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EDUCATION

An interprofessional teaching approach for medical and physical therapy students to learn functional anatomy and clinical examination of the lower spine and hip

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ABSTRACT

Introduction: Pain of the lower back is a frequent symptom and is treated by different health professions. Anatomical as well as clinical knowledge is utmost important for all professions involved in this field. Here, we present a model that brings together an interprofessional team of experts to teach functional and clinical anatomy of the lower spine and hip area to medical and physical therapy students.
Methods: Two groups of medical students ($n = 60$) and physical therapy students ($n = 77$) were designated to two interprofessional clusters, with each cluster of students participating in three workshops, each lasting 40 min. Workshops were guided by university anatomists, an orthopedic physician and physical therapists, and each provided specialized training, such as the conduction of clinical, orthopedic functional tests, the identification and palpation of anatomical structures and demonstrations of human anatomical joint prosections. A questionnaire, consisting of 18 questions regarding subjective anatomical and clinical knowledge and application of clinical assessment techniques was used as the evaluation tool before and after participation in the course. Furthermore, the amount of knowledge gained from peer group participants from the other profession versus the knowledge gained from the instructors was assessed. Descriptive statistics of data as well as quantitative data analysis was carried out for pre–post analysis.
Results: A total of 148 students participated in the pre-course evaluation and self-assessment and 113 students completed the post-course evaluation and self-assessment. 11 of the students, who completed the pre-course evaluation, and five students who completed the post-course evaluation failed to reveal their affiliation and these were only included in the general and corresponding cluster analysis. A final 132 pre-questionnaire and 97 post-questionnaire results were included in the analyses due to a likely group response bias. Scores for all combined groups showed an increase in the pre–post evaluation of 11.7% ($P < .001$). Cluster 1 and 2 (pre–post) score comparisons showed an increase of 13.7% ($P < .001$) and 8.8% ($P < .001$) respectively. A subgroup pre–post-questionnaire analysis demonstrated that medical students from both clusters had the highest increase in scores (17.6% and 19.9%) in comparison to their physical therapy counterparts (9.1% and 5.8%) ($P < .001$). Specifically, medical students profited highly from the anatomy in vivo (palpation) as well as clinical, orthopedic assessment exercises. Sub-question analyses showed that students learned from each other as well as from an interprofessional team of guiding experts/instructors, though mostly from the latter.
Conclusions: This course offers an appropriate and effective model that brings together an interprofessional team of experts to teach functional and clinical anatomy to medical and physical therapy students. Study results demonstrated an increase in subject-specific competencies in functional and clinical anatomy of the lower spine and hip. Medical students demonstrated the highest increase in subjective knowledge, especially in regard to clinical examination and assessment, which highlights the usefulness of this course early in the medical education. All students learned from the exchange with interprofessional group members as well as the instructors.

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1. Introduction

1.1. Background

Extensive knowledge of anatomy is an important part of the foundation for health professionals, such as orthopedic physicians, surgeons and physical therapists. Furthermore, it is also often necessary to be able to transfer and apply this knowledge for functional and clinical assessment of the neuromusculoskeletal system. This, in turn, is a prerequisite for successful treatment. Anatomy as a discipline, therefore, forms a part of the pre-clinical core curriculum in medical and rehabilitation science studies, for example in physical therapy.

At the University of Freiburg, clinical and functional aspects of anatomy, i.e. orthopedics are taught at a later time after pre-clinical courses in anatomy. Despite the fact that both topics are closely related, they are taught independently from one another. It has been reported that preservation of anatomical knowledge in medical studies, leading up to later clinical phases is poor (Prince et al., 2005) which might explain that many advanced medical students and residents feel unprepared for subsequent clinical phases (Bohl and Gest, 2011).

In contrast to the standard medical school curriculum, training and examination regulations in German physical therapy programs require school curricula to provide courses in anatomy, functional anatomy, e.g. palpation and clinical assessment, e.g. orthopedics to be taught parallel to each other, which facilitates an interconnected understanding of these topics.

Since 2013, the medical faculty at the University of Freiburg has offered interprofessional courses as part of a program named *Longitudinal Strand Interprofessionality* (*LongStI*). One of these interprofessional courses, named *Clinical Aspects of Large Joints* is offered to medical students on an elective basis to learn functional and clinical anatomy together with physical therapy students. In this project, students participate in three workshops guided by an orthopedic physician, anatomists and physical therapists to learn the functional and clinical anatomy related to the musculoskeletal system, as well as orthopedic assessments, with a special focus on large joints and surrounding structures. The course was conceptualized to foster key competencies required for later interprofessional practice, such as understanding each other's roles and responsibilities, but also to fill knowledge and experience gaps related to clinical examination and assessment.

To facilitate effective interprofessional learning, an educational paradigm, which allows direct, active interaction and discourse with other professional groups is required. *Peer Assisted Learning*, also referred to as *Reciprocal Peer Teaching* or *Peer Teaching* has been proposed to be a collaborative approach, wherein students alternate roles as teacher and student to develop knowledge and skills through active help and support among status equals or matched companions (Glynn et al., 2006). In other words, "people from similar social groupings, who are not professional teachers, help each other to learn and learn themselves by teaching" (Topping, 1996).

Furthermore, this form of learning forms a part of interprofessional education (IPE), which is defined as occurring "when two or more professions interact within a learning environment to learn with, from and about each other for the purpose of improving collaboration and the future quality of care" (CAIPE, 2002).

