants in the multiple-students condition.

The sequence adopted during the activity was as follows: (1) the PI presented the PE sequence to students; (2) a participant practiced the PE sequence on the PI for 30 minutes, receiving immediate feedback from the PI and from their peers when present; (3) the same participant was videotaped performing the complete PE sequence within 10 minutes; and (4) the participant received final feedback. Steps 2 to 4 were repeated for the other two participants in the multiple-student groups.

Measure of performance

Two of the authors (BM, CSTO), through an iterative process, developed a checklist to assess PE participants' performance (see Additional file 1 for PE components included in the evaluation checklist). They constructed a grid that reflects the skills taught in the curriculum design.

The checklist included 158 items divided into four subscales: (1) positioning, assessing whether the student positions his/her body adequately, relative to patient's position, (2) ordered execution, assessing whether the student respects examination order at each step of PE, (3) gesture precision, assessing whether the student uses the right examination technique and touches the appropriate structure adequately, and (4) procedural efficiency, measuring if the student maximizes the utilization of each patient's position, thereby minimizing repositioning the patient from one posture (standing-sitting-lying) to another.

Inter-rater reliability (IRR) measured by intra-class correlations (ICC), namely the two-way random model for unique measure, showed reliable results when five raters assessed five different participants' performance. The ICCs was 0.95. The principal investigator identified areas for improvement in standardization and provided feedback to the PIs on how to adjust their scoring. As the procedure was shown to be reliable, two of the five PIs who participated in the reliability test, scored videos of participant's performance that we distributed randomly to them. They were blind to the learning activity condition of participants.

Analysis

We calculated a participant's performance score by adding all the checklist items and converting this sum into a percentage. To assess the influence of practicing alone with the PI versus practicing in a group, we compared the mean performance score obtained in the single-student condition and the multiple-student condition using an independent t-test.

Based on the two different learning settings, we subsequently assessed the observation condition and a noobservation condition, by grouping participants from the single-student condition with the first participants in the multiple-students condition (i.e., no-observation condition), and grouping the second and third participants from the multiple-students groups (i.e., observation condition). We also used a mean comparison (t-test) to study the influence of observing a peer once versus twice, on performance of PE skills.

To assess the effect of learning activity situation (individual versus group learning), and of number of observations (zero, one or two observations), an ANOVA was used to compare the performance according to the student order (i.e., single-student, first in multiple-student condition, second in multiple-student condition, and third in Multiple-student condition). To estimate the effect sizes, we calculated partial eta-squared for the ANOVA, and correlations for the t-test comparison.[15,16] We used Cohen's[17] tables to interpret effect sizes.

Results

Influence of peer observations on the acquisition of head-to-toe PE skills

Descriptive statistics of students' performance, for singlestudent vs. multiple-students conditions, are presented in Table 1. It can be observed that participants in the multiple-students condition had higher scores than participants in the single-student condition group ($t[183] = 2.88$, $p < 0.05$, $r = 0.21$).

The descriptive statistics for the no-observation versus the observation conditions are presented in Table 1. Participants who observed at least one peer before their own training performed better than students who did not observe peers ($t[183] = 5.42$, $p < 0.05$), with a moderate effect size ($r = 0.37$), suggesting that the higher scores obtained by the multiple-students condition resulted from the opportunity to observe their peers.

Influence of the number of observations on the acquisition of head-to-toe PE skills

The influence of observing peers when learning PE skills is illustrated in Table 1. Participants' performances vary according to the order in which they executed the PE.

Table 1. Mean performance scores standard deviations and p-value

	N	Mean	SD	P-value
Single-condition	65	76,23	10,64	0.004
Multiple-students condition	120	80,85	10,3	
No observation group*	108	75,9	10,52	< .001
Observation group**	77	83,9	8,92	

* Students from the single condition and the first students of the multiplestudents condition formed the "no observation group".
** The second and third students of the multiple-students conditions formed the "observation group".

Significant differences were found according to the order of student's practice, $F(3, 181) = 9.78$, $p < .001$, n2 $p = 0.14$. Post hoc analyses revealed that differences were significant between the single-student condition and both the second ($p = .002$) and third ($p = .001$) student in the multiple-students condition, as well as between the first student in the multiple-students condition and the second ($p = .001$) and third ($p = .001$) in the multiple-students condition. There was no difference between the single-student condition and first in the multiple-students condition nor between the second and the third students in the multiple-students condition.

Discussion

Participants in the single-student condition and the first participants in the multiple-students condition, i.e., those students who did not have the chance to observe any peer practicing the skills, obtained similar scores but did not perform as well as students who observed their peers (i.e., the 2nd and 3rd participants in the multiplestudents condition). These results are consistent with our initial hypothesis, and seem to provide a demonstration of the value of observation for the acquisition of psychomotor skills required to execute PE.

All participants were equally exposed to the presentation of the skills by the instructor, and had the same amount of time to practice them before performing the whole PE sequence, which suggests that peer observation determined the observed difference in performance. The mechanisms through which peer observation acted were not investigated in this study, but the results are consistent with theories on observational learning that postulate the potential benefits of using modeling to teach skills. Observing their colleagues practicing the PE may have provided the students in the multiple-students condition with opportunities to refine their perception about the to-be-learned skills, and to discern different aspects of the to-be-executed actions.[6] A similar benefit of observation was found in studies on acquisition of surgical skills[10] and other motor skills.[5] The similarity of scores obtained by the 2nd and the 3rd students within the multiple-students condition indicates that there is at best a limited advantage conferred by observing peers during PE training more than once. A finding that is in line with studies in the surgical field.[10]

The effect of the learning condition was only moderate. This moderate effect size could be explained by the fact that those students in the present study were not entirely naive to the to-be-learned skills; they had learned different parts of the PE before the learning activity in which the study was conducted. Consequently, they mainly had to integrate various components of PE that have been previously learned into a head-to-toe examination, which may be different from learning entirely new skills. The performance scores of the participants showed to be high with little room for improvement. Therefore, observing one peer might have been sufficient in this context, but it will need future studies to ensure the amplitude of the size effect in earlier stages of their learning.

We used a detailed grid instead of global ratings to assess the students' performance. This may be seen as a drawback of the study, because detailed checklists have been shown to fail in discriminating between different levels of expertise.[18] On the contrary, global ratings have been used to reliably assess complex competences, or example in surgery.[19] However, the learning activity in the present study was directed for novice students at the same level of their training. Moreover, it aimed at fostering integration of different components of PE psychomotor skills that had been previously addressed in other regular activities, and a detailed assessment of performance was favoured because it would allow for identifying which of the several components of the psychomotor skills had been acquired. A detailed assessment tool was also considered to correspond to the coaching provided by PIs. It also allows a better standardization of the assessment of student's performance to be provided by the PIs.

Another limitation is that is not possible to exclude the possibility that the observed effect on performance was due to interaction among peers, which occurs naturally when students practice in-group. Peer feedbackcould have also contributed to increase the performance, as studies have shown to happen, for example, in writing skills learning.[20] Disentangling the influence of peer feedback from that of peer observation during PE learning requires further investigation.

Ste-Marie and colleagues[5] suggested that future research on observational learning should go beyond experimental designs with a limited number of participants, to be included in regular pedagogical activities. The present study was conducted as part of the regular activities of a medical undergraduate program. The use of a naturalistic setting for the study ensured its feasibility and increases the probability that similar activities will be reproducible in other programs. In addition, the high number of participants would help reducing the selection bias that sometimes occurs in experimental settings. However, the naturalistic setting also poses drawbacks such as an asymmetric design. It was not possible to ensure that the total time on task was equal for each participant, because participants in the multiple-students condition had overall more exposure to the PE so that they could observe their peers. It could be argued, therefore, that instead of deriving from peer observation, the higher performance shown by students in the multiple condition groups was in fact produced by the extra learning time they had. Nevertheless, the fact that there were few additional benefits after observing one peer indicates that there would be limited potential effect of the longer exposure time.

To better understand the value of peer observation when acquiring PE skills, future studies should evaluate if the quality of the peers' performance being observed influences the acquisition of PE skills. In addition to observation of a peer, it would be interesting to examine whether other factors such as observation of standardized video or feedback provided by peers and instructors provides incremental benefit or produces an effect similar to peer observation. Moreover, this study suggested that peer observation increased performance, but students were tested immediately after the learning activity. It is not known whether the positive effects of peer observation would last, and future studies should explore this issue.

Conclusions

In summary, the results of this study support the importance of peer observation in the acquisition of psychomotor skills needed to execute the PE. The opportunity to observe peers performing PE within an instructional context may help participants integrating the multiple components of PE. By using small groups instead of individual training to teach PE, health sciences educational programs may provide their students with an opportunity to observe peers performing a task, allowing modelling to take place during learning and favouring performance improvement.

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Chapter 3

From see one do one; to see a good one do a better one: learning physical examination skills through peer observation

Published as St-Onge C, Martineau B, Harvey A, Bergeron L, Mamede S, Rikers R. From See One Do One; to See a Good One do a Better One: Learning physical examination skills through peer observation. Teach Learn Med. 2013; 25(3):195-200

Abstract

Background: Learning and mastering the skills required to execute physical exams is of great importance and should be fostered early during medical training. Observing peers has been shown to positively influence the acquisition of psychomotor skills.

Purpose : The current study investigated the influence of peer observation on the acquisition of psychomotor skills required to execute a physical examination.

Methods: Second-year medical students (N = 194) learned the neurological physical examination forlow back pain in groups of three. Each student learned and performed the physical examinationwhile the other students observed. Analyses compared the impact of the quantity and the quality of observed performances on students' learning of the physical examination skills.

Results: Students benefited from observing peers while they executed their examination. Moreover, observing a highperforming peer increased the acquisition of physical examination skills.

Conclusions: Results suggest that group learning activities that allow students to observe their peers during physical examination should be favored.

Background

Physical examination (PE) is a core element of physicians' diagnostic decision-making process[1] and medical care provided to patients.[2] Developing PE skills early on during medical students' training and maintaining these skills is therefore of great importance. Unfortunately, medical students entering clinical clerkships often do not appropriately master PE skills,[3,4] or they feel inadequately prepared.[5] Consequently, how to foster learning of skills required for PE is still under discussion.[6,7] The current study addressed this issue by investigating the influence of different aspects of peer observation on learning of PE skills.

An important way to acquire psychomotor skills such as those required to execute a PE, is by observing how other students or experts perform certain tasks. Studies have shown that observing a peer or a model positively influences the acquisition of psychomotor skills.[8,9] It is hypothesized that learners map the performance by the learning models. They develop a blueprint of the to-be-learned task at hand that acts as a reference while performing the task. Consequently, observers use this blueprint to compare it with their own performance while practicing the tasks,[10] which helps in detecting and correcting mistakes. According to Adams[11] this may help observers to engage themselves in this process. Moreover, Schunk[12] has suggested that watching a peer might help to reinforce one's self-efficacy, which may positively influence performance.

Previous studies have shown that observation has a beneficial influence on performance. For instance, studies by Shea, Wulf, and Whitacre,[13] and Granados and Wulf[9] compared dyad training (two students working together) to individual training for suturing skills and cup-stacking skills, respectively. Both studies showed a positive effect of students working in pairs. That is, students in dyads made significantly less errors through continuing practice than individual students, and they performed better in a retention test. Custers and colleagues[14] have shown that observing peers executing a simple surgical procedure (i.e., the excision of a skin lesion and closure of the resulting wound) increased students' performance compared to those who only read a description of the procedure before executing it. In a literature review by Ste-Marie and colleagues it was observed that the type of model observed (skilled vs. unskilled, peer vs. no peer) could influence students' acquisition or perceived acquisition of psychomotor skills.[15] However, no conclusion could be drawn from the studies reviewed, that is, there was no dominant trend as to the influence of the type of model observed.

There is also evidence that observation may help students while learning PE skills. For instance, students who receive formal instructions using a PE video demonstration done by a physician, in addition to a live demonstration done by a nurse instructor, performed better than students who did not receive the live demonstration.[16] Furthermore, Martineau and colleagues[17] showed that observing a peer learning PE skills increased students' PE performance compared to students who did not observe a peer. Interestingly, they also showed that students' performance after observing two peers did not statistically differ from those who observed only one peer.

Most aforementioned studies, however, investigated the influence of (1) the number of observed performances and (2) the type of collaborative learning. Few, if any, studies have investigated the influence of differences in the quality of performances observed on the acquisition of psychomotor skills.

Purposes

The purpose of the current study is to further investigate the influence of peer observation on the acquisition of psychomotor skills required to execute a PE. More specifically, the purpose is twofold: first, to investigate the influence of the number of observed performances, and second, more important, to investigate the influence of the observed performances' quality. It is expected that students observing peers will perform significantly better than students who do not observe peers, but, consistent with previous findings,[18] observing one peer will be as good as observing two peers. Furthermore, it is anticipated that the quality of the observed performance will influence students' acquisition of PE skills. More specifically, it is expected that observing a well-performing peer will improve their own performance more than when they have to observe a poorly performing peer.

Methods

Participants

Participants were 194 second-year students enrolled in a four-year undergraduate MD program of Université de Sherbrooke. Thirty-four participants were excluded from the analysis due to missing data. Ethics approval was obtained at the university were the study was conducted. All participants completed the written consent form.

Setting

The MD program, where the study took place, is a four-year Problem-based Learning (PBL) curriculum followed by an 18-month clerkship. Learning of clinical skills is organized in a series of activities within organ-based modules; they aim at preparing the undergraduate students for their clerkship that begins in the middle of their third year. Teaching of the PE skills takes place at three different levels: PBL sessions, transdisciplinary activities (where students integrate clinical skills related to different organ-based systems previously studied), and several PE practice sessions.[17]

Materials and procedures

Learning task

The learning task in this study serves as an integration activity of the neurological PE taught during the neurology unit and the lumbar region PE taught during the locomotor unit. Students are expected to become able to execute an appropriate integration of these two PEs for a patient presenting with low back pain. The integrative PE comprises the following steps: observing the patient walking, evaluating the amplitude of the movement, searching for neurological signs, executing specific maneuvers to elicit nerve irritation, evaluating the hip and sacro-iliac joints and finally palpating low-back region.

At the end of the activity, students were expected to master the sequence of the exam, the elements to be searched throughout the PE, the position relative to the patient's position, handling of the limbs during their maneuvers, and the precision and the force of their palpation. The completion of the NLE is expected to take about five minutes when PE skills are mastered.

Procedure

Students were randomly divided into groups of three, and separate sessions were run for each group. Each session started by an introduction in which students first watched a videotape of a teacher performing each step of the Neuro-Lumbar Physical Examination (NLE), and received a two-minute presentation of the NLE sequence. Procedural guidelines were posted on the wall so students could refer to them during the task.

After the introduction, students met with a Patient Instructor (PI) to perform the NLE. Prior to the activity, all seven PIs who would participate in the activity received training on the specific sequences they would coach, provided by two investigators (BM, AH). The first student practiced individually the NLE sequence on the PI for 15 minutes and was observed by the other two students in the group. Students decided themselves who would perform the NLE first, second and third. The student received immediate feedback from the PI. Following the practice phase, the student executed the complete NLE sequence within a five minute-period, which was videotaped to be evaluated later. Then the second and the third student completed the same sequence individually. Each session lasted 1.5 hour for each group of three students. Interactions between students were not strictly regulated. While some groups may have fully interacted, other groups may have had limited interactions.

Measures of performance

A checklist was developed to assess students' NLE skills. It was comprised of three subscales: positioning (positions his/her body adequately, relative to patient's position), ordered execution (respects examination order at each step of NLE), and gesture precision (uses the right examination technique, touch the adequate structure), to correspond with how the PE is taught in the curricula. The checklist was developed by two investigators (BM, AH) through an iterative process and comprised 94 items (rated: completed = 1, not completed = 0), grouped in the three subscales described above.

A checklist approach was favoured instead of a more global assessment to favour (1) better discrimination of students who master the skills versus those who do not master the PE skills, (2) better standardization between PIs (a descriptive and comprehensive tool was thought to increase the standardization of PI teaching and assessment), and (3) to be potentially useful to provide explicit feedback.

PIs scored each performance by watching the videos after the entire cohort of students completed the learning activity. There was no time limit for the PI's to execute this task, and assessment of the 94 checklist items took 10 to 20 minutes). Two PIs were selected to complete the assessment task. They first independently rated a sample of videos (n = 7). After each evaluation, the PIs compared their ratings, and divergences in scores were resolved through discussion. Following the standardization process, the remaining videos were randomly assigned to the PIs, which assessed them separately. Cronbach's Alpha for the 94-item checklist was 0.90 indicating an appropriate level of reliability.

Analysis

A total score was computed for all students to measure their NLE performance. The total score was computed by adding all the items of the grid. The sum was converted into a percentage score. Subgroups were created to compare students having observed no peer, one peer or two peers. A one-way ANOVA was conducted to assess the differences between students' NLE skills according to the number of observed performances (zero, one or two). Post-hoc analyses were conducted using Tukey's test. Partial eta-squared, a ratio of error variance and effect variance, was used to estimate the effect-sizes.[19] Cohen's (1988)[20] guidelines for interpreting effect-sizes were applied.

Subgroups were created to investigate the influence of the quality of the observed performance on students' performance. For second and third students, three subgroups were created for these secondary analyses. That is, participants were grouped accorded to the quality of their immediate predecessor's performance. The first group consisted of students who observed poor performing peers (1/3 lower scores; range score of performance observed by second = 15-60; and third students = 31-67), the second group observed average performing peers (1/3 middle scores; range score of performance observed by second = 61-71; and third students = 68-77), and the third group observed high-performing peers (1/3 higher scores; range score of performance observed by second = 72-84; ad third students = 78-85). One-way ANOVA were conducted to compare the influence of the quality of the predecessors' performance (poor, average, high) on the acquisition of NLE skills. Post-hoc analyses were conducted using Tukey's test. Data was analysed using PASW Statistics 18, and significance level was set at $p < .05$ for all comparisons.

Results

Influence of the number of peer observations on the acquisition of NLE skills

Mean subscores and total scores for students having observed zero, one or two peer NLE sequences are presented in Table 1. Performance differed significantly between students having observed zero, one and two NLE, $F(2, 157) = 11.06$; $p = .001$, $\eta_p^2 = 0.12$. A medium effect was observed. Tukey's post-hoc comparisons of the three groups indicated that students who did not observe a peer executing the NLE, significantly differed from the students having observed one NLE, and from students having observed two NLEs. Comparisons between students having observed one NLE and students having observed two NLEs were however not statistically significant.

Table 1. Mean scores (Standard Deviation) and 95% Confidence Interval of participants as a function of the number of neurological and locomotor exam observed

Observed zero Peer NLE[a]		Observed one Peer NLE[b]		Observed two Peer NLE[c]		Post hoc comparison (p)			
M (*SD*)	95 % CI	M (*SD*)	95 % CI	M (*SD*)	95 % CI	0 vs 1	0 vs 2	1 vs. 2	Overall (p)
66.59 (17.30)	[61.91, 71.27]	76.21 (12.06)	[72.95, 79.47]	77.88 (9.36)	[75.23, 80.54]	.001	.001	.799	.001

Note. NLE = Neuro-Lumbar Physical Examination.
[a]N = 55. [b]N = 55. [c]N = 50.

Influence of the quality of peers' performance on the acquisition of NLE skills

Scores for students having observed only one peer (according to the peer's performance level: poor, average or high) are presented in Table 2. Students' performance differed significantly according to the quality of the peer's observed performance, $F(2, 52) = 7.82$; $p = .001$, $\eta_p^2 = 0.23$. A large effect was observed.

Tukey's post-hoc comparisons showed that students who observed poor peer performances scored significantly lower than students who observed average peer performances for total score (p = .006). Significant differences were also observed between students who observed a poor performing peer and students who observed a high performing peer (p = .002). There was no difference between students who observed average peer performance and students who observed high peer performance.

Scores for students having observed two NLE peers' performance (according to the immediate previous peer's performance) are presented in Table 2. Performance differed significantly for these students according to the performance level that was observed just before they executed the NLE, $F(2, 47) = 6.31$; $p = .004$, $\eta_p^2 = 0.21$. A large effect was observed. Tukey's post-hoc comparisons indicated that students who observed poor performances scored significantly lower than students who observed average performances (p = .043). Differences were also significant between students who observed a poor performing peer and students who observed a high performing peer (p = .001). There was no difference between students who observed an average performing peer and students who observed a high performing peer.

Table 2. Mean scores (Standard Deviation) and 95% Confidence Interval of participants' performance having observed one peer and according to the peer's performance level observed and participants' performance having observed two peers and according to immediate previous peer's performance

Number of peers observed	P performance observed		A performance observed		H performance observed		Post-hoc Comparison (p)			
	Mean (*SD*)	95 % CI	Mean (*SD*)	95 % CI	Mean (*SD*)	95 % CI	P vs A	P vs H	A vs H	Overall (p)
One	68.34 (14.01)	[61.58, 75.09]	79.66 (8.18)	[75.71, 83.60]	81.14 (9.02)	[76.50, 85.79]	.006	.002	.911	.001
n =55	n =19		n =19		n =17					
Two	72.33 (12.01)	[66.16, 78.50]	78.95 (5.91)	[75.91, 81.99]	82.65 (5.87)	[79.53, 85.78]	.069	.003	.429	.004
n = 50	n = 18		n = 19		n = 13					

Note. P = poor; A = average; H = high; CI = confidence interval.

Discussion

It has been shown that observation can improve the acquisition of psychomotor skills.[8,9,14] The present study was conducted to further investigate the influence of peer observation on the acquisition of psychomotor skills required to execute a NLE. More specifically, the purpose was to investigate the influence of the number and the quality of observed performances on the acquisition of detailed and precise PE skills. It was hypothesized that observing one peer would increase performance, but there would be a limited added value to observing two peers. In addition, it was hypothesized that observing a high performing peer would increase students' performance more than observing a poor performing peer. The results showed that observing a peer practice and execute a NLE positively influenced participants' performance while learning the skills. This benefit increased when the peers' performance observed was above average.

Bandura[21] suggested that having multiple models would provide learners with opportunities to refine their perception and discern different aspects of the to-be-executed actions. This is also supported by findings in the surgical field.[14] However, our results support the conclusions from these previous studies only partially. The value of observation was reaffirmed by our findings, but there seems to be a limited value of subsequent exposure. Whereas students benefited from observing one peer, the similar performance between participants having observed one NLE and two NLEs suggest that there was a limited value of observing more than one peer during NLE training.[14] It is important to note, however, that students in the present study were not entirely naïve: they had learned different parts of the PE before this learning activity. Consequently, they only had to integrate the neurological and the locomotor parts of the examination together versus learning entirely new skills. Therefore, observing one peer might have been enough in this context, but this might not be the case when students are at the beginning of their learning curve. In addition, consideration should be given to the fact that students were not randomly assigned an order of participation. In particular, the final students who executed the NLE may have influenced the outcome of the study by being less confident or of lower-ability than the students that preceded them. Further studies should control for the ordering of students.

Results indicated that observing a peer is good but observing a good peer is better. These results are consistent with the literature on the acquisition of psychomotor skills. When learning psychomotor skills, watching a skilled model seems to be preferable to watching an unskilled model.[22] Schunk[12] suggested that peers' success may foster observer self-efficacy. Students may feel that if a similar person can accomplish the task, they can also do it. In addition, it may be that a skilled learning model provides a more detailed overview of the task to be executed, therefore helping the observer to construct a better representation of the sequence of movements to be performed. Results of this study provide support for the latter hypothesis. Increases in performance (scores) were due to more precise, organized and efficient execution of the PE. Having observed a high performing peer may have given student the edge to meet the detailed requirements as measured by the explicit and comprehensive checklist.

This study was conducted in a naturalistic setting, that is, during a learning activity embedded in a MD program. This strongly supports the feasibility of creating and inserting similar activities that promote acquisition of psychomotor skills in other health sciences educational programs. Since the study was conducted in a naturalistic setting, the nature and the content of the feedback provided by the PI and peers were not strictly controlled. However this is true for all groups of students and the observed results were insightful. As has been indicted above, order of performance within each group was student determined and may have led to more confident, and possibly of higher-ability, students performing first. However, in spite of the possibility that first students might have been more confident or of higher-ability, it was observed that second and third students performed better, therefore supporting the benefit of observation when acquiring psychomotor skills.

It would be important to further study the influence of observing a peer to better understand what elements influence the performance in order to maximise the time and use of the resources available to health sciences educational programs. Moreover, further studies should also address the impact of observing peers receiving and reacting to feedback while learning complex psychomotor skills. The types of feedback given could also be a variable considered in future research.

Conclusions/scientific and scholarly significance of the study

A collaborative learning setting (i.e., small groups) enables students to observe peers performing a task, and later, to model this performance. The opportunity to observe peers doing PE seems to help students to integrate more rapidly the skills required to perform a PE. The results of this study are of great importance when we consider that medical students entering their clerkship have been reported not to master those skills.[3] Health sciences educational programs that aim at increasing students' PE skills should favour small group learning and peer observation when teaching those skills.

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Chapter 4

The influence of peer feedback on the acquisition of physical-examination skills

Martineau B, St-Onge C, Bergeron L and Mamede S. The Influence of peer feedback on the acquisition of physical-examination skills. Health Professions Education. 2016. In press.

