Asian J Sports Med. 2024 March; 15(1):e136846. https://doi.org/10.5812/asjsm-136846.

Published online 2023 December 23. **Research Article**

Design, Implementation, and Evaluation of Virtual Training on Principles of Physical Medicine and Rehabilitation Based on the ADDIE Model for Medical Students During the COVID-19 Pandemic

Atiye Faghihi [1], Milad Yousefian [2], Elaheh Mianehsaz [3,*], Nayyere Jalalati [3], Mohammad Javad Azadchehr [4] and Alireza Abrahimi [5]

[1] Educational Development Center, Kashan University of Medical Sciences, Kashan, Iran
[2] School of Medicine, Kashan University of Medical Sciences, Kashan, Iran
[3] Department of Physical Medicine and Rehabilitation, Kashan University of Medical Sciences, Kashan, Iran
[4] Infectious Diseases Research Center, Kashan University of Medical Sciences, Kashan, Iran
[5] Department of Prosthodontics, School of Dentistry, Shahid Sadoughi University of Medical Sciences, Yazd, Iran

[*] *Corresponding author*: Department of Physical Medicine and Rehabilitation, Kashan University of Medical Sciences, Kashan, Iran. Email: elaheh.mianehsaz@gmail.com

Received 2023 April 15; **Revised** 2023 November 19; **Accepted** 2023 November 23.

Abstract

Background: Many General Practitioners (GPs) are unable to manage musculoskeletal disorders, chronic diseases, and disabilities.
Objectives: This study aimed to design, implement, and evaluate a virtual Physical Medicine and Rehabilitation (PMR) course for medical students during the COVID-19 pandemic.
Methods: This pre-experimental study used the ADDIE model. The statistical population was all fifth-semester medical students of Kashan University of Medical Sciences, Iran, who chose the PMR course in 2020 - 2021. Educational content and exams in the two fields of musculoskeletal and rehabilitation were virtually compiled. Learners were evaluated based on their knowledge (with exams), attitudes, and satisfaction (with researcher-made questionnaires). Data were analyzed using SPSS16 software with descriptive statistics.
Results: The final exam scores of nearly half of the 55 learners were above 17. About 80% of the students had a positive attitude, and 75% of them were satisfied at the end of the course. They believed this course is a suitable link between the basic and clinical fields, and acquiring rehabilitation skills is necessary for GPs.
Conclusions: Combining musculoskeletal with rehabilitation topics, not neglecting practical aspects such as physical examination, and using educational videos led to the improvement of students' knowledge, attitude, and satisfaction during the COVID-19 pandemic.

Keywords: COVID-19, Educational Models, Medical Students, Physical Medicine and Rehabilitation

1. Background

Musculoskeletal Disorders (MSDs) account for 15% - 30% of referrals to General Practitioners (GPs) (1, 2). In addition, about 30% of the world's population lives with some impairments that benefit from rehabilitation (3). Based on the importance of these two topics, medical graduates must know about MSDs and rehabilitation (4-6). However, studies show that GPs do not have sufficient knowledge and capabilities in these two important issues (3-8). In a study conducted at Harvard University, students did not have adequate self-confidence in musculoskeletal Physical Examination (PE) (4-9). In another study, 80% of Australian interns could not assess handicappers (10). One of the reasons for the failure of GPs in these issues is their lack of sufficient training (11-13).

Physical Medicine and Rehabilitation (PMR) is a specialized clinical field that can provide medical students with the necessary training in the mentioned topics (5). Only 60% of medical faculties in the US and a few countries in Europe, such as Germany, include PMR courses in their general medical curricula (6, 14). In Iran, in the last revision of the general medical curriculum, the PMR course was added as an optional (non-core) course (15).

In the universities where PMR courses are taught, there is no universal or national agreement on their content, course plan, and timing. Following the outbreak of

COVID-19 in 2020 and the impossibility of presenting this course in person, an instructional design was implemented at Kashan University of Medical Sciences to offer it virtually.