It has been reported that IPE should ideally begin early in the training period (Barr et al., 2005), as this allows students to become comfortable working within an interprofessional environment (Gilbert, 2005). It has also been suggested that early interprofessional interaction is a strong adjunct to later participation within future clinical teams (Gilbert, 2005; Barr, 2007). Moreover, it has been discussed that, although the later clinical environment offers a good platform for interdisciplinary interaction, IPE provides an ideal opportunity to encourage appreciation for each other's profession at an early stage (Hamilton et al., 2008). It has even been argued that it is undesirable for health professionals to learn and improve interprofessional skills later in the workplace, when clinical responsibility and patient care stakes are high (McKinlay and Pullon, 2014).

Furthermore, Peer Assisted Learning has been applied to gross anatomy education, which has been reported to lead to student improvements in learning and examination performance (Manyama et al., 2016), as well as developing competencies essential to health care practice, such as team-work, communication and peer-teaching (Sytsma et al., 2015), which are all key competencies of health care professionals.

Previous findings, gained from the last course with the focus on functional and clinical aspects of the knee (Meyer et al., 2017), demonstrated that both medical and physical therapy students appreciated the interprofessional aspects of the workshop and the teaching approach. In addition, this special training lead to a better subjective understanding of knee anatomy.

In the last couple of years, there has been increased attention payed to IPE in medical and health science education. The necessity for IPE in the health sciences for later interprofessional work has been described extensively by the world health organization (WHO) in the *Framework for Action on Interprofessional Education & Collaborative Practice* (WHO Study Group on Interprofessional Education and Collaborative Practice, 2010).

The expert commission for medicine in Germany (Wissenschaftsrat, 2018) has also recently renewed the licensing and regulations recommendations for medical studies in their master plan for 2020. One of these recommendations explicitly states that interprofessional education and training between medical students and students from other health professions should be increased in the medical curriculum of universities to promote and cultivate interprofessional thinking and action. The commission outlined the fact that there is currently a small amount of research undertaken in regard to interprofessional teaching, especially in Germany. Further research is needed to be able to influence curricular changes at the university level. The importance of linking research to modern medical science education is described in the Global Independent Commission Lancet Report "*Health professionals for a new century: transforming education to strengthen health systems in an interdependent world*" (Frenk et al., 2010).

In line with these recommendations, the LongStI course *Clinical Aspects of Large Joints* provides a model that brings together an interprofessional team of experts from different specializations to teach functional and clinical anatomy to medical and physical therapy students. A course was designed and offered for the winter semester of 2019 to teach functional and clinical aspects, as well as orthopedic assessments of the lower spine and hip area.

1.2. Project aim

The objective of the project is the implementation of this interprofessional course into the medical and physical therapy studies. This project will contribute to the research required to advance interprofessional health science education, particularly for medical and physical therapy students, through a novel, collaborative approach in teaching clinical and functional aspects of anatomy.

Furthermore, the project design is intended to evaluate two key areas a) the subject-specific competencies in functional anatomy and clinical examination and b) the interprofessional competencies and collaboration between medical and physical therapy students. In this article, the focus is placed on the former. Interprofessional

aspects of the project will be addressed separately in a subsequent article.

2. Materials and methods

2.1. Course participants

The course was elective for medical students of the University of Freiburg and mandatory for physical therapy students of Furtwangen University and for students from the physical therapy program of Gesundheitsschulen Südwest GmbH (GSSW). The course was carried out at an early stage of medical and physical therapy studies; medical students were in their third semester of study and physical therapy students in their fourth semester of study.

2.2. Interprofessional teaching design

Course participants were allocated to two clusters: the first cluster consisted of medical students from the University of Freiburg ($n = 48$) and physical therapy students from the GSSW physical therapy program ($n = 22$ from the PT school in Freiburg, $n = 16$ from the PT school Emmendingen). As later revealed, an additional 11 students in this cluster failed to reveal their affiliation. In the second cluster, medical students from the University of Freiburg ($n = 12$) and physical therapy students from Furtwangen University ($n = 39$) were grouped together. Each group participated in three workshops, each lasting 40 min (Fig. 1). The second cluster began consecutively. Before beginning the workshops, a short introduction regarding the basic principles of the program, as well as structure and course procedures were provided. Medical and physical therapy students were then combined randomly and were distributed into equal subgroups to facilitate interprofessional communication.

The three interprofessional workshops consisted of the following:

- o A workshop for the conduction of clinical, orthopedic functional tests of the lumbar spine and of the hip joint, led by an orthopedic specialist and assisted by four physical therapists. Here, topics were discussed, such as the general inspection of the lower spine, active and passive range of motion of the hip as well as special, functional tests, such as the Straight Leg Raise and FABER tests (Fig. 1c).
- o A workshop to practice the hands-on systematic identification and palpation of anatomical structures (anatomy in vivo) of the lumbar spine and hip area, such as spinous processes of the lower spine, the anterior superior iliac spine, posterior superior iliac spine, the greater trochanter and iliac crest, led by a physical therapist and assisted by four physical therapists. In addition, the professional roles of orthopedic physicians and physical therapists were discussed (Fig. 1a).
- o Demonstrations of human anatomical prosections, e.g. of the lumbar spine, pelvis and hip area including among others structures like the sacroiliac joint, hip joint, sacroiliac ligament, sacrotuberous ligament, ligament of head of femur, acetabular labrum, iliofemoral ligament, pubofemoral ligament, ischiofemoral ligament, obturator internus muscle, gemelli muscles, iliopsoas muscle, glutei muscles, piriformis muscle and sciatic nerve were guided by two university anatomists. Discussions took place regarding function and basic pathomechanisms (Fig. 1b).