Abstract

Background: Previous studies have suggested that having students observe peers while acquiring physical-examination (PE) skills fosters the acquisition of the psychomotor skills required to conduct a PE. One difficulty, however, has been to disentangle the effect of peer observation from peer feedback, both of which occur when students learn in groups. This study investigated the influence of peer feedback on learning the neurolocomotor physical exam for low-back pain.

Methods: 120 second-year medical students were randomly assigned to a peer-feedback group (n = 61) or a no-peer-feedback group (n = 53), during a regular learning activity with a standardized-patient instructor. Students first practised the NLE in groups of three, with or without peer feedback, depending on the group to which they were assigned. Subsequently, the members of both groups performed the NLE individually. The final NLE was videotaped and assessed later.

Results: *Peer feedback had a positive effect on the acquisition of PE skills* (87.9% vs. 90.8%, p = .023), despite the fact that students had an initial preference for instructor feedback compared with peer feedback.

Conclusions: These results support the use of group activities that give students the opportunity to provide feedback to their peers while learning PE skills.

Introduction

Physical-examination (PE) skills essential for good clinical performance are usually taught in small groups[1, 2] by demonstrating the skills and then providing feedback as students practise them. While this approach is widespread, medical students in a small-group setting know little about the factors that facilitate the acquisition of PE skills. Of the factors that have been studied, observation of peers seems to contribute significantly to psychomotor-skill acquisition.[3,4] With respect to peer influence on PE learning, however, it has been difficult to disentangle the effect of peer observation from that of peer feedback, because both observation and feedback occur simultaneously when students learn together in a naturalistic setting. This article reports on a study aimed at clarifying the specific influence of peer feedback on the acquisition of PE skills in a natural small group learning setting.

Mastering the PE requires medical students to learn and integrate several psychomotor skills. There is some evidence that observing peers may facilitate acquisition of these skills. Ste-Marie et al.[5] reviewed the literature on model observation using the lens of social-learning theory[6] to explore how observation improves the acquisition of motor skills and subsequent sport performance. Peer observation helps because it allows the learner to build up a model that acts as an intermediary blueprint against which the learner can compare his or her own performance, making it easier to detect and correct mistakes.[7,8] For PE skill acquisition, in a natural-learning environment, Martineau et al.[3] showed that second-year medical students who had the opportunity to observe peers while learning an integrated PE performed better than students who did not have this opportunity. A second study by the same team showed that the effect of observation was enhanced when students observed a peer who performed well compared to observing a weaker performance while learning the NLE for low-back pain.[4] Nevertheless, it was difficult to isolate the effect of peer observation in the aforementioned studies from other potentially confounding factors, one of which is feedback.

Van de Ridder et al.[9] defined feedback in clinical education as “specific information about the comparison between a trainee’s observed performance and a standard, given with the intent to improve the trainee’s performance.” This implies that learners receive information from a teacher or from another learner on achieving task goals. Key feedback elements are comments on their actual task performance as well as suggestions on the next steps to be taken in order to raise their level of performance. When learning PE skills in groups, both feedback (from teachers and peers) and the observation of others are part of the learning process. It may be difficult in these contexts to isolate the specific effects of feedback on learning from those of observation.

Hattie and Timperly[10] found that feedback had an effect size on achievement of 0.79 compared to the average effect of all instruction that contribute to schooling, which was 0.40. Feedback is expected to facilitate learning by increasing learners' awareness of the gaps between their current level of performance and the desired one. This effect seems to depend on the type of feedback provided. Feedback providing information about the task and about how to better execute the task tends to have a more positive effect on learning than feedback based on rewards, praise, or punishment.[10]

However, Kluger and DeNisi,[11] and Kluger and Van Dijk[12] found that providing feedback does not always have the intended positive effect, because it can threaten the learner depending on how it is given. They concluded that a more systematic approach to giving feedback could enhance learning and skill performance while protecting the learner's self-esteem. Their findings echoed those of various authors who developed a more structured form of feedback consisting of an intermediate check of performance against expected performance criteria, accompanied by feedback on observed strengths and weaknesses as well as tips for performance improvement.[11, 13-15]

Peer feedback; however, tends to occur in a less formal fashion. Topping[16] suggested that peer feedback could be seen as a formative assessment that supplements the more formal feedback of teachers. It can also be seen as an arrangement structured by a teacher or initiated by learners in order to increase performance.

One of these arrangements is peer-assisted learning (PAL) (i.e., learning support provided to junior students by senior students). While PAL studies have demonstrated that students appreciate feedback from more advanced peers,[17-19] the influence of such feedback on skill acquisition has not yet been investigated.

The influence of peer feedback on future performance has been shown in the area of writing skills, as evidenced by higher performance subsequent to receiving comments from a student of the same level.[20] In a meta-analysis of 123 studies on effective instructions for improving writing skills, Graham and Perin[21] found an effect size of 0.75 for peer assistance. Does peer feedback have the positive impact on medical students? And would PE skills acquisition be influenced by peer feedback?

Norcini[22] is sceptical, because he assumes that peer judgments may suffer from low reliability and validity, which makes them of limited use in fostering learning. Most studies in the medical field have explored the ability of students to accurately assess peer performance, rather than focusing on the effects of peer feedback on student performance. These studies have investigated the reliability and validity of student assessments compared to a gold standard, which is the assessment conducted by teachers.[23, 24] The results of these studies carried out in various medical specialties are variable. For example, in studies on psychomotor skills with advanced medical students, 1st-year postgraduate medical residents (PGY1) overrated their peers' performance in comparison to their teachers' marks[25]. Obstetrics and gynaecology residents underrated it,[26] whereas the rating was similar to that of experts for general-surgery residents.[27] These studies, however, do not provide evidence of the effects of peer feedback on the performance of learners.

Another potential shortcoming for any real impact of peer feedback on performance is the fact that peer feedback is not considered as valuable as feedback provided by teachers, who represent the more knowledgeable source.[28,29] On the other hand, despite students' tendency to prefer teachers' comments, peer feedback has been suggested as potentially more effective, because it brings uncertainty, which might encourage reflection of students on their own performance, as demonstrated by Yang, Badger, and Yu[30] while studying the process of writing essays by students. In their study, students had to analyze the value of comments received by a peer before integrating them into their essays. No correlation was found between receptiveness to a specific feedback provider and performance improvement in an academic writing revision task, suggesting that how students view their peers' comments apparently does not affect what they can gain from them.[29]

To summarise, there is some evidence that feedback provided by peers improves performance skills, at least in the area of writing.[30] In medicine, however, the effect of peer feedback on the acquisition of psychomotor skills necessary for PE remains to be demonstrated.

The purpose of the present study was to investigate the effect of peer feedback on the acquisition of psychomotor skills required to perform a PE in a natural learning setting. We define here peer feedback as any information on the quality of performance provided by peers during the learning activity. It was expected that students who learned in an environment that allowed peer feedback would perform significantly better after the learning activity than students who did not receive peer feedback. A secondary objective was to determine if medical students prefer a specific type of feedback provider and, if so, to assess any related impact on the performance of PE skills.

Methods

Participants

The participants were 143 second-year students taking part in a mandatory learning activity to which this study was linked. Ethics approval was obtained at the university where the study was conducted. All participants had to complete a written consent form before taking part in the activity. Out of the original cohort of 143 students, we excluded four who declined to have their data included in the research; two students, who did not show up for the activity; and ten others who participated in dyads due to organizational issues and were not exposed to same peer feedback timeframe.

After initial data analyses, 12 participants were excluded due to missing data (performance was not recorded or information on the number of students in the group was unknown), and three others were excluded because they were extreme outliers. The final analyses were conducted using data from 112 participants.

Setting

The study took place in an undergraduate medical curriculum, which has a four-year problem-based-learning (PBL) curriculum that includes an 18-month clerkship. Clinical-skills training is part of a series of activities within integrated organ-system modules at three different levels: a clinical-skills session during PBL units, a transdisciplinary activity in which students integrate clinical skills related to different organ-based systems previously studied, and several PE practice sessions.[31]

Materials and procedures

Learning task

The study occurred during a learning activity aimed at integrating the neurological PE (taught during the neurology unit) and the lumbar-region PE (taught during the locomotor unit). Students were expected to appropriately integrate the two parts in order to perform the physical examination of a patient presenting with low-back pain. The low-back-pain PE includes the following steps: observation of the patient walking, evaluation of movement amplitude, search for neurological signs, performance of specific manoeuvers to elicit nerve irritation, evaluation of hip and sacroiliac joints and palpation of the lumbar region.

At the end of the learning activity, the students had to master the sequence of the exam, the position to be taken relative to the patient, the handling of the limbs during the sequence, the precision and the force of their palpation, and the signs to be looked for throughout the PE. Once PE skills have been mastered, students are expected to be able to complete the neurolocomotor exam (NLE) in five minutes.

Procedure

The students were randomly divided into groups of three, and each group was randomly assigned to one of two experimental conditions: peer feedback or no peer feedback. Separate sessions were conducted for each group. Prior to the learning activity, participants answered questions on their preparation for the activity and provided a self-assessment of their ability to perform a NLE. They also answered questions on their preference regarding the type of feedback provider. As five participants did not complete the survey, the analysis of these questions was conducted with data from 107 participants instead of 112.

The learning-activity session lasted for 1.5 hours for each group of three students. It started with an introduction that consisted of watching a video of a teacher performing each step of the NLE. Procedural guidelines were posted on the wall so students could refer to them during the practice phase. After the video, a practice period took place. The first student practised the NLE sequence individually on a standardized-patient instructor (PI) for 15 minutes, while being observed by the other two students in the group. The second and third students then completed the same sequence individually.

Students who had been assigned to the peer-feedback experimental group were instructed to provide feedback whenever they wanted during the session. PIs were instructed to prompt the students to give feedback at three specific times during the session. In the no-peer-feedback groups, students who observed were asked to remain silent and to simply observe the student who was practising. All the students, independent of the group they were in, received immediate feedback from the PI. Prior to the activity, all four PIs who participated in the study had received extensive training by the principal investigator (BM) on the specific sequences for which they would be providing feedback.

During the assessment phase, each student, in turn, performed the complete NLE sequence alone with the PI. They were allowed five minutes to complete the task. The order of evaluation was the same as the order in which they practised. While one student performed the complete sequence alone with the PI, the two other students went into separate rooms to wait their turn. Each student's performance was videotaped for subsequent assessment.

Initial survey

The students were asked to respond to an initial series of seven questions in order to allow for group comparison on (1) the extent to which they had worked with the NLE prior to the study (one question), (2) how much time they had practised or had read about the NLE during the previous week (on a four-point scale: less than 30 minutes, 30 minutes to 1 hour, 1 hour to 2 hours, more than 2 hours) (two questions), (3) their self-assessment of their ability to perform an NLE (using a 10-point Likert scale), and (4) their interest in feedback from peers and the PI (four-point Likert scale: totally agree to totally disagree) (two questions). One participant did not answer the questions on his preference for feedback provider and five did not complete the entire questionnaire.

NLE performance checklist

We opted for a checklist approach instead of global assessment because it corresponds to the motor skills to be learned by students, allowing for more standardized feedback from the PI. It also makes it possible to specifically identify the skills mastered by the students.

Student NLE performance was assessed with a 94-item checklist validated in a previous study.[4] The reliability was good with a Cronbach's alpha of 0.90. In this study, for standardization purposes, two PIs independently rated a sample of seven video-recorded performances, while one PI continued assessing the remaining videos.

For this study, student performance was assessed by a research assistant trained to use the checklist under the supervision of the principal author (BM). Since the patient had to be in the prone position during part of the lumbar exam and since the video could not capture the manoeuvres well enough for the research assistant to assess this part, the PIs assessed nine items on the checklist corresponding to the gesture precision.

Data analysis

To evaluate the comparability of the two experimental groups, the difference in time spent reading or practising the NLE prior to the study was assessed with Pearson's chi-square test. We used a t-test to measure the group-wise difference of students being able to assess their own ability to perform the NLE.

Regarding our main objective, a total score was computed for all students to measure performance on the NLE exam. It was obtained by adding all the checklist items; the sum was converted into a percentage score. A t-test was performed to check for differences in performance between students in the peer-feedback group and students in the no-peer-feedback group. The data was analyzed with PASW Statistics 18 (SPSS 2009), and the significance level was set at $p < .05$ for all comparisons.

To analyse the level of interest in feedback provider, we computed an interest-in-peer-feedback score and an interest-in-patient-instructor-feedback score by adding, respectively, the scores of both questions related to peer feedback and the scores of both questions related to patient-instructor feedback. We performed a repeated-measures ANOVA on these two scores to assess whether the groups were different in their preference and whether, within a group, there were differences between preference for peer feedback or patient-instructor feedback.

Results

Group characteristics

Table 1 presents, on a per-group basis, the students' mean reported preparation for the NLE activity and self-assessment of their ability to perform the NLE. Both groups had previously invested an equal number of hours in practising ($\chi^2(2) = 1.51$, $p = .471$) and reading about the NLE ($\chi^2(2) = 0.094$, $p = .954$) in the previous week. Participants from both groups self-assessed their ability to do the NLE similarly ($t(105) = -.108$, $p = .914$).

Table 1. Characteristics of experimental groups. Distribution of students (in percentage) per amount of time spent in practising and reading about the NLE in the preceding week as a function of experimental condition and level of self-assessment prior to the learning activity (out of 20)

Experimental group	Time spent the preceding week	Practice (%)	Reading (%)	Self-assessment	
				Mean	SD
No-peer-feedback group N = 61	Less than 30 minutes	83.6	67.2	13.33	3.06
	30 to 60 minutes	13.1	27.9		
	1 to 2 hours	3.3	4.9		
	More than 2 hours	0	0		
Peer-feedback group N = 46	Less than 30 minutes	86.7	65.2	13.39	2.96
	30 to 60 minutes	13.3	30.4		
	1 to 2 hours	0	4.3		
	More than 2 hours	0	0		

Note. Data are missing for five of the participants (questionnaires were not filled out).

Mean NLE performance scores for participants

Table 2 provides the mean total NLE performance scores obtained by the students in the peer-feedback and the no-peer-feedback groups. A t-test revealed that performance differed significantly between the two groups—$t(110) = -2.307$, $p = .023$, r = 0.21—although the effect size was small.

Table 2. Participants mean NLE performance scores. Mean scores (%) and standard deviation for each experimental group

Experimental group	N	Mean	SD	P-value
No-peer-feedback group	62	87.89	7.41	$p = .023$
Peer-feedback group	50	90.76	5.31	

Level of interest in feedback provider

Table 3 presents the participants' mean interest-in-peer-feedback score and interest-in-patient-instructor feedback for both groups. There was no significant main effect of experimental condition (i.e. peer-feedback vs non-peer feedback group) on the students' interest, F (1, 104) = 0.380, p = .539. There was, however, a significant main effect of the type of provider on feedback interest (interest-in-peer feedback vs. interest-in-patient-instructor feedback); students were more interested in PI feedback than in peer feedback: $F(1, 104) = 148.24$, $p < .001$, =. 588. The interaction effect was not significant: $F(1, 104) = 0.528$, $p = .360$.

Table 3. Level of interest in feedback providers. Mean score as a function of experimental condition

Experimental group	N	Interest in PI feedback	Interest in peer feedback	P-value
No-peer-feedback group	60	7.60 (0.49)	6.37 (0.96)	p = .539
Peer-feedback group	46	7.78 (0.42)	6.35 (1.37)	
P-value		p < .001		

Note. Data are missing for six of the participants (questions were not filled out).

Conclusion

Martineau et al.[3] and St-Onge et al.[4] have demonstrated that having the opportunity to observe peers while learning PE skills fosters the acquisition of the psychomotor skills required to perform the PE. These studies could not, however, separate the effects of peer observation from those of feedback. This study investigated the specific influence of peer feedback that often occurs simultaneously with peer observation on the acquisition of the psychomotor skills required to perform an NLE.

We hypothesized that students who learn in an environment that allows for and elicits peer feedback would perform the NLE significantly better than students who did not receive peer feedback through having the opportunity to observe their peers. The findings of the present study confirmed this hypothesis. The participants in the peer-feedback group performed better than the participants who did not have the opportunity to receive peer feedback, although both groups considered PI feedback more useful. Moreover, consonant with the literature, we expected students to be more receptive to teacher feedback than peer feedback.

There is an internal process that occurs subsequent to observation and comments from peers that can explain the impact of peer feedback on the acquisition of PE skills.[6] In this case, peer feedback targeting the correctness of a manoeuvre or offering suggestions on the next step seem to affect the learner's internal process. The student receiving the feedback must consider and evaluate this information in terms of accuracy and helpfulness, while integrating the result of these considerations into his or her existing level of experience and understanding.

A similar modelling process is also described in the literature regarding the impact of feedback on learning.[10, 16] The authors of these studies suggest that learners have to integrate the comments made by teachers or their peers about gaps in performance in order to improve their performance. Thus, they can accept that there is a difference between their performance and the desired level of performance or reject the comments or modulate them in order to achieve an enhanced level of performance.

We did note that the effect size was small. One explanation for this can be the influence of peer observation. Bandura[6] suggests that peer observation is an important source of information for learners. From his perspective and that of other authors, peer observation helps in the acquisition of skills because the peer model is used as a blueprint to enhance performance.[7, 8] This blueprint acts as an intermediary model that mirrors the individual's ability in a way that enables the individual to better compare performance. This study afforded both groups the same opportunity to observe their peers, so peer observation cannot explain the difference between the groups.

The higher interest of students for PI feedback may counteract the effect of peer feedback and is another explanation for the small effect size. However, as with peer observation, the difference in interest towards the feedback provider was similar in both groups, so it cannot explain the difference between the groups.

Moreover, Bandura[6] views comments made by peers as exerting a social pressure that modulates the learner's internal process. This type of feedback—verbal or non-verbal—can have a positive or a negative effect, particularly on motivation. This study did not examine the effect of verbal vs. non-verbal feedback. If the non-verbal feedback was perceived positively in the no-feedback group, that could be another explanation for the small effect size of the influence of peer feedback in our study.

The small effect size may also result from the relatively small intervention, that is, peer versus no peer feedback. For all participants, the learning activity included many strategies known to be appropriate for learning psychomotor skills and, consequently, to enhance PE performance: video demonstration of the skills by an expert[5, 32] the possibility of practising the skills, PI feedback, and the opportunity to observe peers performing the skills.[3, 4] The only difference between our two experimental conditions was the presence/absence of peer feedback. Peer feedback was, therefore, added to all other strategies known to enhance PE performance, which could explain its small effect on learning.

A last possible explanation for the small effect size may be that students were not entirely novices. The learning task was to integrate the neurological and the locomotor parts of the examination previously learned. Greater differences between groups could have been found if the students had been at the beginning of their learning for NLE performance.

Because our study took place in the natural classroom setting rather than in a laboratory, there were some limitations in controlling all the variables. One limitation is that we did not have complete control over the level of feedback provided by PIs. This implies that the amount and the quality of PI feedback may have varied across the groups. Furthermore, we did not have strict control over student adherence to the research protocol and instructions that specified that participants in the no-peer-feedback group should remain silent when observing their peers.

A possible drawback of the study was the use of a detailed grid instead of global ratings to assess the students' performance. Our choice was motivated by the fact that detailed assessment of performance allows for better identification of the different psychomotor-skill components in the NLE. The checklist therefore corresponds to the feedback provided by PIs during the learning phase. Furthermore, this checklist was used and validated in a previous study.[4] While we could find differences between students, the global ratings had a different purpose. They have been used to reliably assess complex competences in surgery[33] with a view towards better discriminating between different levels of expertise.[34]

To better understand the effects of peer feedback, future studies should consider investigating the quality and the quantity of peer feedback required to make a difference while learning PE skills. Many factors related to the feedback provided by peers, such as the type of peer feedback, the content addressed, the level of interest, and the accuracy of comments made by peers, have to be assessed. Such studies would contribute to a better understanding of the role of peer feedback in the acquisition of the psychomotor skills necessary for performing an adequate PE.

This study, conducted in a naturalistic environment, demonstrated the positive effect of peer feedback on learning skills required to perform an NLE and its potential role in helping medical students improve their PE performance. Peer feedback seems to complement other learning strategies such as video demonstrations by experts, PI feedback, and peer observation in supporting students while they learn the correct procedures for performing a PE. As group activities for PE learning are used in many medical-school curricula, instructions such as telling students to provide feedback to their peers might help students better acquire the motor skills necessary for the PE. For these reasons, peer feedback should be encouraged during PE learning sessions.

Practice points

- Peer observation and peer feedback contribute to the development of the psychomotor skills necessary for performing a physical examination.

- Medical-school curricula that use group activities in teaching physical-examination skills should consider including instructing students to provide feedback to their peers for the purpose of bettering performance.

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Chapter 5

Characteristics of peer feedback influencing learning of physical examination psychomotor skills

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Abstract

Background: When learning the psychomotor skills for the physical examination in small groups, students have the opportunity of observing and receiving feedback from their peers. Both peer observation and peer feedback are beneficial for learning. Studies have demonstrated that peer feedback has a small effect on students' performance. The purpose of this study is to investigate the influence of quantity and quality of peer feedback on student performance. More specifically, we studied whether the amount of peer feedback received, feedback seeking, and the accuracy and specificity of feedback fostered learning.

Methods: One hundred and eight second-year medical students participated in a regular activity for learning the neurolocomotor physical examination for low-back pain in triads. They observed and practiced the skills besides giving feedback to their peers. Subsequently, they performed the physical examination individually. The learning session and the students' performance were videotaped and assessed later by using a validated checklist. Correlation coefficients were computed to investigate the relationship between the quantity of peer feedback as well as qualitative characteristics such as feedback specificity, accuracy, and feedback seeking, and the students' PE performance.

Results: The average number of peer feedback utterances received by students was 17.8 (SD = 12.6). No significant correlations were found between physical examination performance and the quantity of peer feedback received (r = -0.17; p = 0.07), peer feedback specificity (r = -0.14, p = 0.14) and peer feedback accuracy (r = -0.14, p = 0.14). When feedback that was or not solicited by the student was distinguished, there was a significant, but small, negative correlation (r = -0.21, p = .033) between the amount of peer feedback and students' performance.

Conclusions: Contrary to suggestions in the literature, our study does not demonstrate an impact of quantity, specificity, and accuracy of peer feedback on performance. Only feedback seeking correlated with PE performance, but negatively. A possible explanation is that complex and partly poorly understood interactions of various factors can account for the peer-feedback effect demonstrated in an earlier study. Future studies are needed for a better understanding of peer-feedback efficiency in small-group learning.

Introduction

Gaining expertise in physical examination (PE) requires the acquisition of psychomotor skills.[1] Small-group learning of these skills is an educational strategy that uses the interaction between students to enhance their acquisition and retention.[2] In medical education, small-group activity is the training method of choice for PE learning.[3] In an education setting in which students practice, observe, and talk, the influence of peers on PE performance is suggested to take place via peer observation[4, 5] and peer-feedback.[6] Disentangling their respective contributions is difficult, because peer observation and peer feedback occur simultaneously. Moreover, studies on peer feedback conducted until now do not explain which characteristics of peer feedback influence the performance of students who are learning the PE in small groups. The purpose of the present study was to investigate how peer-feedback characteristics—quantity, specificity, accuracy, and feedback-seeking behaviours—influence the acquisition of the motor skills medical students need to perform a PE.

Van de Ridder et al.[7] defined feedback as "specific information about the comparison between a trainee's observed performance and a standard, given with the intent to improve the trainee's performance" (p. 193). In the context of motor-skill acquisition, feedback—whether given by a teacher or a peer—provides information aimed at reducing the gap between the learner's performance and the skill demonstrated ideally beforehand.

Peer feedback is common in small-group learning and could be seen as a kind of formative assessment that complements the feedback given by teachers.[8] The effectiveness of peer feedback has been demonstrated in the area of writing skills,[9] and PE-skill acquisition.[6] In the latter study, conducted in a natural learning environment, Martineau et al. randomly allocated groups learning the PE for low-back pain to two experimental conditions. The students in the experimental group gave feedback to their peers during practice, as usual, whereas those in the control group were not allowed to provide any feedback to their peers. The difference in performance between the two groups was statistically significant ($p = .023$), in favour of the experimental group. The effect size was small ($r = 0.21$). Despite the fact that an effect of peer feedback was demonstrated, it remains to be seen which characteristics of peer feedback influence the acquisition of psychomotor skills.

Although only few experiments specifically studied the effect of particular characteristics of peer feedback on performance, the general feedback literature is vast. In addition, many general feedback characteristics enhancing performance seem to be relevant for peer feedback as well. Thurlings[10] et al. conducted a literature review of studies published between 2000 and 2012 dealing with how feedback characteristics affect teacher learning. They found 40 variables that had been tested in 61 experimental studies. Thurlings[10] et al. concluded that, to be effective, feedback should be task- or goal-oriented, specific, clear, and bias free. It should be given frequently, be constructive, and support learning. When focused on errors, feedback should be elaborate, encouraging the learner to actively engage to fill the gap between actual performance and the desired outcome.