In instructional design, such as the ADDIE model, critical events are designed to facilitate learning. These steps include learner analysis, context analysis, goal analysis, formulation of educational goals, selection of assessment strategies and tools, production of educational materials, and assessment of learner performance (16, 17).

2. Objectives

This study aimed to design, implement, and evaluate the PMR virtual training course based on the ADDIE model for medical students during the COVID-19 pandemic.

3. Methods

Research Design: The current research is a pre-experimental study (one group) of instructional design type. The statistical population was all medical students (in the basic science stage, fifth semester) of Kashan University of Medical Sciences, Iran, who chose the PMR course as a non-core course in the first semester of 2020 - 2021. Sampling was conducted by census and voluntary methods. Removing the course for any reason or not completing the evaluation instrument were the exclusion criteria. The instructional design was done based on the ADDIE model (17) through 5 stages: Analysis, design, develop, implement, and evaluate (18). It should be noted that before the present study, the Principles of Physical Medicine and Rehabilitation course had been taught twice face-to-face at Kashan University of Medical Sciences. Therefore, in the design, implementation, and evaluation of this new virtual course, students' feedback and teachers' feelings about the previous implementations were used.

The actions corresponding to the 5 steps of the ADDIE model were as follows:

3.1. Analysis

Including needs assessment, learner analysis, teacher analysis, examination of suitable educational platforms, examination of conditions and regulations, and costs.

3.2. Design

Including goals setting, the determination of educational methods and media, educational strategies, and course content (19-26) and tests.

3.3. Develop

In this step, the media, educational materials needed, decisions about teamwork or individuation (learner activities), the formulation of a course plan, and details of the student's evaluation method were provided.

3.4. Implement

Implementing education and supporting the educational program, as well as solving technical problems, was one of the main activities of this stage.

3.5. Evaluate

The impact of the instructional design on the knowledge (with the end-of-course test), attitude, and satisfaction (with researcher-made questionnaires) of the learners was investigated.

(A) Attitude evaluation questionnaire: This questionnaire consisted of two parts: (1) Demographic information; (2) The main questions (12 items) on a five-point Likert scale (from completely agree (5) to completely disagree (1)).

(B) Satisfaction evaluation questionnaire: This questionnaire consisted of two parts: (1) Demographic information; (2) The main questions (21 items in 5 areas: Design, learning, evaluation, instructor, and general sense) with a five-point Likert scale (from completely agree (5) to completely disagree (1)).

To check the face and content validity, the questionnaires were given to 5 experts and experienced persons in the field of PMR, medical education, and virtual education, and CVR and CVI were assessed. Cronbach's alpha coefficient was also used to evaluate reliability (attitude questionnaire: 0.86, satisfaction questionnaire: 0.92). The questionnaires were provided to the students online at the end of the course.

3.6. Data Analysis

The data were analyzed using SPSS16 software with descriptive statistics. The percentage score was calculated to evaluate the attitude and satisfaction of learners. In this method, the total mean score of the items was divided by the maximum score of the given questionnaire (60 in the attitude questionnaire and 105 in the satisfaction questionnaire). The end-of-semester test score (from 0 to 20) was used to evaluate the student's knowledge.

4. Results

Fifty-five students (31 women (56.4%) and 24 men (43.6%)) with a mean age of 21.43 ± 0.99 (range 22 to 31) participated in this research. Six students were married (10.9%), and the rest, 49 (89.1%), were single. The findings based on the stages of the ADDIE instructional design model were as follows:

4.1. Analysis

In the universities where PMR courses are taught, there is no universal or national agreement on their content, course plan, and timing. On the other hand, due to the COVID-19 crisis, the decision of the crisis management headquarters and the Ministry of Health of the country to close the universities, it was necessary to provide virtual courses, so the need to design physical medicine and rehabilitation courses was created. At the analysis step, the course plan was developed. Psychomotor objectives were excluded from the course due to the absence of students (virtual education). Therefore, the specific objectives in the two parts of musculoskeletal and rehabilitation parts were formulated in the form of cognitive and affective, which are listed in the part of the design. To analyze the students before starting the course, the courses taken in the previous semesters were asked from the faculty's education unit. They had the basic knowledge and Information Technology (IT) skills necessary to pass this course due to completing the courses of musculoskeletal anatomy and medical physiology, a completely virtual year. They had chosen the PMR course (one of the elective courses (non-core)) based on their needs, interest, and motivation. The educational platforms in this project were the university's web-based electronic educational system (for uploading content offline and conducting end-of-course exams), Skyroom (for online classes), and WhatsApp (for individual or group questions and answers). The lecturers of this research were two PMR specialists. In the course plan, the division of the content was specified for both teachers to avoid the overlapping of topics.

4.2. Design

The course plan was formulated, and the specific objectives were set as listed below.

After the teaching, the students are expected to the following:

Musculoskeletal part

Cognitive objectives:

(1) Mention the normal range of motion of the joints of the limbs and the spine.

(2) Name the types of postures and draw their schematic shape.

(3) Describe the phases of the normal gait cycle.

(4) Recognize the abnormal types of gait and interpret them simply.

(5) Mention anatomical and kinesiological defects in common MSD.

(6) Analyze simple muscle, skeletal, and neurological disorders through their knowledge of anatomy and kinesiology.

(7) State the difference between types of exercises and give examples.

(8) Mention the basic principles of prescribing and doing exercise for the purpose of health.

(9) Describe the steps and details of the musculoskeletal system PE, including joint ROM, muscle strength, surface anatomy and bony landmarks, sensation, and deep reflexes related to limbs and spine.

(10) Mention the types of neurological and musculoskeletal examination tools and their use.

Affective objective:

(11) Have a plan to do regular exercise in order to maintain health.

Rehabilitation part

Cognitive objectives:

(12) Explain the difference between disability and handicap.

(13) Describe the main method of evaluating patients' function from the perspective of PMR.

(14) Name the gait aids.

(15) Name the members of the rehabilitation team and describe their duties.

(16) Explain the national and international laws regarding the rights of the handicapped.

(17) Name auxiliary tools and rehabilitation methods and describe their use.

(18) Explain the goals of rehabilitation in common chronic diseases.

Affective objectives:

(19) Understand the importance of assessing the patient's function in the history and PE.

(20) Understand the importance of rehabilitation in chronic diseases.

The content was formulated in the form of multimedia files (teachers' lectures), descriptions of clinical cases, videos, different photos of examination tools and PE techniques, podcasts, and text files. The sequence of course content was arranged from whole to part and also from simple topics to complex topics. For the evaluation of the students' knowledge, two virtual exams were designed. The first test on musculoskeletal examinations had 12 multiple-choice questions (MCQ), short-answer, and essay

questions, along with related images and two videos. In the first video, an examination was performed correctly, and the student was asked about the objectives of the examination and the interpretation of the result. In the second video, mistakes were intentionally included in a specific examination, and the student was asked to identify the mistakes and write the correct way to do them. The second test regarding rehabilitation medicine included 40 MCQ, matching, short-answer, and case-based essay questions. Researcher-made questionnaires were prepared to evaluate the attitude and satisfaction, as described in the "evaluation" section.