2.3. Workshop guide professions and expertise

The interprofessional team of experts guiding the workshops are actively involved in teaching. Both university anatomists have over 10 years of teaching experience. The physical therapist, who guided the Anatomy in vivo workshop has over 30 years teaching experience in anatomy and biomechanics. The orthopedic physician works at the university clinic at the University of Freiburg and has 15 years of teaching experience, teaching physical therapists, medical and sport students. In addition, all physical therapists who assisted the workshops are also active lecturers at the physical therapy programs of Furtwangen University and Gesundheitsschulen Südwest.

2.4. Anatomical prosections

Anatomical prosections of the lumbar spine and hip area were used from body donators from the Institute of Anatomy and Cell Biology of the Albert-Ludwigs-University Freiburg. These were used in accordance with body donation agreements.

2.5. Evaluation

An evaluation (self-assessment) was conducted before and immediately after participation in all three workshops. A questionnaire consisting of 18 questions regarding recalling and understanding anatomical knowledge as well as relevant application of clinical assessment techniques was filled out before and immediately after completion of all three course workshops. Questions were rated using a five-point Likert scale (1 = does not apply at all to 5 = fully applies). Furthermore, for each question, two additional sub questions asked whether a) students learned through the exchange with the other interprofessional group members (peer-students) and b) students learned from the lecturers/instructors. These sub-questions were also rated using a five-point Likert scale (1 = does not apply at all to 5 = fully applies).

To test for the reliability (internal consistency) of the questionnaire, which contained 18 questions, a Cronbach's alpha test was performed on the Likert scale response items, which resulted in a very high reliability for the pre-questionnaire (Cronbach's $\alpha = 0.92$) and high reliability for the post-questionnaire (Cronbach's $\alpha = 0.89$).

2.6. Statistical analysis

Data are presented as minimum (Min), maximum (Max), median (Mdn), mean (M) and % based on earned questionnaire scores. In addition, quantitative data analysis was carried out using the Mann–Whitney *U* test for non-parametric independent samples. Programs used for data analyses were Microsoft Excel and GraphPad Prism software (GraphPad Software Inc.) For the calculation of Cronbach's α, statistics software was used (Wessa, 2020).

2.7. Ethical approval

An ethics committee approval was not required for this purely educational course, as determined through the basic questionnaire of the local ethics committee of Furtwangen University. All participants received safety instruction and gave signed consent to adhere to the course procedures prior to participation in the workshops.

3. Results

3.1. Participation

Overall, a total of 148 students, combined from both clusters, completed the questionnaire prior to beginning the workshops

Figure 1. Schematic overview of the interprofessional course design for medical and physical therapy students. (A) Anatomy in vivo hands-on systematic identification and palpation of anatomical structures (anatomy in vivo) of the lumbar spine and hip area. (B) *Anatomy*: Demonstrations of human anatomical joint prosections of the lumbar spine, pelvis and hip area. (C) *Clinical assessment*: Conduction of clinical, orthopedic functional tests of the lumbar spine and of the hip joint.

($n = 38$ students from the GSSW physical therapy program, $n = 39$ physical therapy students from Furtwangen University, $n = 60$ medical students from the university of Freiburg and $n = 11$ students, who were not assigned to any group, since they did not reveal their affiliation). 113 students completed the questionnaire following the course workshops ($n = 34$ students from the GSSW physical therapy program, $n = 26$ physical therapy students from Furtwangen University, $n = 48$ medical students from the University of Freiburg, and $n = 5$ students, who were not assigned to any group, since they did not reveal their affiliation).

97 students from the first cluster filled out the pre-evaluation questionnaires ($n = 22$ students from the GSSW physical therapy program in Freiburg, $n = 16$ from the GSSW physical therapy school in Emmendingen, $n = 48$ medical students from the University of Freiburg and $n = 11$ students with no group assignment). 78 students from cluster 1 filled out the post-evaluation questionnaire ($n = 18$ students from the GSSW physical therapy program in Freiburg, $n = 16$ from the GSSW physical therapy school in Emmendingen, $n = 39$ medical students from the University of Freiburg and $n = 5$ students without group assignment).

In the second cluster, 51 students filled out pre-evaluation questionnaires ($n = 39$ physical therapy students from Furtwangen University and $n = 12$ medical students from the University of Freiburg). The ratio of medical to physical therapy students was almost 1:3. For this reason, instead of having three groups of students participating in all three stations at the same time, two larger interprofessional groups were created and one workshop station remained unoccupied, respectively. However, each group remained 40 min for each station as the first cluster group. 35 students from cluster 2 filled out the post-evaluation questionnaire ($n = 26$ physical therapy students from Furtwangen University and $n = 9$ medical students from the University of Freiburg).

3.2. Pre–post evaluation results

The GSSW physical therapy group in Emmendingen, ($n = 16$) was removed from all result analyses (explanation is provided in the discussion), leaving only the GSSW physical therapy school in Freiburg to be included in the results for the GSSW physical therapy program. This led, therefore to a total of 132 pre-questionnaire and 97 post-questionnaire results to actually be included, evaluated and subsequently reported in the results.

Descriptive statistics for each of the 18 question scores, including sub-question scores are shown in Table 1. Presented in Figs. 2 and 3 are histograms containing the combined pre–post-questionnaire scores for all groups for each of the 18 items of the questionnaire.

The maximum possible score for each subgroup was corrected for both pre- and post-questionnaire scores in the case that questions were left unanswered. This was carried out by subtracting unanswered questions from the total possible score of the corresponding group. The actual group score achieved was then calculated from the corrected maximum possible score.