In their study on peer-feedback efficiency in the area of writing skills, Gielen et al.[9] demonstrated some characteristics of peer feedback that ensure better learner performance. For them, feedback should be given frequently, should be specific and clear, be accurate, and should include justifications to improve writing skills, as was demonstrated in a study on secondary education. In the case of high-school students, interventions for enhancing reflection on feedback by peers did not increase learning. However, in a study on the quality of feedback reports to general practitioners, Prins, Sluijsmans, and Kirschner[11] noted a preference among these general practitioners for reflective remarks from the feedback provider, thereby suggesting that the learner actively seeking feedback may be important. This aspect of feedback—active search for feedback—was studied in organisational psychology,[12, 13] but has just started to be discussed in medical education.[14]

Closer to the learning of psychomotor skills in medical education, Wulf[1] et al. reviewed four factors that have been demonstrated to improve motor-skill performance: the observation of others combined with practice, the focus of attention, self-regulated practice, and feedback. In their article, they highlight particularly the informational function of feedback.

In the light of this literature, some peer-feedback characteristics appear to be specifically worthy of investigation. These are the amount, specificity, and accuracy of feedback as well as the extent to which the student actively seeks feedback. Again, most experiments that tested the impact of these characteristics focused on feedback in general. It is reasonable to expect, however, that similar results apply for the effects of peer feedback . In the next paragraphs, we will explore each of the characteristics of interest more extensively.

Does the amount of peer feedback influence motor-skill performance?

Concerning the amount of peer feedback necessary to improve psychomotor skills, a controversy has arisen that has not been completely resolved by past studies. Contrary to the initial belief that increased feedback enhances motor-skill acquisition,[15] many studies have demonstrated a degrading effect of frequent feedback, at least for learning of simple motor tasks.[16-18] The so-called “guidance hypothesis”[19] explained this dilemma by presuming that frequent feedback reduced the student’s need to appeal to memory, because information was provided through feedback. In an experiment on using a ski simulator to learn slalom techniques, Wulf, Shea, and Matschiner[20] demonstrated that frequent feedback was initially useful for learning complex motor skills, until the participants had acquired a certain degree of expertise. They hypothesised that error detection and correction mechanisms cannot work in the absence of feedback until self-reflection has developed.[16]

One experiment in the field of medical education demonstrated similar results: increased feedback by expert is more beneficial for learning psychomotor skills when a learner begins the training.[21] This study on the acquisition of laparoscopic suturing skills provides—despite methodological shortcomings—a basis for hypothesising about the impact of more feedback on motor-skill performance. O'Connor et al.[21] attempted to determine the amount of feedback necessary to achieve and maintain a performance plateau in laparoscopic suturing. After a session consisting of a video demonstration and instructions on basic laparoscopy, nine medical students were randomly allocated to one of three experimental groups for a training period under different feedback conditions.. During the extensive training period (one hour each day, six days a week for four weeks), the first group received no feedback, the second one got feedback alone and the third one received feedback and written instructions on the laparoscopic suturing procedure. With the help of an optical tracking system, the authors evaluated the time required for each knot, its path length and smoothness. The second and the third groups, which received feedback, performed significantly better than the no-feedback group for all the studied parameters. This was only observed, however at the beginning of the training, for the first eight to fifteen knots. Adding written instructions to feedback did not help, as there were no significant differences between the second and the third groups.

Given the small number of participants and its specific settings, the results cannot be generalised to peer feedback or to other types of training. Both laparoscopic suturing and the PE are complex activities for novice medical students. Considering the variety and quantity of different skills to be learned in PE, we could presume that a greater amount of feedback is more likely to enhance motor skills performance when learners are novices. In light of empirical evidence on the amount of feedback, we could presume that students who receive more feedback will learn faster, at least at the beginning, until they reach a minimal level of expertise[16] or a plateau.[21] However, there is a possibility that too much peer feedback may have a counterproductive effect on performance if the task is not sufficiently complex or if students have a more advanced level of expertise.[16]

Does specificity of peer feedback influence motor-skill performance?

The second characteristic identified in literature reviews conducted by Thurlings et al.[10] and Shute[22] is the specificity of feedback. To have an impact on performance, the feedback provider must give specific information on the task with concrete indications on how to improve to reduce the gap between the learner's performance and the expected outcome. Where psychomotor-skill is concerned, no studies clearly link the specificity of feedback to performance. In a field outside of motor-skill research, Phye and Sanders[23] tested the efficiency of specific feedback versus general feedback in research using verbal analogy for a problem-solving task. Seventy-five psychology students were divided into two groups: one receiving specific feedback; the other general advice. Phye and Sanders found that specific feedback was clearly superior to general advice. In the previously mentioned study on writing skills, Gielen et al.[9] concluded that peer feedback has to be specific and clear to be effective.

There is, however, some research that apparently contradicts these claims in favour of the importance of feedback specificity. Strijbos, Narciss and Dunnebier[24] conducted a study to determine the impact of various peer-feedback content on performance in an academic writing revision task. The results of this study were contradictory. Participants had to revise a text containing various errors. Eighty-nine graduate teacher trainees were assigned to one of five groups. The first group received general written feedback from a high-competent peer. The second group received general written feedback from a low-competent peer. The third group received elaborated specific written feedback from a high-competent peer. The fourth group received elaborated specific written feedback from a low-competent peer. Finally, the last group was the control group, receiving no feedback. Surprisingly, the authors found that the groups receiving general feedback outperformed those receiving elaborated specific feedback during the training. The authors accounted for these contradictory results by citing some methodological shortcomings. Their elaborated feedback condition focused on surface elements of the text to be improved. Moreover, peer feedback was provided in a written form, which they considered artificial, because it excluded informal exchanges between students that are frequent during training.

We found no studies on the influence of specificity of peer feedback on PE and need then to build upon the aforementioned research in other domains. Except for the study by Strijbos et al.,[24] specific feedback seems to be more effective than general or nonspecific feedback, probably because it helps learners focus their attention on the aspects of the task that need improvement. For this reason, specific peer feedback could be expected to have a positive influence on the acquisition of PE psychomotor skills.

Does accuracy of peer feedback influence motor-skill performance?

Accuracy of feedback is the third characteristic of interest. According to Bandura,[25] the comments made by any feedback provider should be as accurate as possible to fill the performance gap, so that feedback complements the observations by the learner him- or herself. Literature reviews have reported accurate feedback to be superior to inaccurate feedback for enhancing performance.[10, 26, 27] It implies that the feedback provider should be a teacher—because he or she is the content expert—in order to maximize the impact of feedback on learner performance. Peers, on the other hand, are not experts. Peer feedback—feedback provided by novices—should be viewed as collaborative learning[7] or as formative assessment,[8] because the accuracy of peer feedback varies necessarily. Gielen et al.[9] defined accuracy of peer feedback in terms of consistency in judgements across peers or concordance of peer feedback with teacher feedback. Gielen et al. tested the hypothesis that the accuracy of comments made by peers would improve the performance of writing skills in high-school students. They found a large variation in the accuracy of peer comments, ranging from totally inaccurate to fully accurate comments. Comments accompanied by a justification positively affected students writing performance, particularly for the peers who had lower pre-test scores. Explanation of peer comments had a stronger influence on students' improvements than the accuracy of these comments. One explanation is that students assess the relevance and accuracy of comments made by their peers before integrating them into their performance and correcting their errors, since peers are not seen as a knowledge authority and reliable source of information, as explained by Yang et al.[28] (who also demonstrated that peer feedback is superior over teacher feedback, despite students' preference for the latter). As learners tend to first evaluate the suggestions put forward by their peers before accepting them, inaccurate feedback may be, therefore, as effective as accurate feedback in leading students to reflection. It could even be argued that wrong suggestions are more conducive to opening a dialogue between learners, which could eventually increase the chance that errors will be corrected and new behaviours will be better integrated. For this reason, we hypothesize that the accuracy of peer feedback would not influence student performance.

Does actively seeking feedback influence motor-skill performance?

The fourth characteristic of interest is actively seeking feedback during the PE learning session. Medical students frequently ask: "How I am doing?" It implies that the learners are actively looking for feedback in order to gauge and adjust their performance. In organisational psychology, feedback seeking has been demonstrated to be a positive characteristic because it ads a resource that the individual can use for learning and development.[12, 13] This has also been found to hold true in medical education.[29-30] Crommelink and Anseel[14] conducted a literature review (principally outside of medical education) to understand feedback-seeking behaviour. They viewed feedback-seeking behaviour as a useful strategy to help learners adapt to their learning environment, depending on individual and contextual mediating factors, such as the preservation of learner's self-image, the learner's interest in the task, and the quality of the interaction between peers or with supervisors. Bok et al.[29] conducted semi-structured interviews with clerks and found that the frequency of feedback seeking during clerkship depends on the potential risks and benefits anticipated by the learner in a context of assessment.

Their results confirmed results found by Teunissen et al.[30] in a previous survey of 166 obstetrics–gynaecology residents. Teunissen et al. concluded that feedback-seeking behaviour depends on the supervisory style of supervisors, influencing learner perceptions of the benefits of seeking feedback as opposed to its eventual possible costs.

Past studies in medical settings revealed that feedback was sought from supervisors, who are authority figures, not from peers. To the best of our knowledge, only one study has attempted to measure the impact of peer-feedback seeking on learner performance. Hwang and Francesco[31] conducted a study with eight undergraduate groups of business-administration students to determine if there was a relationship between different types of feedback seeking and learning performance. The study showed that the students used peers as feedback sources outside of class. The researchers found however no correlation between peer feedback seeking and exam performance. However, one could argue that the feedback sought by a learner is more likely to be integrated in their repertoire by students actively striving to reduce the gap between performance and the desired outcome. In addition, feedback seeking could allow better error detection and correction of poor motor-skill movement. Since, to our knowledge, no real experiment was conducted to test this hypothesis, we decided to do just that.

Hypotheses

Learning psychomotor skills, like such as for the PE, in a small-group setting, provides an opportunity for students to observe their peers and receive feedback. This study concentrated on peer-feedback characteristics that enhance PE performance. Based on our review of the literature, we hypothesised (1) that the *amount* of peer feedback received in a small group would influence student performance of the task set; (2) that the same would apply to the *specificity* of peer feedback; (3) that *actively seeking peer feedback* would also positively affect student performance; and (4) that the *accuracy* of peer feedback would *not* influence student performance.

To test these hypotheses, we conducted a study with second-year medical students, who have to participate in a regular group session to learn the neurolocomotor examination (NLE) for low-back pain. Before the session, the students watched a video displaying an expert demonstrating the examination. After that, they practiced the NLE with a PI in triads and, finally, they performed the NLE individually for assessment purposes. During the training session, the students had to fill out questionnaires where they had to indicate their preference for a feedback provider (patient instructor (PI) or peer), state their self-assessment and self-confidence about efficiently performing the NLE, and their perceived usefulness of peer and PI feedback. The questionnaires were filled at three moments, one before the training sessions with the PI, the second one after that session, and the last one after the execution of individual PE performance. We videotaped each group during the learning session and each individual performance at the end of the session. We recorded each peer feedback comment during the learning session and categorized each one according to the peer-feedback characteristics outlined above. Subsequently, we correlated them with individual PE performance, evaluated by using a grid validated in past research.[5,6] The analyses would provide insight into the impact of the amount of peer feedback and the characteristics of peer feedback—accuracy, specificity, and feedback seeking—on student performance of the particular psychomotor skills.

Methods

Participants

One hundred and forty-nine second-year medical students participated in this mandatory learning activity. Before the activity, students were randomly assigned to groups of three. To ensure uniformity among groups, we excluded seven dyads (which had to be composed due to operational issues) because they did not have the same exposure to peer feedback (the students saw only one performance, received feedback from a single peer, and the activity took less time) as the triads. We also excluded eight students who practiced twice during the session and therefore received more feedback than the other students. Finally, we excluded 19 students due to technical problems (the video recording did not work, the camera angle was wrong, or the performance at the end could not be analysed). We ended up with 36 groups of three students, a total of 108 participants.

Setting

The experiment was conducted during a regular curricular small-group PE learning activity taken by all second-year students in the MD program at the University of Sherbrooke, Canada. This MD program has a four-year, problem-based-learning (PBL) curriculum that includes an 18-month clerkship. Clinical skills are taught in a series of activities in the context of organ-based modules that aim at preparing students for the clerkship, which begins in the middle of third year.[32]

Materials and procedures

Learning task

The goal of the training session where the study was conducted was to teach the students the psychomotor skills needed to perform an accurate physical examination for low-back pain. This neurolocomotor examination (NLE) integrates the musculoskeletal exam and the neurological exam of the lumbar region. The goal was to learn to perform the NLE accurately and at an appropriate pace. To achieve this efficiency, students must execute a sequence of manoeuvres one after the other, depending upon the patient's position (standing, sitting, supine, and prone).

Procedure

During the learning activity, which lasted an hour on average, students were scheduled to work in triads. A patient instructor (PI) taught the students in each small group the psychomotor skills specifically required to perform the NLE (patient positioning, execution of the movements, accuracy, what to look for). The session was organised such that each student would practice in turn with the PI, receiving feedback from both the PI and the other students. After practising, each student performed the NLE alone on the PI with a five-minute time limit (which was the outcome goal of this activity). The PI provided final comments to each student at the end of the session.

Four PIs were hired to train the students. Students scheduled at the same time (in parallel sessions) met together in one group. A PI explained the project to them. Students agreeing to take part in the project signed a consent form. After that, they completed the first questionnaire and watched a demonstration video of the complete NLE performed by an expert. Then, they went into their respective small groups of three students with one PI in a room set up like a physician's office with an examination table. Each student practiced the NLE separately with the PI, while the others watched. After each sequence, the PI asked the students to provide feedback to the one whose turn it was to perform. Afterwards, the PI gave final comments to the students.

After the practice session, the students filled out the second questionnaire. Then, in turn, the students performed the entire NLE (all sequences) alone with the PI, with the goal of finishing within five minutes. The PI started a timer and stopped the student when the five minutes were up. That student filled out the third questionnaire while waiting for the other two to perform the NLE alone with the PI. At the end, the three students met together with the PI for final feedback. We videotaped the practice session and the solo performance of each student at the end of the session. These video recordings were used as sources of data for analysis.

First questionnaire

Before starting the session the students were asked to fill the first questionnaire, which inquired about three issues. First, they informed how many times they had watched the NLE demonstration video before the session. Second, they indicated their interest in feedback from peers by responding to six questions, each one with a four-point Likert scale ranging from entirely disagree (score = 1) too entirely agree (score = 4). (The questions are reported in Table 1). Finally, they rated their ability to perform a NLE and their level of self-confidence in performing the NLE on a scale of 1 to 10.

Second questionnaire

The second questionnaire was filled out after the practice session. Students rated the usefulness of PI and peer feedback during the practice session on a ten-point Likert scale. Six questions (see Table 1) inquired about their satisfaction with the session (information organisation, whether the session helped them to improve their NLE skills and knowledge, whether the PI-to-student ratio was adequate, activity organisation, and whether the atmosphere supported learning). These questions employed a 5-point Likert scales ranging from entirely disagree to entirely agree. Additionally, students were asked again to self-assess their ability to perform the NLE and to rate their self-confidence in performing it on a scale of 1 to 10.

Third questionnaire

The students were asked to fill out this questionnaire after performing the complete NLE alone with the PI. The questionnaire first asked them once more to self-assess their ability to perform the NLE and to rate their self-confidence in performing the NLE, as required in the previous questionnaires. The subsequent seven questions inquired about the impact of peer and PI feedback on their performance, and the value of the feedback they received. The questions had to be answered by using a 5-point likert scale as in the previous questionnaires. (See Table 1 for the items). As nine students did not fill out one of the questionnaires, we excluded them from the questionnaire analysis, but not from the performance analysis.

Practice-session grid

For the purpose of this study, peer feedback was considered to be any verbal remark about NLE performance between students watching a peer practice. We restricted our study to verbal interaction, because completely tracking non-verbal communication was impossible. Two investigators, BM and CSO, developed the grid with the help of two other investigators, SM and HS, through an iterative process. We counted the occurrences of peer feedback that each student received. Each peer-feedback comment was classified as general or specific, accurate or inaccurate, solicited or unsolicited by the student.

To determine the grid's reliability, two research assistants used the grid to code three practice sessions. Divergences were discussed and the definition refined until we achieved an inter-rater reliability greater than .70. Subsequently, one research assistant coded the remaining practice sessions.

Two physicians, BM and AH, independently assessed the accuracy of each specific feedback instance in three practice sessions, resulting in an interrater reliability of 0.84; differences in coding were resolved through discussion. BM coded the remaining practices sessions.

NLE performance checklist

We used a 94-item checklist to assess students' performance when they conducted the NLE alone with the PI. This checklist was used in two other studies[6, 7] with high reliability (Cronbach's alpha of 0.90). The checklist was easy to use because it corresponded to the NLE sequences that students had to master. Under the supervision of the principal author (BM), a trained research assistant assessed the checklist for students' performance.

Data analysis

We used separate repeated measures ANOVA to check for differences in the students' self-assessment and self-confidence in performing the NLE before the activity, after practising, and after performing the complete NLE alone with the PI. Paired comparisons were used to interpret eventual differences.

We computed descriptive statistics for the following variables: how many times students had watched the video prior to the activity, how interested they were in feedback providers prior to the activity, how satisfied the students were with the activity, how useful the feedback provided by the PI and peers was in acquiring the skills needed to perform the NLE, and how the students judged PI and peer interventions during this activity.

To check whether the studied characteristics of feedback influence students' learning, we first counted the number of instances of peer feedback for each student and then coded these instances according to the characteristics of feedback selected to be studied (general or specific feedback and solicited or unsolicited feedback). If a piece of feedback was specific, we determined if it was accurate or not. (See description of the Practice-Session Grid in Materials). We computed correlations between the students' performance and the number of utterances of each type of feedback received to investigate whether these selected characteristics influenced student learning.

Finally, we analysed the students' performance, assessed by using the aforementioned checklist grid (see Materials) to score the NLE performance. Each grid item was assigned a score of zero or one (0 = item omitted or inadequately performed; 1 = adequately performed). The scores were summed and the total score expressed as a percentage of the maximum score. The data were analysed with SPSS 2009.[33] The significance level was set at $p < .05$ for all comparisons.

Results

Group characteristics

Students watched the NLE video between 0 and 4 times ($M = 1.90$, $SD = 1.0$) prior to the activity. The majority of students watched it twice. Table 1 provides the descriptive statistics for the other questionnaire items. The students' responses to the pre-activity questionnaire show that they appreciate the feedback from peers and the PI. Students consider both types of feedback relevant.

In the post-activity questionnaire, student responses revealed their perception that feedback from PI and peers helped them to learn the skills during the activity. Overall, the students appreciated the learning activity setting. The results of the post-assessment questionnaire indicated that the students were satisfied with the feedback received from peers and the PI, and that they found both types of feedback relevant and constructive.

Table 1. Mean scores on the three questionnaires*

	N	Mean	SD
Pre-practice questionnaire			
The best way to learn the NLE is to observe an expert.	103	2.81	0.79
Feedback from peers helps me improve my clinical skills.	103	3.06	0.56
Patient instructors do not have the competencies to help me learn the NLE.	103	1.25	0.50
Feedback is only relevant when it comes from an expert.	103	1.64	0.59
I appreciate learning activities in which I can observe my peers.	102	3.23	0.53
The patient instructor helped me acquire clinical skills through constructive feedback.	103	3.70	0.46
Post-practice questionnaire			
Please indicate, on a scale from 1 to 10, how useful the PI's feedback was during the activity.	106	9.28	0.81
Please indicate, on a scale from 1 to 10, how useful your peers' feedback was during the activity.	100	8.64	1.27
The information presented during the activity was well organized.	106	3.84	0.37
The learning activity helped me improve the clinical skills useful for performing the NLE.	106	3.86	0.35
The learning activity helped me improve the knowledge useful for performing the NLE with a patient.	106	3.75	0.46
The PI-to-student ratio was adequate.	106	3.96	0.19
This learning activity was well organized.	106	3.96	0.19
The teaching context was favourable for learning.	106	3.93	0.25
Post-evaluation questionnaire			
The PI had the appropriate knowledge to teach the NLE.	106	3.91	0.29
My colleagues were quite familiar with the NLE.	106	3.74	0.44
The PI was able to guide me in learning the NLE.	106	3.94	0.23
I often wondered if the comments made by my peer were right.	106	1.71	0.68
The PI gave constructive feedback.	106	3.85	0.36
The feedback from my peers was relevant.	106	3.61	0.55
The feedback from my peers helped me to perform the NLE better.	106	3.56	0.60

4 is the maximum score for the questions, except for 2 that have a maximum score of 10, on feedback usefulness according to providers.

Correlation of characteristics of peer feedback utterances and NLE performance

The mean total score of NLE performance was 77.3% with a standard deviation of 11.2%. Table 2 reports the mean number of peer feedback utterances of each category received by the students. Note that the standard deviations are large: some students received much feedback from their peers, while others received little. Peer's feedback was in most cases specific (86,3% of the total) and only 12.6% was inaccurate. So, the large majority of the peer feedback received (73,1% of the total) was specific and accurate. The majority of feedback was given spontaneously (71.4% of the total). The learners solicited only 28.6% of the peer feedback received.

Table 2. Mean number of peer feedback received by students in each feedback type

	Mean	SD
Number of feedback utterances	17.5	12.6
General feedback	2.3	2.2
Specific feedback	15.1	12.0
Inaccurate specific feedback	2.2	2.2
Accurate specific feedback	12.8	12.8
Unsolicited feedback	12.5	9.0
Solicited feedback	4.9	5.4

Table 3 shows the correlations between the several types of feedback and performance. A significant negative correlation was found between performance and solicited feedback. None of the other correlations reached statistical significance though a tendency toward a negative correlation between performance and the total amount of feedback received was observed.

Table 3. Correlations (Pearson coefficient) between NLE performance score and the number of utterances of types of peer feedback received

Peer feedback utterances	Correlation	*P*-value
Total feedback received	-0.17	0.07
General feedback	-0.11	0.26
Specific feedback	-0.14	0.14
Inaccurate specific feedback	-0.001	0.99
Accurate specific feedback	-0.14	0.14
Non-solicited feedback	-0.12	0.21
Solicited feedback	-0.21	0.03

Student self-assessment and self-confidence

We observed a progression in student self-confidence in their ability to performing the NLE throughout the training as well as in their self-assessment of their performance (see Table 4). The repeated measures ANOVA revealed a significant difference between the three measurements of performance self-confidence (V = 0.78[1], F [2, 98] = 142.88, $p < .001$, $\eta_p^2 = 0.75$). Pairwise post hoc comparisons revealed that the students' self-confidence significantly increased in the three moments of evaluation: before vs after the practice session (t[101] = 14.42, $p <$ 0.001), after the session vs after practice with the PI, (t[100] = 16.93, $p < 0.001$), before the session vs after practice with the PI, (t[103] = 8.23, $p < 0.001$). The same pattern emerged for the measures of self-assessment (V = 0.81, F [2, 98] = 243.87, $p < .001$, $\eta_p^2 = 0.71$). Students self-assessed their performance as significantly higher after than before the practice session, (t[101] = 16.83, $p < 0.001$), after practicing with the PI than after the session, (t[100] = 17.94, $p < 0.001$) and after than before the learning activity (t[103] = 6.01, $p < 0.001$).

[1] Mauchly's test indicated that the assumption of sphericity had been violated when analysing the self-confidence, X^2 (2) = 24.57, p < .001. Only 101 of the 108 students filled in the questionnaire in all three moments.

Table 4. Mean ratings of self-assessment of ability to and self-confidence in performing the NLE, before the activity, after practice, and at the end of the activity (range, 1 to 10; standard deviation into brackets)

	Self-assessment	Self-confidence
Before the activity	7.4 (0.9)	7.7 (1.0)
After the practice session	8.7 (0.7)	8.8 (0.7)
After performing the NLE alone with PI	9.1 (0.7)	9.4 (0.6)

The ratings of self-assessment of ability and confidence, however, were not related with NLE performance (see Table 5), except at the end of the learning activity, when the correlation between performance and self-assessment of ability was significant and the correlation between performance and self-confidence almost reached significance. We found no significant correlation at anytime of the activity between feedback seeking and self-assessment of ability or self-confidence in performance of the NLE, as reported in Table 6.

Table 5. Correlations (Pearson coefficient) between students' NLE performance and self-assessment of ability and self-confidence in performance

	Correlation	*P*-value
Self-assessment before the activity*	.01	.92
Self-assessment after the practice session	.01	.89
Self-assessment after performing the NLE alone with PI	.20	.04
Self-confidence before the activity*	-.05	.64
Self-confidence after the practice session	-.05	.64
Self-confidence after performing the NLE alone with PI	.19	.05

*103 participants complete the first questionnaire instead of 106 for the other two.

Table 6. Correlation (Pearson coefficient) between feedback seeking and self-assessment of ability to perform the NLE and self-confidence in performance

	Correlation	*P*-value
Self-assessment before the activity*	-.17	.09
Self-assessment after the practice session	-.02	.84
Self-assessment after performing the NLE alone with PI	-.04	.67
Self-confidence before the activity*	-.13	.19
Self-confidence after the practice session	-.09	.36
Self-confidence after performing the NLE alone with PI	.04	.67

*103 participants complete the first questionnaire instead of 106 for the other two.