4.3. Develop

In this step, the learning activities of the learners were determined in accordance with their different learning styles and with the aim of covering them, including viewing contents in the Navid system at the appointed time, presenting questions and or the problems in the system, participating in two tests considered and completing two questionnaires to measure attitude and satisfaction. The course plan and evaluation method were provided to the students at the beginning of the course. The contents were uploaded onto the Navid system weekly during fifteen sessions. The content was generally presented with a focus on three main sections: Physical medicine (management of common musculoskeletal disorders and physical modalities), rehabilitation, and ability to self-care (principles of ergonomics and exercise). Also, at this stage, the feedback of the students of the previous face-to-face courses was used to revise and develop the content of the new virtual course. For example, the topic of Gait and Gait Aids (canes, crutches, and wheelchairs) was not offered because of the time limit. Nevertheless, that topic was added to the new virtual course plan. Also, due to the virtualization of the new course, the number and size of the practical unit of the lesson decreased, and some topics, such as Principles of Ergonomics, were added. At the point of the presentation method, the teaching method changed from lecture-based to problem-based, and we used videos to teach the practical part of the course.

The theory content of the course was prepared using scientific sources. About 15 files of 40 to 60 minutes (MP4 format) (based on voice on PowerPoint files using Snagit software) and the podcasts were provided to the students.

For the contents of the practical part of the course, videos on musculoskeletal physical examination techniques and tools (diapazon, monofilament, hammer reflex, and goniometer) and the normal and abnormal gait cycle were provided. In addition, two online meetings were held to solve the students' problems.

4.4. Implement

The implementation was carried out exactly according to the steps designed in the above four steps. At this stage, before uploading the content for students (in the Navid system or WhatsApp), that content was reviewed by course instructors (two physical medicine and rehabilitation specialists), a medical student, an expert in medical education (in terms of the principles of medical education), and an expert in medical informatics (according to e-learning principles) and approved. In addition, students could raise and clear their doubts about the content of the course through the "forum" section of the Navid system as well as WhatsApp and Skyroom.

4.5. Evaluate

At this stage, the opinions of the students regarding the educational contents were continuously examined during the course, which was explained in the previous step. The evaluation was carried out in a summative way (two virtual tests). In addition, at the end of the course, attitude and satisfaction evaluation questionnaires were also completed by the learners, and their results are as follows.

(A) Evaluation of knowledge: Table 1 shows that the grade point average in the PMR course was 16.71 ± 1.76, and the score of nearly half of the students was above 17.

(B) Attitude assessment: The average attitude towards the PMR course among the students was 48.23 ± 5.63 (80.4% of the total point), which indicated that the attitude was favorable. Items 1, 2, 3, 4, 5, and 6 in the attitude evaluation section of Table 2 had the highest averages.

(C) Evaluation of satisfaction: The level of student satisfaction was high (the percentage score in all areas of satisfaction was above 70) (Table 3). The highest level of satisfaction was in the two areas of "learning" and "teacher". Items 1, 3, 4, and 5 had the highest mean in the satisfaction evaluation section of Table 2.

5. Discussion

In this study, a PMR virtual training course was designed, implemented, and evaluated for medical students in 2021. The specific objectives of this study were focused on evaluating students' knowledge, attitude, and satisfaction.

This course was presented to fifth-semester medical students in the basic sciences stage. At this stage, students are studying only in the faculty and laboratory environment and are not exposed to clinical settings. In other words, in this study, early and pre-clinical interaction of students with musculoskeletal PE, the concept of

Table 1. The Amount of Knowledge (Final Exam Score) of Students in the Virtual Training of Physical Medicine and Rehabilitation Course

Variable	No. (%)	Mean ± SD (Min-Max)
Final exam score		16.71 ± 1.76 (11.9 - 20)
< 14	4 (7.3)	
14 - 17	24 (43.6)	
>17	27 (49.1)	

Table 2. The Mean Answers of Students (Highest and Lowest Mean) Concerning Attitude and Satisfaction Toward Virtual Training of Physical Medicine and Rehabilitation Course