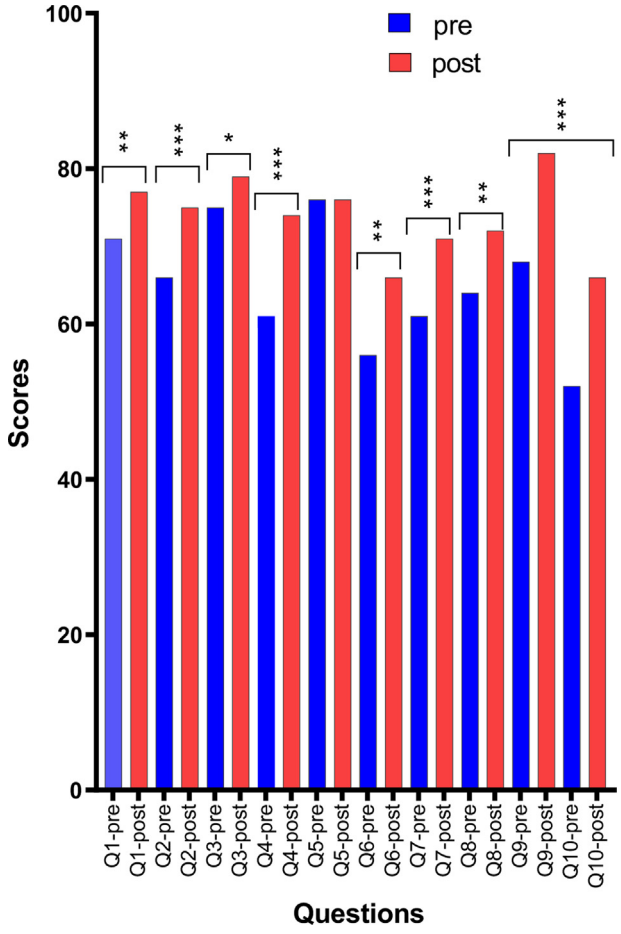

Figure 2. Questionnaire to measure subjective anatomical and clinical knowledge and application of clinical assessment (questions 1–10). Histogram presents scoring for all groups prior to participating in the workshops (pre) and after participation (post) for individual questions in % based on a scale of 100% for questions 1–10. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq 0.001$ (Mann–Whitney *U* test).

A total of 132 questionnaire scores for all combined groups prior to beginning the seminar showed a total score of 59.2%. 97 questionnaire scores for all combined groups following the seminar yielded a total score of 70.9% showing an improvement in the total pre–post evaluation score of 11.7% (Table 2). The Mann–Whitney *U* test demonstrated that this result was highly significant ($P < .001$). Shown in Fig. 4 is the pre–post group comparison for all groups based on Likert scale mean differences.

Cluster 1 and 2 (pre–post) comparisons (Table 3) showed a score increase of 13.7% and 8.8% respectively. These results were highly significant ($P < .001$). Shown in Fig. 5 is the pre–post group comparison for both clusters based on Likert scale mean differences.

Table 1
Descriptive statistics – questionnaire for all groups (pre–post).

	Question	Pre					Question	Post					% Change	*P*-value
		n=	Min	Max	Mdn	%		*n*=	Min	Max	Mdn	%		
1.	I know the anatomical structures (bones, bone reference points, musculature, ligaments, nerves) of the lumbopelvic region	131	2	5	4	71	1.	97	2	5	4	77	+6	.0023**
							a	97	1	5	4	67		
							b	97	1	5	4	79		
2.	I can describe the location and the course of these structures	131	2	5	3	66	2.	96	2	5	4	75	+9	.001***
							a	95	1	5	4	67		
							b	95	1	5	4	77		
3.	I can find these structures on a human model	130	2	5	4	75	3.	96	2	5	4	79	+4	.0259*
							a	95	1	5	3	61		
							b	95	1	5	4	75		
4.	I can find these structures anatomical prosections	126	4	5	3	61	4.	92	2	5	4	74	+13	.001***
							a	93	1	5	3	62		
							b	93	1	5	4	82		
5.	I can describe the function of the hip joint	130	1	5	4	76	5.	93	1	5	4	76	0%	.652
							a	94	1	5	3	62		
							b	94	1	5	4	72		
6.	I can explain the biomechanical significance of the sacroiliac joints	128	1	5	3	56	6.	95	1	5	3	66	+10	.0014**
							a	94	1	5	3	52		
							b	95	1	5	3	62		
7.	I can explain the interaction of different anatomical structures in the movement in the hip joint	131	1	5	3	61	7.	92	1	5	4	71	+10	.001***
							a	92	1	5	3	57		
							b	92	1	5	3	65		
8.	I can explain why the hip joint can function despite its high load	130	1	5	3	64	8.	92	1	5	4	72	+8	.0013**
							a	92	1	5	3	56		
							b	92	1	5	4	69		
9.	I can find and palpate structures of the lumbopelvic region on a human model	131	1	5	4	68	9.	92	2	5	4	82	+14	.001***
							a	92	1	5	4	70		
							b	91	1	5	4	77		
10.	I can explain the forces occurring at the lumbar spine	132	1	5	3	52	10.	90	1	5	4	66	+14	.001***
							a	89	1	5	3	53		
							b	89	1	5	3	61		
11.	I can explain the function of facet joints	131	1	5	3	50	11.	89	1	5	4	66	+16	.001***
							a	90	1	5	2	49		
							b	90	1	5	3	61		
12.	I can assess the function of the hip joint	132	1	5	3	60	12.	89	1	5	4	80	+20	.001***
							a	88	1	5	4	70		
							b	87	1	5	4	79		
13.	I can assess the function of the sacroiliac joints	132	1	5	3	53	13.	87	1	5	4	80	+27	.002**
							a	87	1	5	3	55		
							b	88	1	5	3	60		
14.	I can assess the function of the lumbar spine	132	1	5	3	56	14.	89	1	5	4	75	+19	.001***
							a	89	1	5	3	67		
							b	89	1	5	4	71		