Discussion

The objective of the present study was to identify peer feedback's characteristics that influence the positive effect of peer feedback on PE performance, which was demonstrated in a previous experiment.[6] We hypothesised (1) that the *amount* of peer feedback received in a small group would influence PE student performance; (2) that the same would apply to the *specificity* of peer feedback; (3) that *actively seeking peer feedback* would also positively affect student performance; and (4) that the *accuracy* of peer feedback would *not* influence student performance. To test these hypotheses, we conducted a study with second-year medical students, who have to learn the neurolocomotor examination (NLE) for low-back pain. For our experimentation, we videotaped the learning session and the individual performance of each participant. Subsequently, we computed the amount of peer feedback, the amount of accurate, specific and solicited peer feedback received during the learning session to check whether any of these variables were associated with increased psychomotor skills performance. Contrary to our expectations, neither the amount of peer feedback nor its specificity was associated with students' performance. The amount of feedback received gave us a surprising near negative tendency correlation, instead of a positive one. Moreover, feedback seeking was negatively correlated with performance. As hypothesized, the accuracy of peer feedback was not correlated with students' PE performance.

Our first hypothesis was that the amount of peer feedback would influence acquisition of PE psychomotor skills, with larger amount of peer feedback associated with higher performance, because the NLE would necessitate psychomotor skills that novice medical students would find complex.[20] The literature suggests that students need feedback to enhance error detection and become susceptible to correction mechanisms, especially if their degree of expertise is very low.[19] In our study, however, we failed to find that the amount of feedback was associated with the students' acquisition of psychomotor skills. A possible explanation is that the NLE was in fact simply not complex enough for second-year medical students or that they had sufficiently mastered the technique prior to the study. That could be illustrated by the high NLE performance scores achieved by the students in this experiment (77.3% with a standard deviation 11.2%). Indeed this high NLE mean performance score, with little variation, could explain the very low correlations with the amount of peer feedback and with the different types of feedback. The guidance hypothesis proposed by Salmoni, Schmidt, and Walter[19] could explain our finding of the negative tendency between the amount of feedback and performance. Instead of helping, frequent feedback may have reduced the learner's need to retrieve information on to-be-performed operations from memory, because they were provided by the feedback. This is only said to happen, however, when students have already reached some mastery of the to-be-learned skills. It may have been the case in our study. Prior to the study, our students had already been separately trained to perform the neurological and the locomotor physical examination. Therefore, in the learning activity employed for the present study, the students had only to integrate and refine the manoeuvres for the whole PE sequence. On the other hand, it can be argued that performing appropriate physical examination is never a simple task as indicated by the literature showing that clerks lack mastery of the PE,[34] a view shared by clerks themselves.[35] Furthermore, our students have agreed that the small-group activity promoted their learning, with a score of 3.96 out of 4, which suggests that they still needed learning. Whether the guidance hypothesis applies for PE learning remains therefore to be determined by future research that addresses a set of psychomotor skills that are entirely new to medical students.

The second variable of interest in our study was peer-feedback specificity. We found that 86.3% of feedback instances were specific. We had expected a positive impact of specificity on NLE performance, because feedback efficiency increases when specific information about the learner's progress and some hints for improvement are provided.[9, 36] Medical students are generally performance driven, which makes them good candidates for specific feedback.[1] Our results point in the opposite direction as there was no significant correlation between specific feedback and performance. There is a possibility that our NLE training did not motivate them or that they had sufficient confidence in their mastery of the NLE to use the specific comments provided by their colleagues. The pre-activity self-assessment (7.7 on 10) suggests that most students considered they already had acquired, to a large extent, the to-be-learned skills. As we previously discussed, our students had in fact already acquired these skills to a certain extent, because they had learned them separately in previous curricular activities. That the students had indeed substantially mastered the skills was demonstrated by the high percentage of accurate peer feedback provided. This prior mastery probably explains the lack of influence of feedback amount and specificity on performance.

We found 84.8% of the peer feedback provided to be accurate and accurate feedback did not correlate with performance. Our third hypothesis was that feedback accuracy would have no impact on NLE performance because students generally do not view their peers as authoritative sources of knowledge. Consequently, the students tend to assess the pertinence and accuracy of comments made by their peers before using them to improve their performance.[28] Inaccurate comments elicit a dialogue between learners to discover the accurate answer. Our research supports the claim that having the exact response is not essential to improve the learner's abilities.

In a previous study, Martineau et al.[6] demonstrated a significant effect of peer feedback on NLE performance, despite students having greater interest in PI feedback before the activity. We found a similar interest in PI feedback in the present study. Prior to the activity, they seemed to be more in agreement with the benefit of constructive feedback brought by patient instructor than by peers. After practice, the students found PI feedback more useful than peer feedback (9.28 compared to 8.64 on a scale of 10; $F[1, 99] = 37.683$, $p < .001$, $\eta_p^2 = 0.28$). Nevertheless, their responses to some items show that they appear to value their peer's feedback. Their disagreement to the statement "*Feedback is only relevant when it comes from an expert*," (1.64 out of 4) suggests that students still deemed peer feedback as useful. The students' disagreement (1.71 out of 4) with the sentence "*I often wondered if the comments made by my peers were right"* also challenges the explanation put forward by Yang, Badger, and Yu[28] that learners assess the relevance and accuracy of comments made by their peers before integrating them and correcting their errors. One possible explanation is that the students were not fully aware of the inner reflection generated by observing their peers or by receiving comments from their peers. This phenomenon requires further investigation.

Our last hypothesis was that peer-feedback seeking would correlate positively with PE performance. That was not the case here: we obtained a significant negative correlation. The hypothesis of normality was rejected for solicited feedback. This negative correlation does not support Ashford's claim[12, 13] that feedback seeking will enhance learner's performance. Our negative trend could be explained by assuming that the students who sought for more feedback were the ones who needed it more. The feedback-seeking behaviour reflected, therefore a lower starting-point, which would then translate in poorer performance relative to students who already started with a higher level of mastery of the skills. However, we would expect then that students who self-assessed their ability as lower would ask for more feedback than their colleagues who thought they knew more. We found no correlation between self-assessment of ability or self-confidence and feedback seeking, but one has to keep in mind the importance that students place on being viewed as high performers and maintaining their egos and image to other peers.[29,30] In this sense, medical students may consider that seeking answers to their doubts frequently alters their image, which could inhibit feedback seeking even among students who feel underprepared at the start. In addition, it can also be that students who started in a lower level of mastery were simply unable to accurately self-assess their performance and therefore did not recognize the need to seek feedback. It seems to take time for learners to refine their self-assessment as demonstrated by the significant correlation between performance and self-assessment that occurs only at the end of the activity, after the execution of the sequence with the PI, as reported in Table 5. It can also be that our results are context related, because our students were randomly distributed to the triads and worked therefore with peers they did not know well. This may have affected feedback seeking. The present study was, as far as we know, the first research attempting to investigate the relation between feedback seeking and performance of psychomotor skills required for physical examination, and these factors remain therefore to be explored by further research.

The students greatly appreciated the learning activity, with scores varying from 3.75 to 3.96 on a four-point Likert scale, as revealed by the questionnaires. Their ratings of self-assessment of their ability to perform a NLE and of self-confidence in their performance increased significantly after the activity. This suggests that the learning activity helped learners develop a feeling of competency. This result is in line with Bandura's self-efficacy theory,[25] suggesting that practising to master the PE, observing an appropriate model, and receiving comments from a PI and peers helped students internalize that they were able to reproduce and perform what they had seen and practised.

Our study's strength was that it was conducted in a natural learning environment with a large group of participants, which suggests that the results can be applied to regular curricular activities. However, the naturalistic environment implies also limitations. As mentioned in the introduction, peer influence on PE psychomotor skills learning occurs at least through peer observation and peer feedback, which are intimately linked in a small-group setting. In our study, we did not control for peer observation, which may have affected the results.

Summing up, we aimed at identifying characteristics of peer feedback that influence its effectiveness to foster students' learning of psychomotor skills required for PE. We failed to find meaningful relations between most of the studied characteristics of peer feedback and PE performance. The amount of peer feedback received, as well as the specificity and the accuracy of the peer feedback received by the students were not associated with their performance. The only variable that showed to be related to performance was feedback seeking, which was negatively correlated with students' performance. One explanation for these results could be that the students at the level of expertise of the study participants do not need much feedback, in line with the literature that shows feedback to be useful in the very early phases of the learning process.

The influence of peer feedback on learning possibly involves a complex interaction of numerous factors. Future research aimed to understand peer-feedback characteristics that influence learning should use a design that allows to isolate these factors to determine which ones influence the acquisition of the motor skills required to perform the PE. Furthermore, the effects on learning could be assessed not only immediately but also with retention tests[1] to see if it makes a difference for future practitioners on medium and long term. Pursuing further research to grasp the underlying mechanisms that increase the potential of peer feedback to help future physicians acquire PE skills will allow the medical programs to maximize instruction and enhance the effectiveness of small-group educational activities for learning to perform the physical examination.

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Chapter 6

Learning physical examination in small groups: who wants to go first?

Submitted as Martineau B, Mamede S, Bergeron L, St-Onge C, Schmidt HG. Learning Physical Examination in Small Groups: Who Wants to Go First? 2016.

Abstract

Context: Small group learning activities have been widely employed for the development of psychomotor skills required for performing physical examination. During these activities, medical students practice the to-be-learned skills, observe their peers practising and receive feedback. Peer feedback and peer observation have been shown to influence learning, but it is not known whether skills acquisition is influenced by the order in which students practise in the group activity. As feedback affects learning, and the order of practice possibly influences the amount of feedback that a student receives, perhaps not all students in a small group learning activity benefit equally from it. These two studies investigated the influence of the order in which students practise on the amount of peer feedback received and on the acquisition of psychomotor skills required to perform physical examination.

Methods: Both studies were conducted in a Canadian medical school, in two subsequent years, within a 2nd-year curricular activity for learning physical examination for low back pain. In Study 1, 106 students were randomly assigned to triads, which were subsequently randomized to either a peer-feedback condition (n=48) or a no-peer-feedback condition (n=58). In both conditions, students first practised the physical examination in small groups with a patient instructor, and subsequently performed the physical examination individually. Comments were allowed in the peer-feedback condition whereas students were requested to be silent in the no-peer-feedback condition. For the analysis, students were assigned to one of three observation/practice subgroups depending on the order of practice: (1) first students, who observed twice after practising, (2) second students, observing once before and once after practising, and (3) third students, observing twice before practising. A two-way ANOVA checked the influence of order of practice and of peer feedback on performance. In Study 2, 108 students were randomly assigned to 36 triads for a learning session that had the same structure of Study 1. The number of peer feedback utterances received by each student in the videotaped session was counted. For the analysis, students were assigned to the observation/practice subgroups as in Study 1. A one-way ANOVA compared the amount of feedback received by the three-observation/practice subgroups, and the correlation between the amount of peer feedback received and students' performance was examined.

Results: In Study 1, peer feedback had a positive effect on physical examination performance (89.92% vs 85.67%, p = .026), but no significant effect of observation-practice combination and no significant interaction emerged. Study 2 showed that students who were the first to practise the physical examination in the learning session received more peer feedback utterances than the student who practiced in the second (26.64 vs 13.97; $p < .001$) and in the third place (26.64 vs

11.94, $p < .001$). However, the number of peer feedback utterances received was not correlated with the students' performance, though a tendency emerged that suggested a negative relationship ($r = -.161$, $p = .096$).

Conclusions: Receiving peer feedback is beneficial for learning physical examination relative to the absence of peer feedback. Although students who practised the physical examination first in the learning session received more peer feedback than their colleagues who practised later, they had similar performance at the end. The different combinations of observing/practice did not affect learning, and practising first did not appear to be a disadvantage. These findings allow teachers to reassure students who hesitate to go first. Taken together these results suggest that there may be an optimal amount of peer feedback that fosters learning. Future studies should investigate the optimum combination of peer observation/peer feedback to maximise acquisition of physical examination skills in small group learning.

Introduction

Many medical undergraduate education programs[1] use small group activities as a major instructional strategy for teaching the physical examination (PE). These activities enable students to learn and practise the psychomotor skills required to perform the PE with coaching from a teacher. In addition to providing students with an opportunity to interact with each other and receive peer feedback about their performance, small group activities allow students to observe their colleagues as they practise the PE.

Observing peers while learning psychomotor skills is likely to be an important advantage. Bandura's sociocognitive theory[2] on learning through modelling and Adams' research[3] on the use of a model to increase trainees' performance explain how a learner benefits from observing peers when learning psychomotor skills. The learner acquires a mental blueprint of the task that can be used as a reference in performing the task.[3] In addition, having a template of a peer's performance provides the learner with an opportunity to correct his or her own actions.[5] Therefore, having the chance to observe a to-be-learned task before actually practising it may positively affect the learner's acquisition of the required psychomotor skills.

Studies in the field of medical education have indeed shown that observing peers when practising the psychomotor skills necessary to perform a physical examination has a positive impact on the learner's performance.[4,5] What is less clear is whether the peer observation has necessarily to occur before the learner practises in order to positively influence learning. In a small-group session, peer observation can take place before, during, or after an individual student has had an opportunity to practise the skill.[8] Whether or not the order of observation and practice affects learning is unknown. Ste-Marie et al.[6] deplored a lack of studies to demonstrate the effect of the order of practice/observation. They reported two studies with participants observing a demonstration by an expert model of the to be-done tasks before and during the practice. The first study was conducted with children learning a ball-striking task,[7] and the second one with adults learning how to serve a volleyball.[8] The researchers found that a learner performed better when the model demonstrated the task both before and while the learner practised. In these two studies, however, an expert served as the model, not a peer who was also in the process of learning. Moreover, the to-be-learned task was a simple one, requiring little prior knowledge. Thus, based on these studies it is difficult to hypothesize what would be the influence of the order of practice/observation on acquiring complex skills such as those required for PE when peer observation is involved.

In addition to the possible influence of peer observation, the order in which students practise during small-group activities may have other implications for learning. Such activities imply that one student has to step up and accept to go first, while the others have the opportunity to observe this peer. Many students are reluctant to go first, feeling at a disadvantage, because they do not have the chance to observe peers before practising or because they will be the centre of attention or overloaded by feedback from teachers and peers. If the order of practice affects the amount of feedback received, this could in fact influence learning. Feedback, whether from a teacher or a peer, is an influential factor in psychomotor-skills learning[9] and commonly used in medical education.[10] Furthermore, Martineau et al.[11] demonstrated that peer feedback during PE learning sessions increased the performance of psychomotor skills by medical students, though the effect size was small. In small-group learning, such as the small-group sessions used to teach PE, feedback is suggested to help enhance performance by allowing for error detection.[3]

However, Wulf and Schmidt[12] have reported that excessive feedback (e.g. feedback after each practice) could negatively influence the acquisition of psychomotor skills involved in a simple motor task. In an attempt to understand this contradiction, Wulf, Shea and Whitacre[13] conducted an experiment with a ski simulator, which is a complex psychomotor skill to learn. They found that frequent feedback enhanced performance initially up until the learner had achieved a minimum level of mastery of the skill. Given that PE learning is a complex task and mastery could hardly be achieved in a single session, the fact that the first student receives more feedback could be a great advantage for him or her, while the other students, receiving less feedback, would be somehow penalized. It is not known, however, if these differences in peer feedback do happen. That students in small-group setting possibly receive unequal amounts of feedback due to practice order is a hypothesis that remains to be confirmed by this research. It is also unclear whether eventual differences in the amount of peer feedback received would affect student learning.

Based on the aforementioned discussed literature, it is not clear whether students can equally benefit from small-group learning independent of the order they practise in the group; each student having a different combination of practice/observation and receiving a different amount of feedback. This paper reports on two studies whose purpose was to investigate whether the order in which medical students practise during PE learning sessions influences the acquisition of the psychomotor skills required to perform PE. We addressed this issue by investigating whether learning was influenced by the amount of peer-feedback received and by students' different combinations of the order in which they practise and observe peers.

STUDY 1

This study aimed at determining if the order of practice in the PE session (which implies different combinations of observation and practice) influences medical students' learning of PE psychomotor skills, and if this eventual effect of order of practice was dependent on the opportunity to receive peer feedback.

Methods

Overview

The study was conducted during a regular learning activity of the physical examination skills training in a Canadian medical school. For the purpose of this study, we assigned participants to one of two experimental groups: a group with normal interaction between peers, which allowed for peer observation and peer feedback; another group in which the students could observe but were not allowed to give feedback to their peers. For the analyses, we composed, within each group, three sub-groups depending on the order in which the student had practised: (1) the first students, who observed a peer twice after practising, (2) the second students, who observed once before and once after practising, and (3) the third students, who observed twice before practising. This arrangement allowed for investigating whether the order of practice had an effect on students' learning while simultaneously examining if this effect was affected by peer feedback.

Participants

Participants in this study were 143 second-year medical students in a Canadian medical program in 2011. This medical program has a four-year problem-based-learning (PBL) curriculum that includes an 18-month clerkship. Clinical-skills training is provided at three different levels: a clinical-skills session during PBL units, a transdisciplinary activity in which students integrate clinical skills related to different organ-based systems previously studied and several PE practice sessions. The students who had to take part in a mandatory PE activity in small groups were invited to voluntarily participate in the research.

Out of 143 students invited to participate in the study, four students declined to have their data included in the research. Two students failed to show up for the activity, and we excluded ten others who had their learning sessions in dyads (instead of the triads involved in the study) due to organizational issues. After the initial data analysis, 18 participants were excluded due to missing data (performance was not recorded, information on the number of students in the group was unknown or the position of students in the order of practice was unknown), and three others because they appeared as extreme outliers. Therefore, the final analyses were conducted with data from 106 participants.

The university research ethics committee approved the two studies. Students were requested to sign a consent form to release their data to the researchers.

Materials and procedures

The to-be-learned task

Students had to learn the PE for low back pain, which required them to integrate the sequence for the neurological PE and the lumbar-region PE (which had been learned separately beforehand). The PE sequence to be learned included the following steps for an optimal examination for low back pain: observation of the patient's back and gait; assessment of lumbar movement amplitude while searching for neurological signs, execution of manoeuvres to elicit sciatic irritation, assessment of the hips and sacroiliac joints; and palpation of the low-back region

Learning session

The learning session started with the presentation of a demonstration video of a teacher performing each step of the PE. After the video, the students had an opportunity to practise the PE sequence individually on a patient instructor (PI) while the other two students in the group (see below) observed. After the practice session, each student, in turn, performed the complete PE sequence alone with the PI. Each student's performance was videotaped and assessed later. Each student was allowed five minutes to complete the task. The students practiced for the assessment (i.e. the individual practice with the PI) in the same order in which they had practised for learning.

Before starting the learning session, the students were randomly assigned to groups of three, each group with a PI who had been previously coached to teach the PE to students. Each group was then randomly assigned to one of two experimental conditions: peer feedback (comments allowed during the session) or no peer feedback (students remained silent during the session). Separate sessions were conducted for each group.

Students who had been assigned to the peer-feedback experimental group were instructed to provide feedback whenever they wanted during the session. Moreover, the PIs were instructed to prompt the students to give feedback at three specific times during the session. In the no-peer-feedback groups, students who observed were asked to remain silent and to simply observe the student who was practising. All the students, regardless of experimental condition, received immediate feedback from the PI. The learning session lasted 1.5 hour for each group of three students.

Performance assessment

We used a 110-item checklist to assess the students' video performance when they performed the PE alone with the PI. Each item was rated as completed (1) or not completed (0). This checklist was used in another study, and its reliability proved to be good (Cronbach's alpha of 0.90).[5] This checklist was selected over a global one, because it is more appropriate to novice learners and corresponds to a sequence to-be learned, thereby allowing for better standardization between PIs when they provide feedback.[14] A research assistant, previously trained, analysed the videos under the supervision of the principal investigator (BM), who was available to address questions and doubts about the assessment.

Analysis

For each student, a total score for the performance of PE psychomotor skills was computed by adding the number of items of the checklist successfully completed; the scores were then expressed as percentages. We then computed the mean percentages of performance for each experimental group (No-feedback group vs Feedback group) and for each sub-group of practice/observation combination to which the students were exposed. A two-way ANOVA with practice/observation combination (observing twice after practising; observing once before and once after practising; observing twice before practising) and exposure to peer-feedback (no-feedback vs feedback) as between-subjects factors was conducted on the mean percentages of performance to assess whether order of practice affected performance and whether this depended on receiving feedback.

Results and discussion

Table 1 shows the students' mean percentage score on performing PE motor skills according to the practice/observation combination, and feedback or no-feedback group. The ANOVA showed a main effect of exposure to peer feedback ($F(1, 100) = 5.13$, $p = .026$, $\eta^2 = 0.049$). There was no significant effect of practice/observation combination ($F(2, 100) = 0.32$, $p = .726$) and no significant interaction between exposure to peer feedback and practice/observation combination ($F(2, 100) = 0.35$; $p = .706$).

Table 1. Students' mean score (SD) according to the combination of practice/observation and experimental condition

Practice/observation combination	N	No-feedback group	N	Feedback group
Observing twice after practising (1st student)	19	86.55 (9.20)	16	90.11 (6.14)
Observing once before and once after practising (2nd student)	19	86.99 (11.01)	16	89.72 (6.00)
Observing twice before practising (3rd student)	20	83.59 (12.41)	16	89.94 (9.46)
Overall mean		85.67 (10.90)		89.92 (7.22)

The findings of this first study suggest that students can benefit from peer feedback while learning the PE skills but the order of practice does not affect their learning. Moreover, the findings show that the positive effect of feedback on learning is not related with the order in which students practise. Students benefitted from feedback regardless the combination of practice and observation to which they were exposed.

STUDY 2

As stated in the introduction, the setting of small-group activities in which the PE is taught may involve different amounts of feedback received by students, since students who practise firstly probably receive more feedback from their peers than those students who practise subsequently. If this happens and peer feedback affects learning, as indicated by the first study, practising in the first place would possibly be beneficial for learning. This influence of order of practice was not, however, found in study 1. It may be, therefore, that students receive similar amounts of feedback independent of the order in which they practise during the learning session. In this subsequent study, also conducted in a naturalistic educational setting, we explored this conjecture; peer feedback was not manipulated and rather allowed to occur naturally. The study aimed at determining if the first student to practise in the setting of a small-group PE activity receives more feedback than the other students and at investigating the impact of the amount of feedback received by peers on the physical examination performance.

Method

Participants

Participants for the study were recruited from another class of 149 2nd-year medical students from the same Canadian medical school of Study 1, who participated, in

2012, in the same mandatory learning activity presented in Study 1. For the data analysis, we had to exclude the students who were exposed, due to operational issues, to learning conditions that differed substantially from the ones previewed for the study. We removed from the dataset, therefore, 14 students who worked in groups of two instead of three students, because they did not have the same exposure to peer feedback (they saw only one performance, receive feedback from only one peer, and the activity was shorter for them), and eight students who practised twice during the session, because they received more feedback and practised more than the other groups. We also had to remove 19 students because of technical problems with the video recording, which was either missing or not appropriate for the assessment. One hundred and eight students were therefore included in the analyses.

Materials and procedures

The task and the format of the learning session were the same as in Study 1. The procedure was also the same, except that there were no experimental conditions that differed regarding provision of feedback. All students had to give feedback to their peers during the practice, which was videotaped for analysis; the PI prompted students to give feedback at specific moment during the session.

Analysis

We used the same checklist and the same procedure used in Study 1 to assess student's PE performance. For the purpose of the study, we defined peer feedback as any verbal interactions on the PE performance that occurs between students who watch and the student who practises in each triad learning session. The analysis of the video recordings of the learning sessions aimed at counting the number of times peer feedback occurred when a student was practising. Two research assistants coded three practice sessions by using NVivo 9.[15] Divergences were discussed and the definition refined until a satisfactory inter-rater reliability was obtained (Cohen's $\kappa = .71$; percentage of agreement = 98,8%). After that, one research assistant coded the remaining practice sessions.

We computed the mean number of feedback utterances received by students who practised firstly, secondly, and thirdly during the session. We performed a one-way ANOVA with order of practice as a between-subjects factor (first; second; third) on the mean number of feedback utterances received during the learning session. This analysis checked whether the amount of feedback received depended on the student's order of practice in the group. Secondly, we looked at the relationship between the number of peer-feedback utterances received and students' performance of PE motor skills by computing the Pearson's correlation coefficient.

Results and discussion

Table 2 presents the mean number of feedback utterances received by students according to the order in which they practised during the learning session and the mean score of PE performance obtained by the students. There was an effect of order of practice on the amount of feedback received, ($F(2, 105) = 19.4$, $p < .001$). Students who practised the PE first received more feedback than those who went secondly or thirdly. Post-hoc analyses (with a Bonferroni correction) showed significant differences between first and second student ($p < .001$), and first and third student ($p < .001$). There was no significant difference between second and third students ($p = 1.00$). The correlation between the number of feedback utterances received and performance did not reach significance, but we observed a negative tendency in the relationship ($r = -.161$, $p = .096$).

Table 2. Mean number of feedback utterances received and students' mean percentage scores when performing the PE as a function of participants' order of practice

Order	N	Number of feedback utterances Mean (SD)	PE performance (%) Mean (SD)
1st	36	26.64 (15.25)	83.92 (11.47)
2nd	36	13.97 (5.59)	85.44 (12.00)
3rd	36	11.94 (9.44)	85.72 (13.74)

In Study 2, we confirmed that the student going first to practise in the small-group learning session receives more feedback than the others. However, differently from what we found in Study 1, the amount of peer feedback received did not influence students' performance.