Questionnaire	Area	Item Number	Some Items (Items with the Highest and Lowest Mean Scores)	Mean ± SD
Attitude assessment	–	1	I consider practical teaching of PMR topics essential for medical students.	4.47 ± 0.60
		2	In my opinion, this course can establish a good connection between basic courses (anatomy) and clinical courses.	4.27 ± 0.70
		3	In my opinion, GPs must acquire knowledge in the field of disease rehabilitation in addition to drug treatments.	4.11 ± 0.63
		4	In my opinion, in general, GPs must acquire skills in the field of disease rehabilitation along with drug treatments.	4.18 ± 0.61
		5	Passing this course will be effective in my future dealings with patients in need of rehabilitation services and referring them to related centers.	4.16 ± 0.63
		6	In the future, if my family and I suffer from MSD, and if I need specialized services, I will refer to a PMR specialist.	4.09 ± 0.75
		7	I will teach the exercises taught in this course to my family members and relatives.	3.60 ± 0.78
		8	I will personally apply the exercise recommendations taught in this course.	3.65 ± 0.80
Satisfaction assessment	Design	1	In this course, the possibility of independent learning (regardless of time and place) was available to students.	3.93 ± 0.98
		2	Assignments made students more eager to learn and participate in the class	2.71 ± 1.21
	Learning	3	By watching the video of the examinations, doing the practical work was facilitated	3.94 ± 0.99
	Teacher	4	The teacher's response to students' questions and doubts in virtual space and during the course was appropriate and timely.	4.25 ± 0.72
		5	The way of expression and power of conveying the teacher's concepts was appropriate.	3.93 ± 0.98

Table 3. The Level of Students' Satisfaction with Virtual Training of Physical Medicine and Rehabilitation Course

Variables	Mean ± SD	Mean Percentage Score (MPS)
Design	25.83 ± 5.45	72.5
Learning	15.20 ± 3.28	76
Assessment	14.89 ± 2.80	74.4
Teacher	12.20 ± 2.01	81.3
General sense about the course	11.02 ± 2.68	73.4
Total satisfaction score	78.69 ± 13.81	74.9

disability, and rehabilitation were considered. Gibson's study emphasizes the early introduction of PMR concepts to medical students. It considers it to be the cause of better development of the concepts of rehabilitation and disability in the minds of students during subsequent courses in the coming years of study (6). In different universities in Iran and around the world, PMR concepts are taught to students at different times during the medical course, and there is no consensus about the time of presentation of this course (3). The PMR course is offered as a one-month internship course at Shiraz University of Medical Sciences, Iran (13) and as 17 theory sessions during one academic semester for students in the physiopathology stage at Ahvaz University of Medical Sciences, Iran (12). In some American universities, the topic of rehabilitation is presented as a two-month course in the final year of medicine in neurosurgery and orthopedics courses (27).

Since the current curriculum of general medicine in Iran does not have specific headings for the PMR course, the researchers of the study, using clinical experiences, divided the titles of this course into the two main sections of musculoskeletal (with an emphasis on kinesiology, functional anatomy, and PE) and rehabilitation medicine (by emphasizing the introduction of goals and members of the rehabilitation team). The content taught in this study is similar to the study of Gibson and Mau (6, 12, 27, 28). It also complies with The European Society of Physical and Rehabilitation Medicine (ESPRM) standards for rehabilitation medicine training. In the Kahtan study, a wider variety of disabilities, including learning, hearing, and verbal disabilities, were introduced along with physical disabilities (27), but in the present study, only types of physical disabilities were introduced.

In this study, the presentation of the lesson was virtual, and there were limitations in choosing the teaching methods. Therefore, text files, multimedia files, podcasts, and educational videos were used. In different universities across the world, different methods are used to teach PMR, including lectures, clinical examination workshops, and simulated clinical situations (14). At the University of Hamburg, this course is taught by the e-learning method for 12 weeks (14). Problem-oriented, problem-based learning (PBL), bedside teaching, and case-based teaching are other methods of teaching this subject in other universities in Germany (14).

In this study, MCQ, matching, short-answer, and essay questions were used for evaluation. Based on the results of the Mau study, routine written tests were used in 83% of cases for evaluation of this course, and performance tests such as OSCE (objective structured clinical examination) and other oral tests were used in 17% of cases.