Table 1 (*Continued*)

	Question	Pre					Question	Post					% Change	*P*-value
		n=	Min	Max	Mdn	%		*n*=	Min	Max	Mdn	%		
15.	I can determine, through differential diagnosis, which joint is affected by non-specific pain in the lumbopelvic area	131	1	5	2	49	15.	89	1	5	3	65	+16	.001***
							a	89	1	5	3	57		
							b	89	1	5	3	66		
16.	I can define the lumbar spine movements occurring as a result of hip joint movements	132	1	5	2	47	16.	89	1	5	3	63	+16	.008**
							a	89	1	5	3	63		
							b	89	1	5	3	60		
17.	I can identify different tissue types on a human model through palpation	132	1	5	3	58	17.	88	1	5	4	75	+17	.001***
							a	88	1	5	3	60		
							b	86	1	5	4	68		
18.	On a human model, I can evaluate whether an anatomical structure in the lumbopelvic region shows the expected consistency	132	1	5	2	50	18.	87	1	5	4	68	+18	.001***
							a	87	1	5	3	55		
							b	86	1	5	3	62		

Note: Range of questions from 1 = not at all applicable to 5 = fully applies. Mdn = median, a = in this area I have learned something through the exchange with the other professional group members, b = in this area I learned something from the lecturers. Scoring for individual questions in % based on a scale of 100%. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

Table 2
Group comparison for all groups (pre–post).

Results	*n*=	Min	Max	Mdn	Scoring (%)	Change (%)	*P*-value
Pre	132	1	5	3	59.2		
Post	97	1	5	4	70.9	+11.7	.001***

Scoring in % based on questionnaire with 18 questions grading subjective knowledge of clinical and functional anatomy Mdn = median. All groups = PT program GSSW (cluster 1), medical students (cluster 1), PT program university (cluster 2), medical students (cluster 2), no assignment (cluster 1). The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

Table 3
Cluster analysis (pre–post).

Results	*n*=	Min	Max	Mdn	Scoring (%)	Change (%)	*P*-value
Cluster 1 pre	81	1	5	3	55.7		
Cluster 1 post	62	1	5	4	69.4	+13.7	.001***
Cluster 2 pre	51	1	5	3	64.6		
Cluster 2 post	35	1	5	4	73,4	+8.8	.001***

Scoring in % based on questionnaire with 18 questions grading subjective knowledge of clinical and functional anatomy. Mdn = median. Cluster 1 = PT program GSSW, medical students, no assignment. Cluster 2 = PT program university, medical students. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

High knowledge gains were demonstrated by medical students from both clusters with respect to anatomy in vivo (palpation), as shown with question #9 "*I can find and palpate structures of the lumbopelvic region on a human model*" (15% increase for medical students in cluster 1, $P = .012$ and 33% increase for medical students in cluster 2, $P = .032$ in comparison to 7% increase for GSSW PT students [not significant] and 12% increase for university PT students, $P = .036$. Fig. 6 demonstrates the pre–post group comparisons based on Likert scale mean differences.

Questionnaire items related to clinical and orthopedic assessment also demonstrated high knowledge gains, especially for medical students; these are questions #12"*I can assess the function of the hip joint*" (36% increase for medical students in cluster 1 and 39% increase for medical students in cluster 2 in comparison to no change for GSSW PT students and 10% increase for university PT students), #13 "*I can assess the function of the sacroiliac joint*" (24% increase for medical students in cluster 1 and 23% increase for medical students in cluster 2 in comparison to 9% increase for GSSW PT students and 3% increase for university PT students) and #14 "*I can assess the function of the lumbar spine*" (31% increase for medical students in cluster 1 and 32% increase for medical students in cluster 2 in comparison to 4% increase for GSSW PT students and 8% increase for university PT students). Fig. 7 demonstrates the pre–post group comparisons based on Likert scale mean differences, when combining questionnaire scores for questions 12, 13 and 14. Highly significant results were found for medical students in cluster 1, $P = .001$, medical students in cluster 2, $P = .001$ and university PT students, $P = .001$.

A subgroup pre–post-questionnaire analysis demonstrated a score increase of 9.1% for the physical therapy program at the Gesundheitsschulen Südwest, an increase of 17.6% for medical students from the University of Freiburg (first cluster), an increase of 19.9% for the second cluster medical students and an increase of 5.8% for physical therapy students from Furtwangen University (Table 4). All of these results were highly significant ($P < .001$).

Table 4
Individual group analysis (pre–post).

Results	*n*=	Min	Max	Mdn	Scoring (%)	Change (%)	*P*-value
PT Program GSSW (cluster 1) pre	22	1	5	3	65.9		
PT Program GSSW (cluster 1) post	18	2	5	4	75.0	+9.1	.001***
Medical students (cluster 1) pre	48	1	5	3	50.3		
Medical students (cluster 1) post	39	1	5	4	67.9	+17.6	.001***
PT program university (cluster 2) pre	39	1	5	4	71.1		
PT program university (cluster 2) post	26	1	5	4	76.9	+5.8	.001***
Medical students (cluster 2) pre	12	1	5	2	43.5		
Medical students (cluster 2) post	9	1	5	3	63.4	+19.9	.001***

Scoring in % based on questionnaire with 18 questions grading subjective knowledge of clinical and functional anatomy. Mdn = median. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

Table 5
Learning through the exchange with the other professional group.