General discussion

The present studies aimed at investigating whether the order in which students practise in small groups sessions organized for learning psychomotor skills influences skills acquisition due to differences in combinations of practice/observation and in the amount of peer feedback received, differences that are unavoidable when students take different turns to practise. The findings showed, first, that having the chance to receive feedback from peers fostered learning as compared to a condition in which students were completely deprived from peer feedback (Study 1). Second, the students' order of practice did not influence their learning (Study 1), despite the finding that students who practised first in the learning session received more peer feedback than their two peers who practiced subsequently (Study 2).

Students in Study 2 experienced different combinations of practice/observation and received different amounts of peer feedback during the learning session. The first students to practise received more feedback than their peers and, although they did not have the chance to observe before practising, they were able to observe the next two students practise after their own practice. The students in the second and third positions received approximately the same amount of feedback, both less than the first student. That being said, their practice/observation combination was different, because the second student observed, practised, and then observed again, whereas the third student observed two students before his or her turn to practice. Despite significant differences in the amount of feedback received or a different order in which they practiced and observed peers, the students performed at the same level by the end of the small-group learning activity.

In Study 2, the increased amount of peer feedback received by the first student to practise in a group did not affect the acquisition of psychomotor skills. This finding seems to contradict the positive impact of peer feedback on performance that we found in Study 1. If peer feedback positively influences learning, as shown in Study 1, and the student who practised firstly obtained almost 100% more feedback than the second- and third-to-practise colleagues, the first students should have outperformed the latter ones. It may have been, however, that the first student received too much feedback, part of which was unnecessary for learning. Indeed, the literature suggests that students with a minimum degree of expertise need feedback to enhance detection and correction of errors in performance,[16] at least at the beginning of the learning process.[10] As they progress in their learning, feedback tends to become less important, and Wulf and Shea[10] have even demonstrated that excessive feedback (e.g. feedback after each practice) could negatively influence the acquisition of psychomotor skills. This may explain why the students' PE performance, in Study 2, was not related to the amount of peer feedback that they had received from their peers. The amount of peer feedback received by the first student may have overpassed the learner needs. The first-to-practise students, who were novices and had not mastered the PE, might have appreciated receiving a lot of peer feedback in the beginning, relying on this feedback to remedy performance errors. However, after a certain amount of peer feedback was received, the repeated comments made by their peers may have somehow disturbed the learner, causing the negative tendency observed between feedback and performance. There is possibly a threshold to not exceed to ensure that peer feedback has a positive effect on the learning of complex psychomotor skills such as those necessary to perform a PE. Whereas Study 1 shows peer feedback to be more beneficial than the absence of feedback, Study 2 suggests that there may be a limit to the amount of feedback that can be successfully handled. Of course, this explanation is only a conjecture to be explored in future studies.

The few studies that investigated the impact of "when" to observe versus to practise during learning of psychomotor skills revealed that observation seems to be effective when an expert model is presented as a demonstration before the practice and interspersed during the practice.[6,8] In our study, the students observed an expert model only before practising. Afterwards, they observed peers who were learning in three different combinations: after practising, before and after practising or before practising. The students performed well whatever the combination of order/practice they had. Adding an observation of an expert performance during practice is not usual in the PE small group learning sessions, and our study did not explore whether this would influence students' learning. Our findings did show, however, that provided that an expert performance is observed before the practice it does not matter whether the students have the opportunity to observe additional performances (in our study, by peers) before or after their own practise.

The amount of peer feedback received is only one of the features of feedback that can influence how it affects learning. In the present studies, we did not investigate whether other features, such as the quality of peer feedback provided, would affect learning. It is possible, for instance, that the potential benefit of practising first, and consequently receiving more feedback, depends on the accuracy of the feedback given by peers. This remains to be investigated. Whether there is in fact a threshold for the to-be-received amount of peer feedback after which feedback stops helping, and, if there is, the determination of such threshold, is a question that is still to be answered. Finally, as many medical undergraduate programs use small groups of different sizes for the PE learning, it would be interesting to study if practice order has also no effect on performance in larger groups.

Conclusion

These studies have yielded results that increase what we know about how to organise small group learning activities for the acquisition of psychomotor skills required for PE. They show medical teachers that peer feedback provided during the learning sessions fosters learning relative to the absence of any feedback. Moreover, they inform medical teachers on the effect of the order in which students practise in small group activities on the learning of psychomotor skills, namely, none. This study confirms that this kind of activity offers to each student the same opportunity to acquire the skills being taught independent of the combination of the sequence of observation and practice. Teachers are enabled, therefore, to reassure students reticent to go first.

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Chapter 7

Summary of main findings, implications for medical education and directions for further research

The preceding chapters reported studies on the role of peer influence on medical students' learning of psychomotor skills necessary for physical examination; the theme of this thesis. A review of the literature on peer influence on physical examination (PE) learning in small groups is presented in chapter 1. I highlighted the relevance of studying the topic, because of the challenges involved in teaching PE to medical students.[1-3] In addition, I show that little empirical research has explored the impact of peer influence on PE acquisition of psychomotor skill among medical students. The first chapter reviews also the pertinent literature on acquisition of psychomotor skills, which are a component of PE performance, and concludes with the research questions studied in this thesis.

The research questions were: (1) Does peer observation influence the acquisition of psychomotor skills necessary to master PE? (2) Does the quantity of peer observation influence the acquisition of PE psychomotor skills? (3) Does the quality of the PE observed (i.e., observing a well performing vs. a poorly performing peer) influence the acquisition of the psychomotor skills necessary to master the PE? (4) Does peer feedback influence the acquisition of psychomotor skills necessary to master PE? (5) Which characteristics of peer feedback influence its effect on learning? (6) Does the order of practice influence the acquisition of psychomotor skills necessary to master PE?

Chapters 2 and 3 report studies conducted with medical students with the purpose of addressing the first three research questions on peer observation. After having answered the questions on peer observation, chapters 4 and 5 report studies aimed at answering, respectively, the research question (4) and (5). Finally, chapter 6 describes a study that addressed the last question: whether order of practice in a small group activity affects learning. This final chapter summarizes the main research findings of each study, starting with question that initiates each study and concludes with strengths, limitations and implications for medical education before ending with issues for further research.

Summary of the main findings

First study

Does peer observation influence the acquisition of PE psychomotor skills?

Faced with the observation of inappropriate mastery of physical examination (PE) by medical students who arrive at the clerkship, some authors[1-3] give as explanation the insufficient preparation of students in the previous years of the undergraduate curriculum. The mastering of PE necessitates the integration of many components: anatomy and physiology knowledge, psychomotor skills necessary to execution of the manoeuvres, and clinical reasoning. Cognitively and physically, it seems to be a challenging learning process for novice students. The initial teaching of PE usually occurs in small groups, where there is a demonstration by an instructor followed by practice with coaching and feedback from peers and/or standardized patients. This set up of the learning process is coherent with the theories of acquisition of any psychomotor skills;[4–6] these skills is an essential facet of PE mastery. Despite the importance of PE for clinical practice, there is little empirical evidence on the factors that influence the acquisition of PE psychomotor skills in the medical literature.

In searching for pathways to explore the theme of learning of PE psychomotor skills, the importance of modelling springs from the literature in kinesiology.[7] Modelling is also a key element of social cognitive learning theory. Bandura's work[8] postulates that observation is the starting point of any learning. For him, the learner is actively and continually evaluating what he is observing in his environment to develop from a model the behaviour that he is to adopt.

While students learn in small groups, there are many persons to observe and interact with, not only the instructor, but also the other students in the group. Peers, as a source of modelling, might also influence learning in small groups employed for teaching PE. To contribute to our understanding of the factors influencing the acquisition of PE psychomotor skills, I choose the peer influence on PE acquisition as the theme of this thesis.

My first research question explored the influence of peer observation on PE learning. Observing a model leads learners to develop a mental blueprint of the to-be-learned task, which acts as a reference while performing the task.[5] Literature on the type of model demonstrated that observing an expert offers a significant advantage over no-observation in surgery.[9] The possibility to observe peers and practice is superior to practice alone in a simple motor skills task.[10] To our knowledge, there has been no empirical research on the influence of peer observation influence in PE psychomotor skills acquisition in small groups. It is unclear whether students benefit more from training these skills individually or in a group, as the latter allows them to observe their peers. The present study, conducted in a naturalistic setting, investigated the effects of peer observation on mastering psychomotor skills necessary for physical examination. We hypothesized that students who had the opportunity to observe their peers during the PE learning session would learn more than their colleagues who could not observe.

The study was conducted at the University of Sherbrooke, a Canadian medical school that has a PBL undergraduate program. It was carried out during a mandatory activity where 185 second-year medical students had to learn to perform a head-to-toe PE (excluding neurological examination). Students were assigned to one of two learning settings: a single-student condition (n = 65), in which participants practiced alone with a patient instructor (and therefore could not observe peers), or to a multiple-student condition (n = 120), in which participants practiced in triads under patient instructor supervision (and therefore could observe peers). The students subsequently carried out a complete examination that was videotaped and subsequently evaluated by using a 158-item checklist. The checklist was developed by the researchers through an iterative process and was shown to be reliable, with intra-class correlations of 0.95. A student's performance score was computed by adding all the checklist items and converting this sum into a percentage. Students' performance was used as a measure of learning.

Based on the two different learning settings, we subsequently analysed the performance of the observation condition and the no-observation condition, by grouping participants from the single-student condition with the first participants in the multiple-students condition (i.e., those who did not have the chance to observe any peer composed the no-observation condition), and grouping the second and third participants from the multiple-student groups (i.e., observation condition).

Students in the multiple-student condition learned more than those who practiced alone (81% vs 76%, p <0.004). This result possibly derived from a positive effect of observing peers; students who had the possibility to observe a peer (the second and third students in the groups) performed better than students who did not have this possibility (84% vs. 76%, p <0.001). When the performance of students who observed only one peer was compared with the performance of those who observed two peers, there seems to have no advantage of observing more than one peer over observing only one (83.7% vs. 84.1%, p> 0.05).

The findings support our hypothesis that peer observation positively influence PE psychomotor skills. The benefit of peer observation is in line with learning theories in which modelling plays a key role.[7,8] The peer observed perhaps acts as an intermediary blueprint that complements the expert video seen by students at the beginning of the activity. This intermediary blueprints are possibly nearer to the level of a student's expertise than expert skills; not all subtleties of these skills are reachable by students. Our findings have also suggested that observing more than one peer does not have benefits over observing only one. It remains to be studied whether this is actually the case and whether the quality of the model observed affects the influence of peer observation on learning.

Second study

Does the quantity of peer observation influence the acquisition of PE psychomotor skills? And what about the quality of the peer observation?

The second study, reported in Chapter 3, explored these questions by looking at the effects of the quantity and the quality of peer performance observed on students' learning. The postulate of learning through modelling advocates that observation provides a template for practice,[8] generating the opportunity to correct one's own actions while practicing the skill.[11] Observing a model leads learners to develop a mental blueprint of the to-be-learned task, which acts as a reference while performing the task. Consequently, they use this blueprint to compare it with their own performance while practicing the to-be-learned task, which aids in detecting and correcting mistakes.[5]

Our first study having demonstrated that peer observation positively influences the acquisition of PE psychomotor skills, it was necessary to look at the determinants of the effects of peer observation. Specifically we explored the influence of the quantity and the quality of peer observation on learning in a small group. Regarding quantity, in a study on learning of a basic surgery procedure with 72 novice residents, Custers et al.[9] demonstrated that seeing more than one expert model did not enhance the learner's performance. However, there was a trend near statistical significance toward a positive effect of a second observation. In our first study, we observed a similar result for the effect of peer observation in a context of small-groups of three students learning an integrated head-to-toe PE, which required 10 minutes to be performed. The first purpose of our second study was to verify whether the number of peers' performance observed during the practice affects acquisition of the to-be-learned the skills required for performing an integrated PE for low-back pain, which required a shorter time of five minutes.

Research on learning from models has looked at either peer-models (i.e. models who are at the same level of expertise of leaners, as in the case of medical students in our study) or non-peer-models. The observed model can be characterized as skilled (demonstrating proper execution of technic to be learned), unskilled model (skill execution demonstrate errors) and learning models. The latter type corresponds to the reality of small groups practicing a new skill, when learners are observing other learners progressing from an unskilled level to a skilled performance.[7]

Concerning the influence of the quality of peer observation, research in other domains has studied whether more skilled models are more effective to foster learning than less skilled ones. Results are inconclusive, apparently because this depends on the specific psychomotor skills to be learned.[7] In medical education, as far as we know, there has been no experimental research on this question. Therefore, the second purpose of this study was to investigate the influence of the quality of the peers' performance observed on the acquisition of psychomotor skills.

This study was conducted in the University of Sherbrooke medical school, as part of a mandatory activity where 160 second-year medical students had to learn PE for low back pain. The purpose of the learning task used for this study is to foster integration of the neurological PE taught during the neurology unit and the lumbar region PE taught during the musculoskeletal unit. For the learning session, students were randomly assigned to a group of three students. Each student learned and practiced the physical examination while the other two students in the group observed. At the end of the practicing session, each student performed PE alone with the patient instructor. This performance was videotaped for assessment and analysis.

A checklist of 94 items was used to evaluate the students' performance. The researchers developed this checklist through an iterative process, and it showed to have a good inter-rater reliability (Cronbach's alpha = 0.09). The student's performance score was a sum of checklist items that the student had performed, which was converted to percentage. To address the first research question on the influence of the amount of observation on learning, we created subgroups to compare the performance of students who had observed none of their peers performing, one peer, or two peers. The performance of these subgroups was compared through a one-way analysis of variance with Tukey's test for post hoc analyses.

To analyse the influence of the quality of the observed performance on students' performance, we grouped the second-to-practice and the third-to-practice students into three subgroups according to the performance score of the student whom they had observed. The first group consisted of students who observed poor performing peers (one third lower scores). The second group observed average performing peers (one third middle scores), and the third group observed high-performing peers (one third higher scores).

Results confirmed that there is no advantage of observing more than one peer model for medical students who are learning PE. There was a significance difference between the three sub-groups as shown by the ANOVA, F (2, 157) = 11.06, p = 0.001, $\eta 2/p$ = 0.12. This difference was due to a higher performance of groups having observed at least one peer before their practice compared to group having observed zero peers. There was no significance difference between group having observed one peer and group having observed two peers.

Regarding the quality of the observed performance, our findings showed that benefit of peer observation increased when the peers' performance observed was above average. For students having observed one peer, average performance of 19 students having observed poor performer peer was for 68.34 [61.58-75.09], 19 students who had observed the average performer peer 79.66 [75.71-83.60] and 17 students who had observed high performer peers 81.14 [76.50- 85.79]. Students' performance differed significantly according to the quality of the peer's observed performance, F (2, 52) = 7.82, p = 0.001, $\eta 2/p$ = 0.23.

For students having observed two peers, average performance of 18 students having observed poor performer peer was for 72.33 [66.16-78.50], 19 students who had observed the average performer peer 78.95 [75.91-81.99] and 13 students who had observed high performer peers 82.65 [79.53-85.78]. Performance differed significantly for these students according to the performance level that was observed just before they executed the NLE, F (2, 47) = 6.31, p = 0.004, $\eta 2/p$ = 0.21.

Taken together, these results suggest that group learning activities that allow students to observe their peers during physical examination should be favoured relative to individual study. Students benefited from observing peers while they executed their examination. Moreover, observing a high-performing peer fostered the acquisition of physical examination skills relative to observing a poor-performing peer. Modelling is the key to explain why observation favours learning of psychomotor skills.[8] Our study confirms other research showing that observing a skilled model enhances performance. Lirgg & Feltz[12] suggested that peers' success might increase observer performance, because students' self-efficacy is enhanced by the inner perception that if a similar person can accomplish the task, they can also do it. In addition, it may be that a skilled learning model provides a more detailed overview of the task to be executed, therefore helping the observer to construct a better representation of the sequence of movements to be performed.

Results of this study provide support to our hypothesis that peer's observation increases PE psychomotor skills performance. Small groups enable students to observe peers performing a task, and later, to model their performance. The opportunity to observe peers doing PE seems to help students to integrate more rapidly the skills required to perform a PE. Health sciences educational programs that aim at increasing students' PE skills should favour small-group learning and peer observation when teaching those skills.

Third study

Does peer feedback influence the acquisition of PE psychomotor skills?

The previous studies have suggested that having students observe peers while acquiring physical-examination skills fosters the acquisition of the psychomotor skills required to conduct a PE. If we want to evaluate the impact of peer influence on learning in small groups, we must take account of comment made by peers during the practice. However, it is difficult to disentangle the effect of peer observation from peer feedback, both of which occur when students learn in groups. My third study aimed at clarifying the specific influence of peer feedback on the acquisition of PE skills in a naturalistic small-group learning setting.

Feedback is any information about the comparison between a learner's observed performance and a standard, given with the intent to improve the learner's performance.[13, 14] Key feedback elements are comments on their actual task performance as well as suggestions on the next steps to be taken in order to raise their level of performance. Many authors place feedback as an excellent tool for learning.[13, 14] However, it seems that the feedback does not always produce a positive effect, because it can threaten the learner depending on how it is given.[15, 16] This effect seems to depend on the type of feedback provided. Feedback providing information about the task and about how to better execute the task tends to have a more positive effect on learning than feedback based on rewards, praise, or punishment.[8] Henceforth, the controversy ensued in the literature between the proponents of a systematic way to give a feedback[16] and those saying that feedback is a formative assessment that supplements the more formal feedback of teachers, occurring spontaneously between learners.[17] Norcini[18] is sceptical about the benefits of peer feedback for medical students, because he assumes that peer judgements may suffer from low reliability and validity, which makes them of limited use in fostering learning. Most studies in the medical field have explored the ability of students to accurately assess peer performance compared to teachers that are seen as a gold standard.[18] Those studies, however, do not provide evidence of the effects of peer feedback on the performance of learners.

Nevertheless, in other domains, the positive influence of peer feedback on future performance has been demonstrated, for example, in the area of writing skills, as evidenced by higher performance subsequent to receiving comments from a student of the same level.[19] In a meta-analysis of 123 studies on effective instructions for improving writing skills, Graham and Perin[20] found an effect size of 0.75 for peer assistance.

This result questions the relative impact on learner performance of feedback provided by teachers, who represent the most knowledgeable source, over feedback given by peers, who are seen as lest competent.[20-22] Teachers's feedback may be seen as more valuable but Yang et al.[23] demonstrated a positive impact of peer feedback on writing skills, despite students' preference for teachers' comments. A possible explanation of peer feedback effectiveness is that peer comments bring uncertainty, which might encourage students to reflect on them before integrating them in their personal learning.

The purpose of the third study of this thesis was to investigate the effect of peer feedback on the acquisition of psychomotor skills required to perform a PE in a natural learning setting. The study also explored if medical students are more interested in a specific type of feedback provider and, if so, to assess any impact of such preference on the performance of PE skills.

One hundred and twelve second-year medical students of the University of Sherbrooke participated to a mandatory activity similar to our second study where they have to learn PE for low back pain. The learning task, the duration of the activity, the sequence and the previously validated 94-item checklist used to assess students' performance were similar to the ones employed in the second study. Prior to the learning session, the students answered a questionnaire on their level of preparation, their self-assessment of their ability to perform the to-be-learned PE, and their interest in feedback from peers and the patient instructor (PI).

For the learning session, students were randomly assigned to a peer-feedback group (n = 62) or a no-peer-feedback group (n = 50). In both groups, students first practised the PE in groups of three, with or without peer feedback, depending on the group to which they were assigned. Subsequently, in both groups, each student performed the PE individually. This student's individual performance, which was videotaped and assessed later, was the main outcome measurement of the study. The student's performance score was the sum of the checklist items that he/she had executed, converted to percentage.

Peer feedback was shown to have a positive effect on the acquisition of PE skills (students' performance in the no-peer-feedback and peer-feedback groups, respectively, 87.9% vs. 90.8%), t (112) = 2,307, p = 0.023, though the effect size was small (r = 0.21).

There was no significant main effect of experimental condition (i.e. peer-feedback vs non-peer feedback group) on the students' interest, F (1, 104) = 0.380, p = .539. There was, however, a significant main effect of the type of provider on feedback interest: students were more interested in PI feedback than in peer feedback: F(1, 104) = 148.24, p < .001, =. 588. The interaction effect was not significant: F(1, 104) = 0.528, p = .360.

The findings of this study confirmed that an environment that allows for and elicits peer feedback would be beneficial as students who received peer feedback performed PE significantly better than students who did not. This positive effect of feedback possibly adds, in small group learning of PE, to the one generated by the opportunity to observe their peers. In addition, our research confirms a tendency of students to have more interest in instructor as feedback provider, even if they consider useful the comments of their colleagues. Our findings are in line with studies in the domain of writing skills,[19-23] which demonstrated that peer feedback is efficient despite the preference of students for teacher feedback.

The effect of peer feedback may be explained by the cognitive process that occurs subsequently to observation and comments from peers on the acquisition of

PE skills.[8] In this case, peer feedback targeting the correctness of a manoeuvre or offering suggestions on the next step seems to foster the learner's reflection on his own performance. The student receiving the feedback must consider and evaluate this information in terms of accuracy and helpfulness, while integrating the result of these considerations into his or her existing level of experience and understanding.[14,18] Ste-Marie[7] suggested that addition of feedback increases models effectiveness. Peers feedback allows the learner to readjust the initial expert blueprint seen in the video and the intermediary blueprint coming from peer observation to diminish the gap between learner actual performance and the desired optimal performance he wants to achieve.

The effect of feedback on performance was small, possibly because the learning activity included many strategies known to be appropriate for learning psychomotor skills and, consequently, to enhance PE performance: video demonstration of the skills by an expert,[7,9] practice and peer observation.[24,25] It is likely therefore that the effect of peer feedback is added to the effects of these other factors. Other explanations could be that the students' higher interest for comments made by instructors may mitigate the integration of peer's comments or that the novice status of students reduces their ability to integrate all comments.

This study, conducted in a naturalistic environment, demonstrated the positive effect of peer feedback on learning of psychomotor skills required to perform a PE and its potential role in helping medical students improve their PE performance. Peer feedback seems to complement other learning strategies. Many factors related to the feedback provided by peers, as the content addressed, the quantity, the specificity, and the accuracy of comments, have not been subject to investigation. We went therefore further in our research to obtain a better understanding of how feedback affects medical student acquisition of PE psychomotor skills.

Fourth study

Which characteristics of peer feedback influence the acquisition of the psychomotor skills necessary to master the PE?

Our previous study on peer feedback has not explained which characteristics of peer-feedback may influence its positive effect on the acquisition of psychomotor skills required to perform PE. The fourth study aimed at filling this gap thereby increasing our understanding of peer-feedback influences in small groups learning activities. Its purpose was to investigate whether some peer feedback characteristics, such as the quantity and types of feedback, influence the acquisition of motor skills required by medical students to perform PE. We will present here only the main measurements of this study, which address the aforementioned research question. Additional data that was collected in the same study is reported in chapter 5.

For our studies on the acquisition of psychomotor skills, peer feedback can be defined as any information given to learners by his peers on the outcome or on the quality of his performance with the purpose of reducing the gap between his performance and the optimal one to be mastered.[27] By reviewing the literature on feedback, we could identify some feedback characteristics that seem to influence the extent to which feedback concurs to the improvement of the performance:[26–28] the amount of feedback received, the specificity and accuracy of feedback and the feedback seeking behaviour. These characteristics might be similar to peer feedback.

The first characteristic that we explored was the amount of peer feedback. Contrary to the initial belief that increased feedback enhances motor skills acquisition,[11] some studies have demonstrated a degrading effect of frequent feedback, at least, for simple motor tasks. However, this may change when more complex skills are involved. In an experiment on a ski simulator to learn slalom, Wulf, Shea and Matschiner[29] demonstrated that frequent feedback is initially useful for learning complex motor skills, but only until some degree of expertise has been mastered. The proposed explanation was that error detection and correction mechanisms are not possible when there is no feedback until a certain degree of learning is achieved and self-reflection is developed.[30] As far as we know, there is no empirical research on this issue when peer feedback is concerned in medical education. If we consider the aforementioned research on learning of complex motor skills,[29] an increased amount of feedback is likely to enhance motor skills performance. However, too much peer feedback may have a counterproductive effect on performance if the task is not sufficiently complex or if students have a more advanced level of expertise.

Regarding the specificity of feedback, researchers agree that specific feedback tends to be more effective than general one because it helps learners focus their attention on the aspects of the task that need improvement.[31, 32] When learning concerns psychomotor-skills, as far as we know, there are no studies that clearly link the specificity of feedback to students' performance. Nevertheless, based on research on feedback in other areas, we expected a positive influence of specificity of peer feedback on acquisition of psychomotor skills for PE for medical students.

Accuracy of feedback is the third characteristic of interest. According to Bandura,[8] the comments made by any feedback provider should be as accurate as possible to allow the learner to fill the performance gap. In this way, according to him, feedback complements the observations made by the learner him – or herself. Literature reviews have reported accurate feedback to be superior to inaccurate feedback for enhancing performance.[8, 27, 32] It implies that the feedback provider should be a teacher – because he or she is the content expert – in order to maximize the impact of feedback on learner performance. Peers, on the other hand, are not experts. However, Gielen et al.[19] found that comments accompanied by a justification positively affected students writing performance, particularly for the peers who had lower pre-test scores, despite a large variation in the accuracy of peer comments, ranging from totally inaccurate to fully accurate. One explanation for this finding is that students assess the relevance and accuracy of comments made by their peers before integrating them into their performance and correcting their errors. They tend to do so because peers are not seen as a knowledgeable authority and reliable source of information.[23] As learners tend to first evaluate the suggestions put forward by their peers before accepting them, inaccurate feedback may be, therefore, as effective as accurate feedback in leading students to reflection upon their own performance. It could even be argued that wrong suggestions are more conducive to opening a dialogue between learners, which could eventually increase the chance that errors will be corrected and new behaviours will be better integrated. For this reason, we hypothesized that the accuracy of peer feedback would not influence student performance.