In this study, students' final scores were taken into consideration to evaluate knowledge. The grade point average of the students was 16.71 ± 1.76, and the score of more than half of the students was above 17. Unlike the study of Pakseresht, who reported the knowledge level of virtual course learners low (29, 30), the results of the present study about the knowledge were consistent with Isfahani et al. (31), Hasanian et al. (32), and Boye et al. (33).

According to the findings, there were positive attitudes towards the PMR course in more than 80% of the learners. Most of the students considered this course to be a suitable link between basic science courses (such as anatomy) and clinical courses, and they considered acquiring skills in the field of disease rehabilitation to be essential for every GP. Also, 83% of the students stated that in the future, if they or their families are affected by MSD, they will refer to a PMR specialist. The results of Wong's study showed that after holding a one-day course on rehabilitation for third-year medical students, their attitude increased (34). In another study, 90% of students were interested in presenting the subject of "chronic pain concept and rehabilitation of pain-related diseases", and 84% were interested in the subject of "recognition of impairment and disability and understanding of the concept of rehabilitation of the physically handicapped". In a similar study in Ahvaz, 85% of students believed that training in the field of PMR is necessary for GPs (12).

The findings related to the level of satisfaction showed

that the satisfaction of students in all areas of the questionnaire was above 70%. The highest level of satisfaction was reported in the two areas of "teachers" and "learning". In this study, due to the COVID-19 pandemic and the requirement for virtual teaching, it was not possible to hold the practical part in person, but the teachers tried to replace it by using the description of clinical cases, examination videos, and multimedia files and holding an online class. In Boye's study, the use of an animation-based computer program in addition to the present classroom led to the general satisfaction of the learners and also improved the level of group knowledge in the students (33).

The present research had three limitations. The first limitation was that due to the conditions of COVID-19 and the absence of students in the university, the main goals of the study were focused on the "cognitive" and "affective" areas, so the "psychomotor/practical" goals were excluded. The second limitation was the choice of teaching methods (limited to the virtual training method). The researchers tried to reduce this limitation to some extent by using various material presentations (such as multimedia files, descriptions of clinical cases, videos and different photos of examination tools and PE techniques, podcasts, and text files) and various evaluation methods (taking into account a variety of evaluation exams such as the multiple-choice question, short-answer, case-based essay question along with related images and videos with and without errors and discovering them by students). Another limitation was related to the impossibility of piloting the content of the course to confirm its validity. The reasons for this limitation include the choice of that course unit and the necessity to pass by the students in that academic semester. So, due to the time limit, the educational rules of the faculty, and the absence of students during the outbreak of COVID-19, the piloting of the content was impossible.

5.1. Conclusions

The virtual design of the PMR course, the presentation of musculoskeletal along with the rehabilitation topics, and not neglecting the practical parts such as PE, the use of educational videos, and appropriate evaluation methods could improve the awareness, attitude, and satisfaction of the students. The instructional design model and course plan developed in this study can be a suitable framework for the policymakers of this course in other medical faculties.

Acknowledgments

The authors sincerely appreciate the cooperation of the Clinical Research Development Unit of Kashan Shahid Beheshti Hospital.

Footnotes

Authors' Contribution: A. F. developed the original idea and the protocol. M. Y. wrote the manuscript and participated in designing the evaluation. M. J. A. wrote the manuscript and performed the statistical analysis. E. M. contributed to the development and revision of the idea. N. J. and A. A. prepared additional data for the evaluation

Conflict of Interests: The authors declare there is no conflict of interest.

Ethical Approval: This study was a medical student's thesis, and the Ethics Committee approved it (IR.KAUMS.MEDNT.REC.1399.157).

Funding/Support: This study was financially supported by the Deputy Director of Research, Kashan University of Medical Sciences, Iran, and the grant number is 17003052. The webpage of the grant number is 17003052.

Informed Consent: All subjects of this study were informed about the objectives of the research, and written consent was obtained.

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