Results	*n*=	Min	Max	Mdn	Scoring (%)
PT program GSSW (cluster 1)	18	1	5	4	70.3
Medical students (cluster 1)	39	1	5	3	64.2
PT program university (cluster 2)	26	1	5	3	61.9
Medical students (cluster 2)	9	1	5	2	57.9
Total					Average = 63.5

Scoring in % based on each of the 18 primary questions, asking students to grade how much they learned with help from the other professional group on a scale from 1 (not at all applicable) to 5 (fully applies). Mdn = median.

Table 6
Learning from lecturers.

Results	*n*=	Min	Max	Mdn	Scoring (%)
PT program GSSW (cluster 1)	18	1	5	4	76.4
Medical students (cluster 1)	39	1	5	4	75.1
PT program university (cluster 2)	26	1	5	4	71.8
Medical students (cluster 2)	9	1	5	3	70.0
Total					Average = 73.3

Scoring in % based on each of the 18 primary questions, asking students to grade how much they learned with help from the other professional group on a scale from 1 (not at all applicable) to 5 (fully applies). Mdn = median.

Post-evaluation sub-question (a) for each of the 18 questions "*I learned through the exchange with the other professional group*" (Table 5) lead to an average of 63.5% for all groups in both clusters. Subgroup results are summarized as follows: students from the Gesundheitsschulen Südwest physical therapy program – 70.3%, medical students from the University of Freiburg (cluster 1) – 64.2%, medical students from the University of Freiburg (cluster 2) – 57.9% and physical therapy students from Furtwangen University – 61.9%. Post-evaluation sub-question (b) for each of the 18 questions "*I learned from lecturers*" (Table 6) lead to an average of 73.3% for all groups in both clusters. Subgroup results are summarized as follows: students from the Gesundheitsschulen Südwest physical therapy program – 76.4%, medical students from the University of Freiburg (cluster 1) – 75.1%, medical students from the University of Freiburg (cluster 2) – 70%, and physical therapy students from Furtwangen University – 71.8%.

The 11 students who completed the questionnaire *prior* to beginning the workshop and who could not be assigned to any group, as well as the five students who completed the questionnaire following the workshops and who could not be assigned to any group, were included in the general pre–post group analysis, since individual groups were not considered. Since all students with no assignment were in cluster 1, these were also included in the pre–post cluster analysis for cluster 1. However, this "no assignment" group was not analyzed as a subgroup, as was the case for the assigned professions.

4. Discussion

The purpose of this study was to investigate an interprofessional approach to teaching functional anatomy, clinical examination and assessment of the lower spine and hip area to medical and physical therapy students. Study results from this course support the interprofessional teaching model to increase subject-specific competencies.

Post-questionnaire results demonstrated improvements in student's subjective knowledge in anatomy and in the clinical examination of the lower spine and hip joint, with medical students from both clusters profiting the most from the course in comparison to both physical therapy group counterparts. A distinguishable finding, when analyzing the groups individually was that medical students from both clusters profited considerably more from the anatomy in vivo (palpation) as well as in clinical, orthopedic assessment exercises in comparison to their physical therapy peers.

The compulsory participation of physiotherapy students and the voluntary participation of medical students could have led to a selection bias, regarding motivation to learn. This could have contributed to the greater growth in learning and corresponding score for medical students. As already noted, at this time, this interprofessional course is offered by the university to medical students exclusively on an elective basis, as it has not yet been stablished in the medical curriculum. This bias can be corrected when medical students are required to participate, which is one of the central purposes of this research and course.

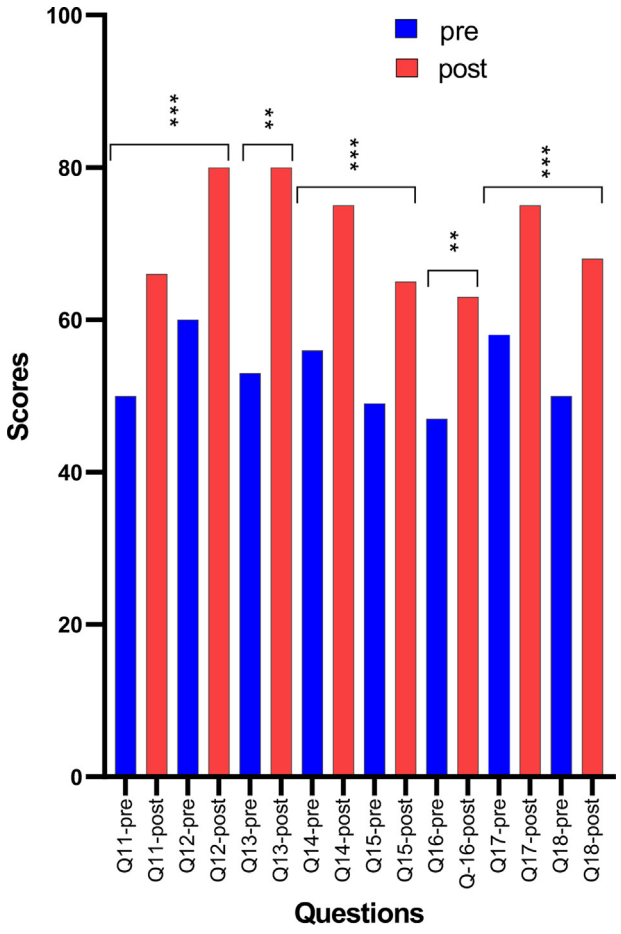

Figure 3. Questionnaire to measure subjective anatomical and clinical knowledge and application of clinical assessment (questions 11–18). Histogram presents scoring for all groups prior to participating in the workshops (pre) and after participation (post) for individual questions in % based on a scale of 100% for questions 11–18. The level of significance was set at $^{*}P < 0.05$, $^{**}P \leq 0.01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