The fourth characteristic of interest is active feedback-seeking during the PE learning session. Medical students frequently ask: 'How I am doing?' It implies that the learners are actively looking for feedback in order to gauge and adjust their performance. In organizational psychology, feedback seeking has been demonstrated to be a positive characteristic because it allows the learner to add a resource that he/she can use for learning and development.[33.34] The importance of feedback-seeking has also been shown in medical education.[35.36] Some studies have explored the factors influencing students' seeking feedback,[36] but, to the best of our knowledge, only one study has attempted to measure the impact of peer-feedback seeking on learners' performance. Hwang and Francesco[37] found no correlation between peers feedback seeking and exam performance in business administration. We could argue that the feedback sought by a learner is more likely to be integrated in their repertoire by students actively striving to reduce the gap between performance and the desired outcome in allowing better error detection and correction of poor motor-skill movement. Since, to our knowledge, no real experiment was conducted to test this hypothesis, we decided to do just that.

The purpose of the fourth study was, therefore, to explore the peer feedback characteristics that favour enhanced PE performance. We thought that greater amount of peer feedback; peer feedback specificity and seeking for peer feedback would influence the performance of students learning PE in small groups. But we hypothesized that peer feedback accuracy would not influence the performance of students learning PE in small groups, because the accuracy would not foster the learner's reflection on the commentaries made by their peers before deciding to integrate comments in future performance.

To test these hypotheses, we conducted a study with 108 second-year medical students from the University of Sherbrooke, who had to participate in a regular group session where they have to learn PE for low back pain. The learning session was similar to the one used for our second and third study. Before the session, the students watched a video displaying an expert demonstrating the examination. After that, they practiced the PE with a patient instructor (PI) in triads and, finally, they performed the PE individually for assessment purposes. We videotaped 36 groups during the practice session and each individual performance at the end of the session. The videos of the practice sessions and students' individual performance were subsequently analysed. To check whether the studied characteristics of feedback influence students' learning, we first counted the number of instances of peer feedback for each student and then coded these instances according to the characteristics of feedback selected to be studied (general or specific feedback, accurate feedback or inaccurate feedback, and solicited or unsolicited feedback). We computed correlations between the students' performance and the number of utterances of each type of feedback received to investigate whether these selected characteristics influenced student learning.

The average number of peer feedback utterances received by students was 17.8, and a large variation was observed (SD = 12.6). No significant correlations were found between PE psychomotor skills performance and the quantity of peer feedback received (r = -0.17; p = 0.07), peer feedback specificity (r = -0.14, p = 0.14) and peer feedback accuracy (r = -0.14, p = 0.14). When feedback that was or not solicited by the student was distinguished, there was a significant, but small, negative correlation (r = -0.21, p = 0.033) between the amount of peer feedback and students' performance.

Contrary to our expectations, neither the amount of peer feedback nor its specificity was associated with students' performance. The amount of feedback received gave us a surprising negative trend, instead of a positive one. Moreover, feedback seeking was negatively correlated with performance. As hypothesized, the accuracy of peer feedback was not correlated with students' PE performance.

Our first hypothesis was that the amount of peer feedback would influence acquisition of PE psychomotor skills, with larger amount of peer feedback associated with higher performance, because the PE would necessitate psychomotor skills that novice medical students would find complex.[19] In our study, however, we failed to find that the amount of feedback was associated with the students' acquisition of psychomotor skills. A possible explanation is that the NLE was in fact simply rather than complex enough for second-year medical students, possibly because they had sufficiently mastered the technique prior to the study. That could be illustrated, by the high PE performance scores achieved by the students in this experiment (77.3% with a standard deviation of 11.2%). Indeed this high PE mean performance score, with little variation, could explain the very low correlations with the amount of peer feedback and with the different types of feedback. The guidance hypothesis, proposed by Salmoni, Schmidt, and Walter,[30] could explain our finding of the negative tendency between the amount of feedback and performance. Instead of helping, frequent feedback may have reduced the learner's need to retrieve information on to-be-performed operations from memory, because they were provided by the feedback. This is only said to happen, however, when students have already reached some mastery of the to-be-learned skills. It may have been the case in our study. Whether the guidance hypothesis applies for PE learning remains therefore to be determined by future research that addresses a set of psychomotor skills that are entirely new to medical students.

The second variable of interest in our study was peer-feedback specificity. We found that 86.3% of feedback instances were specific. We expected a positive impact of specificity on NLE performance, but our results showed no significant correlation between specific feedback and performance. There is a possibility that the students had sufficient confidence in their mastery of the PE to use the specific comments provided by their colleagues. As we previously discussed, our students had in fact already acquired these skills to a certain extent, because they had learned them separately in previous curricular activities. This prior mastery probably explains the lack of influence of the amount and specificity of peer feedback on performance.

We found that peer feedback was accurate at 84.8%, but there was no correlation between the accuracy of peer feedback and the PE performance. Our third hypothesis was that feedback accuracy would have no impact on PE performance because tend to assess the pertinence and accuracy of comments made by their peers before using them to improve their performance.[23] Inaccurate comments tend to elicit a dialogue between learners to discover the accurate answer. Our research supports the claim that having the exact response is not essential to improve the learner's abilities.

The negative correlation, which we found, between peer-feedback seeking and PE performance, does not support Ashford's claim[33, 34] that feedback seeking will enhance learner performance. Our negative trend could be explained by assuming that the students who sought for more feedback were the ones who needed it more. The feedback-seeking behaviour reflected, therefore a lower starting-point, which would then translate into poorer performance relative to students who already started with a higher level of mastery of the skills. However, we would expect then that students who self-assessed their ability as lower would ask for more feedback than their colleagues who thought they knew more. However, we found no correlation between self-assessment of performance or self-confidence and feedback seeking. In this sense, medical students may consider that seeking answers to their doubts frequently alters their image, which could inhibit feedback seeking even among students who feel underprepared at the start. In addition, it can also be that students who started in a lower level of mastery were simply unable to accurately self-assess their performance and therefore did not recognize the need to seek feedback. It can also be that our results are context related, because our students were randomly distributed to the triads and worked therefore with peers they did not know well. This may have affected feedback seeking. The present study was, as far as we know, the first research attempting to investigate the relation between feedback seeking and performance of psychomotor skills required for physical examination, and these factors remain therefore to be explored by further research.

Based on the results of this study, it seems that peer feedback is complex and an interaction of many characteristics is necessary to explain the peer feedback effect demonstrated in an earlier study.[38] Future studies are needed for a better understanding of peer feedback efficiency in a small-group learning.

Fifth study

Does the order of practice in a small group learning session influence the acquisition of the psychomotor skills required for the PE?

Many medical undergraduate education programs[39] use small group activities as a major instructional strategy for teaching PE. These activities enable students to learn and practise the psychomotor skills required to perform the PE with coaching from a teacher, also providing students with an opportunity to interact, to receive peer feedback about their performance and to observe their colleagues as they practise the PE. This setting implies that one student has to step up and accept to be the first to practice, while the others have the opportunity to observe this peer. Many students are reluctant to pass first, feeling disadvantaged, because they do not have the chance to observe their peer before practicing or because there will be the attention centre, overloaded by feedback from teachers and peers. Studies on small group learning, however, do not explain how individuals in a group are influenced by these factors and how this impacts their acquisition of the skills. This raises the following questions: does the order of practice in a small group influence the performance to be mastered at the end of the activity? Do all students participating in a small group learning activity have the same opportunity to acquire the psychomotor skills taught?

Observation of a peer performing the to-be-learned skills can be done before the student practices, during practice or after he/she practices. Students practicing first do not have the chance to observe their peer before they practice; however they could do it after. Although the usual way is to demonstrate before practicing.[7] Some studies found that learner has a better initial performance when the model is presented before and during the practice for sports activity, suggesting that the first student to practice is disadvantaged because of the lack of possibility of observing others.[40, 41]

In addition to the possible influence of peer observation, the order in which students practise during small-group activities may have other implications for learning. If the order of practice affects the amount of feedback received, then the order could in fact influence learning. Feedback, whether from a teacher or a peer, is known to be an influential factor in psychomotor-skills learning.[41] Martineau et al.[39] demonstrated that peer feedback during PE learning sessions increased the performance of psychomotor skills by medical students, though the effect size was small. Frequent feedback seems useful for learning complex motor skills until some degree of expertise has been mastered.[29] It helps by enhancing performance by allowing error detection,[5] even if studies have demonstrated a degrading effect of frequent feedback, at least, for simple motor tasks.[40] Given that PE learning is a complex task, if the first student receives more feedback this would be a great advantage for him or her, while the other students, receiving less feedback, would be somehow penalized. It is not known, however, if these differences in the amount of peer feedback received do happen. If students in small-group setting receive unequal amounts of feedback due to practice order, it will be then important to verify the impact of differences in the amount of peer feedback received would affect PE performance.

Chapter 6 reports on two studies whose purpose was to investigate whether the order in which medical students practise during PE learning session influences the acquisition of the psychomotor skills required to perform a PE. We addressed this issue by investigating whether learning was influenced by the amount of peer-feedback received and by students' different combinations of the order in which they practise and observe peers.

The first study involved 106 second-year medical students from a Canadian medical school taking part in a mandatory PE where they have to learn the integrated PE for low-back pain. The students were randomly divided into groups of three, and each group was randomly assigned to one of two experimental conditions: peer feedback (comments allowed during the session) or no peer feedback (students remain silent). Separate learning sessions, using the same approach described in the previous studies, were conducted for each group. We used the same 94 checklist items to assess students' PE performance.

In the second study, conducted one year after the first one, 108 second-year students from the same medical school participated in the same mandatory PE learning activity used for study 1. The procedure was the same as Study 1 except that there was no experimental group. All students were instructed to give feedback to their peers during their practice, which we videotaped for analysis. Students were also prompted by the PI to give feedback at specific moments during the session.

Results of the first study showed that there were no differences in performance according to the different observation-practice combinations for the no-peer-feedback group (F (2, 55) = 0.56, p = 0.577, for the peer-feedback group (F [2, 45] = 0.12, p = 0.988), neither for both groups (F [2, 103] = 0.41, p = 0.665).

In the second study, we found no significant differences in the PE performance of the students, regardless of the participant order (F [2, 105] = 0.2, p = 0.803) even if students who practiced the PE first received significantly more feedback than the students who practiced second or third (F [2, 105] = 19.4, p <0.001).

Our study showed that small group activities for PE, although offering a different combination of observation-practice for each student in the group, allowed each student in a small group to acquire the same level of psychomotor skill required to perform a physical examination. It seems that peer observation influences the performance whenever it happens. Our results do not contradict that observing before and during the practice is good, as some authors suggest,[45] but it adds that peer-observation could also be beneficial if it happens after practice. The principal explanation is possibly that student remains active and continues to observe after practice with the purpose to enhance their performance.

Even if some studies reported that excessive feedback could negatively influence the acquisition of psychomotor skills,[40] we found that the amount of feedback may not have been excessive, but rather a welcome feedback by students, due to the complexity of psychomotor skills necessary to perform PE. Students might have liked to receive a lot of feedback because they were novices and did not master sufficiently the PE. Our results cannot help us conclude either that less feedback influence positively or negatively the performance. The fact that the first student receives more peer feedback did not negatively influence his psychomotor skills performance.

Students having the same opportunity to observe their peers practice and to observe students receiving feedback on their practice had similar PE performance at the end, whatever their order of practice.

General discussion

The studies conducted for this thesis provided answers to each of the research questions that we have formulated. Learning of PE in most medical schools takes place in small-groups. Peer observation and peer feedback contribute helping students learn PE in these small group sessions. Peer observation possibly helps by allowing students to develop an internal image of the psychomotor skills necessary to master PE. Observing one peer seems sufficient to contribute to learning PE, especially if the observed model is a good performer. Peer feedback also positively influences mastering of PE psychomotor skills. In our study, the positive effect of peer feedback was not affected by factors such as the quantity, the accuracy, the specificity of feedback or the peer feedback seeking behaviour. Even if we were the first to demonstrate a positive effect of peer feedback on PE psychomotor skills learning in small groups, it was impossible to highlight a specific factor that contributes to this effect. This seems more complex and research remains to be done to better understand this phenomenon. Finally, our last study showed that the order in which students practice in a small-group learning session, i.e. before or after observing a peer, does not influence learning. Medical students had similar PE performance at the end of the learning session, whatever their combination of observation and practice. This study provided therefore an answer to the learner or teacher who wants to know if there is a better order to practice in a small group.

The research reported in this thesis brings a contribution to the field of psychomotor skills PE learning in medicine. In the first chapter of this thesis, we discussed the needs to understand how medical students learn PE due to the deficiencies that have been reported in mastery of PE skills.[1, 2] We mentioned the scarcity of experimental studies aimed to explain how novice medical students develop the psychomotor skills necessary for PE in small groups. Our studies on peer's influence on a small group learning open a new line of research focused on the development of better instructional approaches to maximize acquisition of PE psychomotor skills at the undergraduate level. Small groups activities are the most frequent approach used to teaching PE in medical schools, which makes the contribution provided by this thesis particularly relevant.

Implications for medical education

The following paragraphs present the implications emerging from these research findings to the debate on the challenges faced to ensure mastering of PE skills by medical students. Students have been considered not appropriately prepared to perform PE when they reach the clerkship phase.[3] A possible cause for that has been suggested to be inappropriate training throughout undergraduate medical education. This thesis, therefore, searched to understand better how students learn psychomotor skills necessary for PE, which frequently happens in a small group setting. Specifically, the thesis explored the influence of peers on students' learning of PE skills in small groups. This thesis has provided evidence coming from five experimental studies that inform health sciences educational programs on the use of small group learning to favour acquisition of psychomotor skills necessary for the execution of PE examination. As we conducted the studies using two different physical examinations – an integrated head-to-toe PE and PE exam for low-back pain – it is likely that our findings can be extended to other components of PE.

First, students in small groups such as the ones used for the teaching of PE, are not passive receptacle of teachers' comments. Students are active, practicing, observing not only the initial demonstration provided by experts but also other peers trying to perform the to-be-learned manoeuvres the best they can, commenting on their peers practice and searching to integrate commentaries provided by teachers and peers. Given the nature of this type of learning setting, peers exert an influence on each other throughout the PE educational activity. Peer influence, the central theme of this thesis, occurs at least through peer observation and peer feedback, which are beneficial for students, as our research has demonstrated. Educational programs should therefore be encouraged to set instructions that favours peer observation and peer feedback.

Second, our research has reinforced the importance of modelling of psychomotor behaviour for learning, which requires observation. The studies provided a demonstration of Bandura's socio-cognitivist model[8] in medical education. They went out of the research lab to the real settings, as some authors have required,[7] involving entire cohorts of medical students. We demonstrated in the first study that peer observation improves performance; a medium effect size was found. In the second study, we determined that the observation of one peer model is sufficient to explain this improvement. Finally, we demonstrated that students, who observed a peer model that is a skilled performer, will learn more than their colleagues observing poor performers. That is good news, at least, for the first two findings. Simply organizing PE teaching in small groups is sufficient for ensuring that peer observation will help students learn. Our educational setting involved groups of three students with one patient instructor, but the groups can be as small as dyads. Our third conclusion on the importance of the quality of observed peer performance could be more difficult to implement in real practice because of the unavoidable variation in students' skills. The composition of the small groups is generally changing from course to course. But we think that throughout the program, students will have then more chance to observe a skilled model than if they would stay always with the same group.

Third, peer feedback was shown, in our third study, to be beneficial for students' learning of PE psychomotor skills. The size of the positive effect of peer feedback on performance was small, possibly because it is difficult to disentangle peer feedback from peer observation and other educational strategies like expert demonstrations, practice and instructor feedback. We were not able to demonstrate, in our fourth study, that the effect of peer feedback is mediated by characteristics such as the amount, specificity, accuracy or the seeking of peer feedback. It seems that peer feedback can help independent of how specific or accurate it is. At least on the basis of our studies, health professions educational programs that are concerned with improving PE mastering should encourage peer interaction. They could for instance specify in their instructions moments during the sessions when students in the group should comment on the performance of their peers. The discussion that will follow this interaction may provide a chance to correct errors and missed interpretations, which may lead students toward better performance.

Finally, as educators, we often have difficulty to start demonstrations or practice because students hesitate to be the first to practice in a small group setting. They argue that starting first will be disadvantageous, as they would have no possibility of observing peers before practicing and will be the centre of attention, receiving more comments. Our last study, presented in chapter 6, has found no statistically significant differences in the students' PE performance associated with the moment of peer observation or the amount of peer feed back received. It seems that students learn equally well whatever the moment when they have to practice. We can therefore reassure students who are reluctant to start that there will not be any damage for their learning.

Directions for further research

The challenges involved in ensuring PE mastering is a call for researchers concerned with PE teaching to medical students. This dissertation contributed to bringing light on the peer influence on the acquisition of psychomotor skills necessary for medical students to execute PE. That is only one aspect of PE mastering. Those engaged on better understanding PE learning could benefit from questions emerging from this thesis. Unsolved issues came out from the studies and indicate directions for future research.

A first question related with the influence of peer observation on learning, which requires further exploration refers to the optimal size of a small group for learning PE. We obtained some evidence in support of a dyad formation,[10] as it showed that observing more than one peers does not help. In our studies, we used triads, but what will happen if we move toward groups of four, five or six students? Will we have a continuous progression in learning or a decline that will be deleterious at least for some of the students in the group? The answer to these questions will help health educational programs optimize their curriculum.

A second line of research emerging from this thesis refers to peer feedback. Our third study demonstrated the benefits of peer feedback for learning PE psychomotor skills. However, we were not able to determine specific characteristics of peer feedback that could explain its underlying mechanisms. There are two paths that researchers could take to further explore this issue. New studies, ideally under more controlled conditions, could try to investigate more in depth the characteristics that we explored, disentangling the several factors that have probably prevented us from finding effects. Based on our findings in the fourth study, feedback seeking seems a more promising characteristic to study further. This would also be in line with a recent interest in the topic within the medical education domain, with this behaviour being seen as an important marker of the student motivation to learn.[29] The other possible research path is to search for other variables for explaining the efficiency of peer feedback. Thurlings[28] counted in more than forty variables depending on the chosen theory framework. If we stay within Bandura's socio-cognitivist framework,[8] self-efficacy would certainly be a good track for research.

A third issue requiring further exploration is the persistence of the learned performance over time. The ability to reproduce at the end of the session the psychomotor skills required for PE gesture is a first step in the learning process of a good physical examination. However, it will not be sufficient to ensure proper utilization in the clinic, especially if we consider that there is a time lag between the learning activities and the moment in which the students will apply what they learn in the clinic. Retention tests at different moments in time after the training are therefore necessary to explore where what has been learnt remains.[26]

The findings of this thesis help to understand constituents of peer influence on acquisition of PE psychomotor skills at the undergraduate level. These findings can be used, while designing health professions curriculum, to set strategies for PE training in such way that peer influence is maximized and optimal use is made of its potential to contribute to enhance acquisition of psychomotor skills. Avenues for continuing to explore our understanding of PE learning are, therefore, open for future research.

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Appendices

HEAD-TO-TOE INTEGRATED PHYSICAL EXAMINATION

Components of the head-to-toe integrated physical examination

1. General inspection
2. Vital signs: blood pressure, pulse, and respiratory rate
3. Physical examination of the ears, nose, and throat
4. Palpation of cervical lymph nodes
5. Palpation of axillary lymph nodes
6. Lung inspection and auscultation
7. Jugular examination and hepatojugular reflux
8. Cardiac apex
9. Anterior thoracic palpation of the sternochondral and costochondral junctions
10. Cardiac and carotid auscultation
11. Inspection and auscultation of abdomen and femoral area
12. Palpation of abdomen and inguinal area
13. Search of abdominal visceromegaly
14. Vascular examination of lower limbs

STUDY 1
Checklist for the integrated head-to-toe physical examination

Patient Instructor ______ No. _____ Individual _____Student Group ___ Order in the group____

Steps	Procedural efficiency	Positioning (patient and physician)	Signs (Describes what is being looked for)	Technique accuracy and location
Inspection	**1** Follows the order of steps. **2** Sitting	**3** Faces the patient **4** Maintains an overall view	Describes what is being looked for during the visual examination: **5** General appearance **6** Skin colour **7** Breathing difficulty **8** Cyanotic lips **9** Conjunctive colour **10** Follows the above sequence.	**11** Lowers the lower eyelid.
ENT	**12** Follows the order of steps. **13** Sitting	**14** Right side for right ear **15** Left side for left ear **16** Faces the patient for nose and throat	**17** Describes what is being looked for during the examination of the ears, nose, mouth, and pharynx (2/3) **18** Ears **19** Nose **20** Mouth and pharynx **21** Follows the above sequence.	**22** Ambidextrous for the ears **23** Stabilises fingers against the cheek. **24** Uses tongue depressor correctly to inspect areas of the mouth. **25** Handles otoscope correctly.
Cervical lymph nodes	**26** Follows the order of steps. **27** Sitting	**28** Faces the patient	**29** Describes examination criteria for nodes (pain, shape, size, grip: 3/4) **30** Pre-auricular nodes **31** Retro-auricular nodes **32** Occipital nodes **33** Sub-chin nodes **34** Submaxillary nodes **35** Tonsillar nodes **36** Anterior cervical nodes **37** Post-cervical nodes **38** Sus- and subclavicular nodes **39** Follows a logical order	**40** Uses fingertips. **41** Palpates with adequate pressure. **42** Continuous movement of the fingers.
Axillary lymph nodes	**43** Follows the order of steps. **44** Sitting	**45** Faces the patient and slightly moved the armpit examined	**46** Anterior wall **47** Lateral wall **48** Posterior wall **49** Along humerus	**50** Positions hand in the armpit. **51** Supports the arm properly.

Steps	Procedural efficiency	Positioning (patient and physician)	Signs (Describes what is being looked for)	Technique accuracy and location
Lung exam	**53** Follows the order of steps. **54** Sitting	**54** Faces the patient when examining the front. **55** Behind the patient when examining the back	**56** Begins with visual inspection **57** Back inspection **58** Posterior percussion (8 points) **59** Posterior symmetry **60** Anterior auscultation (8 points) **61** Posterior symmetry auscultation **62** Anterior auscultation (3 points) **63** Follows the above sequence.	**50** Positions hand in the armpit. **51** Supports the arm properly.
Neck	**69** Follows the order of steps. **70** Table at 30°	**71** Patient's right side	**72** Examination of jugular (right side) **73** Hepatojugular reflux **74** Execution ordered	**75** Views supraclavicular area. **76** Puts right hand parallel to the costal margin on the mid-clavicle line. **77** Uses tangential light.
Cardiac apex	**78** Follows the order of steps. **79** Table at 30°		**80** Cardiac apex	**81** Places fingers on the appropriate spot on the chest.
Anterior chest palpation	**82** Follows the order of steps. **83** Table is fully reclined.	**84** Changes position to see the patient's face.	**85** Asks the patient if the provoked pain reproduces original complaint. **86** Sternochondral joints **87** Costochondral joints **88** Follows a logical sequence from top to bottom. **89** Follows the above sequence.	**90** Uses thumb to palpate the joints.
Cardiac auscultation	**91** Follows the order of steps. **92** Table is fully reclined.	Cardiac auscultation	**93** Describes what is being looked for during the examination (S1, S2, superimposed noise or S3 or gallop, murmurs: 4/4) With diaphragm: **94** Mitral valve **95** Tricuspid valve **96** Pulmonary valve **97** Aortic valve With bell: **98** Mitral valve **99** Tricuspid valve **100** Right carotid **101** Left carotid **102** Execution ordered	**103** Bell applied lightly. **104** Generally, the stethoscope is placed on the right target areas.

Steps	Procedural efficiency	Positioning (patient and physician)	Signs (Describes what is being looked for)	Technique accuracy and location
Abdominal auscultation	**105** Follows the order of steps. **106** Table is fully reclined.		**107** Describes what is being looked for during the examination (scars, deformities or masses, rash or skin lesions: 2/3) **108** Describes what is being looked for (peristalsis, breath: 2/2) Auscultation for peristalsis **109** At least 2 quadrants Auscultation for murmurs: **110** Aorta **111** Renal arteries **112** Iliac arteries **113** Femoral artery **114** Execution ordered	Stethoscope placed specifically on: **115** Aorta **116** Renal arteries **117** Iliac arteries **118** Lifts undergarment to listen to femoral arteries.
Abdominal percussion and palpation	**119** Following the order of steps. **120** Table is fully reclined.	**121** Changes position to see the patient's face.	**122** Percussion (4 quadrants) Superficial and deep palpation **123** Right subcostal **124** Epigastric area **125** Left subcostal **126** Left lumbar **127** Left inguinal area **128** Hypogastric area **129** Right iliac fosse **130** Right inguinal area **131** Umbilical area **132** Executes the sequence continuously and orderly (femoral pulses, inguinal lymph nodes: 2/2) **133** Execution ordered **134** Describes what is being looked for when lifting undergarment.	**135** Palpates 9 zones by placing the hands in the right place **136** Uses appropriate surface pressure **137** Uses appropriate deep pressure
Visceromegaly	**138** Following the order of steps. **139** Table is fully reclined.	**140** Changes position to see the patient's face.	**141** Liver **142** Right kidney **143** Left kidney **144** Spleen	**145** Ambidextrous **146** Applies appropriate pressure for right exams. **147** Uses 1/3 appropriate techniques for liver examination (pliers, hook, or iliac crest). **148** Kidneys: proper use of the clamp on the right side. **149** Spleen: orients hand under the left costal margin.

Steps	Procedural efficiency	Positioning (patient and physician)	Signs (Describes what is being looked for)	Technique accuracy and location
Inferior limbs	**150** Follows the order of steps. **151** Table is fully reclined.	**152** At the patient's feet	**153** Describes what is being looked for during the examination (asymmetric legs, skin discoloration, hair, skin lesions, swelling: 3/5) **154** Describes what is being looked for: **155** Posterior tibial pulse **156** Dorsalis pedis pulse **157** Pitting edema	**158** Palpates the right structures.
Total score	_______/26	_______/14	_______/83	_______/35

Instructions for scoring:

- Tick what you observe.
- Cross out missing data.
- Under "Steps," tick items that have been completely performed.
- Under "Technique Accuracy and Location," tick items if the movements are accurate and the target areas appropriate.

RECHERCHE 1
Grille d'évaluation de l'examen physique intégré

Patient formateur___ No étudiant___ Individuel___ Groupe___ Ordre dans le groupe___

Éta-pes	Efficacité procédurale	Positionnement (patient et médecin)	Exécution ordonnée	Précision des gestes et localisation
Inspection	**1** Suit l'ordre des étapes **2** Assis	**3** Face au patient **4** Maintient une vision d'ensemble	Décrit ce qu'il recherche: **5** Apparence générale **6** Coloration de la peau **7** Difficulté respiratoire **8** Cyanose des lèvres **9** Couleur des conjonctives **10** Exécution ordonnée	**11** Abaisse la paupière inférieure
ORL	**12** Suit l'ordre des étapes **13** Assis	**14** Côté droit pour oreille droite **15** Côté gauche pour oreille gauche **16** Face au patient pour nez, gorge	**17** Décrit ce qu'il recherche pendant l'examen des oreilles, du nez et de la bouche-pharynx (2/3) **18** Oreilles **19** Nez **20** Bouche et pharynx **21** Exécution ordonnée	**22** Ambidextre pour les oreilles **23** S'appuie sur la joue **24** Utilise optimalement l'abaisse-langue pour inspecter les zones de la bouche **25** Prise adéquate de l'otoscope
Ganglions cervicaux	**26** Suit l'ordre des étapes **27** Assis	**28** Face au patient	**29** Décrit ce qu'il recherche (douleur, forme, grosseur, adherence; 3/4) **30** Pré-auriculaires **31** Rétro-auriculaires **32** Occipitaux **33** Sous-mentonnier **34** Sous-maxillaires **35** Amygdaliens **36** Cervicaux antérieurs **37** Cervicaux postérieurs **38** Sus et sous-claviculaires **39** Les fait dans un ordre logique	**40** Utilise pulpe des doigts **41** Palpe avec une pression adéquate **42** Mouvement continu des doigts
Ganglions axillaires	**43** Suit l'ordre des étapes **44** Assis	**45** Face au patient, légèrement déplacé vers l'aisselle examinée	**46** Antérieure **47** Latérale **48** Postérieure **49** Long humérus	**50** Positionne main dans le creux de l'aisselle **51** Supporte bien votre bras.

Étapes	Efficacité procédurale	Positionnement (patient et médecin)	Exécution ordonnée	Précision des gestes et localisation
Examen pulmonaire	**52** Suit l'ordre des étapes **53** Assis	**54** Face au patient pour antérieur **55** Dos au patient pour postérieur	**56** Inspection avant **57** Inspection arrière **58** Percussion postérieure (8 points) **59** Symétrie de la percussion postérieure **60** Auscultation postérieure (8 points) **61** Symétrie de l'auscultation postérieure **62** Auscultation antérieure (3 points) **63** Exécution ordonnée	**64** Doigt percuté parallèle aux côtes. **65** Sonorité efficace En antérieur, place le stéthoscope précisément **66** Lobe supérieur G **67** Lobe supérieur D **68** Lobe moyen
Cou	**69** Suit l'ordre des étapes **70** Table à 30°	**71** Côté droit du patient	**72** Examen des jugulaires (côté droit) **73** Reflux hépato-jugulaire **74** Exécution ordonnée	**75** Regarde zone sus-claviculaire **76** Met sa main droite parallèle au rebord costal sur la ligne miclaviculaire. **77** Utilise une lumière tangentielle
Apex coeur	**78** Suit l'ordre des étapes **79** Table à 30°		**80** Apex cardiaque	**81** Appose bien les doigts sur le thorax
Palpation thoracique antérieure	**82** Suit l'ordre des étapes **83** Couché	**84** Se place pour voir le visage du patient	**85** Demande au patient s'il présente de la douleur **86** Jonctions sterno-chondrales **87** Jonctions costo-chondrales **88** Suit une séquence logique de haut en bas **89** Exécution ordonnée	**90** Utilise le pouce pour palper les jonctions
Auscultation cardiaque	**91** Suit l'ordre des étapes **92** Couché		**93** Décrit ce qu'il entend (B1, B2, bruits surajoutés ou galop ou B3, souffles: 4/4) Avec diaphragme: **94** Foyer mitral **95** Foyer tricuspidien **96** Foyer pulmonaire **97** Foyer aortique Avec cloche **98** Foyer mitral **99** Foyer tricuspidien **100** Carotides droite **101** Carotides gauche **102** Exécution ordonnée	**103** Cloche est déposée sur la peau sans pression. **104** Globalement, stéthoscope placé au bon endroit pour chaque zone.

Éta-pes	Efficacité procédurale	Positionnement (patient et médecin)	Exécution ordonnée	Précision des gestes et localisation
Auscultation abdominale	**105** Suit l'ordre des étapes **106** Couché		**107** Décrit ce qu'il observe (cicatrices, déformations ou masses, rougeurs ou lésions de la peau: 2/3) **108** Décrit ce qu'il recherche (péristaltisme, souffle: 2/2) Auscultation péristaltisme **109** Au moins 2 quadrants Auscultation souffles: **110** Aorte **111** Artères rénales **112** Artères iliaques **113** Artères fémorales **114** Exécution ordonnée	Stéthoscope placé précisément sur : **115** Aorte **116** Artères rénales **117** Artères iliaques **118** Soulève le sous-vêtement pour ausculter les artères fémorales
Percussion et palpation abdominale	**119** Suit l'ordre des étapes **120** Couché	**121** Se place pour voir le visage du patient	**122** Percussion (4 quadrants) Palpation superficielle et profonde **123** Hypocondre droit **124** Épigastre **125** Hypocondre gauche **126** Flanc gauche **127** Fosse iliaque gauche **128** Suspubien **129** Fosse iliaque droite **130** Flanc droit **131** Péri-ombilical **132** Exécute la séquence de manière continue et ordonnée (pouls fémoraux, ganglions inguinaux: 2/2) **133** Exécution ordonnée **134** Dit ce qu'il recherche en soulevant le sous-vêtement	**135** Palpe les 9 zones en plaçant les mains au bon endroit **136** Exerce une pression superficielle appropriée **137** Exerce une pression profonde appropriée
Viscéromégalie	**138** Suit l'ordre des étapes **139** Couché	**140** Se place pour voir le visage du patient	**141** Foie **142** Rein droit **143** Rein gauche **144** Rate	**145** Ambidextre **146** Exerce une pression appropriée pour les examens du côté droit **147** Foie: utilise une des 3 techniques appropriées (pince, crochet ou crête iliaque) **148** Reins: bonne utilisation de la pince du côté droit **149** Rate: pointe la main vers le rebord costal G

Éta-pes	Efficacité procédurale	Positionnement (patient et médecin)	Exécution ordonnée	Précision des gestes et localisation
Membres inférieurs	**150** Suit l'ordre des étapes **151** Couché	**152** Au pied du patient	**153** Décrit ce qu'il observe (asymétrie des jambes, coloration de la peau, pilosité, lésions de la peau, enflure: 3/5) **154** Décrit ce qu'il recherche: **155** Pouls tibio-postérieurs **156** Pouls pédieux **157** Signe de godet	**158** Palpe les bonnes structures
Score	_______/ 26	_______/ 14	_______/ 83	_______/ 35

Consignes d'évaluation :

- Cochez ce que vous observez et rayez les données manquantes.
- Pour « Exécution ordonnée », cochez si l'élément est bien fait avec toutes les étapes.
- Pour « Précision des gestes », cochez si la précision des gestes et la localisation de l'élément sont au bon endroit.

NEUROLOCOMOTOR EXAMINATION FOR LOW-BACK PAIN

Components of the neurolocomotor examination for low-back pain

- Strength of lower limbs while walking
- Back observation
- Amplitude of lumbar movement (flexion, extension, lateral inclination, and rotation)
- Reflexes of lower limbs (patellar and ankle)
- Sensibility of lower limbs (L3, L4, L5, and S1)
- Tripod test
- Lasegue test (straight leg rising) and strengtened Lasegue on both legs
- Amplitude of hip movement (flexion, rotation, and pain searching)
- Faber test on both legs
- Lumbar palpation (paravertebral muscles, spinal processes from L1 to S1, paravertebral gutters, and sacroiliac joint)

STUDIES 2–5
Checklist for the neurolocomotor examination for low-back pain

Patient Instructor ______ No. _____ Individual _____Student Group ___ Order in the group____

Steps	Positioning	Execution	Signs (Describes what is being looked for)*	Technique accuracy and location
Standing position	**1** Sits behind the patient to test motion range	**2** Asks the patient to cross their arms while standing up.	**18** Force L4	
		3 Asks the patient to take a few steps and return while observing patient's posture and gait.	**19** Posture **20** Gait **21** lameness	
		4 Asks the patient to walk on heels.	**22** Force L5	
		5 Asks the patient to walk on tiptoe.	**23** Force S1	
		6 Observes patient's back.	**24** Swelling / deformities **25** Scoliosis	
		7 Places hands on the right and left iliac crests.		**32** Checks if patient's pelvis is leveled (placed hands exactly on iliac crests or leans to observe the iliac crests).
		8 Stabilises the patient's pelvis with one hand and asks the patient to not bend at the knees. **9** Asks the patient to lean forward and touch the floor.	**26** Pain during flexion	
		10 Presses lightly on the shoulder to achieve maximum flexion that patient could get.	**27** Blocking of the maximum amplitude	**33** Other hand placed exactly on the shoulder.
		11 Brings the patient backward while pulling on shoulder while stabilizing the patient's pelvis with one hand. **12** Exerts pressure to check maximum amplitude.	**28** Pain during extension	**34** Other hand placed exactly on the shoulder.
		13 Asks the patient to lean towards right knee as far as possible. **14** Exerts pressure to check maximum amplitude.	**29** Pain during right lateral inclination	
		15 Asks the patient to lean towards the left knee as far as possible. **16** Exerts pressure to check maximum amplitude.	**30** Pain during left lateral inclination **31** Mentions Schöeber criteria or finger-floor distance at this stage or after the flexion–extension of the back.	
		17 Follows a logical order during this sequence.		

Steps	Positioning	Execution	Signs (Describes what is being looked for)*	Technique accuracy and location
Sitting position	**35** Asks the patient to sit. **36** Sits facing the patient.	**37** Asks the patient to cross their arms to opposite shoulder.		
		38 Asks the patient to turn the right shoulder forward. **39** Exerts pressure to check maximum amplitude.	**54** Pain during right rotation	
		40 Asks the patient to turn the left shoulder forward. **41** Exerts pressure to check maximum amplitude.	**55** Pain during left rotation	
		42 Checks right and left patellar reflexes.	**56** Decreased or increased L4 reflex - Asymmetry	**64** Targets the appropriate spot with the reflex hammer.
		43 Checks right and left ankle reflexes while supporting the foot.	**57** Decreased or increased L5 and S1 reflex - Asymmetry	**65** Targets the appropriate spot with the reflex hammer.
		44 Asks the patient if the sensation is similar on both sides.		
		45 Touches the interior of both thighs.	**58** Sensitivity L3	**66** Touches the exact spot. **67** Touches both sides simultaneously.
		46 Touches the interior of both legs.	**59** Sensitivity L4	**68** Touches the exact spot. **69** Touches both sides simultaneously.
		47 Touches the spaces between the big toe and second toe on both feet.	**60** Sensitivity L5	**70** Touches the exact spot. **71** Touches both sides simultaneously.
		48 Touches the outside of the little toe (metatarsal head) on both feet.	**61** Sensitivity S1	**72** Touches the exact spot. **73** Touches both sides simultaneously.
		49 Executes the right tripod: performs an extension of the knee while holding the leg above the heel. **50** Puts the other hand on the thigh to stabilise the knee.	**62** Looks for pain or blokage.	**74** Executes the movement at an appropriate speed (slow).
		51 Executes the left tripod: performs an extension of the knee while holding the leg above the heel. **52** Puts the other hand on the thigh to stabilise the knee.	**63** Looks for pain or blokage.	**75** Executes the movement at an appropriate speed (slow).
		53 Follows a logical order during this sequence.		

Steps	Positioning	Execution	Signs (Describes what is being looked for)*	Technique accuracy and location
Supine position	**76** Asks the patient to lie on back, legs straight. **77** Raises the table footrest.	**78** Elevates the right leg in extension, with the right hand under the sole and the left hand on the knee (Lasegue).	**95** Lumbar pain irradiating to the calf.	**110** Executes the movement at appropriate speed (slow). **111** Raise leg between 30^0 and 60^0.
		79 Exerts pressure on the extended leg by pressing the foot while pressing down on the knee with the other hand (Strengtened Lasegue).	**96** Lumbar pain irradiating to the calf.	**112** Places hands under the sole of the foot. **113** Visibly exerts sufficient pressure.
		80 Flexes the right knee toward the abdomen.	**97** Hip flexion.	**114** Stops at vertical axis. **115** Flexes knee upward.
		81 Brings the right thigh to 90^0.		**116** Stops at vertical axis. **117** Stabilises leg with left hand.
		82 While in this position, rotates leg towards the right and towards the left.	**98** Hip rotation.	**118** Keeps the knee at 90^0. **119** Does not force the movement.
		83 Places the hand on the knee and exerts pressure on the right hip.	**99** Hip pain.	**120** Visibly exerts sufficient pressure. **121** Stay at vertical axis during the pressure on knee.
		84 Puts right ankle onto the left knee.		
		85 Exerts downward pressure on right knee while stabilising the pelvis with left hand (Faber).	**100** Buttocks, hip, groin pain **101** Sacroiliac pain	**122** Put hand on left iliac crest.
		86 Elevates the left leg in extension, with right hand under the sole and left hand on the knee (Lasegue).	**102** Lumbar pain irradiating to the calf.	**123** Executes the movement at appropriate speed (slow). **124** Raises leg between 30^0 and 60^0.
		87 Exerts pressure on the extended leg by pressing the foot while pressing down on the knee with the other hand (Reinforced Lasegue).	**103** Lumbar pain irradiating to the calf.	**125** Places hands under the sole of the foot. **126** Visibly exerts sufficient pressure.
		88 Flexes the left knee toward the abdomen.	**104** Hip flexion	**127** Stops at vertical axis. **128** Flexes knee up.
		89 Brings the left thigh to 90^0.		**129** Rest at vertical axis. **130** Stabilises leg with left hand.
		90 While in this position, rotates towards the right and towards the left.	**105** Hip rotation	**131** Keeps the knee at 90^0. **132** Does not force movement.
		91 Place the hand on the knee and exert pressure on the right hip.	**106** Pain	**133** Visibly exerts sufficient pressure. **134** Rest at vertical axis.
		92 Puts left ankle on right knee.		
		93 Exerts downward pressure on left knee while stabilizing the pelvis with right hand (FABER).	**107** Buttocks, hip, groin pain **108** Sacroiliac pain	**135** Put hand on right iliac crest.
		109 Mentions that they will check the plantar cutaneous reflex for the Babinski sign if hyperreflexia observed at any time while the patient is in the supine position.		
		94 Follows a logical order during this sequence.		

<table>
<tr><th>Steps</th><th>Positioning</th><th>Execution</th><th>Signs (Describes what is being looked for)*</th><th>Technique accuracy and location</th></tr>
<tr><td rowspan="8">Lying on stomach position</td><td rowspan="8">136 Asks the patient to turn onto their stomach.

137 Places a pillow under the patient’s abdomen.

138 Asks the patient to place their arms alongside their body.

139 Ensures the patient’s face is visible.

140 Moves upward to be in line with the patient’s buttocks.</td><td>141 Begins to palpate paravertebral muscles on one side (right or left).</td><td>149 Spasm</td><td rowspan="7">154 Exerts sufficient pressure.</td></tr>
<tr><td>142 Palpates paravertebral muscles on the opposite side.</td><td>150 Spasm</td></tr>
<tr><td>143 Palpates spinal processes of L1 to S1 or S1 to L1.</td><td>151 Pain</td></tr>
<tr><td>144 Begins to palpate paravertebral gutters on one side (right or left).</td><td rowspan="2">152 Pain</td></tr>
<tr><td>145 Palpates paravertebral gutters on the opposite side.</td></tr>
<tr><td>146 Begins to palpate one sacroiliac joint (right or left).</td><td rowspan="2">153 Pain</td></tr>
<tr><td>147 Palpates the opposite sacroiliac joint.</td></tr>
<tr><td colspan="3">148 Follows a logical order during this sequence.</td></tr>
<tr><td>Total score</td><td>___/16</td><td>_____/54</td><td>_____/45</td><td>_____/60</td></tr>
</table>

Instructions for scoring:

- Tick what you observe.
- Cross out missing data.
- Under "Steps," tick items that have been completely performed.
- Under "Technique Accuracy and Location," tick items if the movements are accurate and the target areas appropriate.

*The column of "Signs (Describes what is being looked for)" was not considered for the analysis.

RECHERCHES 2–5
Grille d'évaluation de l'examen physique neurolocomoteur pour lombalgie

Patient formateur___ No étudiant___ Individuel___ Groupe___ Ordre dans le groupe___

Étape	Position-nement	Exécution	Éléments recherchés (Décrit ce qu'il recherche)*	Précision des gestes et localisation
Debout	**1** Se place dos au patient pour tester l'amplitude articulaire.	**2** Demande au patient de se lever en ayant les bras croisés.	**18** Force L4	
		3 Demande au patient de faire quelques pas (aller-retour) tout en observant la posture et la démarche.	**19** Posture **20** Démarche **21** Boiterie	
		4 Demande au patient de marcher sur les talons.	**22** Force L5	
		5 Demande au patient de marcher sur le bout des pieds.	**23** Force S1	
		6 Observe le dos.	**24** Gonflement/ difformités **25** Scoliose	
		7 Met les mains sur les crêtes iliaques D et G.		**32** Vérifie si le bassin est au niveau (place les mains sur les crêtes iliaques et/ou se baisse).
		8 Maintient en place le bassin du patient en précisant de ne pas plier les genoux. **9** Demande au patient de se pencher vers l'avant pour toucher au sol.	**26** Douleur à la flexion	
		10 Presse légèrement sur l'épaule une fois le maximum de flexion atteint par le patient.	**27** Blocage de l'amplitude maximale	**33** Met l'autre main à l'endroit approprié sur l'épaule.
		11 Amène le patient vers l'arrière en tirant sur l'épaule tout en soutenant le bassin du patient d'une main. **12** Exerce une pression vers l'arrière pour vérifier l'amplitude max.	**28** Douleur à l'extension	**34** Met l'autre main à l'endroit approprié sur l'épaule.
		13 Demande au patient de se pencher vers son genou D le plus loin possible tout en l'assistant dans son mouvement. **14** Exerce une pression pour vérifier l'amplitude max.	**29** Douleur à l'inclinaison latérale D	
		15 Demande au patient de se pencher vers son genou G le plus loin possible tout en l'assistant dans son mouvement. **16** Exerce une pression pour vérifier l'amplitude max.	**30** Douleur à l'inclinaison latérale G **31** Parle du Schöber ou de la mesure doigts-sol à cette étape ou après la flexion-extension du dos.	

		17 Respecte l'ordre d'exécution de la séquence debout.

Étape	Position-nement	Exécution	Éléments recherchés (Décrit ce qu'il recherche)*	Précision des gestes et localisation
Assis	**35** Demande au patient de s'asseoir. **36** Se place face au patient.	**37** Demande au patient de plier les bras sur ses épaules.		
		38 Demande au patient de tourner l'épaule D vers l'avant tout en l'assistant dans son mouvement de rotation. **39** Exerce une pression pour vérifier l'amplitude max.	**54** Douleur à la rotation D	
		40 Demande au patient de tourner l'épaule G vers l'avant tout en l'assistant dans son mouvement de rotation. **41** Exerce une pression pour vérifier l'amplitude max.	**55** Douleur à la rotation G	
		42 Fait les réflexes rotuliens D et G.	**56** Diminution ou augmentation du réflexe L4 - Assymétrie	**64** Frappe au bon endroit avec le marteau réflexe.
		43 Fait les réflexes achilléens D et G en soutenant la plante du pied.	**57** Diminution ou augmentation du réflexe L5 et S1 - Assymétrie	**65** Frappe au bon endroit avec le marteau réflexe.
		44 Demande au patient de lui dire si la sensation est similaire des deux côtés.		
		45 Touche la face interne des deux cuisses.	**58** Sensibilité L3	**66** Touche le point précis. **67** Fait le mouvement des deux côtés en même temps.
		46 Touche la face interne des deux jambes.	**59** Sensibilité L4	**68** Touche le point précis. **69** Fait le mouvement des deux côtés en même temps.
		47 Touche au-dessus de l'espace D et G entre le gros orteil et le 2^{e} orteil.	**60** Sensibilité L5	**70** Touche le point précis. **71** Fait le mouvement des deux côtés en même temps.
		48 Touche la partie externe du pied.	**61** Sensibilité S1	**72** Touche le point précis. **73** Fait le mouvement des deux côtés en même temps.
		49 Fait le tripode D : effectue une extension du genou D en tenant la jambe sous le talon. **50** Met l'autre main sur la cuisse pour se stabiliser.	**62** Douleur ou blocage	**74** Fait le mouvement à une vitesse appropriée (lent).
		51 Fait le tripode G : effectue une extension lente du genou G en tenant la jambe sous le talon. **52** Met l'autre main sur la cuisse pour se stabiliser.	**63** Douleur ou blocage	**75** Fait le mouvement à une vitesse appropriée (lent).
		53 Respecte l'ordre d'exécution pour la séquence assise.		

Étape	Position-nement	Exécution	Éléments recherchés (Décrit ce qu'il recherche)*	Précision des gestes et localisation
Couché sur le dos	**76** Demande au patient de se coucher sur le dos, jambes allongées. **77** Tire le pied de la table.	**78** Jambe étendue, main D sous la plante du pied et main G sur le genou, élève la jambe D en extension (Lasègue).	**95** Douleur lombaire irradiant au molet	**110** Fait le mouvement à une vitesse appropriée (lent). **111** Lève la jambe entre 30^0 et 60^0.
		79 Renforce le Lasègue en pressant le pied en flexion, jambe étendue et soutenue avec l'autre main.	**96** Douleur lombaire irradiant au molet	**112** Laisse sa main sous la plante des pieds. **113** Exerce une pression suffisante visible à l'œil.
		80 Fléchit le genou D sur l'abdomen.	**97** Flexion de la hanche	**114** Arrête à la verticale. **115** Fléchit le genou au maximum.
		81 Ramène la cuisse D à 90^0.		**116** Arrête à la verticale. **117** Fixe la jambe avec la main gauche.
		82 Dans cette position, fait rotation de la hanche D vers la droite et la gauche.	**98** Rotation de la hanche	**118** Garde le genou à 90^0. **119** Ne force pas.
		83 Place la main sur le genou et appuie pour exercer une pression sur la hanche D.	**99** Douleur à la hanche	**120** Exerce une pression suffisante visible à l'œil. **121** Arrête à la verticale.
		84 Bascule la cheville D sur le genou G tout en soutenant le genou D.		
		85 Exerce une pression vers le bas sur genou D tout en maintenant le bassin G avec l'autre main (Faber).	**100** Douleur à la fesse et à la hanche/aine **101** Douleur sacro-iliaque	**122** Met une main sur la crête iliaque gauche.
		86 Jambe étendue, main D sous la plante des pieds et main G sur le genou, élève la jambe G en extension (Lasègue).	**102** Douleur lombaire irradiant au mollet	**123** Fait le mouvement à une vitesse appropriée (lent). **124** Lève la jambe entre 30^0 et 60^0.
		87 Presse le pied en flexion, jambe étendue et soutenue avec l'autre main.	**103** Douleur lombaire irradiant au mollet	**125** Laisse sa main sous la plante des pieds. **126** Exerce une pression suffisante visible à l'œil.
		88 Fléchit le genou G sur l'abdomen.	**104** Flexion de la hanche	**127** Arrête à la verticale. **128** Fléchit le genou au maximum.
		89 Ramène la cuisse G à 90^0.		**129** Arrête à la verticale. **130** Fixe la jambe avec la main gauche.
		90 Dans cette position, fait rotation de la hanche G vers la droite et la gauche.	**105** Rotation de la hanche	**131** Garde le genou à 90^0. **132** Ne force pas.
		91 Place la main sur le genou et appuie pour exercer une pression sur la hanche G.	**106** Douleur à la hanche	**133** Exerce une pression suffisante visible à l'œil. **134** Arrête à la verticale.
		92 Bascule la cheville G sur le genou D tout en soutenant le genou G.		
		93 Exerce une pression vers le bas sur genou G tout en maintenant le bassin D avec l'autre main (Faber).	**107** Douleur à la fesse et à la hanche/aine **108** Douleur sacro-iliaque	**135** Met une main sur la crête iliaque droite.
		109 Indique qu'il ferait le réflexe cutané plantaire D et G ou qu'il rechercherait le Babinski, si hyperréflexie.		
		94 Respecte l'ordre d'exécution pour la séquence couché sur le dos.		