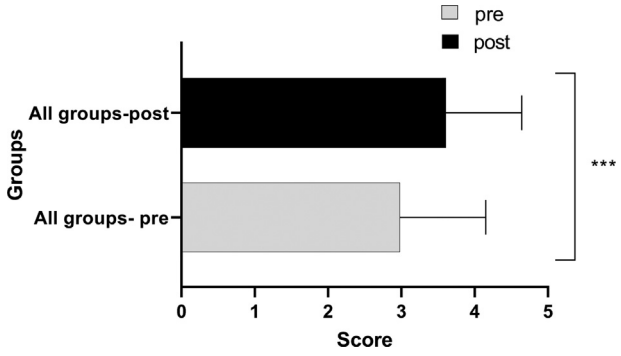

Figure 4. Group comparison for all groups (pre–post). All groups = GSSW PT program, medical students (cluster 1), no assignment, PT program university, medical students (cluster 2). Likert scale from 1 (not at all applicable) to 5 (fully applies). Results based on pre–post mean differences. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

In contrast to the previously published *LongStI* course *Clinical Aspects of Large Joints*, which focused on teaching clinical aspects of the knee, there was no written anatomy exam to compare the subjective increase in knowledge to objective gains. Although the last course's written exam led to a small improvement in test scores for course participants versus nonparticipants, these results were not significant. Moreover, conducting the exam subsequent to the course was recognized as a potential bias, since the course is

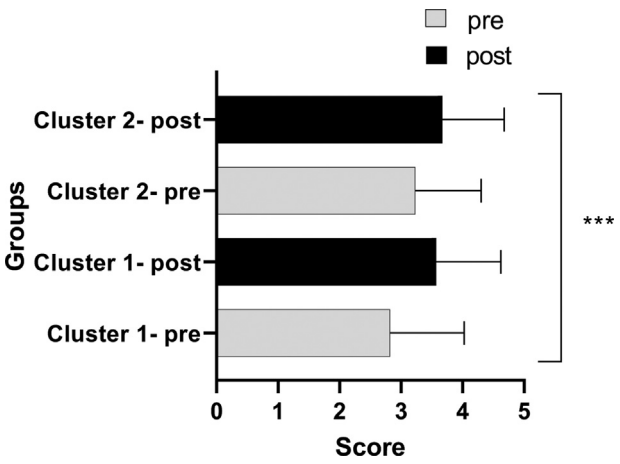

Figure 5. Cluster 1 and 2 comparison (pre–post). Cluster 1 = PT program GSSW, medical students, no assignment. Cluster 2 = PT program university, medical students. Likert scale from 1 (not at all applicable) to 5 (fully applies). Results based on pre–post mean differences. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

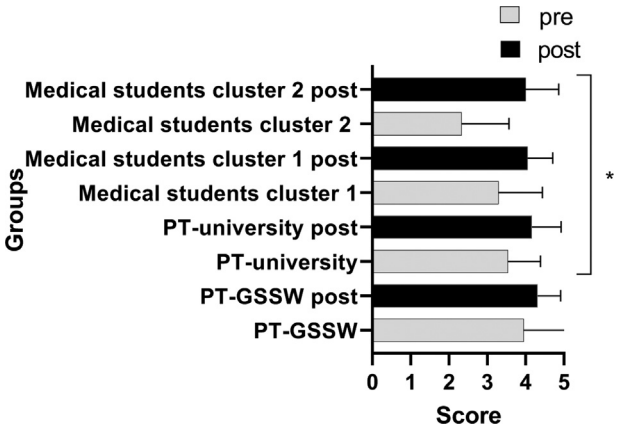

Figure 6. Question 9: "*I can find and palpate structures of the lumbopelvic region on a human model*". Pre–post scores based on Likert scale from 1 (not at all applicable) to 5 (fully applies). Results based on pre–post mean differences. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

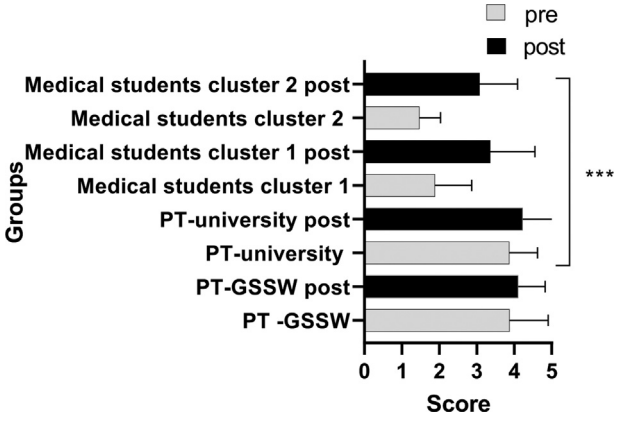

Figure 7. Questions 12, 13, 14: "*I can assess the function of the hip joint, sacroiliac joints and lumbar spine*". Pre–post scores based on Likert scale from 1 (not at all applicable) to 5 (fully applies). Results based on pre–post mean differences. The level of significance was set at $^{*}P < .05$, $^{**}P \leq .01$, $^{***}P \leq .001$ (Mann–Whitney *U* test).

elective and participation is mostly driven by student motivation, which could explain differences in exam results when comparing medical students who participated in the course with those who did not. For these reasons, a written examination was not carried out for this course and we chose instead to measure student's professional skills and competencies through a self-assessment questionnaire. For future evaluations, objective structured clinical examinations (OSCEs) may also be used.