<table>
<tr><th>Étape</th><th>Position-nement</th><th>Exécution</th><th>Éléments recherchés (Décrit ce qu'il recherche)*</th><th>Précision des gestes et localisation</th></tr>
<tr><td rowspan="8">Couché sur le ventre</td><td rowspan="8">136 Demande au patient de se tourner sur le ventre.
137 Met un oreiller sous le ventre du patient.
138 Demande au patient de mettre les bras le long du corps.
139 Se place avec la tête orientée vers le haut du corps du patient.
140 Se positionne à hauteur des fesses du patient.</td><td>141 Palpe les muscles paravertébraux droits.</td><td>149 Spasme</td><td rowspan="7">154 Exerce une pression appropriée.</td></tr>
<tr><td>142 Palpe les muscles paravertébraux gauches.</td><td>150 Spasme</td></tr>
<tr><td>143 Palpe les apophyses épineuses de L1 à S1 ou de S 1 à L1.</td><td>151 Douleur</td></tr>
<tr><td>144 Palpe les gouttières paravertébrales droites.</td><td rowspan="2">152 Douleur</td></tr>
<tr><td>145 Palpe les gouttières paravertébrales gauches.</td></tr>
<tr><td>146 Palpe la jonction sacroiliaque droite.</td><td rowspan="2">153 Douleur</td></tr>
<tr><td>147 Palpe la jonction sacroiliaque gauche.</td></tr>
<tr><td colspan="3">148 Respecte l'ordre d'exécution pour la séquence couché sur le ventre.</td></tr>
<tr><td>Score*</td><td>_______/ 10</td><td>_______/ 58</td><td>_______/ 44</td><td>_______/ 42</td></tr>
</table>

Instructions pour l'évaluation :

- Marquer les observations.
- Inscrire 0 pour les données manquantes.
- Dans la colonne « Exécution », sélectionner un item s'il est bien fait.
- Sélectionner le dernier item de « Exécution » si la séquence est faite dans l'ordre parfaitement (l'étudiant peut obtenir ce point même s'il oublie certains éléments de la séquence. L'important est que les items qui ont été faits, aient été faits dans l'ordre).

* La colonne des « éléments recherchés » n'a jamais été considérée pour les analyses.

QUESTIONNAIRES – STUDY 3

STUDY 3
Practice neurolocomotor examination with a patient instructor (PI)
Pre-activity questionnaire (#1)

Familiarity with the neurolocomotor examination

Please indicate your experience with the neurolocomotor examination by responding to the following.

Less than 30 minutes	From 30 to 60 minutes	From 1 to 2 hours	More than 2 hours
1	*2*	*3*	*4*

1.	During the last week, I practised the *neurolocomotor examination*.	1	2	3	4
2.	During the last month, I practised the *neurolocomotor examination*.	1	2	3	4
3.	During the last 6 months, I practised the *neurolocomotor examination*.	1	2	3	4
4.	During the last week, I read about the *neurolocomotor examination*.	1	2	3	4
5.	During the last month, I read about the *neurolocomotor examination*.	1	2	3	4
6.	During the last 6 months, I read about the *neurolocomotor examination*.	1	2	3	4

Neurolocomotor-examination skill

Please indicate your levels of confidence and performance with respect to the neurolocomotor examination.

7. I would rate my level of confidence in performing a complete neurolocomotor examination as:

Not confident									Very confident
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

8. I would rate my skill level in performing a complete neurolocomotor examination as:

Minimum									Maximum
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Feedback

Please indicate your level of agreement with the following items.

Totally disagree	Disagree	Agree	Totally agree
1	*2*	*3*	*4*

9.	The best way to learn how to perform the neurolocomotor examination is to observe an expert.	1	2	3	4
10.	Feedback from peers helps me improve my clinical skills.	1	2	3	4
11.	Patient instructors do not have the competencies needed to help me learn how to perform the neurolocomotor examination.	1	2	3	4
12.	Feedback is only relevant when it comes from an expert.	1	2	3	4
13.	I appreciate learning activities where I can receive feedback from my peers.	1	2	3	4
14.	Patient instructors helped me improve my clinical skills through constructive feedback.	1	2	3	4

RECHERCHE 3
Pratique de l'examen lombaire intégré avec un patient formateur
Questionnaire pré-activité (No 1)

Familiarité avec l'examen physique lombaire

Veuillez indiquer votre exposition à l'examen physique lombaire intégré :

Moins de 30 minute	De 30 à 60 minutes	De 1 à 2 heures	Plus de 2 heures
1	*2*	*3*	*4*

1.	Dans la dernière semaine, j'ai pratiqué l'examen lombaire intégré.	1	2	3	4
2.	Dans le dernier mois, j'ai pratiqué l'examen lombaire intégré.	1	2	3	4
3.	Dans les derniers 6 mois, j'ai pratiqué l'examen lombaire intégré.	1	2	3	4
4.	Dans la dernière semaine, j'ai lu à propos de l'examen lombaire intégré.	1	2	3	4
5.	Dans le dernier mois, j'ai lu à propos de l'examen lombaire intégré.	1	2	3	4
6.	Dans les derniers 6 mois, j'ai lu à propos de l'examen lombaire intégré.	1	2	3	4

Habileté à exécuter l'examen physique lombaire

Veuillez indiquer votre niveau de confiance et d'habileté:

7. J'évalue mon niveau de confiance à exécuter un examen lombaire intégré à:

Peu confiant									Totalement confiant
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

8. J'évalue mon niveau d'habileté à exécuter un examen lombaire intégré à:

Habileté minimale									Habileté maximale
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Rétroaction

Veuillez indiquer votre niveau d'accord avec les énoncés suivants :

Totalement en désaccord	En désaccord	En accord	Totalement en accord
1	*2*	*3*	*4*

9.	La meilleure façon d'apprendre l'examen physique lombaire intégré est d'observer un expert (clinicien).	1	2	3	4
10.	La rétroaction de mes pairs m'aide habituellement à améliorer mes habiletés cliniques.	1	2	3	4
11.	Les patients formateurs n'ont pas les compétences requises pour m'aider à apprendre l'examen physique lombaire intégré.	1	2	3	4
12.	Une rétroaction est seulement pertinente lorsqu'elle provient d'un expert.	1	2	3	4
13.	J'apprécie les activités d'apprentissages où il m'est possible de recevoir de la rétroaction de mes pairs.	1	2	3	4
14.	Le patient formateur m'aide à développer mes habiletés cliniques par le biais d'une rétroaction constructive.	1	2	3	4

STUDY 3
Practice neurolocomotor examination with a patient instructor (PI)
Post-activity questionnaire (#2)

Please indicate your level of agreement with the following items.

Totally disagree	Disagree	Agree	Totally agree
1	2	3	4

Satisfaction

1.	The information presented during the activity was well organized.	1	2	3	4
2.	Audio-visual material was pertinently used during the activity.	1	2	3	4
3.	The learning activity helped me improve the clinical skills useful in performing the neurolocomotor examination.	1	2	3	4
4.	The learning activity helped me improve knowledge useful in performing the neurolocomotor examination with a patient.	1	2	3	4
5.	I learned about specific procedures.	1	2	3	4
6.	This clinical experience influenced my personal development as a medical student.	1	2	3	4
7.	The student-to-PI ratio was adequate.	1	2	3	4
8.	This learning activity was well organized.	1	2	3	4
9.	The teaching context was favourable to learning.	1	2	3	4

Comments

10. What did you like most about this activity?

____
____
____

11. What did you like least about this activity?

____
____
____

12. Do you have any suggestions for improving this activity?

____
____
____

RECHERCHE 3
Pratique de l'examen lombaire intégré avec un patient formateur
Questionnaire post-activité (No 2)

Veuillez indiquer votre niveau d'accord avec les énoncés suivants:

Totalement en désaccord	En désaccord	En accord	Totalement en accord
1	*2*	*3*	*4*

Satisfaction

1.	L'information présentée était bien organisée.	1	2	3	4
2.	Il y a eu une utilisation pertinente d'audio-visuel.	1	2	3	4
3.	La session d'apprentissage m'a aidé à améliorer mes habiletés à faire l'examen physique lombaire intégré.	1	2	3	4
4.	Cette session d'apprentissage à améliorer mes connaissances à faire l'examen physique lombaire intégré avec un patient.	1	2	3	4
5.	J'ai appris à propos de procédures spécifiques.	1	2	3	4
6.	Cette expérience clinique a influencé mon développement personnel en tant qu'étudiant en médecine.	1	2	3	4
7.	Le ratio étudiant/patient formateur était approprié.	1	2	3	4
8.	Cette activité pédagogique était bien organisée.	1	2	3	4
9.	L'environnement d'enseignement était favorable à l'apprentissage.	1	2	3	4

Commentaires

10. Quels sont les éléments que vous avez le plus appréciés dans le cadre de cette activité?

____

____

____

11. Quels sont les éléments que vous avez moins appréciés dans le cadre de cette activité?

____

____

____

12. Quelles suggestions auriez-vous pour améliorer cette formation?

____

____

____

STUDY 3
Practice neurolocomotor examination with a patient instructor (PI)
Post-assessment questionnaire (#3)

Neurolocomotor-examination skill

Please indicate your level of confidence and your ability to in perform a neurolocomotor examination.

1. I would rate my level of confidence in performing a neurolocomotor examination as:

Not confident									Very confident
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. I would rate my skill level in performing a neurolocomotor examination as:

Minimum									Maximum
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Feedback

Please indicate your level of agreement with the following items.

Not applicable	Totally disagree	Disagree	Agree	Totally agree
NA	*1*	*2*	*3*	*4*

3.	The patient instructor had the appropriate knowledge to teach the neurolocomotor examination.	NA	1	2	3	4
4.	My colleagues had good knowledge about the neurolocomotor examination.	NA	1	2	3	4
5.	The patient instructor interacted well with the students.	NA	1	2	3	4
6.	The patient instructor had a good attitude.	NA	1	2	3	4
7.	My colleagues had good attitudes.	NA	1	2	3	4
8.	The patient instructor was able to guide me in learning the neurolocomotor examination.	NA	1	2	3	4
9.	The patient instructor gave constructive feedback.	NA	1	2	3	4
10.	The patient instructor’s feedback gave me confidence.	NA	1	2	3	4
11.	My colleagues interacted well with each other.	NA	1	2	3	4
12.	The patient instructor used his experience constructively.	NA	1	2	3	4
13.	The feedback from my peers was relevant.	NA	1	2	3	4

RECHERCHE 3
Pratique de l'examen lombaire intégré avec un patient formateur
Questionnaire post-évaluation (No 3)

Habileté à exécuter l'examen physique lombaire

Veuillez indiquer votre niveau de confiance et d'habileté :

1. J'évalue mon niveau de confiance à exécuter un examen lombaire intégré à :

Peu confiant									Totalement confiant
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. J'évalue mon habileté pour exécuter un examen lombaire intégré à :

Habileté minimale									Habileté maximale
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Rétroaction

Veuillez indiquer votre niveau d'accord avec les énoncés suivants :

Ne s'applique pas	Totalement en désaccord	En désaccord	En accord	Totalement en accord
NSP	*1*	*2*	*3*	*4*

3.	Le patient formateur avait les connaissances nécessaires pour donner la formation.	NSP	1	2	3	4
4.	Mes collègues avaient une bonne connaissance de l'examen physique lombaire intégré.	NSP	1	2	3	4
5.	Le patient formateur interagissait bien avec les étudiants.	NSP	1	2	3	4
6.	Le patient formateur avait une bonne attitude.	NSP	1	2	3	4
7.	Mes collègues avaient une bonne attitude.	NSP	1	2	3	4
8.	Le patient formateur était capable de me guider dans mon apprentissage de l'examen physique lombaire intégré.	NSP	1	2	3	4
9.	Le patient formateur donnait une rétroaction constructive.	NSP	1	2	3	4
10.	La rétroaction du patient formateur m'a mis en confiance.	NSP	1	2	3	4
11.	Mes collègues interagissaient bien entre eux.	NSP	1	2	3	4
12.	Le patient formateur a utilisé son expérience de façon constructive.	NSP	1	2	3	4
13.	La rétroaction de mes collègues était pertinente.	NSP	1	2	3	4

QUESTIONNAIRES – STUDY 4

STUDY 4
Practice neurolocomotor examination with a patient instructor (PI)
Pre-activity questionnaire (#1)

Neurolocomotor-examination skill

1. Please indicate your level of confidence in performing a neurolocomotor examination.

Not confident									Very confident
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. Please indicate your skill level in performing a neurolocomotor examination.

Minimum									Maximum
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Neurolocomotor-examination video

3. How many times did you watch the neurolocomotor-examination video posted on Moodle (not counting the showing today)? Please indicate the exact number (enter 0 if you have never watched the video):

Number of times = __________

Feedback

Please indicate your level of agreement with the following items.

Totally disagree	Disagree	Agree	Totally agree
1	*2*	*3*	*4*

4.	The best way to learn how to perform the neurolocomotor examination is to observe an expert.	1	2	3	4
5.	Feedback from peers helps me improve my clinical skills.	1	2	3	4
6.	Patient instructors do not have the competencies to help me learn how to perform the neurolocomotor examination.	1	2	3	4
7.	Feedback is only relevant when it comes from an expert.	1	2	3	4
8.	I like learning activities in which I can observe my peers.	1	2	3	4
9.	The patient instructor helps me acquire clinical skills through constructive feedback.	1	2	3	4

RECHERCHE 4
Pratique de l'examen lombaire intégré avec un patient formateur
Questionnaire avant l'activité (No 1)

Habileté à exécuter l'examen physique lombaire

1. Veuillez indiquer votre niveau de confiance à exécuter un examen lombaire intégré à :

Peu confiant									Totalement confiant
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. Veuillez indiquer votre niveau d'habileté à exécuter un examen lombaire intégré à:

Habileté minimale									Habileté maximale
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Visionnement du vidéo

3. Combien de fois avez-vous visionné la bande vidéo de la séquence de l'examen physique lombaire (sans compter le visionnement que vous faites aujourd'hui)? Indiquez le nombre exact (inscrire 0 si vous n'avez pas fait le visionnement):

Nombre de visionnement = __________

Rétroaction

Veuillez indiquer votre niveau d'accord avec les énoncés suivants :

Totalement en désaccord	En désaccord	En accord	Totalement en accord
1	*2*	*3*	*4*

4.	La meilleure façon d'apprendre l'examen physique lombaire intégré est d'observer un expert (clinicien).	1	2	3	4
5.	La rétroaction de mes pairs m'aide beaucoup à améliorer mes habiletés cliniques.	1	2	3	4
6.	Les patients formateurs n'ont pas les compétences requises pour m'aider à apprendre l'examen physique lombaire intégré.	1	2	3	4
7.	Une rétroaction est seulement pertinente lorsqu'elle provient d'un expert.	1	2	3	4
8.	J'apprécie les activités d'apprentissages où il m'est possible d'observer mes pairs.	1	2	3	4
9.	Le patient formateur m'aide à développer mes habiletés cliniques par le biais d'une rétroaction constructive.	1	2	3	4

STUDY 4
Practice neurolocomotor examination with a patient instructor (PI)
Post-activity questionnaire (#2)

Neurolocomotor-examination skill

1. After the learning activity, my level of confidence in performing a neurolocomotor examination is:

Not confident									Very confident
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. After the learning activity, I would rate my skill level in performing a neurolocomotor examination as:

Minimum									Maximum
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Feedback

3. Please indicate, on a scale of 1 to 10, how useful patient-instructor feedback was during the activity.

Very useless									Very useful
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

4. Please indicate, on a scale of 1 to 10, how useful peer feedback was during the activity.

Very useless									Very useful
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Satisfaction

Please indicate your level of agreement with the following items.

Totally disagree	Disagree	Agree	Totally agree
1	*2*	*3*	*4*

5.	The information presented during the activity was well organized.	1	2	3	4
6.	The learning activity helped me improve the clinical skills useful in performing the neurolocomotor examination.	1	2	3	4
7.	The learning activity helped me improve knowledge useful in performing the neurolocomotor examination with a patient.	1	2	3	4
8.	The student-to-PI ratio was adequate.	1	2	3	4
9.	This learning activity was well organized.	1	2	3	4
10	The teaching context was favourable for learning.	1	2	3	4

Comments

11. What did you like most about this activity?

12. What did you like least about this activity?

13. Do you have any suggestions for improving this activity?

RECHERCHE 4
Pratique de l'examen lombaire intégré avec un patient formateur
Questionnaire après l'activité (No 2)

Habileté à exécuter l'examen physique lombaire

1. Après l'activité d'apprentissage, veuillez indiquer votre niveau de confiance à exécuter un examen lombaire intégré à :

Peu confiant									Totalement confiant
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. Après l'activité d'apprentissage, veuillez indiquer votre niveau d'habileté à exécuter un examen lombaire intégré à :

Habileté minimale									Habileté maximale
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Rétroaction

3. Veuillez indiquer, sur une échelle de 1 à 10, l'apport de la rétroaction du patient formateur dans votre apprentissage d'aujourd'hui:

Très inutile									Très utile
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

4. Veuillez indiquer, sur une échelle de 1 à 10, l'apport de la rétroaction de vos pairs dans votre apprentissage d'aujourd'hui:

Très inutile									Très utile
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Satisfaction

Veuillez indiquer votre niveau d'accord avec les énoncés suivants:

Totalement en désaccord	En désaccord	En accord	Totalement en accord
1	*2*	*3*	*4*

5.	L'information présentée était bien organisée.	1	2	3	4
6.	La session d'apprentissage m'a aidé à améliorer mes habiletés à exécuter l'examen physique lombaire intégré.	1	2	3	4
7.	Cette session d'apprentissage à améliorer mes connaissances pour exécuter l'examen physique lombaire intégré avec un patient.	1	2	3	4
8.	Le ratio étudiant/patient formateur était approprié.	1	2	3	4
9.	Cette activité pédagogique était bien organisée.	1	2	3	4
10.	L'environnement d'enseignement était favorable à l'apprentissage.	1	2	3	4

Commentaires

11. Quels sont les éléments que vous avez le plus appréciés dans le cadre de cette activité?

12. Quels sont les éléments que vous avez moins appréciés dans le cadre de cette activité?

13. Quelles suggestions auriez-vous pour améliorer cette formation?

STUDY 4
Practice neurolocomotor examination with a patient instructor (PI)
Post-assessment questionnaire (#3)

Neurolocomotor-examination skill

1. After performing the neurolocomotor examination on my own, I would rate my level of confidence in performing a neurolocomotor examination as:

Not confident									Very confident
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. After performing the neurolocomotor examination on my own, I would rate my skill level in performing a neurolocomotor examination as:

Minimum									Maximum
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Feedback

Please indicate your level of agreement with the following items.

Totally disagree	Disagree	Agree	Totally agree
1	*2*	*3*	*4*

3.	The patient instructor had the appropriate knowledge to teach the neurolocomotor examination.	1	2	3	4
4.	My colleagues had good knowledge about the neurolocomotor examination.	1	2	3	4
5.	The patient instructor was able to guide me in learning the neurolocomotor examination.	1	2	3	4
6.	I often wondered if the comments made by my peer were right.	1	2	3	4
7.	The patient instructor gave constructive feedback.	1	2	3	4
8.	The feedback from my peers was relevant.	1	2	3	4
9.	The feedback from my peers helped me to better perform the neurolocomotor examination.	1	2	3	4

RECHERCHE 4
Pratique de l'examen lombaire intégré avec un patient formateur
Questionnaire après l'évaluation (No 3)

Habileté à exécuter l'examen physique lombaire

1. Après l'exécution de la séquence, seul avec le patient formateur, veuillez indiquer votre niveau de confiance à exécuter un examen lombaire intégré à:

Peu confiant									Totalement confiant
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

2. Après l'exécution de la séquence, seul avec le patient formateur, veuillez indiquer votre niveau d'habileté à exécuter un examen lombaire intégré à:

Habileté minimale									Habileté maximale
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Rétroaction

Veuillez indiquer votre niveau d'accord avec les énoncés suivants :

Totalement en désaccord	En désaccord	En accord	Totalement en accord
1	*2*	*3*	*4*

3.	Le patient formateur avait les connaissances nécessaires pour donner la formation.	1	2	3	4
4.	Mes collègues avaient une bonne connaissance de l'examen physique lombaire intégré.	1	2	3	4
5.	Le patient formateur était capable de me guider dans mon apprentissage de l'examen physique lombaire intégré.	1	2	3	4
6.	Je me demande souvent si les commentaires de mes collègues sont exacts.	1	2	3	4
7.	Le patient formateur donnait une rétroaction constructive.	1	2	3	4
8.	La rétroaction de mes collègues était pertinente.	1	2	3	4
9.	La rétroaction de mes collègues m'a permis de mieux exécuter l'examen physique lombaire intégré.	1	2	3	4

Acknowledgements

First, I want to thank my family—starting with my wife, Agnes Desrochers, and my two children, Felix and Flavie—for their unwavering support throughout all the years of gestation of this thesis. Their comments helped me to persevere in this to the end, even through some hard times when my clinical work and faculty involvement cut into my time with them and to work on my thesis.

Second, I would like to acknowledge the contribution of my supervisors Professor Henk Schmidt and Professor Silvia Mamede. I am also grateful for the collaboration between the Faculty of Medicine at the Université de Sherbrooke and Professor Henk Schmidt that introduced me to quantitative research in medical education. This collaboration motivated me to undertake this doctorate in medical education. When I started working on this project, my past research of the qualitative type did not predispose me to developing expertise in empirical research. Professor Schmidt has helped me ask the right questions. I was surprised myself in producing significant results among medical students because I doubted we could demonstrate anything in this high-performance sub-group of students whose training takes many years. Comments of Professor Schmidt carried through incessant work of Pre Silvia Mamede, which was a constant support in this collaboration. I also want to acknowledge the contribution of Professor Remi Rikers, who participated in the development of the first two studies in this thesis.

The research program on which this thesis is based would not have been possible without the support of a leading research team. I would begin my thanks with Professor Christina St-Onge, the director of the Research Chair in Medical Education, who coordinated the various research professional and grant applications required. Second, Linda Bergeron, who served as Senior Research Officer, was a great help in exacting work. Professor Anne Harvey, physiatry, who was a collaborator at various moments, helped me to develop the grid for assessing the psychomotor-skill performance of students.

I also want to acknowledge the collaboration of the team of standardized patients at our medical school, without whom the experiments could not have taken place. Suzanne Robert and Sophie Dryburgh-Larouche, who, guided by their attention to detail, maximized the interface between the research team, the medical program, and the students. Their generous collaboration helped me in several stages of my work as well as in organising the clinical-skill program. The patient instructors trained by them delivered and continue to deliver a high level of training to our students. In addition, I am grateful to the cohorts of students who agreed to participate in this research aimed at understanding how they learned the physical examination.

Lastly, I greatly appreciate the financial assistance provided by the medical program of my faculty for the initial research work and that from the Society of Physicians at the Université de Sherbrooke for grants for the other studies underpinning my thesis.

Curriculum vitae

Bernard Martineau, a native of Chicoutimi, Quebec, Canada, received his medical degree from Université Laval (Québec) in 1980 and completed his residency in family medicine in 1982. He practised in St-Tite-de-Champlain as a family physician for two years without teaching. He then moved to the rural family medicine unit in Lac Etchemin, which was affiliated with Université Laval, where he began his career in education. He served as director of this family unit from 1987 to 1999. He served on various committees at Université Laval and at the Canadian College of Family Physicians while maintaining clinical and teaching activities. In 1999, he joined the faculty of the Université de Sherbrooke, where he continues with his clinical work and teaching in family medicine.

He earned a master's degree in psychopedagogy in 1993 at Université Laval. In 2003, he completed a 3rd cycle diploma in Higher education at the Université de Sherbrooke's School of Education focusing on development of clinical skills abilities. Based on his thesis, he developed and coordinates an innovative reform of clinical-skill teaching for the PBL curriculum at that institution.

In 2006, during a sabbatical, he worked on developing an interuniversity course in medical pedagogy for the universities of Poitiers, Tours, and Limoges in France. In 2009, he undertook a research program on the acquisition of psychomotor skills for the physical examination that is the subject of this doctoral thesis. In 2013, while maintaining his clinical activities and undergraduate involvement, he became involved in continuing professional development as the director of Centre of Continuing Education at the Université de Sherbrooke.

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