Sub-questions provided insight as to who influenced the increases in anatomical and clinical knowledge. Course participants from all groups indicated through post-questionnaire analysis that they had learned more from the interprofessional instructors present than from the other professional group, with a difference of 9.8%. For several questions such as: "*I can find the structures anatomical prosections*" this was to be expected, since anatomists guided students with the anatomical prosections.

There were, however, exceptions in which medical students from both groups profited the same from course lecturers and group counterparts, for example for the question: "*I can find and palpate structures of the lumbopelvic region on a human model*." For two questions, medical students profited more from physical therapy group members than from the lecturers: "*I can assess the function of the lumbar spine*" and "*I can identify different tissue types on a human model through palpation*." It is also worth noting that for several questions related to the anatomy in vivo (palpation) and clinical examination and assessment, such as: "*I can assess the function of the hip joint*" and "*I can assess the function of the sacroiliac joint*", medical students profited virtually the same from physical therapy peers as they did from the instructors.

These interesting results highlight the versatile learning environment that was created, in which two different groups of students partly learned from each other and partly from an interprofessional team of guiding experts, which underscores the concept of learning *from*, *about* and *with* each other, as described by the Center for Advancement of Interprofessional Education (CAIPE, 2002). A more detailed analysis regarding the interprofessional aspects of our course will be addressed separately in a subsequent article, since these were assessed with a separate, questionnaire that was created to especially evaluate interprofessional education.

Overall, our findings well support the notion that also learning from peers, recognized as *Peer Assisted Learning*, is important and should be considered highly relevant for teaching anatomy within an interprofessional setting (Hamilton et al., 2008; Smith et al., 2015; Sytsma et al., 2015; Manyama et al., 2016). Moreover, it can be expected that an interprofessional teaching approach, as presented with our course, has lasting effects on student perceptions, as has been previously reported (Sytsma et al., 2015).

In the beforementioned published course (Meyer et al., 2017) 30 students participated in the interprofessional workshops. However, a total of 148 students participated in this course, with 113 completed pre- and post-course evaluation questionnaires. It must be noted that a total of 35 participants, who filled out the pre-evaluation questionnaires did not complete post-questionnaire evaluations. It is speculated that these students either did not participate in the workshops, i.e. they left the seminar at a certain time after filling out the pre-evaluation questionnaire, or they participated in the workshops and failed to fill out the post-evaluation questionnaire.

A very likely response bias was detected upon carrying out the pre–post score calculation for the GSSW physical therapy group in Emmendingen. For two reasons, this group was removed from all result analyses, as the responses would have skewed the data. The first reason was identified in the pre-questionnaire analysis, as the group's collective self-assessment score regarding anatomical knowledge and clinical and orthopedic assessment was rated at 84%, which can be regarded as including extremely positive responses. This was very high in comparison to the other groups: GSSW physical therapy group in Freiburg (66%), the Furtwangen University physical therapy program (71%) and University of Freiburg medical programs (50% and 44%). It is speculated that the group overestimated their knowledge at the beginning of the seminar. The second reason was attributed to the group's neutral or random responding in the post-questionnaire evaluation. This response bias can be described as inattentive responding that does not reflect a certain response category (Meade and Craig, 2012). This "lack" engagement with the post-questionnaire evaluation could be observed by the Likert responses, given overwhelmingly to response scores "3" or "4" for large portions of the questionnaire, which led to a *decrease* in the collective pre–post-questionnaire score results of 8%. In other words, participation in the course led to a decrease in knowledge, which is unlikely.

Further assessment revealed that the statistically-significant results for the total pre–post evaluation and cluster analysis would not be affected, i.e. would remain unchanged, if the GSSW physical therapy group in Emmendingen were included in these analyses.

Regarding the "no assignment" participant profession, it is very likely that students from the medical program or physical therapy programs simply failed to reveal their affiliation on the questionnaire. It is also speculated that several of these were students belonging to the dentistry program at the University of Freiburg, and that these students left the indication of study program blank, as the questionnaire only allowed students to indicate whether they belong to either the university medical program or to one of the two participating physical therapy programs. It can be noted, that, although students of the university's dental medicine program receive almost the same pre-clinical training in anatomy as university medical students in the first two years, their participation in this course would have been accidental.

The first cluster of medical students ($n = 48$) was four times larger than the second cluster of medical students ($n = 12$). This may be attributed to the second group beginning in the late afternoon.

The 18-item questionnaire was created especially for this study to measure subjective subject knowledge, based on Bloom's Taxonomy, which is used to structure and classify learning objectives and skills in a hierarchical manner (Adams, 2015). The questionnaire demonstrated a good to very good internal consistency, showing a very high reliability for the pre-questionnaire (Cronbach's $\alpha = 0.92$) and high reliability for the post-questionnaire (Cronbach's $\alpha = 0.89$), which may allow for the questionnaire to be used for future studies to evaluate knowledge of anatomical and clinical, orthopedic assessment of the lower spine and hip region through self-assessment.

5. Conclusion

This course offers an appropriate and effective model that brings together an interprofessional team of experts to teach functional and clinical anatomy to medical and physical therapy students.

Study results support the innovative interprofessional teaching approach that was used for medical and physical therapy students to increase subject-specific competencies in functional anatomy and clinical examination and assessment. In this course, medical students demonstrated the highest increase in subjective knowledge, which might highlight the usefulness of the course early in the medical education. All students learned from the exchange with interprofessional group members as well as the instructors, which seems to reflect the importance of the interaction between both groups of students and instructors.

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Conflict of interest

The authors of this manuscript have no competing interests to declare.

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